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_3) and nitric acid (HNO_3). 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 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 Birkeland-Eyde process was first put into operation about 1905 It consists of blowing wind through a huge electric arc At the inconceivably 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 Birkeland-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 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.

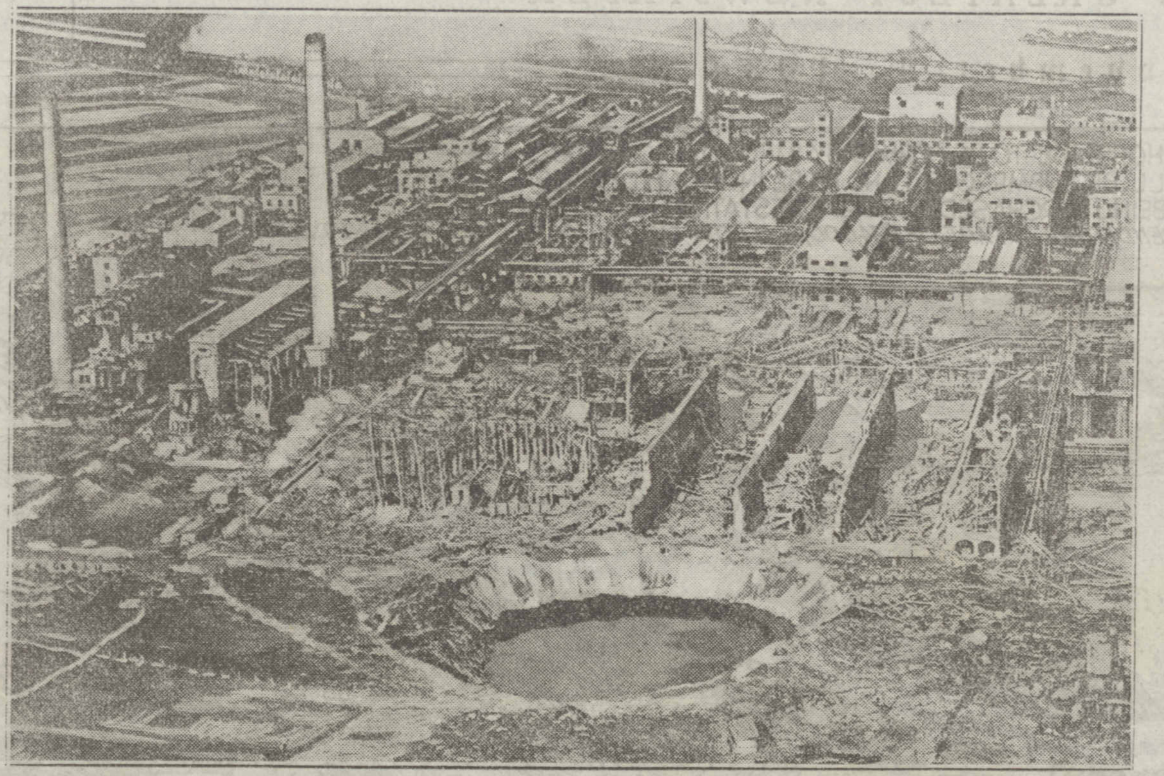
It may be of interest at this time to mention the subsequent fate of Haber This outstanding scientist who had rendered a greater service to his country in its hour of need than any one else, was compelled to resign his positions and honors early last year because certain authorities felt that he was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

This process of combining nitrogen 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.

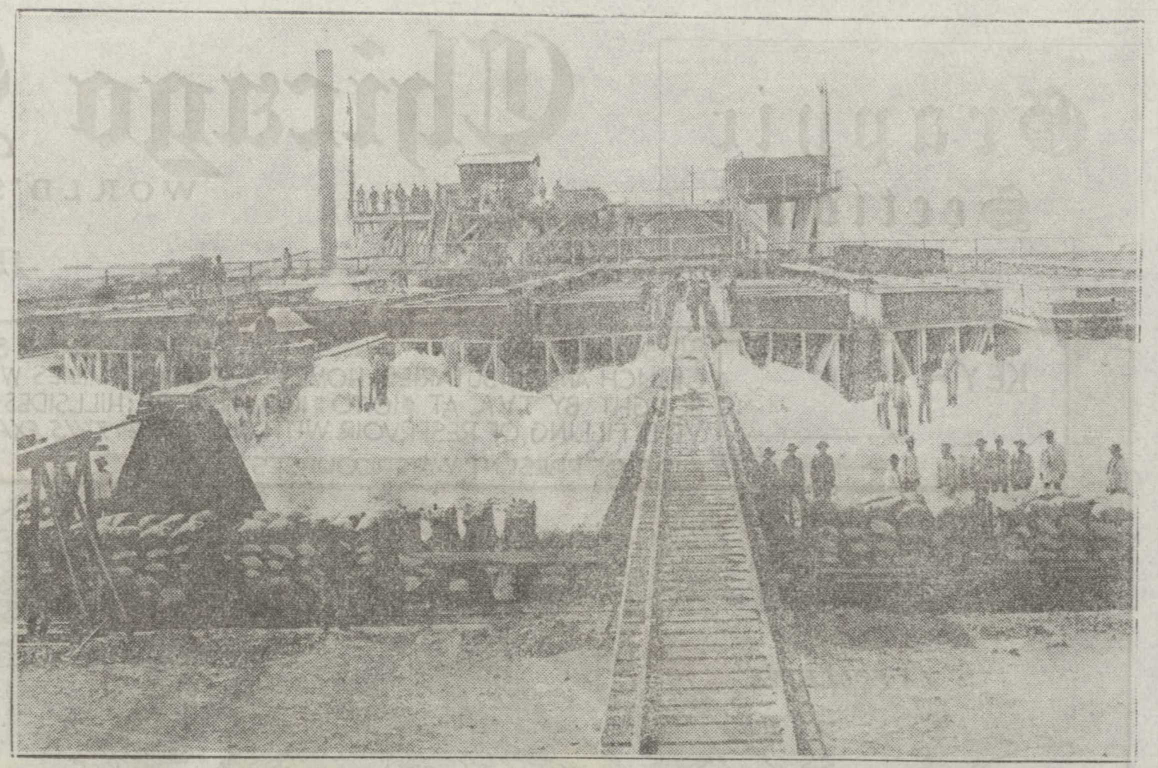
Now the chief trouble in using catalysts is the fact that they are delicate things and are very easily poisoned by the presence of traces of certain impurities This particular iron catalyst proved to be unusually sensitive toward these poisons and it was necessary to expend vast amounts of ingenuity 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 market which dropped from 65 per cent in 1909 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.



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.



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.

BIRKELAND-EYDE PROCESS

$N_2 + O_2 \rightarrow 2NO$ (NITROGEN, OXYGEN, NITRIC OXIDE)

$2NO + O_2 \rightarrow 2NO_2$ (NITRIC OXIDE, OXYGEN, NITROGEN PEROXIDE)

$4NO_2 + 2H_2O + O_2 \rightarrow 4HNO_3$ (NITROGEN PEROXIDE, WATER, OXYGEN, NITRIC ACID)

CYANAMIDE PROCESS

$CaC_2 + N_2 \rightarrow CaCN_2 + C$ (CALCIUM CARBIDE, NITROGEN, CALCIUM CYANAMIDE, CARBON)

$CaCN_2 + 3H_2O \rightarrow CaCO_3 + 2NH_3$ (CALCIUM CYANAMIDE, WATER, CALCIUM CARBONATE, AMMONIA)

HABER PROCESS

$N_2 + 3H_2 \rightarrow 2NH_3$ (NITROGEN, HYDROGEN, AMMONIA)

OSTWALD PROCESS

$NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$ (AMMONIA, OXYGEN, NITRIC ACID, WATER)

Diagram showing nitrate extraction formulæ.

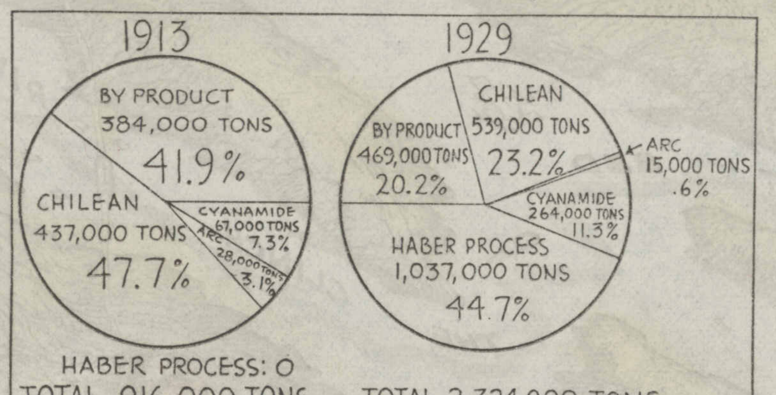


Diagram showing nitrate extraction formulæ now in use.

The late Dr. Frederick Haber, distinguished German scientist, who during the war developed a method of producing nitrates from the air.

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.

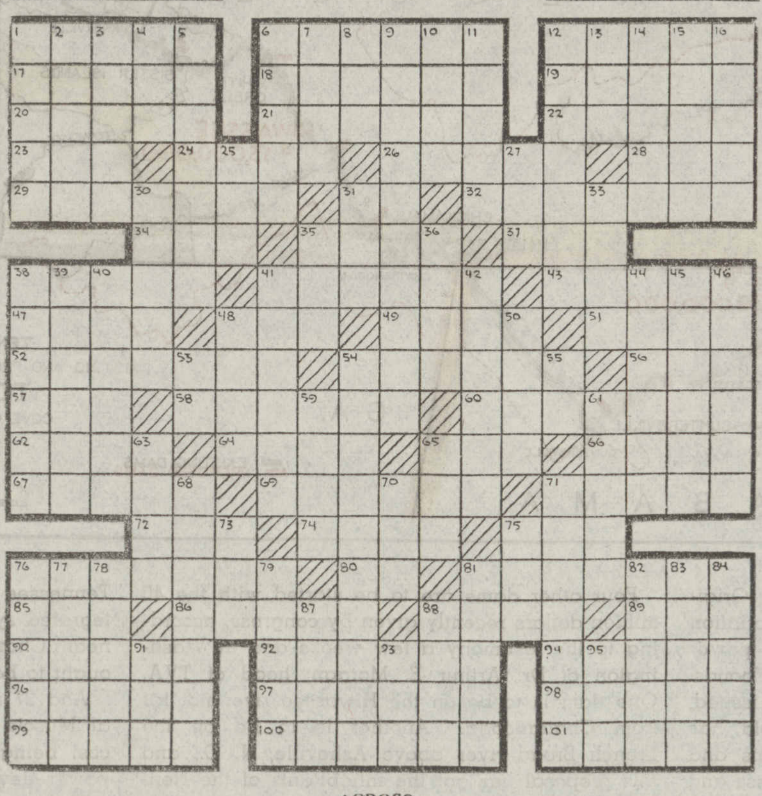
How do the refineries recover or separate the gold in jewelry from the base metals? — E. R. C., Chicago.

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.

Crossword Puzzle



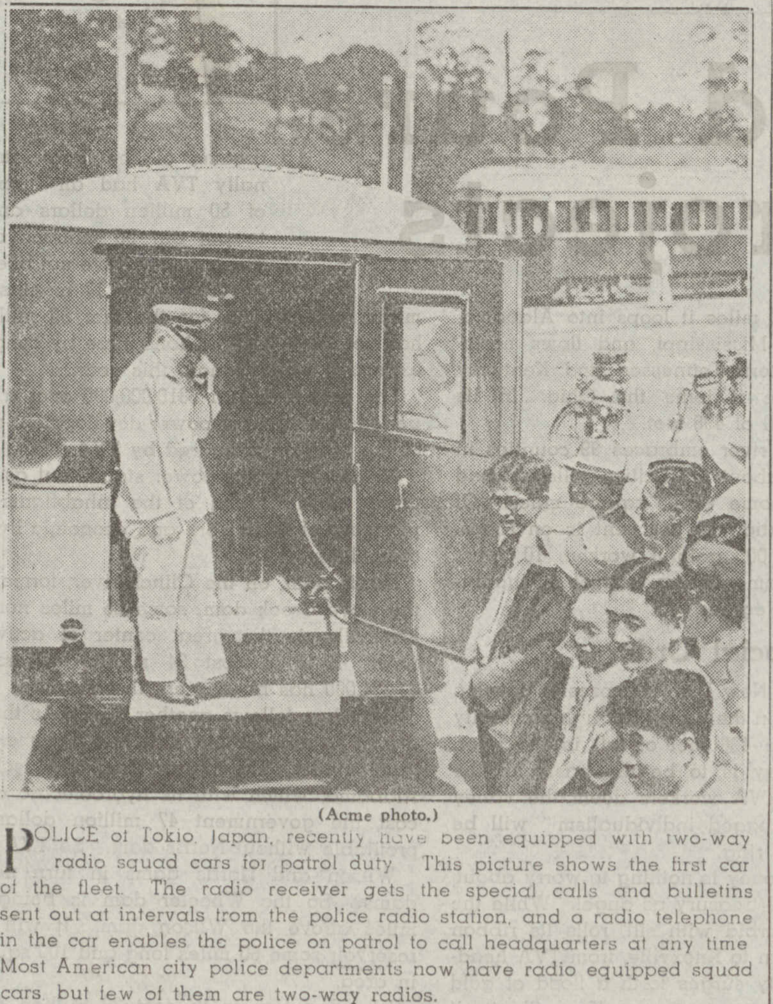
ACROSS

1—Station
6—Struggle
12—Horsehairs
17—Goddess of peace
18—Eats away
19—Exultant
20—Elector
21—New
22—Registers
23—Poem
24—Rage
26—Amend
28—Hardened
29—The earth
31—Deity
32—Muses
34—Do
35—Jaunt
37—Bind
38—Extra tire
41—Becomes insane
43—Furnish food
47—Belonging to me
48—Cunning
49—Angers
51—Learning
52—Ungrateful person
54—Injections
56—Measure of weight
57—Name for lion
58—Affectionate
60—Satisfy
62—Parts of heads
64—Skins
65—Beings
66—Company of people
67—Roofing material
69—Recompense
71—Classify
72—Age
74—Lubricates
75—Feather neck piece
76—Burn
80—Southeast
81—Story set to music
85—Fowl
86—Begins
88—Ground
89—Hurried
90—Lessen
92—High shoe
94—Smells
96—Gas measure
97—Variety of explosive asphaline
98—Rents
99—Entreaties
100—Gets again
101—Mistake

DOWN

1—Square of turf
2—Wear away
3—Give out
4—Unit
5—Raised level portion of earth
6—Treat
7—Woody plant
8—Fabulous bird
9—Making ideals
10—Small opening
11—Bar
12—Derived from selenium
13—Yale
14—Cup (French)
15—Mammal of weasel family
16—Birds' homes
25—Social insect
27—Negation
30—More uncommon
31—Age
33—Apportions
35—Attempts
36—Father (French)
38—Express pleasure
39—Shaped like pine cone
40—Kind of goat
41—Smart
42—Needs
44—Valuable New Zealand timber
45—Gnaws away
46—Restores
48—Halt
50—Undermines
53—Morindin dye
54—Entwine
55—Spanish (abbr.)
59—Combining form: ileum
61—Glory
63—Tree trunk
65—Bitter vetch
68—Rubbers
70—Beverage
71—Express sympathetic sorrow
73—Siamese coin
75—Bar
76—Bite repeatedly and noisily
77—Revolt
78—Growing out
79—Ardent
81—Concerns
82—Roaring
83—Combining form: ankle
84—Genus of geese
87—Value
88—Native of Kurlan Peninsula U. S. S. R.
91—Beverage
93—Cravat
95—The (German)

Jap Police Radio Car



(Acme photo.)

POLICE of Tokio, Japan, recently have been equipped with two-way radio squad cars for patrol duty This picture shows the first car of the fleet. The radio receiver gets the special calls and bulletins sent out at intervals from the police radio station, and a radio telephone in the car enables the police on patrol to call headquarters at any time Most American city police departments now have radio equipped squad cars but few of them are two-way radios.

More Consecutive Twins

THESE children, as you may guess, compose two more teams of consecutive twins. At the right are Otto and Robert Born, who will be 11 years old next December 27th. At left are Alfred and Alma Born, who were 13 years old on September 5th. They are the children of Mr. and Mrs. E. Born of 1827 West 34th place, Chicago. Since the first picture of consecutive twins appeared in these columns several weeks ago, the pictures of nine more pairs have been received.