

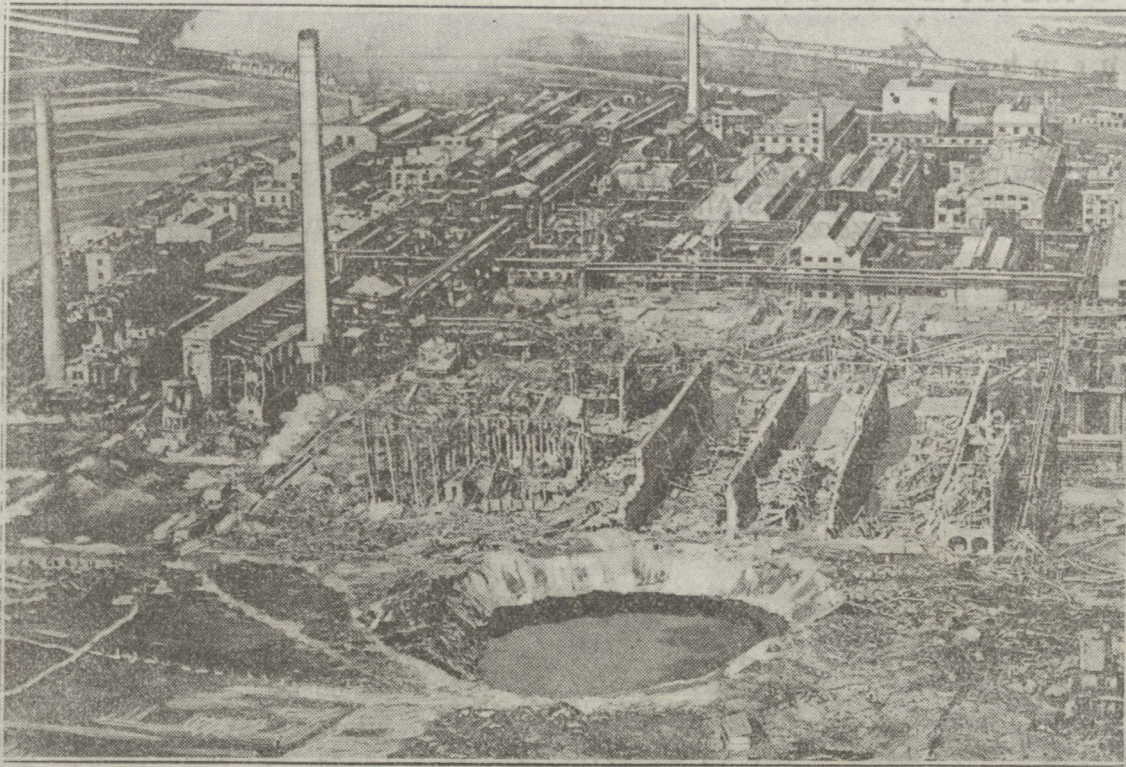
# Chemicals from the Air, Vital on Farm and Battlefield, a Triumph of the Laboratory

By Thomas M. Beck

ABOUT fifty years ago Chile waged a successful war of conquest against Peru and as the only spoils of victory received a large stretch of sandy desert. This desert was quite valuable, however, since beneath its surface lay immense beds of a soft sandy rock that consisted to the extent of about half its weight of two valuable chemicals sodium nitrate and potassium nitrate. There were no other reserves of nitrates anywhere else in the world, and Chile proceeded to make the most of its monopoly. Assured of a large and continual source of national income the Chileans settled back to lead easy and prosperous lives. But during the last fifteen years, as a result of the activity of a few German chemists and engineers they have seen these nitrate beds become almost a national liability and are now facing the painful problem of trying to find some new source of income for the country.

But before going on with this story, it might be well to explain why nitrates are so important. The element nitrogen is an important component of all living material. And while the air around us is four-fifths nitrogen, this nitrogen is uncombined with other elements and happens to be too unreactive to be assimilated by living matter, and so might just as well not be there. In order to be useful to plants and animals, it must be "fixed," that is, combined with certain elements. The two most important forms of combined nitrogen are ammonia (NH<sub>3</sub>) and nitric acid (HNO<sub>3</sub>). Both of these and especially ammonia, are needed to supply the ever increasing world demand for fertilizers; and nitric acid has the additional value of being the one essential ingredient in the manufacture of all explosives. Prior to about thirty years ago, most of the world's ammonia was obtained as a by-product from the manufacture of coal gas and coke, while the source of the nitric acid was Chilean nitrate.

But it was a fact that the sources of such highly essential commodities would some day be exhausted. At the start of the century the great British physicist, Crookes, painted a most gloomy picture of the white race, immersed in an ocean of nitrogen, starving to death



Airplane view of a wrecked nitrate plant at Oppau, Germany. The factory was demolished by a terrific explosion, the exact cause of which never has been accurately determined. Scores of workers were killed, and the property loss ran into millions.

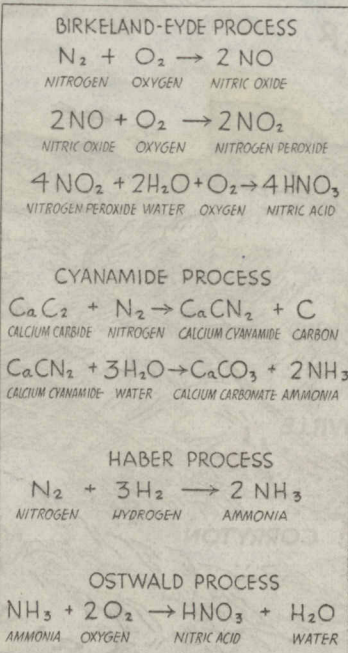


Diagram showing nitrate extraction formulae.

for lack of it in the right form. This dreadful prospect spurred many scientists on to try to find some means of tapping the limitless reservoir of air. The first commercially practical method known as the Birkland-Eyde process was first put into operation about 1905. It consists of blowing wind through a huge electric arc. At the incon-

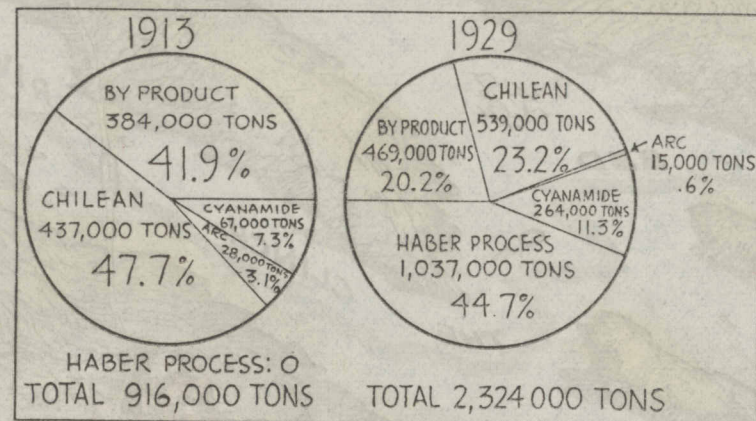


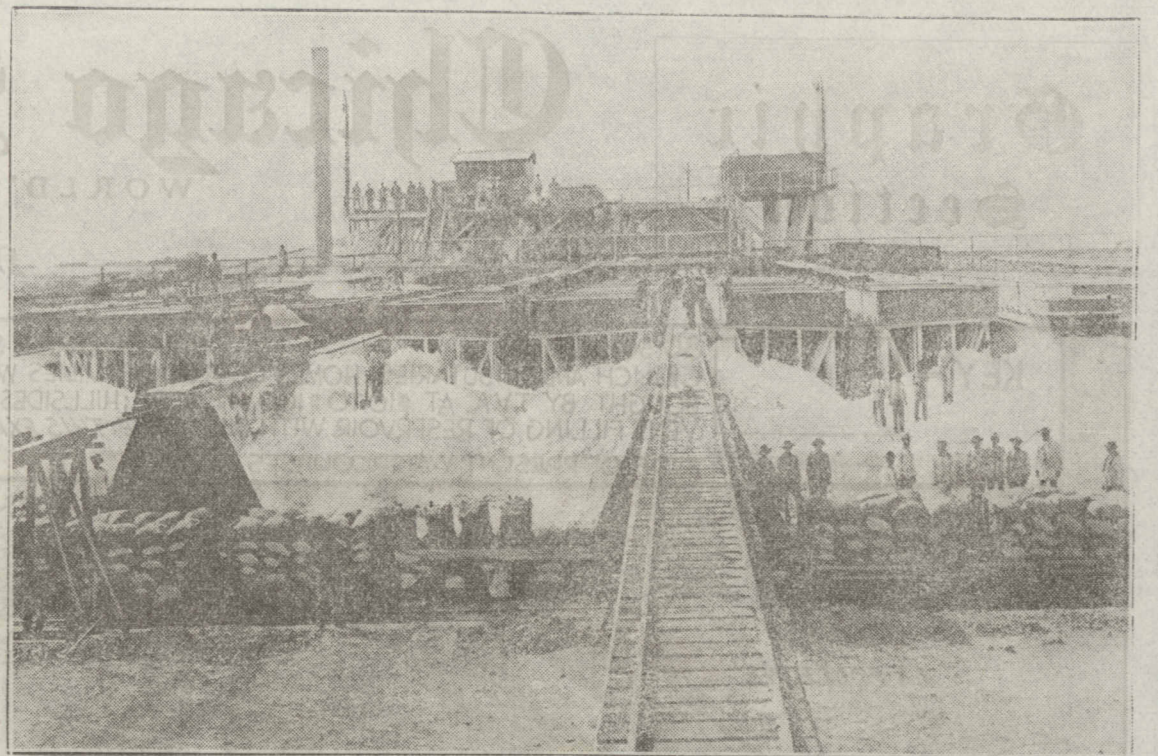
Diagram showing nitrate extraction formulae now in use.

ceivably high temperature of the arc the nitrogen and the oxygen of the air combine to the extent of a few per cent, to form a colorless gas known as nitric oxide. The mixture is cooled rapidly whereupon the nitric oxide combines with some of the rest of the oxygen forming nitrogen peroxide, an unpleasant red gas. This gas, still mixed with air, is then bubbled through hot water, which converts it into nitric acid. This method while leaving nothing to be desired in the way of cheapness and availability of its raw materials unfortunately requires a tremendous amount of electrical power to run the arc. About 70,000 kilowatt hours are used up for each ton of

nitrogen fixed. Consequently, the process is nearly obsolete at present. It is used only in a few out of the way places in Norway where there is a lot of water power and not much else to use it for.

A second method is the cyanamide process, developed in 1908. Calcium carbide is the raw material. This substance is well known for its power to generate the inflammable acetylene gas when mixed with water and is prepared by heating lime and coke in an electric furnace. When heated to 2000°F. and a current of nitrogen passed over it, the carbide absorbs the gas to form calcium cyanamide which in turn on treatment with water yields ammonia. This method which is the one for which the Muscle Shoals plant was built uses only a fifth of the power that the Birkland-Eyde process does, but it is not quite so efficient as the later Haber process. However, it is by no means obsolete at the present time.

Since ammonia is a compound of nitrogen and hydrogen, the obvious method of trying to prepare it would seem to be that of bringing these two elements together and making them stick. The late Prof. Haber undertook this problem about thirty years ago



Here is a typical natural nitrate plant in Chile. In the foreground are shown the settling vats and piles of refined nitrate, ready to be loaded into cars or ships and transported to market.

in Germany, and while he found that its solution was a theoretical possibility, the practical difficulties were great enough to make commercial application rather improbable.

But in 1914 came the World war and the British fleet blockaded Germany in the confident hope of shutting off its supply of nitrates and therefore of its munitions. Consequently it became imperative for the Germans to investigate fully every possible source of nitrogen fixation. Great sums of money were placed at Haber's disposal and within a year or so he had developed a beautiful method of synthesizing ammonia thereby freeing the Fatherland from any further worry about a possible munitions shortage.

It may be of interest at this time to mention the subsequent fate of Haber. This outstanding scientist who had rendered a greater service to his country in its hour of need than any one else, was compelled to resign his positions and honors early last year because certain authorities felt that he was incapable of becoming a good German. He retired to Switzerland where he died shortly afterward.

This process of combining nitro-

gen and hydrogen involves all manner of technical difficulties. Haber had figured out that the reaction gave the best yields at very high pressures and low temperatures. But at low temperatures it goes on at an immeasurably slow rate, and Germany could not afford to wait a thousand years for its fixed nitrogen. Consequently it became necessary to find a catalyst for the reaction. A catalyst is a substance the presence of which speeds up a reaction in some mysterious way without itself undergoing any permanent change. The one chosen for this reaction was a special form of powdered iron.

Now the chief trouble in using catalysts is the fact that they are delicate things and are very easily poisoned by the presence of traces of certain impurities. This particular iron catalyst proved to be unusually sensitive toward these poisons and it was necessary to expend vast amounts of ingenuity and labor to find ways of preparing super-pure nitrogen and hydrogen. It was found that the best yield of ammonia could be obtained by running the reaction at 1000°F. and under several thousand pounds pressure. Under these conditions, the hydrogen weakened the steel walls of the container, with the result that the whole plant occasionally blew up, but the engineers eventually solved this problem.

Of course, ammonia is not nitric acid, the parent of explosives, so the whole process would have been useless from a wartime standpoint had it not been for the simultaneous development of the Ostwald method of making this change. Ammonia when mixed with air and passed over a catalyst of hot platinum, is burned to nitric acid. Since this reaction gives off a lot of heat no power is needed for it. All that is necessary is that the ammonia be diluted with the correct amount of air to keep the platinum at exactly the right temperature.

With the return of peace, the Germans had the trick of fixing nitrogen so well worked out that they were able to challenge the Chilean monopoly. The natural

nitrate magnates fought back with every trick that they could think of, such as price fixing and output restriction, but all they succeeded in doing was to encourage their rivals' expansion. The result is shown by the Chileans' share of the world nitrogen which dropped from 65 per cent in 1903 to 50 per cent in 1913 to 20 per cent in 1927 and to 10 per cent in 1931. So it would appear that Prof. Crookes' dire prophecies were groundless. Instead, worried bankers gather together these days and try to figure out what can possibly be done with the world's surplus fixed nitrogen.

## Scientific Queries Answered

Mr. Beck will be glad to answer questions of scientific nature. Address: Thomas M. Beck, Graphic Section, Chicago Tribune. For personal reply, inclose stamped, addressed envelope.

Recently I have been reading about a new synthetic rubber that is being prepared. Is this a result of the work that Edison was doing some years back? — R. R. L., Chicago.

No. Edison was looking for a new source of natural rubber. This new rubber differs chemically from the natural product and perhaps should be called an imitation rather than a synthetic rubber. This does not imply that it is inferior to the natural product. As a matter of fact, in some respects it appears to be superior, but it is still too expensive to find any great general use.

How do the refineries recover or separate the gold in jewelry from the base metals? — E. R. C., Chicago.

The lower metals, such as copper, can be removed by heating the alloy with sulphur, nitre or some such oxidizing agent. The silver is separated from the gold on a large scale by complex electrical methods; on a small scale, by treatment with sulphuric acid or with aqua regia (a mixture of nitric and hydrochloric acids).

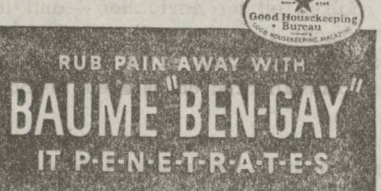
Are the differently colored neon lights all made by using the same neon gas? — C. W. H., Danville, Ill.

No. Neon itself produces only the red color. Other colors must be made by using other gases.



Stop that pounding — "Ben-Gay" penetrates skin... muscle... joints

Kill those neuralgic and head pains with "Ben-Gay," the original Baume Analgesique. Just rub on a generous quantity. No matter how far in the pain is, "Ben-Gay" will find it—will stay in the pain area—and rout it! For "Ben-Gay" has a powerful hypsensitizing (pain-relieving) action. It has power to penetrate, power to kill the pain when it gets at it. Look for the red "Ben-Gay" on the box.



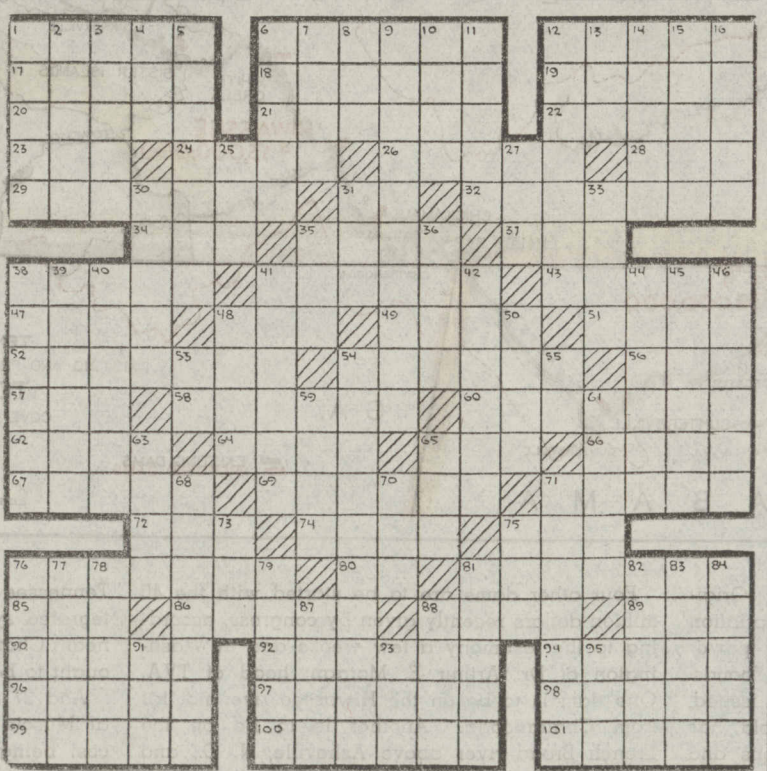
**RUB PAIN AWAY WITH BAUME "BEN-GAY" IT PENETRATES**

**PUBLIC ENEMY NO. 1**

Don't lose valuable time or be half sick with a "common cold"—public enemy No. 1. Do like millions of Americans—use Kondon's Nasal Jelly daily... Kondon's stops a cold where it starts—the nose.

**KONDON'S NASAL JELLY**  
Plain or Ephenedrine  
AT ALL DRUG STORES

## Crossword Puzzle



- 1—Station  
2—Struggle  
3—Horsehair  
4—Gods of peace  
5—Exit away  
6—Exultant  
7—Elector  
8—New  
9—Registers  
10—Poem  
11—Rage  
12—Amend  
13—Hardened  
14—The earth  
15—Deity  
16—Muses  
17—Do  
18—Jaunt  
19—Blind  
20—Extra tire  
21—Becomes insane  
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