The results thus agree closely with the value 40.142 since obtained by Hinrichsen, who was not cognizant of my work. A further investigation is now being undertaken at Harvard to show whether other methods, executed with great care, support or discountenance this high value.

COMMERCIAL AQUA AMMONIA, ITS EFFECT UPON IRON, ITS IMPURITIES, AND METHODS FOR DETERMINING THEM.

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THE very extensive development of refrigerating plants, large and small, throughout the country during the last decade has greatly increased the manufacture of aqua ammonia.

Formerly aqua ammonia of 26° Bé., or 29.0 per cent. NH_3, was shipped in carboys. The shipments of aqua soon became so large that it was no longer practicable to transport in such cumbersome and fragile receptacles, and recourse to metal carriers was had. But ammonia was known to attack most metals seriously. W. R. Hodgkinson and N. E. Bellairs[1] found that all metals which form soluble double salts with ammonium salts are most acted upon by ammonia solution. Zinc, nickel, and cobalt are, after copper, most rapidly attacked. Lead dissolves more slowly, and iron, aluminum, and magnesium do not appear to dissolve at all.

Lunge says[2] that aqua ammonia in contact with iron, "gives rise to red precipitates of iron oxides."

Lunge's opinion was evidently held by European ammonia manufacturers, for in one of the larger works that the writer visited in Belgium in 1897, the absorber for the ammonia gas was a lead-lined vessel, and the aqua produced was shipped in carboys.

The opinion was held by certain manufacturers that aqua made from the distillation of sulphate of ammonia with lime would not attack iron, but that aqua made from crude ammonia liquor would.

To ascertain the effect of ammonia on iron and determine if an iron absorber could be used in place of a lead one, and if aqua could be shipped in iron drums and iron cars, various experiments

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[1] *Proc. Chem. Soc.*, 9, 146 (1895).

[2] "Coal-Tar and Ammonia," p. 685.

were undertaken. In these experiments, (1) absolutely C. P. aqua, made from C. P. sulphate, distilled with C. P. lime into distilled water, (2) the ordinary commercial aqua, made from sulphate, and (3) several samples, containing different percentages of impurities, all made from the direct distillation of crude liquor without first forming the sulphate, were used.

To ascertain the effect of these different ammonia solutions upon iron, small bottles, 7 inches high and 1.5 inches in diameter, were partly filled with the ammonia solution, and a bright nail, carefully cleaned by filing, was introduced into the solution, and left in contact with it twenty-four hours before examination.

The composition of the ammonia solutions used was:

1. Practically chemically pure aqua, containing 28 per cent. NH_3.

2. Aqua from sulphate, containing organic matter equivalent to 10 cc. centinormal potassium bichromate per 100 cc. aqua, 0.046 gram per liter carbon dioxide, no chlorine, no sulphate, 2 grams per liter pyridine, and 28.5 per cent. NH_3.

3. Thirteen samples of aqua from crude liquor containing organic matter equivalent to from 5 to 80 cc. potassium dichromate, carbon dioxide from 0.1 to 2 grams per liter, chlorine 0.0 to 0.1 gram per liter, and pyridine, 0.1 to 5 grams per liter, and 28.5 per cent. NH_3.

Upon examining the samples after exposing twenty-four hours, it was found that the C. P. aqua, that made from sulphate, and eight of those made from crude liquor, remained perfectly clear, and the iron was in no way acted upon; but that five were badly attacked, the nail being decidedly rusty, and the solution cloudy with reddish yellow oxide, very finely divided, which remained in suspension and would not settle. It was thought the nails had not been perfectly cleaned, because the composition of the ammonia solutions was so slightly different; five other nails were put into fresh solutions of the same kind, and after twenty-four hours all remained perfectly bright, and the solutions perfectly clear, showing that metallic iron, if perfectly free from specks of rust, is unattacked by strong solutions of ammonia, even if these solutions contain 2 grams per liter carbon dioxide, 5 grams per liter pyridine, and a high percentage of organic matter.

But, of course, it is impossible to so treat the inside of an iron absorber, a drum or tank, that its surface shall be entirely free from rust, and consequently when one begins to make aqua ammonia in an iron absorber, or ship it in drums or tank cars, reddish precipitates of iron oxide, which settle with great difficulty, are formed.

Further experiments with iron nails in different stages of oxidation were made with the same solutions, and it was found that a nail freshly rusted forms immediate and continued discoloration of the aqua, while a nail with a thick coating of old rust completely covering the iron does not influence the ammonia solution in the slightest degree.

To be able therefore to absorb strong ammonia solution in an iron vessel, or to ship it in drums or tank cars, it is necessary in some way to coat the surface of the iron with an oxide. This is not an easy matter. Boiling the drum in a weak solution of permanganate of potash will do it, but this is expensive. It has been found, from experiment, however, that by continuous use of the iron absorber, or by repeatedly shipping in drums or cars, this desirable coating is formed, and the aqua is finally not discolored. In the language of the factory, the tank becomes "seasoned," and when this has taken place there is no further trouble from discoloration by iron oxides.

For the rusting of iron it is necessary that water, carbon dioxide, and oxygen, must come in contact with the metal.

The reactions illustrating its formation are:

$$Fe + 2H_2CO_3 = \underset{\substack{\text{Ferrous acid}\\ \text{carbonate.}}}{FeH_2(CO_3)_2} + 2H.$$

$$H_2 + O = H_2O.$$

$$2FeH_2(CO_3)_2 + O = Fe_2O_3 + 4CO_2 + 2H_2O.$$

Only traces of carbon dioxide and water are necessary to cause continuous rusting.

In the above reaction it is free carbonic acid that reacts with the iron. In ammonia solutions there can be no free carbonic acid, as all carbon dioxide, even in the air above the liquid, is present as ammonium carbonate. It seems quite possible that the weak affinity of iron for carbonic acid would not be sufficient to remove the latter from ammonium carbonate; in other words, it is only free carbonic acid that is available for rusting iron.

All of our experiments with aqua have verified the following conclusions:

A. Concentrated aqua not only does not rust *clean* iron, but it actually prevents its rusting, even in the presence of water, oxygen, and ammonium carbonate. This conclusion indicates that *free* carbonic acid is necessary in the rusting of iron.

B. If iron, freshly rusted and still moist, be treated with concentrated aqua, the rusting continues for a considerable length of time. In this case we have iron coated, presumably, with more or less ferrous acid carbonate, $FeH_2(CO_3)_2$. This gives off free carbon dioxide and water in contact with the iron, and even in the strong aqua solution the rusting may be indefinitely continued by means of this very small amount of carbon dioxide.

C. Iron, which has been rusted for a considerable time, is not affected by concentrated aqua. The iron here is coated with ferric oxide and not ferrous acid carbonate, so there is no carbon dioxide available to cause further rusting.

The impurities to be found to a greater or less degree in aqua ammonia are carbon dioxide, tarry organic matter, pyridine, and seldom, if ever, hydrogen sulphide.

CARBON DIOXIDE.

The two methods which we have found to be best adapted for the determination of the small percentage of carbon dioxide in aqua are what may [illegible] termed the "precipitation" and the "direct titration method." The latter is the best, being the most accurate, as well as the most rapid.

Precipitation Method.—To 100 cc. aqua ammonia, in a suitable flask,[1] add 5 cc. normal sodium hydroxide,[2] and boil until the bulk of the solution is reduced to about 20 cc.[3] While still hot add 5 cc. barium chloride solution, drop by drop, and with constant shaking, filter immediately and quickly by suction, and wash the flask and filter five times, using about 10 cc. of water for each washing.[4] Return the precipitate and filter to the flask, add excess of fifth-normal sulphuric acid, boil to remove carbon

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[1] A conical flask of about 300 cc. capacity is most convenient.

[2] The amount of carbon dioxide in 5 cc. of the normal sodium hydroxide must be determined and allowed for in the aqua analysis.

[3] By boiling down, all ammonia is removed, and all carbon dioxide retained as sodium carbonate.

[4] The object of the washing is to remove all traces of sodium hydroxide. The wash-water must be neutral and free from carbon dioxide, but should contain phenolphthalein, so as to carry out the removal of sodium hydroxide intelligently. The filter will still be slightly pink after washing five times, but this number has been found to give best results. Further washing dissolves barium carbonate and gives too low results.

dioxide and titrate back with fifth-normal sodium hydroxide, using phenolphthalein as an indicator.

$$1 \text{ cc. N/5 NaOH} = 0.0044 \text{ gram } CO_2.$$

$$\text{No. of cc. N/5 } H_2SO_4 - \text{cc. N/5 NaOH} \times 0.044 = \text{grams per liter of } CO_2 \text{ in the aqua tested.}$$

The accuracy of this method was tested as follows:

I. 100 cc. of an aqua to which ammonium carbonate had been added was neutralized and the carbon dioxide present very carefully determined by absorption and weighing in the usual way.

Result: 100 cc. aqua contained 0.1253 gram carbon dioxide, which, for 25 cc. aqua would be 0.0313 gram carbon dioxide.

By the Precipitation Method.—(1) 25 cc. aqua contained 0.0315 gram carbon dioxide; (2) 25 cc. aqua contained 0.0317 gram carbon dioxide.

II. Tests by this method, omitting the evaporation of solutions containing a known amount of sodium carbonate, resulted as follows:

Carbon dioxide contained, gram.	Carbon dioxide found, gram.
0.0042	0.0042
0.0042	0.0044
0.0084	0.0079
0.0084	0.0081
0.0084	0.0092
0.0084	0.0088
0.0168	0.0169

III. Duplicate determinations, by this method, on 20 samples of aqua, have agreed in every case (with one exception) within 0.001 gram carbon dioxide per 100 cc. aqua.

Direct Titration Method.—1. To 100 cc. of the aqua, contained preferably in a 300 cc. conical flask, add 5 cc. normal sodium hydroxide and boil until the bulk of the solution is reduced to about 20 cc.

2. To this residue add 50 cc. of water (neutral, free from carbon dioxide and containing phenolphthalein), cool to 10° C., and bring to the neutral point by adding: first, normal sulphuric acid until the end point is nearly reached; next, tenth-normal sulphuric acid until the last trace of pink is just removed. *Excess of sulphuric acid must not be present at any time during this neutralization.*

3. To the solution thus neutralized add a measured quantity of tenth-normal sulphuric acid (usually 10 cc.), boil two

minutes to remove carbon dioxide, cool, and titrate back with tenth-normal sodium hydroxide.

(No. of cc. N/10 H_2SO_4 — cc. N/10 NaOH) × 0.044 = grams per liter CO_2 in the aqua.

The carbon dioxide contained in 5 cc. normal sodium hydroxide must be determined and allowed for in the aqua analysis.

Concerning the respective steps of this analysis the following facts may be noted :

1. When aqua ammonia is boiled down in the presence of sodium hydroxide all carbon dioxide is retained as sodium carbonate, even though the evaporation be carried nearly to dryness. The purpose of boiling down with sodium hydroxide is to remove all ammonia, to reduce the bulk of the solution, and to retain all carbon dioxide as sodium carbonate.

2. The addition of acid as described, will set free a little carbon dioxide which may partially volatilize from the solution if the latter be too concentrated. By dilution with 50 cc. of water, this cause of error is averted.

Before bringing to the neutral point the solution must be cooled to a low temperature (below 10° C.), otherwise the phenolphthalein color end point is not sufficiently distinct. Also there is less liability of loss of carbon dioxide by too rapid addition of acid, if the solution be well cooled.

The end-point is just reached when sufficient acid has been added to convert all the sodium carbonate into sodium bicarbonate, since the former is alkaline and the latter neutral to phenolphthalein. This neutralization is represented by the equation :

$$2Na_2CO_3 + H_2SO_4 = Na_2SO_4 + NaHCO_3.$$

Excess of sulphuric acid must not be present at any time during this neutralization, because it will almost certainly cause a loss of carbon dioxide before excess of alkali can again be added.

3. The final step is the decomposition of the sodium bicarbonate by addition of an excess of sulphuric acid, the removal of carbon dioxide by boiling, and the titration of the excess of sulphuric acid by alkali.

$$2NaHCO_3 + \underset{98}{H_2SO_4} = Na_2SO_4 + 2H_2O + \underset{88}{2CO_2}.$$

One cc. tenth-normal sulphuric acid (0.0049 gram sulphuric acid) sets free 0.0044 gram carbon dioxide.

Hence :

$$(\text{No. of cc. } N/10\ H_2SO_4 - \text{cc. } N/10\ NaOH) \times 0.0044 = \text{grams } CO_2 \text{ in } 100 \text{ cc. aqua.}$$

RESULTS.

TESTS WITH SODIUM CARBONATE SOLUTIONS CONTAINING A KNOWN AMOUNT OF CARBON DIOXIDE.

Carbon dioxide contained. Gram.	Carbon dioxide found by direct titration method. Gram.
0.0042	0.0042
0.0084	0.0080 0.0085 0.0087 0.0078 0.0080 0.0085 0.0080
0.0168	0.0166 0.0161 0.0164
0.0084	0.0088 0.0086

The last two determinations were made at night, by the light of incandescent lamps.

A large number of determinations of carbon dioxide in aqua by this method, and a comparison of its results, on the same aquas, with those obtained by the precipitation method, have fully confirmed its accuracy.

CONCLUSIONS.

From the results obtained the conclusion is reached that the direct titration method for carbon dioxide in aqua ammonia is, all points considered, the best. It is accurate, rapid, and simple.

Equally accurate results can scarcely be obtained by the precipitation method, and the direct titration method requires less careful manipulation, takes less time, and avoids the liability to error which is occasioned by precipitation and washing of the barium carbonate. On the other hand in using the direct titration method, sulphides, if present, must be removed before making the titrations, while this removal is unnecessary in the case of the precipitation method.

Tarry organic matter, as found in ammonia, is best determined by oxidation with potassium bichromate instead of potassium permanganate, which in the cold does not completely oxidize, and at boiling temperature is itself decomposed, whereas potassium bichromate does not undergo decomposition, and with its use check results may be obtained even at different times of boiling. The method was devised by Mr. J. G. Hazard, and is the one we have adopted.

Potassium permanganate affects pyridine slightly, but by no means entirely oxidizes it. We therefore prefer to make a test for the organic matter with potassium bichromate which does not oxidize pyridine at all, and then make a separate determination of the pyridine. The method is as follows:

DETERMINATION OF ORGANIC MATTER IN AQUA AMMONIA.

Make up fiftieth-normal solutions of ammonium sulphate, ferrous sulphate, potassium permanganate, and potassium bichromate.

Introduce 10 cc. of aqua (from pipette) into a 300 cc. Erlenmeyer flask, add 20 cc. fiftieth-normal potassium bichromate solution (from burette), and 50 cc. dilute sulphuric acid (1 : 3). Heat to boiling and boil gently for about twenty minutes, adding distilled water if necessary to keep the volume above 50 cc. After boiling, cool to temperature of the room and add fiftieth-normal ammonium ferrous sulphate solution (from burette) in excess, and titrate back to faint pink color with fiftieth-normal potassium permanganate. The pink color will always fade out in a short time.

Add number of cubic centimeters potassium permanganate used, to number of cubic centimeters potassium bichromate used, and subtract number of cubic centimeters ammonium ferrous sulphate used. Deduct number of cubic centimeters potassium bichromate used up in a blank sample, and report result as number of cubic centimeters centinormal potassium bichromate used per 100 cc. aqua.

The end-point of the method appears to be perfectly definite, no further oxidation occurring by boiling considerably longer than the prescribed twenty minutes. The results obtained have indicated that all organic coloring-matter, or compounds which may change over into colored products are determined by this method, while pyridine, and perhaps other stable organic bodies, are unattacked. A sample of aqua to which pure pyridine had been added gave almost exactly the same result as it gave by a test before the addition.

PYRIDINE.

Pyridine in aqua to be used in making liquid ammonia causes much trouble in the compressors and must be kept down to a low figure.

For the detection of traces of pyridine in commercial ammonia, "H. Ost recommends that the sample should be nearly neutralized when the odor of pyridine may be recognized. By distilling the nearly neutralized liquid, collecting the distillate in hydrochloric acid, evaporating, and extracting the residue with absolute alcohol, a solution is obtained containing but little ammonium chloride. What is present is removed by boiling off the alcohol and adding platinic chloride solution when, on evaporating the filtrate and adding alcohol, the pyridine chloroplatinate crystallizes in smooth, ramifying, orange-red prisms, readily soluble in boiling, but very sparingly in cold water."

But this is only a qualitative determination, while the following method gives excellent results quantitatively:

DETERMINATION OF PYRIDINE IN AQUA AMMONIA.

100 cc. of the aqua are nearly neutralized with sulphuric acid (1 : 5), keeping the mixture moderately cool meanwhile, so that pyridine will not be volatilized. Finally, cool to 20° C., add 1 or 2 drops of methyl orange and bring exactly to the neutral point with normal acid and alkali.

This neutral mixture is then placed in a suitable distilling flask and distilled until 70 cc. have passed over, the distillate being collected in 30 cc. of cold water contained in a small receiver.

Unless the aqua contains an unusually large amount of pyridine (*i. e.*, over 2.5 grams per liter), the 100 cc. of liquid now in the receiver contain *all the pyridine* which was present in the aqua and a small amount of free ammonia. The amount of ammonia (NH_3) which is thus carried over will usually be equivalent to about 2 cc. normal solution.

Cool the contents of the receiver to below 10° C., add phenolphthalein, then, from a burette, mercuric chloride solution until the last trace of pink is just removed, and finally 4 drops more of mercuric chloride solution to insure complete removal of the ammonia.

The mercuric chloride removes all the free ammonia according to the equation

$$HgCl_2 + 2NH_3 = \underset{\text{white precipitate}}{NH_2HgCl} + NH_4Cl.$$

Phenolphthalein is colored by free ammonia, but not by pyridine, so that the pink color of the solution is just removed when all the free ammonia has been acted upon.

The mixture is now filtered and the filtrate, containing pyridine bases alone, is titrated with normal sulphuric 'acid, after adding one drop of methyl orange for an indicator.

$$1 \text{ cc. normal } H_2SO_4 = 0.079 \text{ gram pyridine.}$$

RESULTS OF DETERMINATIONS OF KNOWN QUANTITIES OF PYRIDINE IN AQUA.

Grams per liter present	1.16	2.16	4.16	2.2	1.16
" " " found	1.11	2.0	4.11	2.3	1.15

Water, to which a known quantity of pyridine was added, was carried through the method.

Grams per liter present	1.9
" " " found	1.9

In the manufacture of aqua it is a great convenience to know, without making an analysis, the percentage of ammonia in an aqua by simply taking the degree Baumé. The temperature of the manufactured article as it leaves the absorber, of course, varies slightly.

Having determined the percentage of ammonia in three samples of different strengths, we have found the degree Baumé of each at temperatures varying from 10° C. to 30° C., and after plotting these on a chart, we have worked up the following table, by which, at a glance, one may learn the percentage of ammonia in a given sample of aqua, having determined the temperature and degree Baumé.

In shipping strong aqua, 29 to 30 per cent., to a hot climate in tank cars, one must take into consideration the great expansion of ammonia at temperatures which are likely to prevail in the summer months, and see to it that his tank will withstand the pressure as, of course, the tank will be sealed up. The following

PER CENT. OF AMMONIA IN AQUA FOR TEMPERATURES BETWEEN 10° C. AND 30° C., AND ANY DEGREE BAUMÉ READING BETWEEN 24° AND 27°.

COMMERCIAL AQUA AMMONIA.

Bé.	10° C.	11° C.	12° C.	13° C.	14° C.	15° C.	16° C.	17° C.	18° C.	19° C.	20° C.	21° C.	22° C.	23° C.	24° C.	25° C.	26° C.	27° C.	28° C.	29° C.	30° C.
24.0	26.2	26.0	25.8	25.7	25.5	25.3	25.1	24.9	24.8	24.6	24.4	24.3	24.1	23.9	23.7	23.6	23.4	23.3	23.1	22.9	22.8
.1	.4	.2	26.0	.8	.7	.5	.3	25.1	25.0	.8	.6	.5	.3	24.1	.9	.8	.6	.4	.3	23.1	23.0
.2	.6	.4	.2	26.0	.8	.7	.5	.3	.2	25.0	.8	.7	.5	.3	24.1	24.0	.8	.6	.5	.3	.2
.3	.8	.6	.4	.2	26.0	.9	.7	.5	.4	.2	25.0	.9	.7	.5	.3	.2	24.0	.8	.6	.5	.3
.4	27.0	.8	.6	.4	.2	26.1	.9	.7	.5	.4	.2	25.1	.9	.7	.5	.4	.2	24.0	.8	.6	.5
.5	.2	27.0	.8	.6	.4	.3	26.1	.9	.7	.6	.4	.3	25.1	.9	.7	.6	.4	.2	24.0	.8	.7
.6	.4	.2	27.0	.8	.6	.5	.3	26.1	.9	.7	.6	.5	.3	25.1	.9	.7	.6	.4	.2	24.0	.9
.7	.6	.4	.2	27.0	.8	.7	.5	.3	26.1	.9	.8	.6	.5	.3	25.1	.9	.7	.6	.4	.2	24.0
.8	.8	.6	.4	.2	27.0	.9	.7	.5	.3	26.1	26.0	.8	.6	.5	.3	25.1	.9	.7	.6	.4	.2
.9	28.0	.8	.6	.4	.2	27.1	.9	.7	.5	.3	.2	26.0	.8	.6	.5	.3	25.1	.9	.7	.6	.4
25.0	.2	28.0	.8	.6	.4	.3	27.1	.9	.7	.5	.4	.2	26.0	.8	.6	.5	.3	25.1	.9	.7	.6
.1	.4	.2	28.0	.8	.6	.5	.3	27.1	.9	.7	.6	.4	.2	26.0	.8	.6	.5	.3	25.1	.9	.7
.2	.6	.4	.2	28.0	.8	.7	.5	.3	27.1	.9	.7	.6	.4	.2	26.0	.8	.6	.5	.3	25.1	.9
.3	.8	.6	.4	.2	28.0	.9	.7	.5	.3	27.1	.9	.7	.6	.4	.2	26.0	.8	.6	.5	.3	25.1
.4	29.0	.8	.6	.4	.2	28.0	.9	.7	.5	.3	27.1	.9	.7	.6	.4	.2	26.0	.8	.6	.5	.3
.5	.2	29.0	.8	.6	.4	.2	28.0	.9	.7	.5	.3	27.1	.9	.7	.6	.4	.2	26.0	.8	.6	.5
.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.9	.7	.5	.3	27.1	.9	.7	.6	.4	.2	26.0	.8	.7
.7	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.5	.3	27.1	.9	.7	.6	.4	.2	26.0	.8
.8	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4	.2	27.1	.9	.7	.6	.4	.2	26.0
.9	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4	.2	27.1	.9	.7	.6	.4	.2
26.0	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4	.2	27.1	.9	.7	.5	.3
.1	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4	.2	27.1	.9	.7	.5
.2	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4	.2	27.1	.9	.7
.3	.8	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4	.2	27.1	.9
.4	31.0	.8	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4	.2	27.0
.5	.2	31.0	.8	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4	.2
.6	.4	.2	31.0	.8	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6	.4
.7	.6	.4	.2	31.0	.8	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8	.6
.8	.8	.6	.4	.2	31.0	.8	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0	.8
.9	32.0	.8	.6	.4	.2	31.0	.8	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2	28.0
27.0	.2	32.0	.8	.6	.4	.2	31.0	.8	.6	.4	.2	30.0	.8	.6	.4	.2	29.0	.8	.6	.4	.2

table shows the pressure developed by strong ammonia solutions exposed to different temperatures:

PRESSURE PRODUCED BY EXPOSING AQUA AMMONIA TO DIFFERENT TEMPERATURES.

The apparatus in which this test was made consisted of a cast-iron fitting piece with a pressure gauge and a mercury gauge attached. The relation of the liquor to the unoccupied space of the apparatus was the same as the relation of liquor in a tank car to the unoccupied space of the car. The apparatus was set in a water tank which was heated externally, and readings of the pressure gauge end of the mercury gauge made at every degree of temperature. The thermometer was placed in the aqua.

Experiment was carried to 120.2° F.

The rate of heating was 1° every six minutes.

The percentage of ammonia was 28.5, and the number of cubic centimeters aqua used was 2800.

°C.	°F.	Pounds pressure.	Inches mercury.
23	73.4	2½	4½
24	75.2	3	6½
25	77.0	4	7½
26	78.2	4½	8¼
27	80.6	5	9¼
28	82.4	5	10¼
29	84.2	5	11¼
30	86	6	12½
31	87.8	6½	13¾
32	89.6	8	16
33	91.4	8	17½
34	93.2	9	18¼
35	95	9½	19
36	96.8	10	20½
37	98.6	10½	21¾
38	100.4	11	22¾
39	102.2	11½	23¾
40	104	12	24¾
41	105.8	12½	25½
42	107.6	13	26¾
43	109.4	13½	27¾
44	111.2	14	28¾
45	113	14½	29¾
46	114.8	15	30¾
47	116.6	15½	31¾
48	118.4	16	32¾
49	120.2	16½	33¾

A NITROGEN APPARATUS.

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THE purpose of this apparatus, as illustrated and described herewith in detail, is to secure greater rapidity in the ordinary nitrogen estimation. The method adopted in this apparatus for estimating nitrogen is by distilling the alkaline mixture in a current of steam, using the same steam which makes the