be done artificially without adding greatly to the expense. The managers of the works at Aigues-Mortes have now under consideration a plan of this character to enable them to work all through the year. With their present arrangements they are treating 1,000 cubic meters of sea water a day; and they obtain from the filtering beds an average of 2 lb. of magnesia persquare yard of surface per day. The extent of the beds is being increased to treat a larger quantity of water in the coming summer season. The present output is six tons a week. The dried magnesia slime is stowed away in sheds, to be calcined and moulded into bricks, the manufacture of which is carried on throughout the year.

CYANIDE OF POTASSIUM.

CYANOGEN, C_2N_2 =26, discovered by Gay-Lussac 1815, is a compound radical, which, in its chemical character, is analogous to the halogens chlorine, bromine, and fluorine, and assumes in the formation of combinations the part of an elementary substance just as ammonium NH_4 , another compound radical, will do. Cyanogen never occurs naturally in its pure state, but is found as a sulphocyanide in the saliva of man, and but rarely in some vegetable matter; but it can be formed from many organic and inorganic bodies by various processes. It is a gas, being composed of carbon and nitrogen in the proportion of two equivalents of the former to one equivalent of the latter= C_2N_2 ; and in its capacity of a quasi element is designated by the symbol Cy. It is inflammable, burns with a beautiful purple flame, generating carbonic acid, and setting free nitrogen. Its solutions are easily decomposed; they turn turbid and brown, resulting in a series of newly formed combinations, as hydrocyanic, cyanic, oxalic, carbonic, or formic acids, urea, and ammonia.

Cyanogen combines with other elements; with metals into cyanides, and with hydrogen into hydrocyanic acid, which is extremely poisonous, and known by the name of prussic acid, and is in every way analogous to hydrochloric acid.

Gay-Lussac prepared pure cyanogen by heating in a small retort the salt called cyanide of mercury. Similarly to the liberation of oxygen from oxide of mercury, the cyanide of mercury is divided into its elements, cyanogen being set free, while metallic mercury, paracyanogen, and carbon remain. This process has proved to be of the greatest importance in organic chemistry, has opened a large field for investigations, and has shown us a compound which is physically and chemically analogous to an element, in consequence of which the doctrine of compound radicals has been introduced.

Cyanogen has a powerful affinity for the alkali metals; their combinations are soluble in water, and proceed when a base is neutralized by hydrocyanic acid. When potassium is heated in cyanogen gas, it takes fire, burning in a very beautiful manner, resulting in cyanide of potassium, KCy . Passing the vapors of hydrocyanic acid into a cold alcoholic solution of potash, a chemically pure and crystallized cyanide can be obtained.

Liebig has published a very easy and excellent process, which, however, does not yield a pure article, it being always mixed more or less with cyanate of potash. Eight parts of ferrocyanide of potassium (yellow prussiate) are rendered anhydrous by gentle heat, and intimately mixed with three parts of dry carbonate of potash. The mixture is thrown into a red-hot earthen crucible and kept in fusion until gas ceases to be evolved, and the fluid portion of the mass becomes colorless. The crucible is left at rest for a moment, and then the clear salt decanted from the heavy black sediment, which is principally metallic iron in a state of minute division. The reaction is explained by the following equation: $2(2KCy + FeCy) + (2KO, CO_2) = 5KCy + KO, CyO + 2Fe + 2CO_2$. Ferrocyanide of potassium heated to whiteness in a nearly closed earthen vessel evolves nitrogen and other gases, and leaves a mixture of carbon, carbide of iron, and cyanide of potassium.

For this process Donovan recommends the use of a wrought iron mercury bottle. When no more gas issues, the iron bottle is cooled, and to get at the product, is cut by chisel and sledge-hammer.

Cyanide of potassium forms colorless cubic or octahedral crystals. The commercial article comes in white, opaque, amorphous masses, of a sharp, alkaline, bitter taste and an alkaline reaction. It exhales, when exposed to air, the peculiar odor of hydrocyanic acid. It is readily soluble in water, but sparingly in alcohol. It is decomposed by the weakest acids, even the carbonic acid of the atmosphere. The usual impurities found in cyanide are hydrate, carbonate, cyanate, and formate of potash. It is a powerful solvent for oxides and cyanides of many metals, and especially for the haloids of silver, finds therefore employment in photographic and electro-metallurgical operations, especially in galvanoplasty and electro-plating. To use it as a fixing agent for gelatine-emulsion plates, it must be perfectly pure. Any of the impurities mentioned would lead to a weakening or destruction of the film. It is a powerful poison, acting upon the system like hydrocyanic acid, fatally in most cases. Its effects are loss of sense, smallness of pulse, contraction of the pupils, convulsions, and death. Antidotes are chlorine water or chloride of lime; diluted ammonia may be given internally and the vapors inhaled, and cold embrocations. Messrs. Smith, of Edinburgh, have recommended a mixture of the sulphates of protoxide and sesquioxide of iron to be swallowed after a solution of carbonate of potash, thus converting the poison, with the antidotes, into Prussian blue.—*E., Photo. Times.*

IMPROVED POTASH DEVELOPER FOR COLLODION EMULSION PLATES FOR TRANSPARENCIES, ETC.

For the benefit of those who work collodion emulsion (either washed or unwashed) for lantern slides, etc., this developer will be found to surpass anything that has hitherto been published. Carbonate of ammonia is a very unstable salt, and two samples can scarcely be obtained alike; so that the results given by different samples are at times anything but pleasing, and very confusing to one who is, perhaps, not well up to the making of lantern slides and transparencies. Carbonate of ammonia in the developer works well if a good sample can be obtained, and gives a very nice effect, but on the whole I give the preference to the

potash as given below, for with it almost any range of color and tone can be obtained.

I make two solutions as follows:

SOLUTION P.

Pyrogallie acid..... 96 grs.
Absolute alcohol..... 1 oz.

SOLUTION A.

Potassium carbonate..... 300 grains.
" bicarbonate 150 "
" bromide..... 60 "
Soda acetate..... 120 "
Water..... 12 ounces.

To develop put into a clean measure:

Solution P..... 10 to 20 mins.
Solution A..... 2 drachms.
Water..... 2 drachms.

This is at once poured over the plate as soon as it is washed free from alcohol. Before development, the plate is flooded with alcohol and then soaked in water until the latter drives off the alcohol and is evenly absorbed in film.

When I was first making experiments with the carbonate to get rid of the uncertainty of the ammonium salts, I made up the solution from a bottle of potassium carbonate which had not been opened for at least six months. I made up at the time about twenty-four ounces, as I had a lot of work in hand, and it worked splendidly, and I was delighted with it; when I had used all the solution I made another fresh lot up, but lo and behold, its action was totally different; instead of giving, as before, a warm, ruddy tone, it was a poor, wretched, smoky, dirty color, and I could not make it out. I tried for days and days; tried different samples of carbonate, but all to no purpose—nothing but a poor, miserable color. A cause I knew there must be, and my mind was set upon hunting it out; and after several weeks I hit upon it, in this way: it occurred to me that as the bottle I first used from had not been used from for at least six months, I thought possibly that the upper layer might have become converted into bicarbonate, and if so, the salt used was in reality carbonate and bicarbonate mixed, and it was very easy to make the experiment by adding bicarbonate, which I at once did; and, to my delight, I got the color again, and far better; to further test it, I made up several solutions from several samples as before, the results were all the same—a fine warm color that could be toned by platinum to any color required; it only remained, then, for me to settle on the proportions, which took me some little time to do, which is as I have given above.

I find it perfection for negatives of ordinary density, and it also works well with very intense negatives, provided a full exposure be given. But if very thin negatives are used, the difficulty can be easily overcome by doubling the bicarbonate, *i. e.*, three hundred grains instead of one hundred and fifty; and for negatives which are merely ghosts the bicarbonate can be further increased with advantage. With the bicarbonate increased, any amount of contrast can be readily obtained. When showing the above formula to a friend a short time since, he asked me what made me so stupid as to combine carbonate and bicarbonate, as every one knew they were both the same; the chemist where he dealt had told him so. I told him that the sooner he cut his chemist's acquaintance the better, and go to a practical man for his photographic chemicals. The bicarbonate acts as a restrainer in a very peculiar way. I tried using bicarbonate only, but to no purpose, leaving out the bromide, and I found that the proportions as given to be the best. With this developer there is less tendency of the film to slip. Negatives can be obtained with very short exposures with collodion emulsion by leaving out the bicarbonate, and increasing the carbonate to three hundred and sixty grains; in negatives it is not a question of color. In making transparencies in the camera, I find it best not to stop the lens down too much, only just sufficiently to get perfect sharpness, if warm tones are required; if stopped down to the smallest stop, no matter how long the exposure, the tone is never so good.—*William Brooks, Brit. Jour. of Photo.*

HOW TO MAKE GELATINO-CHLORIDE PAPER FOR PRINTING WITHOUT DEVELOPING.

THE process is so simple that any one with the least knowledge of photography can make their own ready sensitized paper.

A formula that I have found to answer well, giving results closely resembling albumen, and printing an excellent chocolate red which may be toned to any extent, is:

Gelatine (Nelson's No. 1, and Coignet's, equal parts)..... 175 grains.
Chloride of ammonium..... 18 "
Rochelle salts (Potassio tartrate of soda)..... 50 "
Nitrate of silver..... 75 "
Methylated alcohol..... ¼ ounce.
Water..... 5 ounces.

To make: First obtain a colored bottle, orange-yellow by preference, but "greenery-gallery" will do; the operations can then be performed in ordinary daylight. Of course, if a white bottle be used, a red or yellow light of some kind must be adopted. Pour in the five ounces of water, add the salts, and then all the gelatine; leave this about fifteen minutes to soak, then apply heat, and melt; when at a temperature of about 100 Fahr., add the silver, in crystals, all at once, put in the cork, and gently agitate the bottle for several minutes. The emulsion is very thin and transparent at this stage, as the organic salt forms slowly; it must now be kept at a temperature of about 100 Fahr. for ten minutes, when the alcohol should be added, and after standing for a short time, the emulsion will be found much thicker, and can be poured out to set, or can be used upon the paper at once without washing, as preferred. A very slight washing suffices, all that is necessary, or in fact desirable, is to cut the emulsion into threads and soak for a short time in two or three changes of water, adding a little more alcohol after remelting.

The paper may be coated by rolling the paper face outward upon a light roller, then laying upon the warm emulsion, allowing it to unfold itself; at the

same time drawing the paper slowly over the emulsion, and then laying upon some level surface to set. I, however, prefer to wet the paper thoroughly with warm water, and squeegee it lightly on to a piece of glass, pouring the emulsion on to the wet paper, upon which it flows well, and then putting upon a level surface to set, afterward removing from glass and pinning up to dry. About three drachms will be required for a surface 8 × 5. Good Rive's answers well, and in all probability the paper will curl up somewhat as it dries; this, however, is of no consequence, as this is easily removed, and the paper rendered quite flat, by rolling face outward upon a moderate-sized roller, and keeping in that position for a time.

I was some time before arriving at a satisfactory method of toning, as, although the prints looked just the right color, they obstinately refused to tone in a satisfactory manner in any ordinary toning bath. This difficulty I have now overcome, and the following method will give any desired tone: Print a little deeper than required; when finished, wash slightly, and then immerse the prints in a solution of sulphocyanide of ammonium, twenty grains; water, one ounce; then place, without washing, in toning bath; the acetate of soda and borax bath works well, and gives good tones. If time is an object, the prints may be fixed in five minutes in a solution of hypo one part, water six parts. I however prefer a weaker solution, consisting of hypo one part, water sixteen parts, in which it is necessary that the prints be left for about fifteen minutes, and moved occasionally, as the organic salt takes longer to fix out than the haloid salt, though this depends, to a certain extent, upon the quantity of gelatine used: the larger the proportion of gelatine, the longer the time required in the hypo. If not fixed properly, a reddish-gray stain, quite fatal to the print, will be left. So far from this being a drawback, it may be taken as a positive advantage, as the prints *must* be properly fixed, and are therefore all the more likely to be permanent. The prints must not be examined in white light; a sheet of thin yellow paper over the window is, however, all that is required. After fixing, wash well, and mount while wet, upon glass that has been rubbed with French chalk, and strip off when thoroughly dry. Alum can be used if thought desirable, but in my own practice have as yet found no necessity for it; at the same time, in warm weather its use will, of course, be compulsory.

The advantages of this paper are many; it is, for instance, very suitable for travelers, as it seems to keep indefinitely; prints considerably quicker than albumenized paper; can be toned any time after printing; promises to be absolutely permanent. I have had a print, one half covered with thick orange paper, the other half uncovered, exposed to strong sunlight for several days without being able as yet to detect the slightest difference in the color of the two halves; and negatives can be printed from before varnishing, etc.

I may add in conclusion that the above instructions must be strictly adhered to, and results will then be obtained excellent albumenized paper in rapidity and, at least, equaling it in excellence.—*J. Barker, Brit. Jour. of Photo.*

THE ROLLING PLANIMETER.

By F. H. REITZ.*

A LARGE number of new planimeters have been introduced of late years, and accounts of these have from time to time appeared in this journal. Among these may be mentioned the various constructions of Amsler's planimeter, Hohmann-Coradi's precision planimeter, Günther's planimeter, Kloth's planimeter, and, lastly, Hohmann-Coradi's suspended planimeter. To these may now be added the *rolling planimeter*, an instrument which may be described as the outcome of an extensive series of protracted experiments made by Herr Coradi, which led him to the peculiar solution of the problem we are now going to explain.

In the new instrument, four distinct features are embodied, each of which may be set down as a *sine qua non* of a proper construction of a planimeter. In the first place, the unit of the vernier is so small that surfaces of quite diminutive size may be determined by it with sufficient accuracy; and in this respect the new planimeter seems to have stolen a march on its older rivals. Secondly, the space to be encompassed at one fixing of the apparatus is very large in proportion to the dimensions of the apparatus, more especially in the case of long-stretched diagrams or drawings, which occur very frequently in practice. Thirdly, the results are scarcely ever affected by the nature of the surface of the paper on which the diagram is drawn or printed; and, fourthly, the whole arrangement of the instrument is such as to admit of all its parts being kept in good working order for a great length of time.

The engraving is a perspective view of the instrument, taken from a photograph.

The frame, B, is supported by the shaft of the two rollers, R¹, the surfaces of which are fluted in a peculiar way. To the frame, B, are fitted the disk, A, and the axis of the tracing arm, F. The whole apparatus moves in a straight line to any desired length upon the two rollers resting on the paper, while the tracing point travels around the diagram of which the measurement is required.

Upon the shaft that forms the axis of the two rollers, R¹, a minutely divided miter-wheel, R₂, is fixed, which gears into a pinion, R₃. This pinion, being fixed upon the same spindle as the disk, A, causes the disk to revolve, and thereby induces the rolling motion of the entire apparatus.

The measuring roller, E, resting upon the disk, A, travels thereon to and fro, in sympathy with the motion of the tracing arm, F, this measuring roller being actuated by another arm fixed at right angles to the tracing arm, and moving freely between pivots. The axis of the measuring roller is parallel to the tracing arm, F. The top end of the spindle upon which the disk, A, is fixed pivots on a radial steel bar, C C₁, fixed upon the framing, B.

According to the general theory of planimeters furnished with measuring rollers, it is immaterial what line the free end of the tracing arm travels over; nevertheless, there is some practical advantage in the construction of the apparatus to be obtained by causing that end to travel as nearly as possible in a straight

* Translated from the *Zeitschrift für Vermessungs-Wesen* (The Surveyor's Journal). 1884. No. 20.

line. Still, for the reason given heretofore, it is obvious that a slight deviation from the straight line would not involve any inaccuracy in the result.

Seeing that the fulcrum of the tracing arm keeps traveling in a straight line, it appears advisable, in evolving the theory of the apparatus, to assume a rectangular system of co-ordinates, and fix upon the line along which that fulcrum travels as the axis of abscissæ.

The passage of the tracing point around the perimeter of a diagram may be looked upon as being made up of two motions, one parallel to the axis of abscissæ and the other at right angles to that axis. Inasmuch as the latter of these two motions, in the direction of the axis of ordinates, is, after all, but an alternate motion of the tracing point, which takes place in an equal ratio, until the tracing point has returned to the spot it had started from, no one point of the circumference of the measuring roller is continuously moved forward in consequence of this motion. Therefore, it is only necessary to take the differential motion of the tracing point in the direction of the axis of abscissæ into consideration.

In the diagram, the same letters of reference denote identical parts or organs as in the upper cut; the letter D denoting the distance between the fulcrum of the tracing arm and the axis of the disk, A. In connection with the diagram, it remains to be determined what must be the quantity representing the motion of a point on the surface of the measuring roller, E, while the tracing point travels to the extent of dx . If the construction of the planimeter be correct, the quantity referred to must appear as the product of the differential quotient of the surface with reference to rectangular co-ordinates ($y dx$), multiplied into a constant derived from the dimensions of the instrument.

It is obvious that as the tracing point moves to the extent of dx , a point in the circumference of the rollers of such a radius as R_1 has must also be shifted to the extent of dx . This being so, any point in the

area of the diagram traced around, we find, by integrating equation 2 and setting down the circumference of the measuring roller as U, the area of the diagram as J, and the difference in the reading as N, that:

$$J = N \cdot \frac{U R_1 R_2 F}{R_3 D} \dots \dots \dots (3)$$

The formula 3 shows that the distance of ag of the roller from the fulcrum of the tracing arm, g , is immaterial, and does not affect the results obtained by the use of the instrument.

Messrs. Luckhardt & Alten, of Cassel, Germany, supply these instruments.

THE PRODUCTION OF AMMONIA FROM THE NITROGEN OF MINERALS.*

By Mr. GEORGE BELLBY.

THERE is probably room for considerable difference of opinion as to the origin of combined nitrogen in the early stages of the world's development, but it will be pretty generally admitted that the available sources of combined nitrogen at the present day are all, either directly or indirectly, organic. Cyanogen compounds and their derivatives, ammonia salts and alkaloids, nitrates and oxides of nitrogen, are invariably produced from nitrogen which has previously existed in the combined form in organic tissues. The vast stores of such nitrogen contained in beds of coal and peat must, as far as we can see at present, remain in the future the main source from which the supplies for industrial use will be obtained. Owing to the abundant supply of natural nitrate of soda in Chili and elsewhere, it has hitherto been quite unnecessary to devise any artificial process for the production of nitric acid or nitrates. The guano deposits of South America were for many years the chief source of the ammonia salts used in agriculture, and caused the ammonia produced in gas

processes as ammonia, formed a powerful stimulus to producers of ammonia to increase their output, and at the same time roused the interest of those who, like the owners of blast furnaces and coke ovens, had hitherto allowed large quantities of ammonia to go to waste. The gas companies had for years been perfecting plant for washing out the ammonia from their gas, and the increased output thereby brought about must have been very considerable.

Iron and coke makers turned their attention with renewed interest to the treatment of the gases from their furnaces and ovens for the recovery of ammonia. These efforts were directed to the recovery from the products of destructive distillation of the ammonia naturally resulting from that operation. It is now pretty generally understood that in destructive distillation, as ordinarily practiced in the gas manufacture, only one-sixth to one-twentieth of the nitrogen of the material distilled is obtained as ammonia. This important fact was noted in more than one standard work on applied chemistry, but attracted no attention either in scientific or technical circles.

Dr. Lunge, in his work on "Coal Tar Distillation," published so recently as 1882, quotes a table of analyses by Dr. Meymott Tidy, showing the amount of nitrogen in various coals, and comparing the possible with the actual ammonia yields of the gas companies. The result of his comparison is to show that, in illuminating gas making, only one-sixth of the total nitrogen was obtained as ammonia.

My own interest in the subject dates from 1870, when Mr. A. R. Gillespie, managing director of the Oakbank Oil Company, suggested that I should analyze all the shales then known to exist in the Midcalder field, both those which were considered worth working for the paraffin products and those which were not. It was thought possible that some of the poorer oil shales might yet be sufficiently valuable for their ammonia to admit of their being profitably worked. The determination of the nitrogen in these shales showed that, by the process of distillation as then practiced, only one-sixth of the nitrogen was obtained as ammonia. The fate of the missing five-sixths at once excited our interest, and the research was carried on until the whole was accounted for.

As oil shales are practically unknown in England, a few words of description at this point may make clearer what is to follow. The oil shales of Scotland are found below the coal measures, and are generally associated with marls, limestones, and sandstones. The specimens before you will show you how unlike coal in appearance the shales are. They are generally of a brown or gray color, the richer portions are tough, and cut like leather, while the poorer are stony and slate-like. They contain a very large percentage of mineral matter, sometimes as much as 80 per cent., and generally about 73 per cent. When heated to redness in a close vessel, true shales do not soften or cake, the pieces alter neither in size nor shape, but after all the volatile matter is distilled off, the residue or spent shale, which is soft and black, has still the outward form of the original shale. There are four principal seams, or groups of seams, worked in Scotland; among these, one of the best defined and most extensively worked is the Broxburn shale, so called from having been first found in Broxburn, in Linlithgowshire. It is not, however, confined to that particular district, but is at present worked at points as much as 12 to 15 miles apart. This shale was in regular use at Oakbank in 1870, and special attention was therefore given to the study of the behavior of its nitrogen. By the process of distillation as practiced at that date, the shale was subjected for from 12 to 20 hours to a low red heat, in iron retorts, a current of steam being passed through the retort during the distillation. The volatile hydrocarbons and other vapors were cooled by passing through condensers. The distillate from one ton of shale consisted of about 30 gallons of crude paraffin oil and 60 to 80 gallons of ammoniacal liquor, the large volume of the latter being due to the condensation of the steam passed through the retort. This ammoniacal liquor contained ammonia equal to about 15 lb. of sulphate. The primary object of the use of a current of steam in the retort was to obtain a maximum yield of paraffin products, through the protective action of the steam in sweeping away the hydrocarbon vapors as they were formed, and before they could be decomposed by overheating; but it is quite certain that this use of steam increased the yield of ammonia, the gain probably amounting to five or six per cent. of the original nitrogen. The coke or residue of this shale (specimens exhibited), known as spent shale, was, in 1870, sent to the refuse heap as of no value; but, in the three following years, the successive efforts of Mr. Wm. Young and Mr. N. M. Henderson resulted in the invention of the Henderson retort, in which, by means of ingenious mechanical contrivances, the exhausted residue, or spent shale, was dropped while still hot into a slow combustion furnace, in which the small percentage of carbon, associated with a very large amount of earthy matter, was made to supply a large proportion of the heat necessary for the distillation of the shale. The ash, or earthy residue, was now obtained practically free from fixed carbon, and was sent to the refuse heap.

Returning now to the researches of 1870, analysis of the Broxburn shale showed that it contained 0.72 per cent. of nitrogen, and that by the system of distillation then followed, the distribution of this nitrogen among the residue and products was such that of 100 parts of nitrogen in the shale—

17.0 parts appeared as ammonia in the watery distillate.
20.4 parts appeared as alkaloidal salts in the oil.
62.6 " " in the spent shale.

Or, expressing these proportions in actual numbers, and calculating the nitrogen into its equivalent of sulphate of ammonia, the following results are obtained:

One ton of shale contains nitrogen equal to 74.8 lb. of sulphate of ammonia.	
The watery distillate contains ammonia equal to	12.7 lb.
The alkaloidal tars in the oil contain nitrogen equal to	15.3 "
The "spent shale" or coke contained nitrogen equal to	46.8 "
	74.8 "

The knowledge thus gained was the base from which

THE ROLLING PLANIMETER.

pitch-line of the miter-wheel, R_2 , must necessarily move to the extent of $dx \frac{R_2}{R_1}$. By the same motions, a point of the disk, A, is moved at a distance a of the layer of the measuring roller to the extent of $dx \frac{R_2}{R_1} \times \frac{a}{R_1}$. In Fig. 2, this quantity is denoted by $a b$, therefore:

$$a b = dx \frac{R_2}{R_1} \times \frac{a}{R_1} \dots \dots \dots (1)$$

In consequence of the position of the axis of the measuring roller, the motion of the disk, A, to the extent of $a b$ produces a further shifting of a point in the circumference of the measuring roller to the extent of $c b$, while the measuring roller itself travels to the extent of $a c$. It, therefore, becomes necessary to find a formula for the value of $c b$.

It will be readily perceived that $c b = a b \sin(\alpha + \beta)$, seeing that $d a b = 90^\circ$ and $c a g = 90^\circ$, wherefore $c a f = \alpha$ and $f a b = \beta$. Now we have $\sin(\alpha + \beta) = \sin \alpha \cos \beta + \cos \alpha \sin \beta$; again:

$$\sin \alpha = \frac{y}{F}, \cos \alpha = \sqrt{1 - \frac{y^2}{F^2}}, \sin \beta = \frac{a f}{a d} = \frac{a g \sin \alpha}{a d} = \frac{a g y}{a d F}$$

$\cos \beta = \frac{d f}{a d} = \frac{D - a g \sqrt{1 - \frac{y^2}{F^2}}}{a d}$. If these values be substituted in the equation of $c b$, we find:

$$c b = a b \left(\frac{y}{F} \times \frac{D - a g \sqrt{1 - \frac{y^2}{F^2}}}{a d} + \sqrt{1 - \frac{y^2}{F^2}} \times \frac{a g y}{a d F} \right) =$$

$a b \frac{y D}{F a d}$; again, substituting the value of $a b$ as per 1, we find:

$$c b = y dx \frac{D \times R_2}{F \times R_1 \times R_2} \dots \dots \dots (2) \quad Q. E. D.$$

Seeing that the sum of $c b$ is equal to the difference in the reading multiplied into the circumference of the measuring roller, and that $\int y dx$ is equal to the

making to be looked upon as a by-product, only to be worked up under favorable circumstances; the industrial production of ammonia for its own sake was therefore not seriously attempted. These facts must, to a large extent, be held to account for the lack of a vigorous and rational treatment of the subject of ammonia production from the vast stores of combined nitrogen existing in the old organic deposits of the peat and coal fields. Turning, however, to the technology of cyanogen compounds, we find a much fuller record of technical research. The industrial world needed cyanides, and as no convenient natural stores of them had been provided—as was the case with nitrates and ammonia salts—cyanides had to be produced artificially. In the researches on the manufacture of cyanides, we might fairly expect to find the germ of a rational knowledge of such of the properties of organic nitrogen as are related to its conversion into ammonia. This expectation is not disappointed; the records of the researches of English, German, and French chemists in this field are not only deeply interesting, but they are both instructive and suggestive.

The earliest studies on the behavior of the nitrogen of organic substances during destructive distillation were made in this connection, and it was then first recognized that the temperature of distillation had a most important influence on the ultimate distribution of the nitrogen among the products of distillation and the residual charcoal. Karmrodt found, in carbonizing horn, that at three temperatures, ranging from a low red to a white heat, the residues contained respectively 7, 5, and 2 per cent. of nitrogen, the last resulting from the highest temperature. The significance of such a fact as this, as bearing on ammonia production, evidently did not appear to the investigators, who were simply bent on devising an economical process for the manufacture of cyanides, and to whom the inevitable production of ammonia was an evil to be as far as possible minimized.

The rapid exhaustion of the guano deposits, and the increasing consumption of ammonia salts for agricultural purposes, so acted on the ammonia market that, in the year 1879, the price of sulphate of ammonia had risen to £20 per ton. This high price occurring along with a general fall in the value of several of the commodities produced at the same time or by the same

* Paper read before the Society of Arts on February 12, 1885.