SULFUR IS A BASIC MATERIAL OF CHEMICAL INDUSTRY

... along with salt, limestone, and coal. Here are uncounted tons of it, better than 99 per cent pure. It has been mined from beneath more than 500 feet of quicksand and rock on the Louisiana coast—which sounds difficult but has been extremely easy ever since Chemist Herman Frasch thought of the perfect way to do it forty-six years ago. Three concentric pipes pierce the quicksands to the underlying sulfur. One pipe carries hot water, which melts it; another carries compressed air to blow it out; the third carries the sulfur to the surface. Here you see it, as painted for FORTUNE by Eminent American Artist Charles Burchfield, standing in the great, glistening, yellow monuments that are left after the sulfur has cooled and hardened, and the wooden bins have been knocked away. The sulfur has been molded in these setback steps so that great man-crushing chunks will be less likely to break off. FORTUNE calls sulfur sulfur because the American Chemical Society has ruled that sulphur is an archaic spelling.
**Chemical Industry:**

It is perhaps the most progressive industry alive. It lowers prices, but has few market wars. Bankers never heard of it until the World War, when it was a hundred and twenty-three years old. Three companies account for about two-thirds of its assets, although hundreds of companies make it up. It sells acids, alkali es, ammonia, and diphenylparaphenylene diamine—and if you don’t see what you want, ask for it.

From his laboratory in Dayton, Ohio, Thomas Midgley Jr. one morning a few years ago telephoned to Detroit to talk to his intimate scientific and personal friend, Charles Franklin Kettering. They chatted for a moment about minor matters and then, according to the recollection that Mr. Midgley later had good reason to write down, Mr. Kettering said: "Midge, I was talking to Lester Keilholtz last night and we came to the conclusion that the refrigeration industry needs a new refrigerant if it ever expects to get anywhere. So I told Lester that I would call you and have you see him to talk it over. He is leaving for Dayton tonight."

Duly the next day Mr. Keilholtz arrived at Dayton, and he and Mr. Midgley sat down together. Mr. Keilholtz was then chief engineer of Frigidaire; Mr. Midgley was the brilliant chemist chiefly responsible for discovering why automobile engines knocked, and then developing a substance—a tetraethyl lead—that would stop them from doing it. Now Mr. Keilholtz wanted Mr. Midgley to try his hand at something else. He is leaving for Dayton tonight.

Mr. Midgley listened and was dubious. Seemingly, no one had considered it possible that fluorine might be non-toxic in some of its compounds. If the problem before us were solvable by the use of a single compound, then that compound would certainly contain fluorine. Still working in the library, the Midgley team decided to synthesize a product containing fluorine, which was said to boil at −20° Centigrade, but whose other properties were entirely unknown. Its name was dichlorodifluoromethane.

Starting with antimony trifluoride, it wasn’t hard to make. But the antimony trifluoride, being a specialty chemical in no demand whatever, was hard to come by. Midgley corralled five one-ounce bottles of it; so far as he knows, that was all the antimony trifluoride in the whole U.S. From one bottle they made a few grams of dichlorodifluoromethane—a water-clear liquid. They put it in a test tube, furiously boiling at room temperature, under a bell jar with a guinea pig, while a physician watched earnestly for symptoms of the guinea pig’s collapse. There were none. The guinea pig breathed dichlorodifluoromethane with equanimity and unconcern, and the predictions of the Midgley team were triumphantly fulfilled. The job had taken three days!

Big, bespectacled, jovial Chemist Midgley got the Perkin Medal this year—next to a Nobel prize, the most resounding acclaim a U.S. chemist can receive. Chemist Midgley has a sound instinct for the dramatic; and in the course of making his acceptance address he demonstrated the qualities of his new substance by personal experiment. He drew in a lungful of the

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The small size of chemical industry conceals its vast importance, whether in peace or in war. For its importance, definition, and characteristics see:

**CHEMICAL INDUSTRY:** I this page

For the chemistry behind the industry turn to:

**CHEMICAL INDUSTRY:** II page 162

Sulfuric acid page 166

Chlorine page 168

Ammonia and nitrogen page 170

Hydrogen page 170

For chemical and financial summaries of companies, see as follows:

Du Pont page 85

Allied Chemical & Dye page 87

Union Carbide page 89

American Cyanamid page 90

Dow Chemical page 164

Monsanto Chemical page 166

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warmed gas as casually as he draws in tobacco smoke, held his breath for a moment, and then blew it softly through a rubber hose into a beaker in which stood a lighted candle. The candle flame wavered and went out.

Nontoxic, noninflammable, dichlorodifluoromethane is, to all intents and purposes, something new in man’s world. It existed before Midgley, but only because someone, somewhere, had once happened to synthesize it. Its use was unknown; its very existence obscure. Its utility to the refrigeration industry would never have become known were it not for the fact that, Anno Domini 1937, the chemist is in possession of something that has been tagged with the momentous phrase “a technique of discovery.”

But there is another aspect to dichlorodifluoromethane. It represents an industry. This previously unknown material and its chemical cousins are now tonnage chemicals. Hundreds of thousands of refrigerators were supplied with them this year, and since each refrigerator requires from two to four pounds, hundreds of tons have rolled out in tank cars from the plant of Kinetic Chemicals, Inc. (a du Pont and General Motors jointly owned subsidiary) during 1937. Dichlorodifluoromethane manufacture has called for other chemicals like carbon tetrachloride and has provoked a new activity in the mining of fluor spar for its fluorine in Kentucky and Illinois.

WE MAY, then, take Mr. Midgley as a token of the strange industry with which this article is concerned. It is a small industry, made up of three dominant companies (du Pont, Allied Chemical & Dye, Union Carbide & Carbon), plus some fifty smaller companies listed on the Big Board or the Curb (Dow and Monsanto are typical among such companies), plus hundreds of still smaller ones. The total value of the products of all is, perhaps, $700,000,000 a year. As industries go, it is extremely new. It is as broad in its scope as it is difficult to define. For want of a better term, we may call it chemical industry. Its activities, obscure to the layman, can best be expressed by saying that it is engaged in making something into something else—not by altering shapes and sizes visible to the eye but by working with the unseen and unseeable building materials of the chemist: atoms and molecules. Working principally with its two great weapons of heat and pressure, it busies itself with making things that are new, things that are cheaper, things to make other things, things that the eye of the ultimate consumer seldom if ever
falls upon. Chemical industry is not concerned with a great many things that the U.S. public and the U.S. Government think it is: chemical industry does not mean writing ink, fireworks, candles, or mucilage—although all of these things are essentially chemical products. In the case of chemical industry, then, we had best go back for a moment to the man who in truth began it, although his aim was notably less.

The man who began it was the Frenchman Nicolas Leblanc—and the year of his achievement was 1794. Nicolas Leblanc was not trying to make history. He was just trying to make a little money. French glass factories, then as now preeminent, had been accustomed to get their essential supplies of alkali from Spain—where the Spaniards burned seaweed to get ashes and took barilla (the alkali, sodium carbonate) from them. But the British armies had cut France off from this supply, and it was primarily to aid the glassmakers that Leblanc began hunting for some means of making a cheap alkali, independent of Spain or the hindrance of the British.

To this activity he had been spurred by a prize of 12,000 francs offered by the French Academy for a process by which soda could be made from salt. By what prescience the Academy had decided that the one might conceivably be made from the other is unknown, for the element sodium, common to salt and soda, was yet to be discovered. But if the Academy stabbed in the dark it stabbed in precisely the right place, and Leblanc, starting to work in 1784, had the answer three years later. He treated salt with sulfuric acid, and thus made “salt cake,” or sodium sulfate. He roasted the salt cake with charcoal and thus made a cheap alkali, independent of Spain or the hindrance of the British.

Now between what Leblanc did and what other men had previously done with chemical materials, there should be made an immediate and not only on chemistry but on economics. He was the first person on record to do any such thing. For a practical end, with deliberate intention, and for a profit, Leblanc had involved chemical processes like leather tanning, dyeing, distilling, glassmaking, for so long that pedants can wander in Phoenicia or Egypt or China (“the Chinese invented gunpowder”) to their hearts’ content and find the beginnings of this sort of “industrial chemistry” wherever it pleases them.

But what Leblanc did was different from all this. For a practical end, with deliberate intention, and by scientific means as he knew them, he set out to make something into something else, with his eye not only on chemistry but on economics. He was the first person on record to do any such thing. Upon that, as a distinction, rests his unjustly faded and obscure historical fame—and upon that, as a definition, rests the entire structure of modern chemical industry. With endless improvements, refinements, ramifications, and complexities added, the chemical industry continues its deliberate and calculated course of making something into something else.

If Leblanc had not committed suicide because the French Revolution cost him his plant and process, he might have seen that course begin. A prime peculiarity of chemical industry is that you seldom accomplish one thing at a time; your accomplishments take place two, five, or seventeen at once. Leblanc produced his cheap alkali primarily for the benefit, so he thought, of French glass. As a result there soon began to grow an entire new industry which was now enabled by cheap alkali to find a wider and wider market for something that had been, in Leblanc’s day, a product of luxurious scarcity. The product was soap, out of which was to flow a new society, a new domestic economy, a new conception in men—personal hygiene—where the large-scale manufacture of soda by Leblanc’s process gave the rapidly mechanized industry a new and cheaper means of whitening its great new output of cloth without sunshine. It was typical of chemical industry then, and now that Leblanc’s discovery upset the economics of perfume and incense making, and of any other business that prospered because of the lack of soap. It was even more typical that Leblanc’s process, before beginning, burned up the rubbish pile and utterly forgotten; a new and better process for cheap alkali arose to take its place. Most typical of all, chemical industry is today working toward “soapless soaps,” which require no alkali to make. The segment of chemical industry represented by this cycle of change is small, but it is extremely characteristic.

The processes of modern chemical industry are as many and varied as the products they produce. About the processes it is important to remember that the method made famous by the late Thomas Alva Edison—which consisted of trying everything
BLUE GAS & BLOW-RUN GAS
... are the products of these retorts that belong to du Pont's big plant at Belle, West Virginia. By treating coke with steam the Belle plant makes these gases, which it can convert by high-pressure synthesis into ammonia or alcohols with equal ease, depending upon markets.

Photographs for Fortune by Rittase
conceivable by the imagination—has been supplanted by the approach that we observed in watching Mr. Midgley: mathematical and deliberate, you should remember that you seldom perceive it, of and by itself, with any of your senses (unless it is a drug), for it is either deeply concealed in something familiar, or it has died in giving birth to something else. The chances are against your awareness of diphenyl paraphenylene-diamine. Yet if you knew where, in your everyday life, to look for it, you would there also discover paracresol paroxymethylenes and perhaps also tetramethylthiuram disulfide. All three of them may be in your automobile tires, as curing or accelerating or anti-oxidizing agents. You have already discovered the sizable amount of dichlorodifluoromethane that may be in your kitchen. If your wife has a wool garment of a lovely golden orange hue, it may have been helped to take its color by 4,4'-dimethyldianbenzo-phenol. But if you ever feel the need for 3,4-dihydroxyphenylmethylaminomethylenecarbinol hydrochloride you need only go to your neighborhood druggist and ask him. He would supply you with adrenalin.

But no matter how fantastic the names get—and they are practical, systematic descriptions, not abracadabra—it is important to remember that practically everything in chemical industry springs from four utterly simple raw materials: coal, sulfur, limestone, and salt—plus that relative newcomer, petroleum, and the celebrated "free goods" of the economist, air and water. From these raw materials the first products that chemical industry manufactures are "heavy" acids (sulfuric, nitric, hydrochloric); alkalis (soda ash, caustic soda); multitudes of products of coal tar; commercial gases (hydrogen, chlorine)—plus such basic materials as ammonia, industrial alcohols, and solvents. You could without trouble multiply this list by two or three, but among the so-called heavy chemicals these are the heaviest, the most basic, the most fundamental to the art of living in the world that the chemist has created.

AND chemical industry can best be defined as the highly imaginative and creative industry that makes these fundamentals, and a relatively few others, cheaper products than the products of nature. This aim is to synthesize scores and scores of products. Or they may have been helped to take its color by another means, chemical industry put on weight and stature through the nineteenth century—but so quietly that the outside world never knew it was there. A seventeen-year-old boy, who was to become the famous Sir William Perkin, in 1856 made the world's first synthetic dye, using coal tar that was the refuse of gasworks—and the entrepreneurs of mid-nineteenth century England passed by the significance of what he had done with a total lack of comprehension. (Not so the Germans; Germany saw the vastness that lay in this new synthetic chemistry, and her early

FIRST characteristic of the industry is its extreme youth. Leblanc's discovery and the beginnings of the Industrial Revolu-tion both occurred during the last half of the eighteenth century. That would seem to make the chemical industry no younger than any other sort of industrial activity. But whereas the entrepreneurs of the eighteenth and nineteenth centuries instantly grasped the significance of the steam engine and the power loom, they did not grasp the significance of chemical industry. Consequently, chemical industry remained in a world apart. It grew, and it served other industries, without attracting either their notice or the notice of financiers. Calls for more and more of Leblanc's alkali led to calls for more and more sulfuric acid with which to make it. Then came an alkali process—the Solvay process—better than Leblanc's, but one that called for quantities of ammonia, instead of acid. From that grew the increasing importance of the byproduct coke oven that supplied the ammonia. By such means, chemical industry put on weight and stature throughout the nineteenth century—but so quietly that the outside world never knew it was there. A seventeen-year-old boy, who was to become the famous Sir William Perkin, in 1856 made the world's first synthetic dye, using coal tar that was the refuse of gasworks—and the entrepreneurs of mid-nineteenth century England passed by the significance of what he had done with a total lack of comprehension. (Not so the Germans; Germany saw the vastness that lay in this new synthetic chemistry, and her early

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<td>...basic largest factor in heavy chemicals. Probably proves better than one-third of domestic alkali requirements. Leading manufacturers of chemicals (especially sulfuric), ammonia, dyestuffs, and coal-tar distillates make chlorine, and many another important chemical vital to the chemical process industries. Has 250,000,000 bushel plant at Hopewell, Virginia, for the fixation of atmospheric nitrogen. Is said never to have been used to capacity. Hence Hopewell is potentially important—if it isn't a white elephant. Research: only fair compared to du Pont or Carbide. CUSTOM-ERS: Other manufacturers, particularly chemical processors. Glass, soap, textile, leather, fertilizer, and petroleum are heavy buyers; also motorcar, metal, paper and pulp, agricultural industries.</td>
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<td>...Alfred was born big in 1906 via mergers. Stays big. Extremely secretive; President H. F.Atherton's 1936 letter to shareholders used 281 words including salutation, signature, and date, which might have seemed verbose to former Chairman (but still guiding light) Orlando F. Weber. A vigilant defender of the American chemical industry, and itself, against foreign invasion. Biggest secret was financial, not chemical—the make-up of its marketable security account, which averaged (1929-34) $53,075,000. Today, owning N. Y. S. &amp; S. &amp; SEC. Com. Allied has revealed holdings of U.S. Steel and Air Reduction stocks at a cost of $22,859,000—worth $58,532,000 December 31, 1936, $86,761,000 October 19, 1937. A &quot;nondisclosure&quot; investment account of $28,860,000 is still needles</td>
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| Dividends since organization $328,600,000 |  |
| Earned since 1926 $86,025,000 |  |
| Dividends since 1926 $19,957,000 |  |
| Shares of common $1,079,000 |  |
| Shares in treasury 187,558 |  |
| Authorized (all par) 3,143,423 |  |
| Div. per share 10/26 |  |
| 1936 sales, N.Y.S. 250,500 |  |
| High 1937-43; Low-193 |  |
| Net earnings, 1936 $26,054,000 |  |

| Dividends, 1936 | $18,880,000 |
| Earned per share, 1936 | $11.44 |
| Undistributed—profits tax | $80,800 |
| Return on av. inv. capital | 18.6% |
| Equity per share | $67.68 |
| Surplus, end of 1936 | $170,111,000 |
| Property account (net) 1920 | $66,856,000 |
| Ditto, 1936 | $270,000,000 |
SULFUR IS A NUISANCE
... as well as an essential to chemical industry. All this equipment is necessary in du Pont’s plant at Belle to remove sulfur that would contaminate the gases used as described on the previous picture page. But this nuisance-sulfur is not wasted; du Pont resells it to one of its subsidiaries that makes sulfuric acid.
twentieth-century chemical preeminence was based upon its

In the U.S. the production and consumption of basic heavy
chemicals went forward by slow increases—but chemical industry
remained outside the haughty purview of the Empire Builders,
the Robber Barons, the Merchant Princes. It remained in the
hands of men who had started little plants to make products that
industry needed, but that no one knew anything about. But with
the World War the U.S. was suddenly thrust upon its own resources
for the production of dyes and medicinal products that it had always
imported from Germany. Only ignorance can say that reunions
requirements were the means to chemical industry’s growth, but it is
nevertheless true that the War finally brought U.S. chemical in-
dustry to its maturity. And when Francis P. Garvan as Allen Prop-
certy Custodian seized the German chemical patents in this country
and turned them over to the Chemical Foundation, which had been
created to receive them, the U.S. began for the first time
an independent chemical life. Then, and thereafter, the bankers,
the entrepreneur class, heard of chemical industry for the first time:
in January, 1920, for example, such companies as du Pont, Union
Carbide, Allied Chemical & Dye, Monsanto, Dow, etc., were
yet to be listed upon the New York Stock Exchange. Previous to
that chemists had not needed bankers. The expansion of chemical
industry was slow enough to be financed out of earnings. And
bankers had barely heard of chemists. Chemically, then, chemical
industry dates from Leblanc and 1791; industrially, chemical in-
dustry was recognized only after the World War.

Its youth and its upbringing lend to chemical in-
dustry its second characteristic: it is as progressive an
alcohol plant almost overnight (page
a n economy. The industry never holds on to an old
fo re v e r. But the industry sheds no tears. After all, it
makes its own acid; if it can do with less it has made
p r oduct or an old process when it can find new ones;
peaks of its production have thus, perhaps, been passed
wastes so little that the packer’s utilization of the pig

One reason for this efficiency and progressiveness is that the
industry has, for its whole life, been intertwined, intermar-ri
ted with science. No other one industry has such a training
ground as the chemical industry has in the laboratories and class-
rooms of this country’s universities. Unlike the railroadmen or the
men in iron and steel, the men in chemical industry have been
rigorously trained for their careers by the most intensive sort of
scientific education. The habits and practices of the chemical in-
dustry put the word “research” into the spoken language. And it
is not merely the technical staffs where the trained men are. J. G.
Davidson, Vice President in charge of sales for Union Carbide’s
Carbide & Carbon Chemicals subsidiary, is a Ph.D. in organic
chemistry. Elon Hocker, President of Hooker Electrochemical,
is the holder of an earned doctor’s degree. Since the 1880’s young
du Ponts have worn a deep path between Wilmington and Massa-
chetts Tech in Cambridge. And in a chemical plant, if you
are not the holder of a college degree you likely are to be a
janitor.

The efficiency of the chemical industry goes one step further
and takes the form of a considerable economic enlightenment. The
industry faces an unexampled obsolescence in plant and equip-
ment. It meets this not only with a ruthless accountant’s pencil
but by a ruthless scrapping of equipment or process as soon as it
begins to falter. But it is in questions of price policy and structure
that the most interesting examples of economic policy in an indus-
try make themselves felt.

UNION CARBIDE & CARBON CORP.


CHEMICALLY

... four general divisions: Electrodes, Car-
bons, and Batteries; Calcium Carbide and
Gases; Alloys and Metals; Synthetic Organic
Chemicals. In the 1926 report a list of prod-
ucts jammed fourteen pages of a dry
brochure, compared to five pages of an equal-
dry one in 1919. Carbide’s greatness is due
primarily to the electric furnace, born of the
carbon arc, with which it has a “partial skill
monopoly.” From the furnace comes calcium
 carbide; hence acetylene (Prest-O-Lite), once
only an illuminant, now, with oxygen, a
whole system of gas welding. From the fur-
nace developed Alloys and Metals: chromium,
tungsten, vanadium; also Haynes Steelite,
a nonferrous metal alloy with nearly diamond
hardness at red heat, used in tool steel, oil-
well drills. From carbon comes flashlight and
radio batteries, millions of motor brushes, car-
bon electrodes, etc. New, with a great specu-
lative kick, are Synthetic Organics. Carbide &
Carbon Chemicals Inc.—subsidiary—is a
leader in high-pressure synthesis, from which
it makes wood alcohol (methanol) that never
saw wood. Also, Carbide makes commercial
ethyl alcohol—“grain alcohol”—not from
wheat but by hydrating ethylene—a product of petroleum dis-
tillation. And countless other organs which
can well change the natural state of the
world as new uses appear. Plastics for Viciro-
la records, toothbrushes, dentures, or what
have you to replace? Antifreeze (Prestone, derived
from same foundation as mustard
gas), rust inhibitors, carbon dioxide for Dry
ice, Perfofax gas, even gasoline (natural gas or
case-harding gasoline), sold in bulk to oil com-
panies, come from Carbide’s Synthetic
Division. Pioneers—16; this firm—95; with
wholesale stocks—1,115; this in the U.S. and Canada;
more abroad. Research: preeminent. CUS-
TOMERS: steel, petroleum, marine, motor-
car, aeronautical, railroad, electrical, textile,
lacquer, pharmaceutical, paper, photo-
graphic, explosives, and scores of subdivisions
of these and other industries.

FINANCIALLY

... pure as Ivory Soap. Even 1917 merger
was without stock fees for promotion or serv-
ices, making Carbide lonely in merged com-
pany. Carbide is the result of internal grow-
ing pains, acquisition, and merger. And for
that reason means at first a very unusual, Paten-
ted and good will: $1. Depreciation: all the traf-
} ic will bear. Expansion: good times and bad.
1935 property account: $158,000,000; in 1936
$250,000,000 after 1931’s vicious write-down.
Earnings: two hairs under du Pont without
General Motors. Smart, young mentally,
hard biting, candid, racing under control.
Perfect dividend record. No preferred stock.

Dividends since 1919 = $81,825,000
Earned since 1915 = $88,916,000
Dividends since 1925 = $198,996,000
Shares of common 1936 = 9,000,743
Shares of preferred = 5,770
1936 sales, N. Y. S. E. = $96,900
High 1927—111; Low—69 (Oct. 19)
Cash and equivalent to funded debt 1936 = $1,125
funded debt 1936 = $166,025
Since 1925 Carbide has paid $90,816,000 to
surplus from net earnings, more than du
PONT or Allied, the other two of the Big
Three chemicals, less, percentagewise, than

$14,500,000
$45,814,000
$23,409,000
$14,179
$57,41

smarter small Monsanto, American Cyanamid, or Dow. But enough. Has only funded debt of
any size in Big Three—considering Pon
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Smart, young mentally, hard biting, candid, racing under control. Perfect dividend record. No preferred stock.
The chemical industry was born reaching out for lower prices: Leblanc was hunting for a cheap alkali. This is more than a symbol of chemical industry; it is an unalterable birthmark. The people of Leblanc's day needed more soda; they didn't know it, but they did. Therefore make it cheaper, and you could sell more of it—lots more of it. Looked at in this sense, every success of industrial chemistry is a success of economics as much as a success of test-tube science. Just as the man in the street did not know in 1784 that he needed to be the same man in the street today is unaware of his need for iso-octane. Yet he may come to need it very badly, for it is already an internal-combustion engine fuel of a greater efficiency than the highest-grade gasoline—and is consequently a vivid new possibility facing aviation engineers. Moreover, chemical industry is itching to get prices down enough so that some day iso-octane can enter the automobile market.

The very necessity that the chemical industry is under of developing new products and new markets at the same time is at once its greatest challenge and greatest asset. The laboratory has always known how to make a new product months or years before the plant could make it; but before the plant could match the laboratory and create effective demand, it had to hammer its costs down to a point where the price made sense in a practical world. Aluminum's advantages of lightness, luster, electrical conductivity, and resistance to corrosion had been known for years before there came along a young man named Charles Martin Hall. But aluminum's attractions, before Hall devised an electrolytic process to win it from its ore, were only tantalizing—for aluminum cost $1.2 a pound. It now averages twenty-one and a half cents.

[Continued on page 157]

### AMERICAN CYANAMID CO.

100 shares Dec. 31, '36 = $10,320 = 100 shares A, 400 B Dec. 31, '36 = $80,350 = $12,974 Oct. 19, '37

#### CHEMICALLY

... fourth largest; not a very good fourth, but heading the so-called little fellows. In 1909 Cyanamid was hot stuff with the only nitrogen-fixation process worth much. But it remained a simple fertilizer and mining chemical company. Principal product: calcium cyanamide, made by blowing nitrogen through white-hot calcium carbide. Crushed, it was fertilizer (75 per cent of Cyanamid's business); and the cyanamide could readily become cyanide, because cyanide is used in modern metal refining processes. The Haber process of nitrogen fixation left Cyanamid on its back in 1927. Then, by acquisition and merger, Cyanamid got into chemicals. Fertilizer is now a slim 10 per cent, but important because of concentrated plant foods (ammonium potassium phosphate); mining chemicals about 15 per cent. Cyanamid has developed quite a stable: it makes beetlevare and other plastics, dyestuffs, pharmaceuticals, explosives, gypsum, insecticides, rubber chemicals, alkalis, heavy acids. It owns big bauxite deposits from which comes sulfate of aluminum, iso-met, Cyanamid even goes in for biological products. The company is more exciting chemically today than it has been for years—it has an up-baby-and-at-em attitude (required in this industry) and a very keen interest in resins from pathologic anhydride that are currently bedeviling the older lacquers like Duco—which puts Cyanamid on the other side of the fence after all those years (1909-37) of tugging along. Cyanamid is unique not only in having made a chemical comeback, it is unique because its President, William B. Bell, is a lawyer.

#### FINANCIALLY

... after being for long like a gentleman who has honourably paid all his debts only to find himself seedy. American Cyanamid now has a new overcoat, hat, shoes; smokes fifty-cent cigars. Reason: the miscellany that came in with fertilizer starting with 1927 and then American Cyanamid's shareholders. Those shareholders know what a beating is, also some of the hazards of chemical investments. (And there are hazards. Do not be fooled by those miracles the Big Three have wrought!) The company has an up-sixeslike Duco—which puts Cyanamid on the other side of the fence after all those years (1909-37) of tagging along. Cyanamid is not only in having made a chemical comeback, it is unique because its President, William B. Bell, is a lawyer.

<table>
<thead>
<tr>
<th>Dividends since 1926</th>
<th>$1,185,000</th>
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<tbody>
<tr>
<td>Earned since 1926</td>
<td>$4,785,000</td>
</tr>
<tr>
<td>A voting shares, 1936</td>
<td>$69,943</td>
</tr>
<tr>
<td>B shares, 1936</td>
<td>$454,445</td>
</tr>
<tr>
<td>Div. per share, 1936</td>
<td>$1</td>
</tr>
<tr>
<td>1936 sales, N. Y. C. E.</td>
<td>686,750</td>
</tr>
<tr>
<td>High (B) 1937-37, low-17 1/2 (Oct. 19)</td>
<td></td>
</tr>
<tr>
<td>Net earnings, 1936</td>
<td>$4,455,000</td>
</tr>
</tbody>
</table>

Earned per share '36 A and B: $1.77
Return on av. inv. cap.—1936: 9.437%
Equity per share (A and B): $18.66
Earned surplus, 1936: $18,879,000
Property account (net) 1925: $4,609,000
Ditto, 1936: $42,536,000
Ditto, 1937: $24,101,000

$39,000,000 in common stock to finance additions; waterlogged in 1951, the shareholders were asked to cut the par value of their shares in half; they did, wiped off virtually all of the new money. Management, therefore: realists. Shareholders: lambs. Then Cyanamid dug in, showed no red figures (minuscule black ones), whanged away at research, took the normal, violent depreciation charges, paid no dividends (1931-33), emerged in 1933 with $4,099,000 profit for a change. In 1934 it paid a token dividend of twenty-five cents, got back to $1 in 1936, currently paid $1 extra. Today this staid old-new chemical is pretty pleased with itself and chemistry. Small funded debt.
change a thousandfold and more you find the true basis upon which chemical industry goes forward.

In the chemical firmament thus displayed, there are always a dozen or more men who shine the brightest. One such is Thomas Midgley Jr., whom we met at the beginning of this article. He is a Vice President of the Ely Lilly Co. and a member of the Board of Directors of the American Electro-Metallurgical Products Co., which manufactures a variety of metal compounds and alloys. He is also President of the American Chemistry Society, which holds its annual meeting every year in a different city.

TWICE a year, once in spring, once in fall, The American Chemical Society holds a national meeting, attended by members from all parts of the country. The membership is now over 10,000, and the meetings are attended by many more. The purpose of these meetings is to bring chemists together to discuss their work and to learn from each other.

For its fall meeting this year the society went to Rochester, New York. And on the evening of the first day, at cocktail hour, the bar at the Hilton Hotel was filled up with chemists, who were bound on conviviality and the gay life. Everybody ordered a drink, and the bartenders glowed with that sort of anticipation which only chemists can create. But then, as they looked on in shocked and almost tearful surprise, the man who ran the bar was the American Chemical Society's Secretary, who had just announced that he was resigning. The reason given was that he had been offered a position as Secretary of the American Chemical Society in Europe. This news was the talk of the town, and the crowd that gathered around him soon grew to over a thousand. The evening ended with a dance, and the chemists were still talking about it the next day.

With none of Midgley's drama or dash, Chemist Irving Langmuir, of General Electric's No. 1 research man, is an equal drawing card as a speaker. But whereas a Midgley audience listens with fascination, a Langmuir audience listens with awe. The most honored and best loved of the American Chemical Society members is Dr. Langmuir, who is respected not only for his scientific contributions but also for his integrity and honesty.

All these names together will give you a Kay good idea of who's who in the scientific brains that mold and motive chemical industry. Search any other industry you like; you will not find in it any such aggregation of trained minds as these gentlemen possess. The chemical industry is one in which scientists and engineers are both highly valued and respected. The work that is done here is of the utmost importance, and it is carried out by men who are always striving to improve the products they produce. This is why the chemical industry has been able to grow so rapidly in recent years, and why it continues to be one of the most important industries in the world.
liberal arts. McKeon came out first as a visiting professor in history; later he was made a professor of Greek and Dean of the Division of the Humanities. A soft-spoken, special person, he eventually got himself "home" as a member of the philosophy department by convincing them that he knew a lot and had no desire to force his opinions upon them. Buchanan has recently departed for St. John's College in Annapolis, where, with Stringfellow Barr, another Hutchins man, he hopes to apply the educational program outlined in *The New Scholarship in America* to a small liberal-arts institution.

All this would be relatively unimportant if it were merely a matter of personalities. But the fight over Adler, McKeon, and Buchanan is not a personal fight; it goes, in fact, straight to the heart of the curriculum. On President Hutchins's office wall there is the original of a Thurber cartoon that pictures two women pointingderisively to a glum young man at a party. One of the women is saying: "He doesn't know anything except facts." The other is pointing to U. S. education as a whole and saying: "It doesn't know anything except facts." It is significant, however, that President Hutchins is pointing to educational problems in U. S. education as a whole and saying: "It doesn't know anything except facts." Educational problems in the curriculum of higher education are not a matter of personalities. They are pointing to general problems of curriculum that are universal to the liberal arts. McKeon came out first as a visiting professor in history; later he was made a professor of Greek and Dean of the Division of the Humanities. A soft-spoken, special person, he eventually got himself "home" as a member of the philosophy department by convincing them that he knew a lot and had no desire to force his opinions upon them. Buchanan has recently departed for St. John's College in Annapolis, where, with Stringfellow Barr, another Hutchins man, he hopes to apply the educational program outlined in *The New Scholarship in America* to a small liberal-arts institution.

**University of Chicago**

*Continued from page 154*

method: Darwin, for instance, had a hunch that his evolutionary theory was correct before he had piled up the facts to prove it. What Hutchins's critics fear is that, when he speaks of the "truth," he is referring not to the fruitful hunch that leads to scientific advance but to the "truths" of arbitrary philosophies or revealed religion. The neo-scholastic, so they tell us, is not interested in truth as a matter of verified hypothesis, but in truth as a matter of prior metaphysical assumption. To date, however, Hutchins has not proclaimed himself a neo-scholastic. As a matter of fact, he behaves very much like a liberal pragmatist. His appointments at Chicago have included representatives of all schools of thought: his defense of academic freedom has maintained freedom at Chicago for those who disagree with him. His enemy, Harry Gideonse, has written a book called *The Higher Learning in a Democracy* that is a ringing reply to Hutchins's own *Higher Learning in America*, and Gideonse has had the unpromised support of many like-minded members of the faculty, not to mention a lot of the students.

**Chemical Industry: I**

*Continued from page 90*

To these generalities there are, of course, exceptions. That same Prestone which is Carbide's pride and achievement costs $2.95 a gallon largely because Carbide holds patents on its production. Someday that price will have to drop sharply—and it will drop when competition begins. When competition begins a protected price will not, however, become a price-war price, if the past performance of chemical industry may be taken for a guide to its future.

For the next characteristic to be noted is that the chemical industry, despite its slowly lowering curve of real prices, is an "orderly" industry. It was practicing "cooperation" long before General Johnson invented it in 1898. It has seldom been bedeviled by overproduction, has had no private depressions of its own, and has not often involved itself in long or bloody price wars. The alcohol sector of the industry has frequently been guilty of disorderly conduct, and alkali made by the Solvay process has got into some nasty brawls with electrolytic alkali. But by and large the chemical industry has regulated itself in a manner that would please even a Soviet Commissar.

This characteristic is all the more surprising when you consider some of the situations that the industry faces. In the first place, technological competition operates at constant high pressure, and new processes displace old ones with some violent dislocations—like the dislocation that took place when synthetic methanol all but destroyed the manufacturers of methanol (which is wood alcohol) made from the distillation of wood. In the second place, the industry lacks the full cooperation of its second largest unit—Allied Chemical & Dye. This tight-lipped, secretive, and suspicious company gives nothing to the industry and asks nothing from it. It need ask nothing, for it is completely self-contained—more so even than du Pont, and has no competing industry to which most of the men seldom go to the meetings of the American Chemical Society. It calls its own tunes.

Yet it has never for long called tunes too fast for the rest of the industry to dance to. The rest of the industry walks docently, greedily, into Grand Marshal, du Pont, viewing it with a happy and beneficent eye. Its gentlemanly instincts are all against pushing and crowding. If, for example, you were to present du Pont with an idea that du Pont thought fitted better into the economic structure of Union Carbide, du Pont might well tell you, with grace but insistence, to take your idea to its competitor. The industry that believes in lowering prices does not believe in market wars. The industry that is in the public mind personified by the du Ponts is, in other and extremely non-Liberty League words, the practicalization of one dichotomous sort of planned economy.

**Basic reason for this state of affairs is that** industry is just not an industry: it is also a profession. The Manufacturing Chemists Association, to which most "proprietors" in the industry belong, is a quiet but active lobby, which occasionally talks about prices—who can say that it does not discuss costs? But on its agenda it has other
the plant clean, to turn a few valves, to weigh final products and dump them in sacks than to perform the feats of strength and skill and courage needed in a steel mill. A sulfuric-acid plant may be turning out dozens of tons of acid a day, yet the "crew" is apt to consist of one man, sitting in a glass cage and writing up a log of the day from the readings of automatic gauges. But because things can always go badly wrong in a chemical plant, the industry prefers intelligent labor, and its wages are relatively high. Last year they stood at 65.08 cents an hour and $26 a week compared to about 50 cents an hour and $23 a week in all factories—and most chemical employees work fifty-two weeks a year. The industry is at peace, has always been, and always expects to be. Settled usually in rural surroundings, it thinks it offers to John L. Lewis a minimum reason or opportunity for organization. But the prime characteristic of chemical industry is the extraordinary proliferation of its products. Like so many of its characteristics, this one is largely inherent; it is all but impossible for one process to make only one thing. "It is," said the late Arthur D. Little, one of the country's greatest chemical engineers, "as though a cotton mill, to make thirty-five yards of cloth, was forced also to turn out forty shoes."

Thus the chemical industry is engaged in a perpetual economic and scientific juggling act. It no longer likes to use the word "byproduct" (although it still has to, occasionally), for the word is steadily losing its meaning. Suppose you are in the business of electrolyzing a salt solution to get caustic soda, as a "product," plus hydrogen and chlorine as "byproducts." Then the demand for caustic soda slackles off (as it has done) and the demand for chlorine

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**LAYMAN'S GUIDE TO**

Here are the Primary Materials on

<table>
<thead>
<tr>
<th>COAL</th>
<th>AMMONIA</th>
<th>SALT</th>
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<tr>
<td>COKE</td>
<td>COAL TAR</td>
<td>HYDROGEN</td>
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<td>CHLORINE</td>
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<td>CAUSTIC SODA</td>
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<td></td>
<td></td>
<td>QUICKLIME</td>
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<td></td>
<td></td>
<td>CARBON DIOXIDE</td>
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And from the Secondary Products above, here are a few

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The products shown here are only a small fraction of the products that chemical industry can produce by its atomic and molecular permutations and combinations. The chemist has so many tricks that any attempt to relate one substance on this page to almost every other substance, as the chemist does, would produce a crisscross of relationships which would be bewildering. Thus, this diagram deals with the simplest straight-line relationships only.
goes sharply up (as it is now doing). What is your "byproduct" now? For such reasons the industry now defines a byproduct only as something for which a full use has not been developed. In the industry's world, such products are few, and becoming fewer.

A perfect example of the industry's juggling act lies in the relationship between two heavy organic chemical products, acetone and butyl alcohol. The best means of producing one also produces the other. During the War, acetone was a vital necessity for the high explosive, cordite. The British bought acetone in this country by the ton to treat their nitrocellulose; with the U.S. they set up here a company from which present Commercial Solvents Corp. grew. As it made more and more acetone, more and more butyl alcohol piled up in its plants as a useless, noxious byproduct. The company could not even dump it in the Wabash River; health authorities forbade. So it dug an expensive hole, and lined it with expensive concrete, and dumped the butyl alcohol in that—wondering how much it would have to pay someday to get rid of it, and how.

Instead, the War came to an end and everywhere vast stocks of nitrocellulose were left in various stages of treatment. And about that time Charles Franklin Kettering, whom we have met before at the beginning of this article, demanded on behalf of the automobile industry a better, faster-drying finish for car bodies than anything existing. The chemical industry found it for him—found it in treating nitrocellulose with solvents made from butyl alcohol, which turned out to be a perfect basis for the whole new lacquer industry which then and there began to arise. Today butyl alcohol is developing wider and wider uses as a solvent—and its makers now and again wonder vaguely what they are going to [Continued on page 162]

INDUSTRIAL CHEMISTRY
which Chemical Industry depends.

SULFUR

WATER

AIR

SULFUR DIOXIDE

OXYGEN

NITROGEN

of the Chemists' Combinations and the results of them.

SALT

AIR

SULFUR DIOXIDE

Refrigerant
Fumigation
Bleaching Agent
Petroleum Refining

Used in every
Chemical Industry

Cleaning Metals
Textiles
Dyes

Glass
Tanning Leather
Water-Softeners
Soap

The Organic Heavy Acid

Solvents
Plastics
Plasticizers
Antifreeze

Welding Metals
Cutting Metals

Solvents
Plastics

Noninflammable Textiles
Plastics
Film (Motion Picture)

Fertilizer
Gold Mining

Cellulose

The Organic Heavy Acid
SOMEDAY a historian will pay to the nine­teenth century and to the honor it deserves. In the midst of its matron-chopped prigs and swooning ladies it produced almost every basic discovery upon which the twentieth century is founded. And it had more important chemical operations of the present day in its proper balances and relationships, we must first spend five minutes with the nine­teenth century and inaid succession view its most important chemical landmarks.

1. The first synthetic dye is discovered. By the age of seventeen, young William Henry Perkin was good enough to be an assistant to the great chemist A. W. von Hofmann, whom Victoria's Prince Consort had brought from Germany to teach at the Royal College of Chemistry in London. Working in 1856 with coal tar from gas retorts, for which no earthly use was known, Perkin produced aniline. That was no great trick; Perkin merely wanted the anil­line because he had a theory that from it he could synthesize quinine, and thus break the Dutch monopoly. To his bitter disappoint­ment he could achieve nothing even resembling the handsome white crystals of quinine; he found himself with only a tarry black solution. Into it he dropped a piece of silk. Why he did that, he was never in years after­ward able to explain—but when he drew out his silk it was stained a deep purple, and the purple would not wash out. It was, in other words, a dye: the first dye ever made from any source except a root, a bark, or a berry. A firm of dyes, the Messrs. Pullar, of Perth, admired the color. They acknowledged the importance of having made a dye from such a source as coal tar, but they were afraid that its use would make dyed goods so expensive that they could be used only for printers' rollers, etc. However, Electrochem­i­cal announced that it was building new cap­acity on the West Coast to hydrogenate fats. Membership in the Chemical Society increased by 50 per cent. Prices were firm and demand was brisk.

Chemical Industry: II

Sulfuric acid on the wane, and chlorine's star rising. High-pressure synthesis; methanol (wood alcohol), ammonia, and nitrogen; the future of hydrogen.

[Continued on page 164]
for the manufacture of glass, and for the production of caustic soda, or sodium hydroxide, which, in its turn, was to become an essential in the textile industries, in the great quantities of caustic soda. Rayon industry, it, too, would have needed other new chemical engines, at first glance in the ammonia it needed, set in motion still other processes. The Solvay process, in reaching out to find the ammonia it needed, set in motion still another new chemical engine, at first glance in no way related to it. This was the byproduct coke oven. The iron and steel industries, to which coke was a basic need, clung to the so-called beehive oven, which produced a hard coke that resisted crushing from the load it bore in it. If the beehive oven wasted all the other products produced by coking coal, one of these products was ammonia—and because of the need of the Solvay process for ammonia it gradually came about that the byproduct oven supplanted the beehive and became, for a while, the most important source of commercial ammonia for the production of dyes and other products. The lighthorse waste products of coal distillation were saved as carefully as the coke itself. Perkin's discovery of a synthetic dye to be made from the coal-tar waters out of the coke oven, making its significance felt—but when it did, the process of coke production lent it an all but inexhaustible source of raw material.

Petroleum is a story. Kerosene lamps were still lighted by whale oil, supplied to the U.S. by New England's whale fleets. It was getting steadily more expensive, and it stank. For more than a decade before Drake well came in at Titusville, Pennsylvania (that was in 1859), people had been skimming a few barrels a day from surface oozings of petroleum in the Titusville area. Because it had been discovered that petroleum, like whale oil, was a "burning oil." But it was Professor Benjamin Silliman the younger who gave this piddling business a new reason for being, when from the oil he made the first careful and studied fractional distillations. Something called coal oil came from distilling petroleum—and it burned better than whale oil had ever burned. It was that which started the hunt for petroleum on the grand scale—for a source that would yield not just a few barrels a week, but hundreds upon hundreds of barrels a day. When the Drake well came in, Silliman's process of fractional distillation was ready for it—but the greatest prize of the process was to produce coal oil. There were lower and higher boiling fractions too, but they were nuisances. The higher boiling fractions were useless (the discovery of their uselessness as lubricants was still a decade away). And so, before boiling fraction carbide, was worse than useless: it was a menace. It tended to make coal-oil lamps explode—one of the greatest household hazards of grandfather's day. And the greatest problem of the first distillers of oil was to throw away that gasoline without getting pinched by health or other civic authorities for maintaining a nuisance. For more than thirty years thereafter, the industrial chemist waited to find an outlet for this byproduct of the commercial production of coal oil.

Electrolux gas. In 1800 Alessandro Volta made his momentous discovery of the electric battery, and in the same decade it was discovered that an electric current could be obtained by connecting two metal electrodes into a battery, put the electrodes in water to which you had added a little acid, and under the influence of the current the water decomposes into its component hydrogen and oxygen. The principle established here was the principle of electrolysis. But it was a long while before that principle found any commercial uses. By 1880 chemists were pretty sure that electricity was going to be an extremely valuable weapon, but they weren't sure for what. Then Charles Martin Hall used an electrolytic process to produce cheap aluminum, and its uses became obvious. But before there was a small electrolytic plant at Niagara Falls for electrolyzing salt. Today electrolysis goes on wherever power is cheap—and electrolysis produces great quantities of those two vitally important chemicals, caustic soda and chlorine. Before there was a small electrolytic plant, industrial electricity was a laboratory curiosity, but it was now swiftly rising (page 170).

5. Frasch mines sulfur. Before Herman Frasch developed a new mining process, the

[Continued on page 166]
Sulfuric acid

TF LEBLANC’S soda process was the Adam of industrial chemistry, sulfuric acid, made of its rib, was its Eve. Sulfuric acid, salt, limestone, and coal were Leblanc’s raw materials and all but the first were ready to hand. Sulfuric acid had been known for centuries and had first been made in small lots as a kind of laboratory curiosity. Later, a few hardsy built little plants to make the acid in sturdy lead chambers instead of fragile glass tubes and bottles. Fumes of burning sulfur supplied sulfur dioxide; when mixed with niter (mostly oxides of nitrogen) were added, the sulfur dioxide would combine with air and water to make the oily sulfuric acid. That was good enough for a business, but the growing soda business needed tons and tons of acid. Thus the small lead chambers became bigger, and still bigger, and soon there were plants that took in fumes, steam, and air at one end, converted most of the mixture to acid, and left the niter fumes to blow out wasted at the other.

As volume increased and competition pushed prices down, the niter acid was much more and more serious; particularly so since niter was needed for wartime and mining explosives. (That was long before Chile’s nitrate beds, later to save the Allies in the World War, had been exploited.) Happily, the acid makers soon found at least a partial escape from their trouble; somebody discovered that the brown fumes from a burning wood plant as a waste was precisely what was put in at the beginning. Well and good, said the acid makers, we shall catch it and make it work over and over again. So they did, and thus the weak, weak, acid, they did catch it and were able to use it over and over again. The need for niter dropped to a tiny fraction of what it had been, acid remained cheaper than ever, and actual purer.

This cheaper acid was finding wider and wider uses. The chemist Liebig made his great study of plant-food necessities; he put together his artificial manures, consisting of potash, phosphoric acid, and guano, and farmers began to be persuaded to use them. That called for sulfuric acid to produce phosphoric acid—first out of bones, later out of waste bone black from sugar refineries, still later out of phosphate rock from South Carolina, Tennessee, and Florida. The thriving new business of petroleum refining began to drink up tons of sulfuric acid to improve its products. Galvanizing and tin-plating of steel needed other tons for cleaning the raw metal so that the plating would stick. Garum works were using acid to recover gold and silver for the developing fertilizer market. Perkin had made his first dye, and the Germans were swiftly building a wholly new industrial structure upon his discovery—all of which were made possible by one acid. In Sweden, Nobel had given the explosives business a big push with his invention of dynamite; sulfuric acid powder was being made of wood pulp or cotton by the action of sulfuric acid and nitric acid (made with sulfuric). But by that time Leblanc’s cheap alkali process, which had started sulfuric acid on its careening course, was completely licked by the Solvay process—which needed no acid. The prime mover behind sulfuric’s growth disappeared; and in the curious economics of chemistry that was all to the good, for an acute shortage of sulfuric acid might otherwise have developed. Other needs sprang up so swiftly that sulfuric acid production never halted for a day.

These new consumers needed acid more concentrated than the lead-chamber process could produce. As the discontent with chamber acid grew, a chemical inquiry began as to why it was, year before, that an English vinegar maker had not been successful with a sulfuric acid process on which he had a patent, and which had looked wonderful but hadn’t worked. The vinegars of Peregrine Phillips, halting stumbl on the fact that when
sulfur dioxide and air were passed over hot platinum, they combined to form sulfur trioxide, and that this need only be dissolved in water to make sulfuric acid directly and completely. The platinum was left in the end just as it was in the beginning, its power to promote the combination of air and sulfur dioxide entirely unimpaired. At least, that was what the patent said. But the process hadn't worked well for Phillips. His trouble turned out to be that impurities in his sulfur poisoned the platinum catalyst and made it refuse to react even when there was no sulfur dioxide. This was known and this new “contact process” for sulfuric acid was well under control, the process still accounted for very little production. The reason: sulfur pure enough for the contact process scarcely existed, and purification was too expensive. But that was before Herman Frasch brought sulfur, better than 99 per cent pure, up from under the quicksands of the Louisiana coast. Once this was accomplished, sulfuric acid, still cheaper, still more plentiful, emerged its modern phase of use. Of all the things made by chemical industry and consumed without going through the formalities of a sale, sulfuric acid is probably the best example. In the peak year 1929 a quarter of the total production probably never saw the market. Each consumer—and every consumer—takes a careful look into the matter to decide whether he will buy his acid, or make it. Reasons for this principally involve freight charges. So much air and water combine with sulfur to make sulfuric acid that the acid that goes out of the plant weighs some three times as much as the sulfur that comes in. And the dangerously corrosive and burning acid is tough to handle compared to the innocuous sulfur from which it is made. Obviously then, there is good reason for building sulfuric-acid plants as close as possible to consuming markets and keeping them scattered and little, without caring very much how they relate geographically to the sulfur supply.

Sulfuric acid has been the pig iron of chemical industry. In 1929 its sales reached an all-time peak of 5,600,000 tons, worth $45,600,000—and this was only some 70-odd per cent of the total production. It has never returned to that peak (although chemical industry in general has) and there are those who think that it never will. Nothing is more characteristic of the chemical industry than the way it outgrows the products and conceptions of its youth—and there are some signs that the industry is beginning to outgrow its previous dependence on sulfuric acid. The new petroleum industry can no longer afford to treat its products as roughly as it used to. Therefore in this industry new refining agents—solvents and synthetic compounds—are replacing sulfuric acid. The fertilizer manufacturers are beginning to find new ways to make plant food from phosphate rock without sulfuric acid. Pickling steel for galvanizing and for other uses is being done without sulfuric acid—hydrochloric acid is taking its place. And whereas hydrochloric acid used to be made almost entirely from sulfuric acid’s action on salt, it is now being made from the hydrogen chloride that comes as a waste of petroleum distillation. Chlorine, indeed, is taking an industrial importance that increases almost daily—and to it we should look next.

*That is what chemists know as a catalyst, but an explanation of how it works has filled volume after volume with words that explain nothing at all of how or why a catalyst works.

Chemical Industry

[Continued from page 166]

Chlorine

As LEBLANC’s soda process fostered sulfuric acid manufacture to supply one of its raw materials, so one of its byproducts set another chemical wheel spinning by leading to chlorine. Chlorine is a gas, but it is used in syntheses. To make soda you treated salt with sulfuric acid to form sodium sulfate, which you wanted, and hydrogen chloride, which you did not. As long as soda makers made only a little soda, the winds blew this acid gas harmlessly away. But as soda production grew the air about soda plants became more and more noxious. In England, where Leblanc’s process was put to real work, it was only a little while before the new petroleum industry can no longer afford to treat its products as roughly as it used to. Therefore in this industry new refining agents—solvents and synthetic compounds—are replacing sulfuric acid. The fertilizer manufacturers are beginning to find new ways to make plant food from phosphate rock without sulfuric acid. Pickling steel for galvanizing and for other uses is being done without sulfuric acid—hydrochloric acid is taking its place. And whereas hydrochloric acid used to be made almost entirely from sulfuric acid’s action on salt, it is now being made from the hydrogen chloride that comes as a waste of petroleum distillation. Chlorine, indeed, is taking an industrial importance that increases almost daily—and to it we should look next.

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Chemical Industry

[Continued from page 166]

Chlorine

As LEBLANC’S soda process fostered sulfuric acid manufacture to supply one of its raw materials, so one of its byproducts set another chemical wheel spinning by leading to chlorine. Chlorine is a gas, but it is used in syntheses. To make soda you treated salt with sulfuric acid to form sodium sulfate, which you wanted, and hydrogen chloride, which you did not. As long as soda makers made only a little soda, the winds blew this acid gas harmlessly away. But as soda production grew the air about soda plants became more and more noxious. In England, where Leblanc’s process was put to real work, it was only a little while before the new petroleum industry can no longer afford to treat its products as roughly as it used to. Therefore in this industry new refining agents—solvents and synthetic compounds—are replacing sulfuric acid. The fertilizer manufacturers are beginning to find new ways to make plant food from phosphate rock without sulfuric acid. Pickling steel for galvanizing and for other uses is being done without sulfuric acid—hydrochloric acid is taking its place. And whereas hydrochloric acid used to be made almost entirely from sulfuric acid’s action on salt, it is now being made from the hydrogen chloride that comes as a waste of petroleum distillation. Chlorine, indeed, is taking an industrial importance that increases almost daily—and to it we should look next.

*That is what chemists know as a catalyst, but an explanation of how it works has filled volume after volume with words that explain nothing at all of how or why a catalyst works.

Chemical Industry

[Continued from page 166]

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Ammonia and nitrogen

The layman knows ammonia only as something on the kitchen shelf—and this is not ammonia at all but a weak solution of ammonia in water. When the chemist speaks of ammonia he means anhydrous ammonia (without water), which is a gas and becomes a liquid only when subjected to sufficient pressure. The molecule of ammonia consists of one atom of nitrogen and three atoms of hydrogen—and the production of ammonia from the nitrogen of the air is a triumph that some sober historians of chemistry have ranked in importance to the race with the discovery of fire.

Inert and useless, 1,690 pounds of nitrogen press down upon every square foot of the earth’s surface. Sir William Crookes in 188 predicted the imminent end of civilization upon the presumption that the combined nitrogen that is an essential ingredient of every form of animal and plant life would be exhausted. Nitrogen from the air could be “fixed”—that is to say, could be combined with other elements into useful and nourishing forms—only by certain peculiar bacteria living on the roots of leguminous plants. The bodily wastes of animals are rich in useful nitrogen, and the farmer nourishing his plants with manure was doing his work of restoring nitrogen to the life cycle. But the enormous dissipation of nitrogen after a single use was helping to throw the entire cycle off its proper balance. Moreover, nitrogen in the form of nitrates was vital to the explosives industry—and the principal source of world supply was the great nitrate deposits of Chile.

The virtual world monopoly of Chile in nitrates was a matter of primary world concern when a methodical German, Fritz Haber, found the essential clue to the whole riddle of nitrogen fixation in 1908.* Using extremely high pressures and temperatures he was able, with the aid of a catalyst made mostly from iron, to cause nitrogen from the air to combine with hydrogen in the ratio of one to three, producing ammonia. The process, experimentally well-developed in 1908, was working at full plant scale by 1913—and the first wide-scale use was helping to throw the entire cycle off its proper balance. Moreover, nitrogen in the form of nitrates was vital to the explosives industry—and the principal source of world supply was the great nitrate deposits of Chile.

*Peaceloving Fritz Haber lived until 1918. But at his death he was living in Switzerland as a voluntary exile from Nazi Germany.

The Haber process was the first example of a practical chemistry of a new kind—the chemistry of high-pressure synthesis. It is a technique that can be used for more than one end. For example, remember that incandescent coke plume steam produce a mixture of hydrogen and carbon monoxide; upon that combination hangs another vital industrial development. If a hydrogen and carbon-monoxide mixture is put into the compressors of the same apparatus that makes ammonia, out comes methanol—still known as wood alcohol from the days in which it was produced entirely by the distillation of wood. A change of catalyst is necessary, but otherwise the same plant can be set to work producing an entirely different product. Indeed, Commercial Solvents Corp. a decade ago made this very shift. After building an ammonia plant to consume hydrogen made as a byproduct of its fermentation processes, Commercial Solvents later became involved in making methanol by combining its hydrogen and carbon monoxide; upon that combination hangs another vital industrial development.

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...make ammonia or methanol from this hydrogen or hydrocarbons. But neither does it lie in plants that are fired by coal that has perhaps jounced 400 miles in coal cars across country to be delivered from mine to point of consumption. Since the hydrogenation of coal produces liquid hydrocarbons, the chemist wants to know why these hydrocarbons should not be processed at the mine mouth with hydrogen made from coal and steam and then pumped in pipe lines, like the hydroelectric power of more or less pure water at mountain heads of power consumption, there to be burned as fuel for steam engines or in the cly-

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