Scientific American

FOUNDED 1845

MARCH
1948

50 cents
a copy

PROGRESS IN INDUSTRY

REFINING PHOSPHORUS

VITAL TOOL FOR Management!

Use it to SPREAD the national debt!

WITH MANAGEMENT BACKING, PAYROLL SAVINGS PLAN CAN HELP BUSINESS AND NATION

In 19,000 companies, the Payroll Savings Plan (for the regular purchase of U. S. Savings Bonds) has made employees more contented in their jobs—has cut down absenteeism—has even reduced accidents!

In addition, of course, the Plan builds financial security for each participant. Each Bond pays $4 at maturity for every $3 invested.

But the Plan has other, far-reaching benefits —to business and to the nation—which are equally important to you.

SPREADING THE NATIONAL DEBT HELPS SECURE YOUR FUTURE

The future of your business is closely dependent upon the future economy of your country. To a major extent, that future depends upon management of the public debt. Distribution of the debt as widely as possible among the people of the nation will result in the greatest good for all. How that works is clearly and briefly described in the brochure shown at the right. Request your copy—*today*—from your State Director of the Treasury Department's Savings Bonds Division.

WHY EXECUTIVE BACKING IS VITAL

Employees still want the benefits of the Payroll Savings Plan. In fact, they *need* the P. S. P., because banks don't sell Bonds on the "installment plan"—which is the way most workers prefer to buy them. But wartime emotional appeals are gone. Human nature being what it is, the success of the Plan in your company is liable to dwindle unless a responsible executive keeps it *advertised*. The *reasons* for promoting it are as important as ever—to you, your company, and your country.

So—today—*check up* on the status of the Payroll Savings Plan in your company. *Act* on your responsibility to see that it is vigorously maintained.

The State Director will gladly help.

"The National Debt and You,"

a 12-page pocket-size brochure, expresses the views of W. Randolph Burgess, Vice Chairman of the Board of the National City Bank of New York, and Clarence Francis, Chairman of the Board, General Foods Corporation. Request your copy from the Treasury Department's State Director, Savings Bonds Division.

The Treasury Department acknowledges with appreciation the publication of this message by

Scientific American

This is an official U. S. Treasury advertisement prepared under the auspices of the Treasury Department and the Advertising Council

Scientific American

Founded 1845

ON THE COVER: Elemental phosphorus in the process of manufacture. For the story of phosphorus see page 101.

PICTURE CREDITS

Cover — Monsanto Chemical Company
100 through 104 — Monsanto Chemical Company
105 — The Western Union Telegraph Company
106 through 108 — Western Electric Company
109 through 114 — Westinghouse Electric Corporation
115 — *Electronics*
116-117 — Westinghouse Electric Corporation
118 — Stromberg-Carlson Company
119 — Austenal Laboratories
122 through 126 — Foster D. Snell, Inc.

Subscription Rates:

ONE YEAR—$5

TWO YEARS—$9

THREE YEARS—$12.50

Canada 50¢, foreign $1 per year additional.

WHEN you change your address, please notify us immediately, giving your OLD as well as your NEW address. Postal requirements are such that our subscription files are arranged geographically, not alphabetically. Because of this, failure to give your old address may result in delaying receipt of copies.

SCIENTIFIC AMERICAN, March, 1948. Vol. 178. No. 3. Owned and published by Scientific American, Inc., 24 West 40th Street, New York 18, N. Y. Entered at the New York, New York, Post Office as second-class matter June 28, 1879, under act of March 3, 1879. Additional entry at Orange, Connecticut. Published monthly by Scientific American, Inc., 24 West 40th Street, New York 18, N. Y.

In This Issue • March 1948

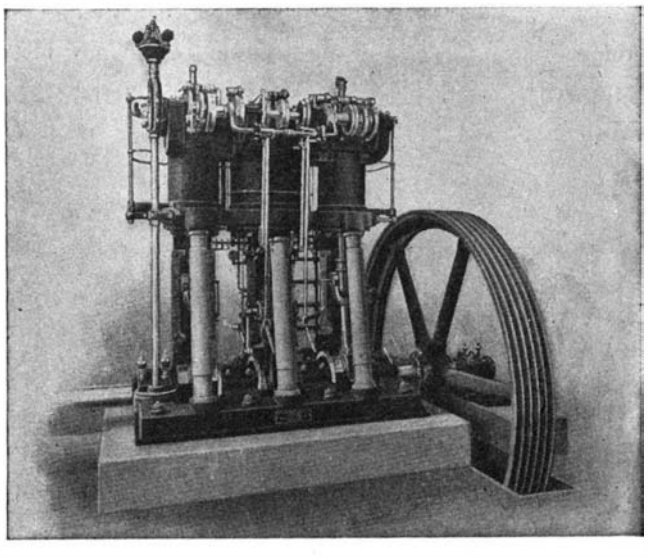
50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of March, 1898)

KLONDIKE AND CALIFORNIA — The expected rush to the Klondike is already well under way, and judging from the present indications, it is probable that the army of fortune-hunters which will enter this inhospitable region during the coming season will far exceed in numbers the emigration to California in the days of forty-nine. To those who foresee the disappointment which is, of necessity, in store for the majority of these people, it would be a consolation to be assured that the Klondike exceeds the California gold fields in richness. Unfortunately there is no evidence that it does. It is probable that not one in a hundred of the California miners found the fortune or even a hint of the fortune for which he set out. The proportion is likely to be even smaller in Alaska.

DIESEL'S HEAT MOTOR — An improvement, marking an advance as important in its way as that of the internal combustion motors over those using external combustion, has been made by Mr. Rudolph Diesel, of Munich. The experiments which led to the construction of the present successful machine, which is known by the name of the inventor, began in 1882, and the conditions which govern the machine were fully formulated in 1893. In the ordinary



forms of gas or oil engine the charge is ignited by a jet, hot tube or electric spark and the combustion is so rapid as to be practically explosive. In the Diesel motor the igniting spark or jet is dispensed with altogether, and the temperature of ignition is secured by the compression of pure air.

MAINE DISASTER — As we go to press the mystery which envelops the "Maine" disaster is as great as ever and the country is still anxiously awaiting the verdict of the Court of Inquiry. So faithful have the members of the board, the survivors of the "Maine," and the divers who are at work on the wreck been to the policy of silence which has been enjoined by the administration, that practically nothing of an authoritative or expert character regarding either the cause of the wreck or its present condition has been made public. Meanwhile, both the administration and Congress have been taking all necessary steps to place the country in a state of full preparedness for such complications as might follow upon the publication of the Court of Inquiry's report, if it should prove that the "Maine" was blown up by design.

A MUSICAL WHEEL — The bicycle has reached another phase of its constant development through a novel and highly interesting invention, consisting in a musical instrument which may be attached to any bicycle and plays popular airs, without the aid of the rider, in a loud and melodious manner, when the machine is in motion. This instrument constitutes an entertaining companion for the bicyclist on his roamings, which are frequently rather lonely; it is so much more welcome as it will be a companion entirely submissive to the rider's wishes.

100 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of March, 1848)

A NEWLY INVENTED RAIL — The whole of the line of railway between Darlington and York in England is being relaid with new rails, chains and sleepers. The rail is of new invention, and of a very superior make, and is considered as a great improvement upon the old description, as the surface of the rail being convex, it presents much less surface to the wheel, and thereby the friction is much reduced—a great desideratum.

COAL TRADE — The average freight of coal from Philadelphia to Boston in 1847, was $2.75 per ton. In 1848 it will be $1.75, making a difference in favor of the buyer of one dollar per ton. Besides the inland freight to Philadelphia, will be reduced perhaps an average of 25 cts. or more, and some reduction must be expected in our rates here. Altogether we expect to put coal into Boston, at not far from $5 per ton of 2,240 pounds, for the opening; and we trust our eastern friends with that assurance, will not have to look abroad for supplies.

DEAFNESS — M. Bonnafont, of Paris, a military surgeon, gave an account at the January session of the Academy of Sciences, of a method employed by him in cases of deafness, to ascertain whether the nerve of sound has lost all its susceptibility. He has ascertained that the skull is a good conductor of vibration, and that, if it be struck by vibrating objects, the nerve of the ear is acted upon whenever its susceptibility has not been entirely destroyed.

KNITTING BY STEAM — A number of influential inhabitants of Ipswich, England, have introduced into that town an important branch of industry, likely to give employment to a large number of persons. Machines are now at work knitting stockings by steam. The work is done with beautiful accuracy. One young person can attend to three machines, and each machine will knit one stocking in three hours.

IMAGE OF THE SUN — M. Becquerel has announced to the Academy of Sciences, at Paris, that he has ascertained that the image of the sun with its colors may be obtained on a plate of silver properly prepared. The preparation consists in submitting cautiously the plate to the action of chlorine. A fine photographic image of the sun, in which the orange, yellow, green, and blue are distinctly marked, is then obtained.

AN ANNOUNCEMENT TO OUR READERS

The editorial function of the Scientific American, as it is stated on the cover of this and other issues, is the reporting of "progress in industry." This is one of the last issues of the Scientific American which will be published under this policy. In May the Scientific American will become an entirely new magazine.

The Scientific American will no longer restrict itself to reporting progress in industry. It will cover all of science: the physical, biological and social sciences, as well as their more significant applications in medicine and engineering. The new Scientific American will be designed for an audience of intelligent laymen. Among these are the scientists themselves, the medical men and engineers, the executives and managers of industry and those engaged in such non-technical professions as teaching and the law.

It has already been announced on this page that the new Scientific American would be founded on a unique collaboration between the scientists and a new board of editors. Since then some of our readers, knowing who the scientists are, have sensibly asked: "Who are the editors?" The Board of Editors of the new Scientific American, together with some pertinent biographical data, is presented herewith:

The Board of Editors

The editor and publisher of the new Scientific American is Gerard Piel, 33. Piel's principal professional experience has been as science editor of the national magazine *Life* and as assistant to the industrialist Henry J. Kaiser. As indicated by his title, Piel will devote some of his time to the business problems of the new Scientific American, but he will also be the head of its editorial staff.

Managing editor of the new magazine is Dennis Flanagan, 28. Like Piel, Flanagan has received most of his professional experience as science editor of *Life*. Under Piel, Flanagan will coordinate the various editorial functions of the Scientific American.

Another member of the Board of Editors is Leon Svirsky, 43. Svirsky has worked as a reporter for the New York *World* and the New York *World-Telegram* and successively as education, science and medicine editor of the weekly news magazine *Time*. Svirsky is also editor of the current study of the U. S. daily press entitled *Your Newspaper*.

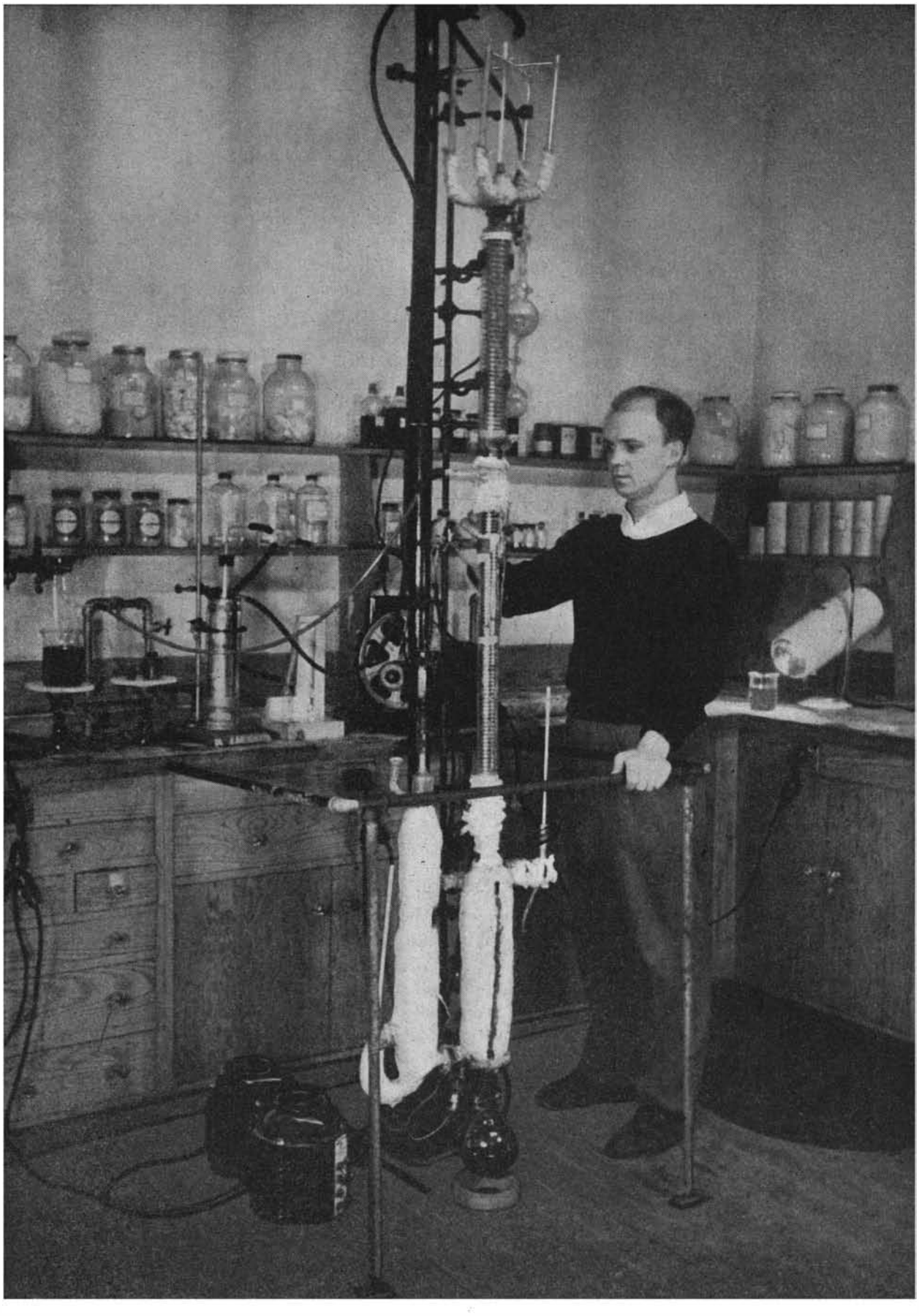
Overseeing the graphic arts in the new Scientific American is K. Chester, 29. Chester has been variously an artist, an art director and a photographer, the latter for *Life* and other national magazines. Immediately after the war Chester was Chief Photographer for the International Tribunal at Nuremberg.

The fifth member of the Board of Editors is Albert G. Ingalls, 60. Ingalls, as any long-term reader of the Scientific American knows, has been a member of the staff of this magazine since 1923. In recent years his principal contribution to its pages has been *Telescoptics*, the monthly column known to all amateur astronomers. In the new Scientific American, Ingalls will continue to write his column and will also assist with other editorial duties.

The Work of the Board

The work of the Board of Editors has been discussed in previous announcements. It begins with the common conviction of the editors that the men who are best qualified to write about science are scientists. Since scientists, however, must devote most of their time to science, the editors must undertake a large part of the job of communication between the scientist and the intelligent layman.

The work of the editors is naturally synonymous with the aims of the new Scientific American. It will primarily create a magazine which communicates scientific information to the intelligent layman in a language which is neither technical nor patronizing. In accomplishing this, the new Scientific American will fill a large gap between the scientific and technical press on the one hand and the general newspapers and magazines on the other. And in bridging this gap it will also contribute to the diffusion of information among the compartmentalized specialties of science. But the highest aim of the new Scientific American will be to present scientific knowledge to the end that science shall occupy the same place in the mind of every thinking citizen that it occupies as an integral part of our modern civilization.



A technician running a fractional distillation of a phosphorus compound. Through such analysis the purity and uniformity of the product is maintained

Scientific American
MARCH • 1948

PHOSPHORUS: BEARER OF LIGHT AND LIFE

First Isolated Three Centuries Ago, It Is a Key Constituent Of Life's Perpetual Cycle. The First of Two Articles

By William Mann

IN A CERTAIN sense, phosphorus served to introduce mankind to modern chemistry. It was the first chemical element to be discovered by a single man bent on research. As happens with most new elements, the usual controversy about the priority of this discovery arose, and in the 17th Century there were several claimants for the honor. But an impartial study made in our own time of authentic letters written by the disputants nearly three centuries ago, confirms the claims of a certain Hennig Brandt of Hamburg, Germany. It seems clear that in the year 1669 this "uncouth physician who knew not a word of Latin" (one of the numerous sneers published about him by more educated and jealous opponents) was the first human being on this planet to see the impressive glow of elementary phosphorus.

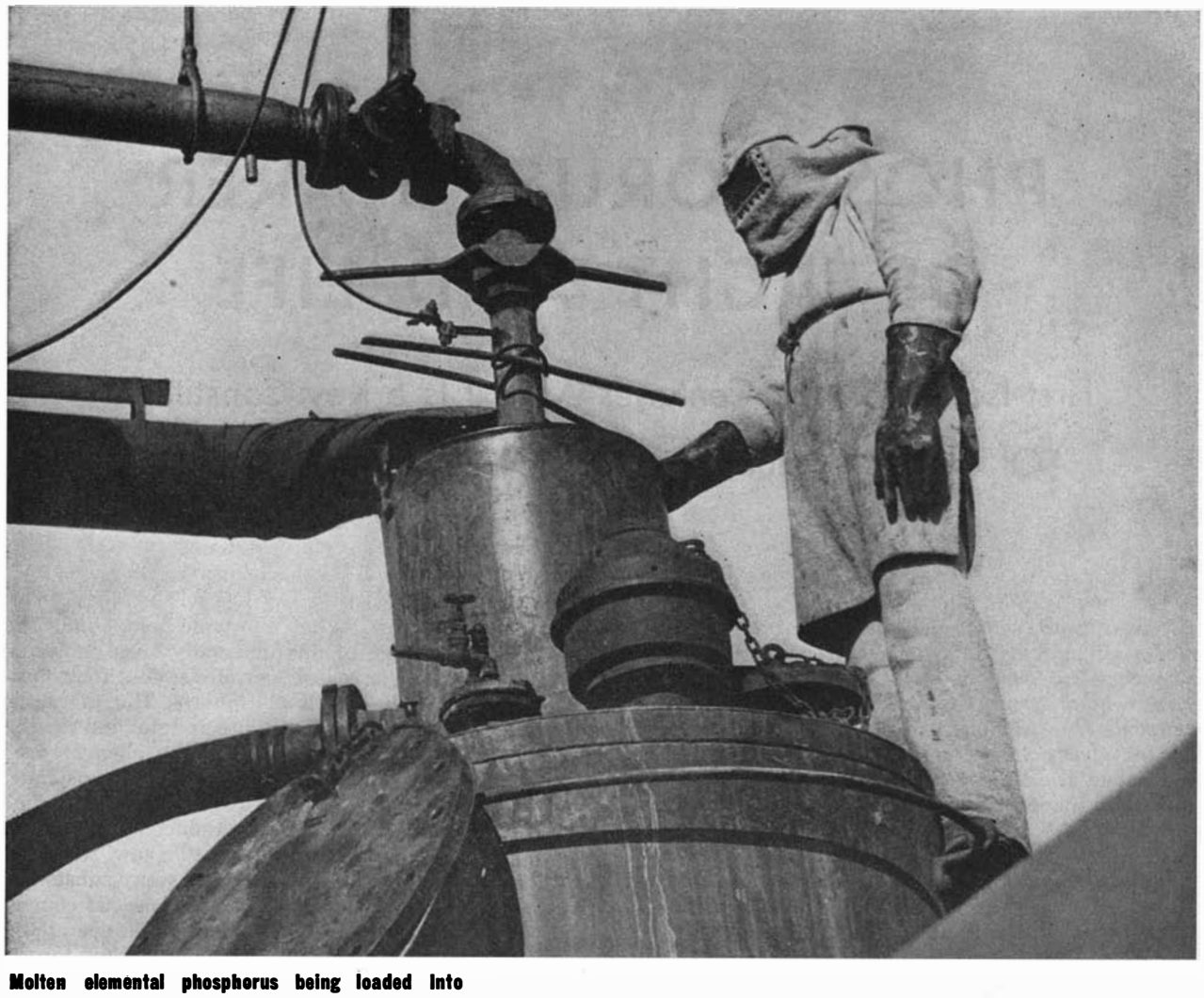
There are older elements, of course. Six that are found native or are easily reduced from their ores—silver, gold, iron, copper, lead and tin—are even mentioned in the older parts of the Bible. And certain others, such as carbon and sulfur, have been known and used from time immemorial. The prehistoric discoverers of all these are lost in the dim corridors of time. But phosphorus is not found native, and is difficult to reduce from its compounds. Its discovery was therefore a pioneer achievement of great importance. Without proper furnace equipment phosphorus would be difficult to prepare today.

PHOSPHORUS IN THE LABORATORY — These facts are reflected in present-day analytical practice. Phosphorus is found in a host of products, and the modern analyst is often called upon to determine it; but none of the recommended procedures call for a direct determination of elementary phosphorus. Generally speaking, the more reactive an element is, the harder it is to handle, and the practical analytical chemist therefore would rather not see his phosphorus in the active elementary state. It is much easier to work with this element indirectly and in stable combinations. The chemist prefers to titrate the nice yellow compound of hydrated ammonium phosphomolybdate, which is very easy to make and to keep. Also, it has a molecular weight of 1931, which is enormous for an inorganic compound. The practical advantage of this unusually large molecule is that if any of it is lost in transfer less than one-sixtieth part of the loss is phosphorus. But this huge molecule makes a very bulky precipitate, and for the higher percentages of phosphorus the chemist prefers to weigh ignited magnesium pyrophosphate, which is slightly more than a quarter phosphorus.

When Hennig Brandt first produced elementary phosphorus, he was amazed at what he saw. It turned out to be a white and rather soft and waxy substance, and even when cold it glowed in the dark. Of course, he was not looking for such a new substance at the time. Like most alchemists, he was looking for an older shining yellow element. He was in fact trying to make gold out of human urine, or trying to use urine for the conversion of silver into gold. In short, he had set for himself a research objective of considerable difficulty and the mere discovery of a new uncoinable element was probably something of a scientific disappointment to him.

Nevertheless, Brandt swallowed his disappointment and proceeded to live for the rest of his life by exhibiting his strange offspring in dark rooms, and by advertising its allegedly valuable medicinal properties. Occasionally he sold a small sample of it, or even gave some away; but the method of preparation remained a closely guarded secret. On one occasion he disclosed his secret to a Dr. J. D. Krafft of Dresden for 200 thalers, on condition that it go no farther. But Dr. Krafft did carry it farther. He even went to England and showed the glowing substance to King Charles II and his court for a consideration. During this visit, and in return for some secret data about "uncommon mercuries", Krafft hinted to Robert Boyle that phosphorus was prepared from "somewhat that belonged to the body of a man."

From that moment the days of the secret were numbered, and soon after phosphorus became a commercial product on a small scale. The great Dr. Boyle, a real scientist, and considered by some historians to be the Father of Chemistry, was well acquainted with the importance of urine to alchemical theory and practice; it was probably one of the



Molten elemental phosphorus being loaded into a tank car for shipment. Protective clothing guards worker from dangerous splashes and spray

first things he tried as a result of the hint. Knowing what to look for and where, it was only a question of time before such a shrewd and experienced operator heated the residue from evaporated urine high enough to reduce the sodium ammonium phosphate with carbon already present or with added sand, and distilled over the free phosphorus into water. As with atomic fission in our time, the real secret was out as soon as the phenomenon was described. There remained only an engineering problem that yielded to developmental research. Robert Boyle was successful on September 30, 1680, though his method was not published until some time after his death.

"ENGLAND HAVE MY BONES" — About a century after the first discovery of phosphorus, it was discovered to be an important constituent of bones. In 1771 Karl Wilhelm Scheele announced that bones heated with sand yielded phosphorus; and a few years later he learned that it could be obtained more easily and in larger amounts by treating the bones with nitric acid. Its great value as an agricultural fertilizer was soon recognized and the phosphate industry took root in England. Bones treated with acid continued to be one of the main sources of phosphorus and applied directly to the soil as bone ash. But in Apparently the bones were at first simply ground up and applied directly to the soil as bone ash. But in 1840 the famous German agricultural chemist, Justus von Liebig, pointed out that if the bones were first treated with sulfuric acid the phosphate in them would be more soluble and therefore more readily absorbed by the crops. Two years later a certain John B. Lawes took out the first British patent for the treatment of bone ash with sulfuric acid, and the superphosphate industry was soon on its way. It developed with astonishing rapidity in England. No one asked too closely just where the bones came from. It is recorded that the numerous battlefields of the Continent were combed for the bones of old soldiers to be shipped to England for a final tour of duty in the phosphate acid vats.

Bones of all sorts make very good phosphate (there are about three pounds of it in the average adult skeleton), but bones were always in definitely limited supply. In those days some of the lower classes of Europe were beginning to rebel against the starvation which was normal then and is still normal in parts of the world. They insisted on staying alive and even on keeping their children alive. More intensive agriculture was indicated. Liebig accord-

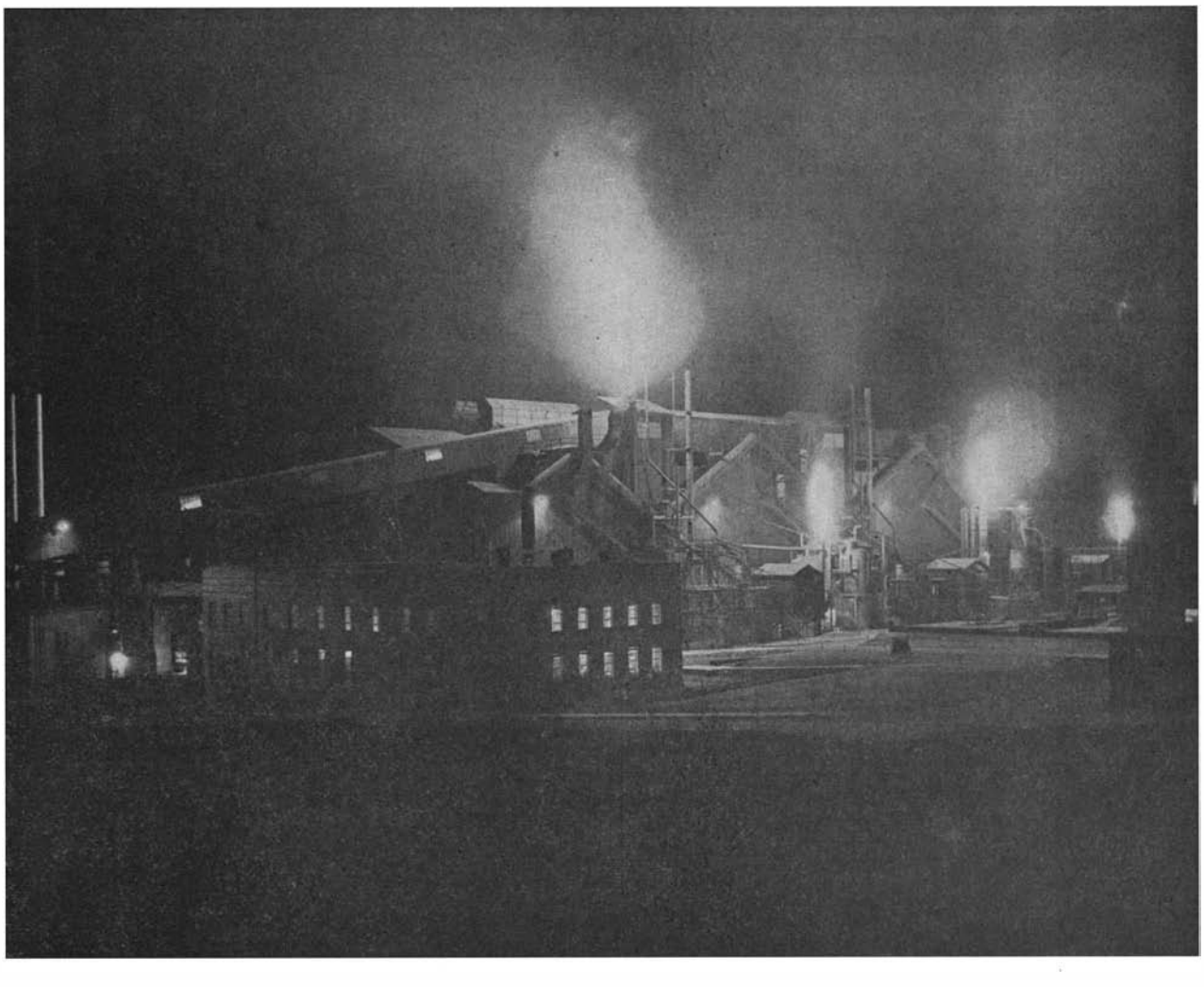
ingly turned his attention to mineral sources of fertilizer. In 1857 he suggested that phosphate-bearing rocks could be ground up and treated with sulfuric acid just as readily as bones, and the results would be better for agricultural as well as sentimental reasons. This suggestion was well received as it fitted in well with industrial progress. The trick is to make a phosphate product soluble enough for the plants, but not soluble enough to be washed out by the first rain. Development was again rapid, and only five years later (in 1862) the production of superphosphates in England by this new method had reached the relatively enormous total of 200,000 tons per annum. It may relieve the minds of our more squeamish readers to learn that even our baking powders are no longer derived from bones, as they once were, and not so long ago either. Presumably these were the bones of animals, obtained from non-military abbatoirs.

One of the factors that helped the South recover from the economic disaster of the Civil War was the development of the phosphate rock industry in South Carolina in 1867. Almost at once the United States became the foremost phosphate-producing nation in the world. This position has been maintained ever since. There are very large deposits of the highly insoluble minerals *phosphorite,* $Ca_3(PO_4)2$, and *apatite,* $CaF_23Ca_3(PO_4)_2$, in Georgia, Florida, the Carolinas, Tennessee, Montana and in some other states.

These two minerals are the source of all the phosphorus and phosphorus compounds of commerce today. They constitute one of our greatest natural endowments, simply because nothing will grow in soil that has no phosphorus in it. Cheap phosphorus means more food and therefore the element is responsible to a considerable degree for the great increase in the world's population during the last century. If all these additional hungry mouths are to be filled, artificial phosphate fertilizers in suitable form must be added to the soil.

BRANDT'S METHOD — Stripped of the extraneous alchemical verbiage found in the old accounts, Brandt apparently discovered phosphorus by evaporating large volumes of urine gently until the water and the more volatile chlorides were gone, adding sand to the solid residue and finally distilling the mixture in a retort at white heat. Sooner or later the necessity of catching the distillate in water, not an unusual step in those times, was also discovered. The early directions for this preparation contained a wealth of

Night view of the elementary phosphorus plant of the Monsanto Chemical Company at Monsanto, Tennessee



abracadabra, and called for days of waiting for favorable developments and signs. These generally unpleasant details may be passed over quickly, but the remarkable fact remains that the underlying reactions described by Brandt, in so far as their basic chemistry goes, are the same as the reactions applied today in the most modern phosphate plants. This is true whether one is thinking of the blast furnace method, or the oil-fired furnace, or even the electric furnace which is most commonly employed in the United States today. It should be mentioned that the electrical methods applied in the plants of the Tennessee Valley Authority and Monsanto Chemical Company, for instance, are not electrolysis procedures, as in caustic production. The current is used solely as a source of heat.

We know now that Brandt must have reached a temperature in the neighborhood of 1450 degrees, C. to bring about the reactions and the distillation. Assuming that after ignition the very small proportion of phosphate in the residue was present in combination with lime, the first reaction was:

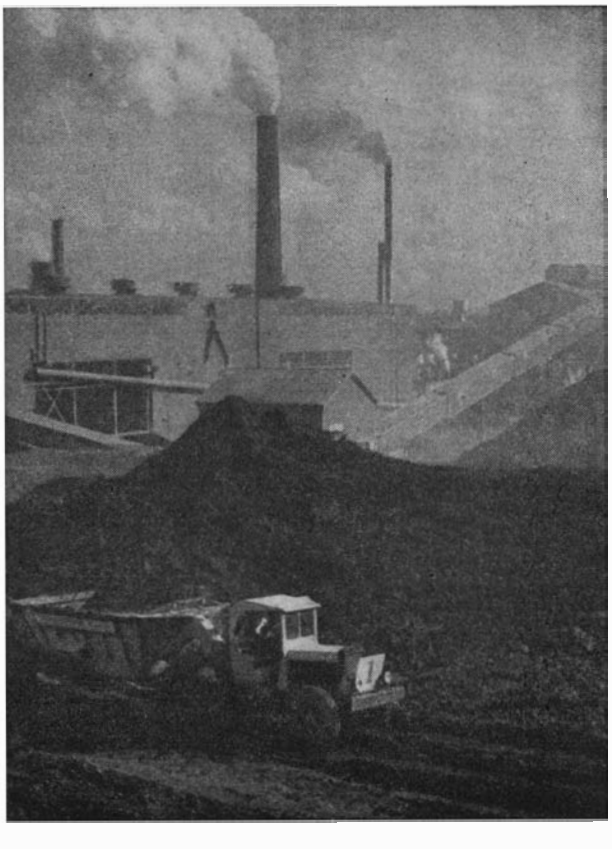
$$Ca_3(PO_4)_2 + 3SiO_2 \rightarrow 3CaSiO_3 + P_2O_5$$

Remembering that carbon was also present from organic wastes such as urea, we have:

$$P_2O_5 + 5C \rightarrow 5CO\uparrow + 2P\uparrow$$

The final products are both gases at elevated temperature, and would readily pass into a distillate. As we have said, these are the basic reactions by means of which phosphorus is prepared today in the most modern chemical engineering equipment, with the help of enormous installations and with all sorts of electronic controls. After issuing from the furnace the phosphorus vapor is passed through a condenser and liquefied under water. It solidifies at 44.1 degrees, C. and is then stored and shipped out of contact with air.

Piles of crushed phosphorus-bearing rock awaiting processing. Such rock is by far the most plentiful source of phosphorus



The carbon monoxide gas that comes with it from the furnace is not wasted, but is led off to be used as fuel for the process. The calcium silicate slag which is formed in the first reaction drops to the bottom of the furnace and from here it is drawn off.

WHITE, RED AND BLACK — It is important to remember that the product so obtained, that is, by condensing phosphorus vapor, is always the extremely poisonous white phosphorus, sometimes called "yellow" because of a superficial layer it acquires on exposure to light. But white or yellow, phosphorus will "dissociate" one from wordly affairs quickly and efficiently. Phosphorus shines in the dark and in the cold. It was this astonishing phenomenon of "cold light" that intrigued the early workers. Some of them used to spend their days evaporating huge amounts of urine in a vain effort to increase the yield and to obtain enough phosphorus to light up a room. The illustrious philosopher, Gottfried Leibniz, was much interested in illuminating a room for his patron, Duke Johann Frederich of Hanover, with the material.

The light from phosphorus is not due to internal changes, as in the case of radium, which also glows in the dark. It is due to slow oxidation. But if heated in air up to 30 degrees, C.—cooler than the temperature of the human body—the oxidation is so accelerated that white phosphorus bursts into flame. Since it burns at such a low temperature, the element must be protected from oxygen by covering it with a layer of water.

When white phosphorus is enclosed in a vessel protected from air and heated to about 250 degrees, C. a remarkable transformation takes place. The white solid turns to a red powder consisting of minute monoclinic crystals, and a good deal of heat is liberated at the same time. This substance is the famous safe red phosphorus. It is safe for a number of reasons. It is no longer a particularly toxic substance. It is now insoluble in all known solvents, a fact that probably accounts for its much decreased toxicity. It does not have to be kept under water any more to avoid spontaneous combustion. It does not catch fire now below 330 degrees, C. In addition, its melting point has jumped from 44.1 to 590 degrees, C. and this only when squeezed with a pressure of 43 atmospheres. In other words, it never would melt under ordinary conditions. If heated sufficiently, it would go directly from a solid into a gaseous state, i.e., it would sublime.

There is one more kind of phosphorus that comparatively few people have seen, namely, black phosphorus. This does not refer to the discolored product contaminated with dark impurities that is sometimes observed. It is an artificial allotrope formed by Professor Percy Bridgman, the famous Harvard authority on high pressure methods, by heating white phosphorus at 210 degrees, C. under a pressure of 15,000 atmospheres. It turns out to be a heavy material that looks like graphite. Unlike other forms of phosphorus, it is able to conduct an electric current to some extent.

MICROWAVES IN COMMUNICATION

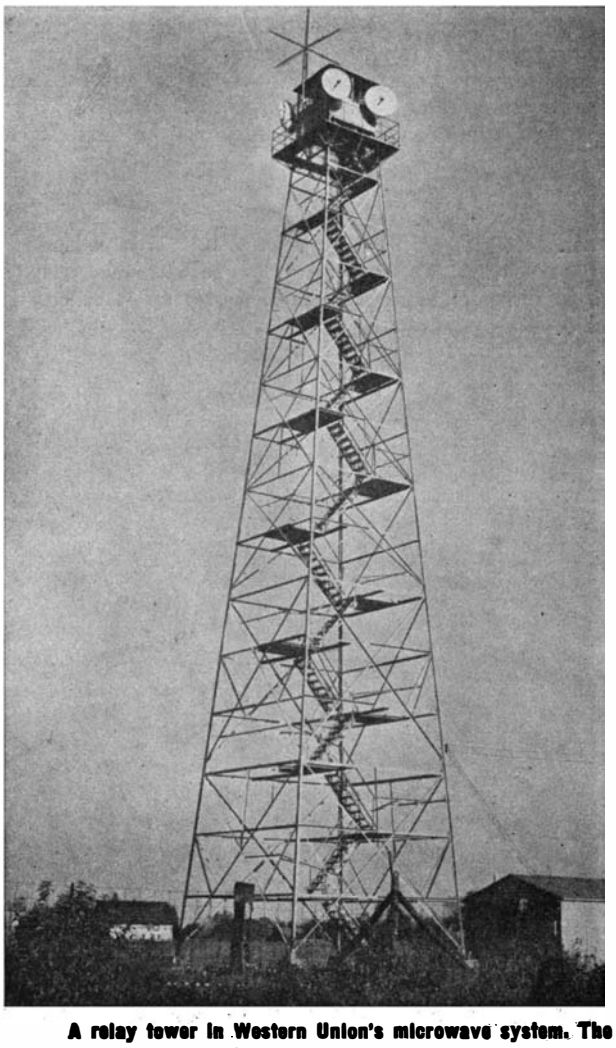
Highest Frequencies of the Radio Spectrum, Applied in Radar, May Ease the Congestion of U. S. Telephone and Telegraph Lines. An Account of How Microwaves Are Already in Use for Relay Transmission Between Cities

By Deane H. Uptegrove, Jr.

EVER since Samuel Morse sent his first message over a telegraph wire, the demand for telephone, telegraph and other wire-using services has been increasing steadily through good times and bad. If each communications circuit in use today required an individual pair of wires, the number of pairs needed to meet the demand between any two major cities in the United States would be staggering. This condition is relieved by standard circuits which make it possible for three telephone conversations and several telegraph signals to be carried simultaneously over only two pairs of wires. On branch routes this is usually sufficient. Economical operation over main arteries, however, requires far more drastic measures. The use of modulated carrier currents has improved the situation by making it possible to send hundreds of telephone conversations or telegrams over the same pair of wires at the same time. Still greater efficiency has been obtained by the use of coaxial cable. But even coaxial cable is limited in the number of communications circuits that it is able to carry.

Another growing demand for communications facilities is made by the television industry. The recent strides that have been made toward bringing television into the home of the average American have focused attention on the fact that television broadcasters badly need a network system to transmit programs over the entire United States. Because of the wide range of frequencies involved, ordinary wire and cable facilities are not suitable for television transmission except over very short distances. Coaxial cable is used regularly for television, but is not completely satisfactory because it can transmit frequencies only up to three megacycles. A minimum of four megacycles would more nearly meet television requirements.

The shortage of communications circuits has been accentuated by the shortage of copper which began with the war. And to all of these difficulties must be added those which are accepted as routine in the operation of cable and wire systems: ice, high winds, falling branches and trees, poles broken by wandering automobiles. Even when cables are carefully pro-



A relay tower in Western Union's microwave system. The system can handle over 2,000 messages simultaneously

tected in underground conduit, accidents can happen.

POINT-TO-POINT RADIO — All this led engineers long ago to consider radio for point-to-point communication between land stations. There has already been considerable use of radio in overseas telephone service, ship-to-shore telephone, and more recently the mobile telephone service for automobiles and trucks. The use of radio as a substitute for wires and cables, however, has not been practical because the useful radio frequency spectrum of earlier days simply was not big enough to satisfy the demand. The Federal Communications Commission, in cooperation with other countries, had to dole out the available frequency assignments with the greatest care, permitting the use of long distance frequencies only for those purposes where there was no alternative to radio. Television or multi-channel communications service were out of the question because they would use such wide chunks of spectrum space that there would be no room for anyone else at all.

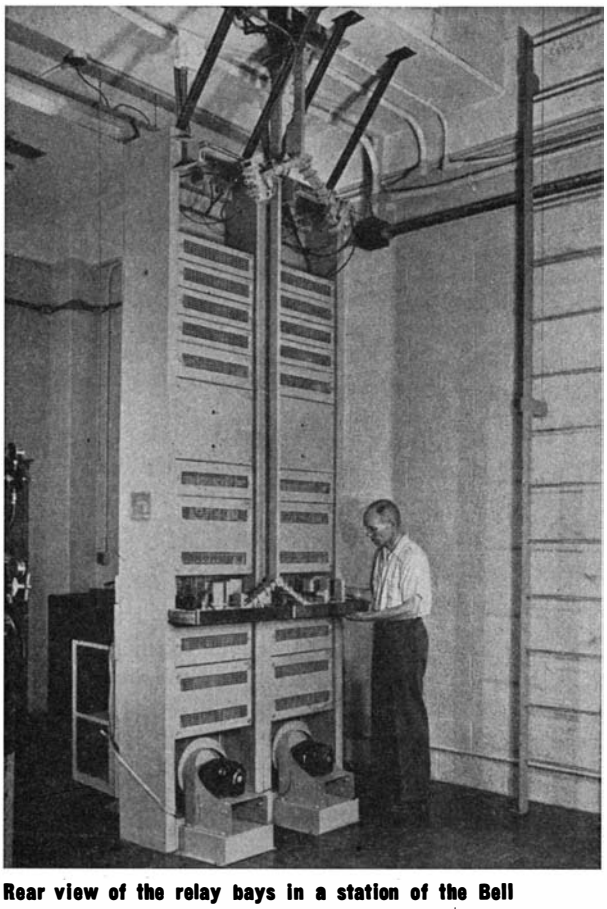
Next to the atomic bomb, probably the greatest development that came out of the war was radar and the exploration of the vast regions of the electromagnetic spectrum above 3,000 megacycles. This made room for all kinds of new uses for radio. Some day even the microwaves will probably be as crowded as the longer waves are today (frequencies as high as the Television and Frequency Modulation Broadcasting frequencies have already been the scene of many battles). For the present, however, there is room for nearly anyone who wants to get into the microwave region.

These super-high frequencies are the answer to the problem of new channels for point-to-point communication. Even the broad bands of modulation frequencies required for high quality television transmission are a small percentage of the usual carrier frequency. The highest frequencies are not seriously troubled by rain, snow, or fog. Unlike the lower frequencies, they are not affected by static and most kinds of man-made interference. Another advantage is that they can be transmitted by highly directional antennas of conveniently small dimensions. The horn used in the Bell System antenna described below, for example is about ten feet wide. If a similar horn could be built to work on four megacycles it would have to be almost two miles wide!

One of the stations in the microwave relay links between New York and Boston. Directional antennas are mounted on roof

The Bowdoin Square Building, which is the Boston terminal of the Bell System's New York to Boston microwave relay route. The antennas can be seen at the top of the building

LINE-OF-SIGHT PATH — The greatest disadvantage in using microwaves for long distance communication is that these waves follow a "line of sight" path and ordinarily do not follow the curvature of the earth beyond the horizon. This means that it is necessary to have repeater stations located at intervals along the route, generally situated on the highest available hill in order to have the longest reach to the next horizon. However, the advances in microwave technique in the last few years have made the design of circuits, waveguides, antennas, vacuum tubes and other microwave equipment a much less formidable problem. Already some engineers contend that frequent microwave repeaters are more economical to maintain than a cable system. It is easy to see why the domestic wire and cable companies, notably the Western Union Telegraph Company and the American Telephone and Telegraph



Rear view of the relay bays in a station of the Bell relay link. Note the wave guides leading up to ceiling

Company, are seriously interested in microwave radio.

Western Union has been operating an experimental microwave system between New York and Philadelphia since 1945, and has plans for extending it to cover nearly all parts of the country. The Western Union system operates in the neighborhood of 4,000 megacycles (7½ centimeters) with relay points at an average of every 25 to 60 miles. Antennas with parabolic reflectors are used, located on towers from 60 to 120 feet in height. On sections longer than about 15 miles, fading due to reception over multiple paths is conquered by diversity reception making use of two receivers whose antennas are separated vertically by about 25 feet. The 4,000 megacycle carrier frequency is modulated by a one megacycle sub-carrier, and this in turn is frequency modulated by multiplexed telegraph signals in the band of 30 to 150,000 cycles. At the intermediate relay stations the received signal is demodulated back to one megacycle, and this one megacycle sub-carrier is used to modulate the outgoing signal. The sub-carrier is not demodulated except at the ends of the line. This makes possible considerable simplification of the equipment at these intermediate points. In fact, modulators and demodulators do not have to be too accurately in line because both the carrier and sub-carrier are frequency modulated. This method of transmission makes possible some distortion of wave form without affecting the multiplexed telegraph signals it carries.

The multiplexing system used in microwave transmission divides the 30 to 150,000 cycle band into 32 voice-frequency channels, each about 3.000 cycles wide. Each voice frequency channel can be divided into eight multiplex telegraph channels and by means of a time-division system, each multiplex telegraph channel can be used for four teleprinters. All this adds up to making possible the transmission of *Over 2,000 Messages at the Same Time,* half in one direction and half in the other.

NEW YORK TO BOSTON — American Telephone and Telegraph (the Bell System) has recently put into operation a microwave system between New York and Boston. This is also being extended from New York to Chicago. Between Boston and New York the microwave beam makes eight jumps over seven intermediate radio relay stations spaced about thirty miles apart. On the roof of each radio relay station are four antennas, two facing along the route toward New York and two facing along the route toward Boston. This allows for two-way operation with one antenna of each pair for transmitting, the other for receiving. The antennas are horns with metal lenses in their ten-foot-square openings. These metal lenses consist of a series of metal vanes arranged in such a way that they produce the same effect on radio waves as a glass lens produces on light waves. They are covered with a sheet of plastic across the openings to keep out birds and ice. The beam from this type of antenna is less than two degrees wide—so concentrated that practically no power can escape from one antenna into any other than that for which it is intended. It is therefore possible to design the intermediate repeaters simply

The New York terminal of the Bell System's New York to Boston microwave chain at 32 Avenue of the Americas

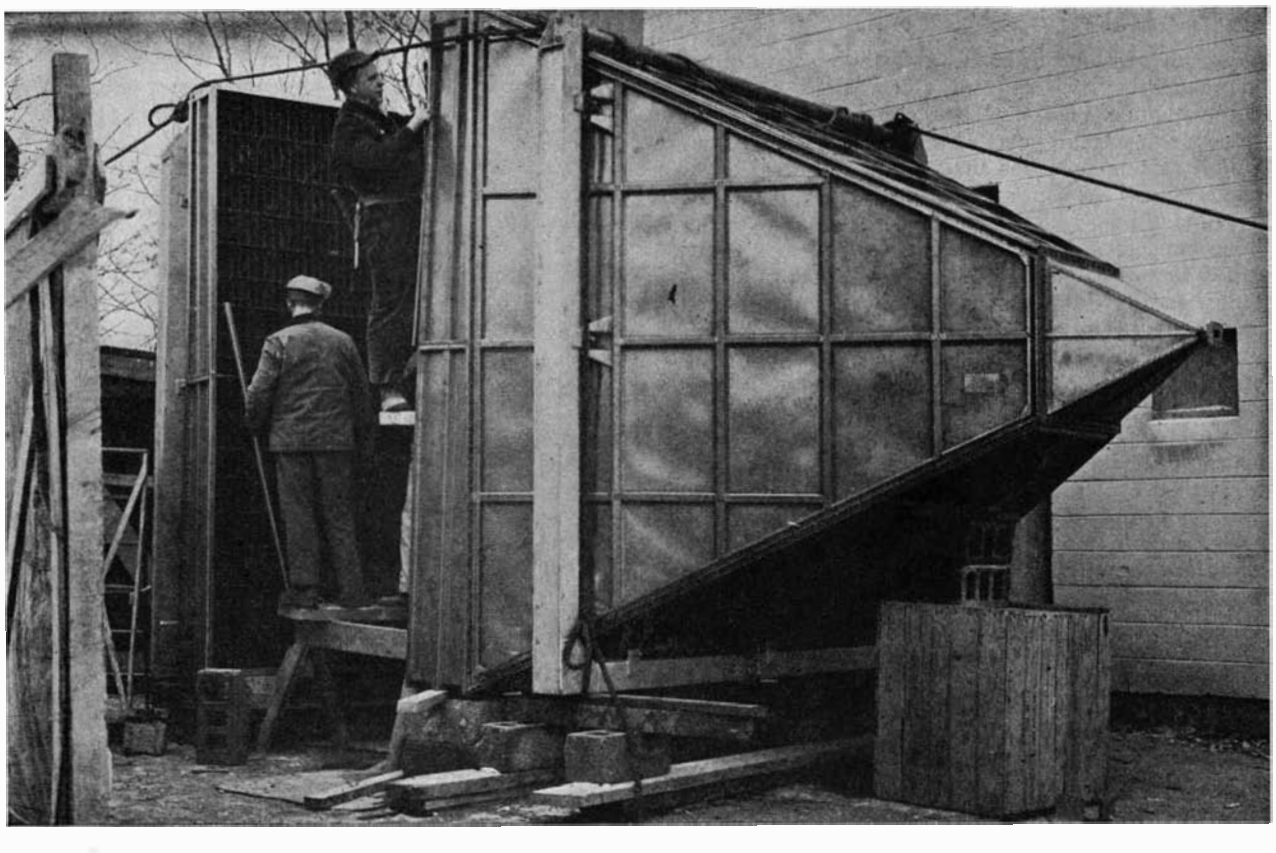
as broad band amplifiers, able to handle substantially any type of signal using any kind of modulation. At present this system is set up to use frequency modulation, but amplitude and pulse modulation are being tested as well. For operation of these circuits, frequencies in the range 3700 to 4200 megacycles have been assigned by the F. C. C. This should give room enough for at least six two-way broad band channels on a route. Each of these can be made wide enough for color television if required.

In addition to the accomplishments of these two organizations, several television broadcasters have set up microwave radio circuits and several more are at the discussion stage. The Philco Radio and Television Corporation has a system now working between New York, Philadelphia and Washington to interchange programs between WNBT in New York, WPTZ in Philadelphia and WNBW in Washington. The General Electric Company has a microwave link to connect WRGB in Schenectady with New York City. The Raytheon Manufacturing Corporation has plans for microwave radio links between San Francisco and Los Angeles and between New York and Boston, but does not have any on the air at the present time. Various plans have also been suggested for coöperative arrangements for television networks between groups of broadcasters.

TELEVISION PICK-UPS — Microwaves are also often used in television broadcasting for local pick-ups from sports events, news incidents and other points of interest remote from the studio but within the "line-of-sight" range. Wire facilities are also used for this purpose, but this use is generally limited to short distances and often involves extensive rearrangements of existing cables. The Bell System has microwave radio equipment suitable for television pick-ups, and most of the broadcasters have specially equipped trucks and portable transmitters which can be quickly set up almost anywhere. For example, when President Truman was given an honorary degree at Princeton last spring, the ceremony was televised and sent by microwave from one of the taller Princeton buildings to Mount Rose, New Jersey, which is a relay point in Philco's New York-Philadelphia system. The Philco system carried the program to television station WNBT in New York and from there it was sent back over the American Telephone and Telegraph Company's coaxial cable to Washington.

Microwaves as a means of point-to-point communication have a long and hilly road ahead. There are technical differences of opinion and there are those who say that it is too expensive. The need for this type of facility, however, is urgent and the highest hills have already been passed. Engineers are becoming more and more familiar with how to handle this great new region of the radio spectrum. In the years ahead we can expect to see the United States covered with a series of microwave networks connecting every major city, bringing television programs from every part of the country to every other part of the country and carrying thousands of telegrams and telephone conversations without cables or wires.

A metal lens assembly being inspected and cleaned before being hoisted into position on the relay station's roof. The metal lens focuses the microwaves much the same as a glass lens focuses light, and it permits the use of far less transmitting power than would otherwise be possible



PHOTOCHEMISTRY IN INDUSTRY

Electromagnetic Radiation, Engineering Chemical Reactions Through the Use of Specially Designed Lamps, Is a Powerful Tool in Many Modern Processes

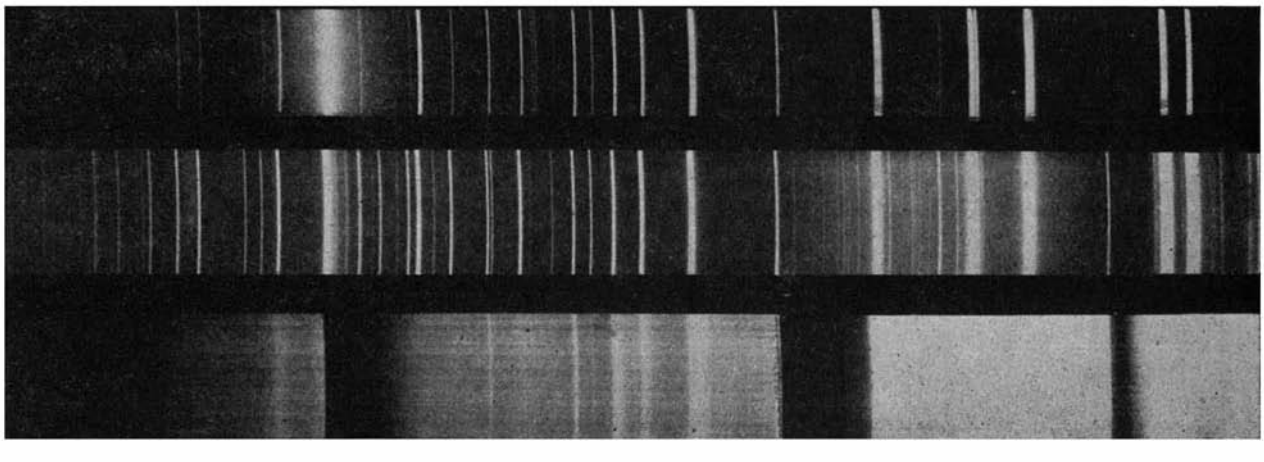
By E. W. Beggs
Westinghouse Lamp Division

DURING the next five years, only a day in scientific history, we will see more new uses made of the chemical effect of light and ultra-violet rays than in all the history of the chemical sciences. People absorb ultra-violet through their skin and the magic of photochemistry creates Vitamin D for bodily health. The photographic arts, first widespread field of use for the chemical effects of light, enrich our lives with pictures. Blueprint and photocopy machines gradually supplant the mimeograph and even the typewriter. Bleaching is done indoors under batteries of ultra-violet lights. Now new chemicals and improved chemical processes are created through intelligent application of radiation to solutions, gases, films and mixtures as they pass through chemical reaction chambers.

Photochemical action results when electromagnetic waves such as light and ultra-violet cause a chemical change. In photography, the light rays change the silver salts on which they fall so that black silver metal is left after the film is developed. In growing plants, chlorophyll reduces carbon dioxide and forms carbohydrates through the aid of radiant energy from the sun. A mixture of hydrogen and chlorine is relatively inactive in the dark but these gases combine with explosive violence if light rays fall upon them. Photochemistry deals, therefore, with a wide range of reactions. In some the radiations are merely a "trigger" or catalyst. In others, the radiant energy is absorbed and becomes a part of the potential energy stored in the products of the reaction. Photochemical reactions vary widely in mechanism as well as in the character of their products. Nonetheless all reactions which take place primarily because of radiation are called photochemical.

The history of photochemistry is long and full. The knowledge of Photosynthesis in plant growth and the bleaching properties of light are as old as the science of chemistry. The drying and hardening of paints, the making of patent leather and the rela-

Photospectrographs of low, medium and high pressure mercury discharges in quartz (top band, 10 microns; center band, 35 centimeters; bottom band, 100 atmospheres). Increasing pressure causes shift toward longer wave lengths



tionship of sunlight to human health came long before photography and today's budding market for radiations which promises to create new, cheaper and better products of many sorts.

The action involved in photochemistry is generally the same in all its applications. First, of course, the radiations must be absorbed by the chemicals involved. Without absorption, there is no reaction. Second, the absorbed rays must work a change in the reagents. Generally this consists of a displacement of an electron in an atom or molecule, resulting in increased chemical activity in one or more of the reagents. If this promotes a reaction that would not occur in the dark, the action is photochemical. Such reactions, of course, take many forms. Some of the most common are exothermic, others are endothermic. In the former, where heat is given off, the reaction takes place slowly without light. Here the radiations can perform the function of a catalyst. In the endothermic, as in plant growth, radiant energy becomes an essential part of the reaction. The energy of radiation is ultimately given up and appears as increased potential energy in the end products. This is generally the result of a reduction process.

Photosynthesis in plants involves the absorption of infra-red radiation, visible light and a small amount of near ultra-violet rays. Photographic processes generally utilize visible light, although some limited applications depend on ultra-violet or infra-red energy.

The absorption of near ultra-violet, at a wave length of about 3,650 Angstroms, causes a marked increase in the chemical activity of chlorine. Under the influence of ultra-violet, chlorine combines readily with benzene, toluene and similar compounds to create insecticides and other valuable end products. The radiations at about 2,967 Angstroms in the ultra-violet region manufacture Vitamin D in the human skin.

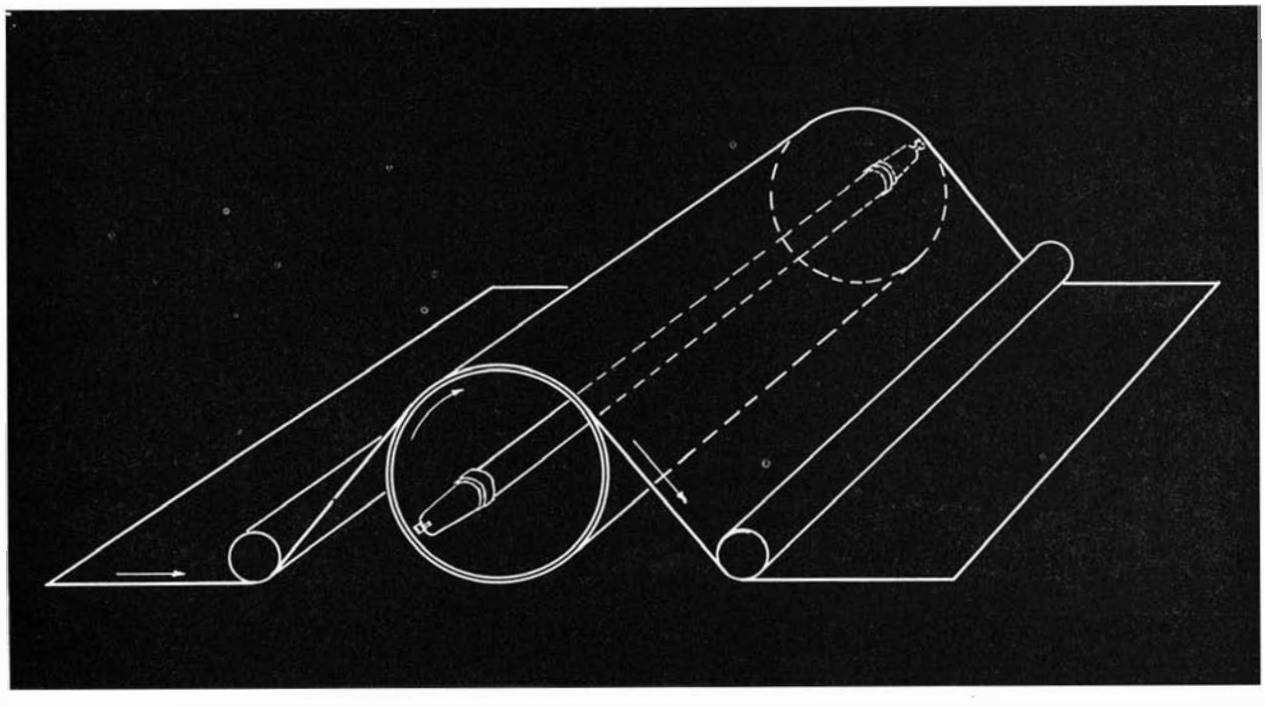
Rays shorter than these are useful in stimulating the chemical action of oxygen, hydrogen and other elements.

FROM INFRA-RED TO X-RAYS — So the entire range of the electromagnetic spectrum, from the infra-red down to just short of X-rays, is applied in photochemistry. Today, however, the greatest activity is in the application of those radiations which induce chlorine to combine with hydrocarbons. This is largely because the radiations required for this may be readily generated and controlled. Mercury vapor discharge lamps of suitable design generate the rays efficiently and in large amounts. Aluminum reflectors direct the rays and special glass plates and tubes transmit them with relatively little loss.

The spectrum of mercury consists of spectral lines ranging principally from 1,850 to 10,000 Angstroms. At low pressures, the most powerful radiation is in the line at 2,537 Angstroms. As the pressure rises, due to heavier loading of the discharge tube, the power in the longer wave length lines increases. Finally, at extremely high pressures such as 100 atmospheres per square inch, where heavy walled quartz discharge tubes are required, the long ray lines are stronger and wider and an important background band of energy appears. Thus the type of radiations obtained from mercury vapor lamps can be controlled somewhat by varying the loading of the discharge.

Each photochemical reaction has its own special requirements but all need the proper source of energy. This naturally involves the lamps and equipment used to reflect and transmit the necessary radiant energy. First, of course, the chemist must know what spectral lines or bands are needed. Second, he must know what intensity of radiation is required. Third, he must consider the familiar

A simplified sketch of a continuous blueprint machine. The long tubular light source at the center of the rotating drum assures even exposure



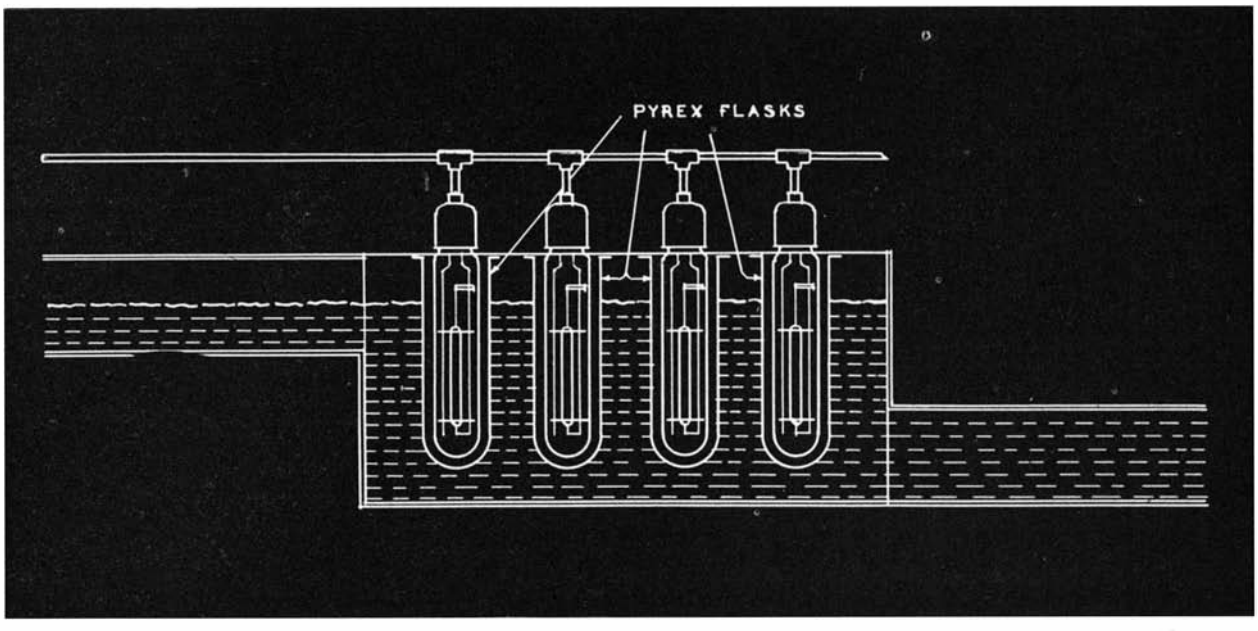


Diagram of a battery of lamps enclosed in pyrex flasks, arranged for a continuous flow operation

physical-chemical factors of pressure, temperature and concentration. Last, he must calculate capacity and speed which determine the scale of a particular photochemical process and which in the end set the wattages of the lamps and dimensions of the equipment.

CHLORINE AND BENZENE — A laboratory experiment in which chlorine and benzene are irradiated with ultra-violet, causing them to combine and form one or more of the chlorobenzenes, is photochemistry reduced to its simplest terms. Chlorine gas is dissolved in benzene until the solution turns to a strong yellow color. When a photochemical lamp is placed over the beaker containing the solution, the rays activate the chlorine so that the solution becomes colorless. The top layer clears first. Then the colorless layer becomes thicker or deeper. In a few minutes the entire solution is clear as water, all the available chlorine having combined with the benzene.

This reaction may be carried out in the open air at room temperature under a chemical hood with the simple equipment described. More elaborate operations require enclosures for the lamps, reflectors to redirect the rays most efficiently to the reagent, glass plates or piping to separate the lamps from the gases or solutions. To these details must be added facilities for control of temperature and pressure as well as for the proportions or concentrations of the reacting chemicals.

A study of some representative photochemical installations now in regular operation shows several basic arrangements of the lamps and auxiliary equipment. Most photochemical reactions can be conveniently carried out by one or another of the designs now used. Certain applications, of course, will be encountered which require new methods of ap plying the radiations.

The oldest and simplest photochemical installation is very much like the experiment described above, with the lamps suspended over the reaction vat. The reagents may be stationary or may flow past the irradiation area. This arrangement has been used experimentally for the precipitation of uranium salts. It can also be used for the chlorination of benzene or other similar reactions.

Another method of applying radiation in a photochemical process is to mount a single lamp in a glass tube that penetrates deep into a kettle of reacting solutions. This encloses the reagents and provides protection for the lamp and its wiring system. Where the reaction is to be of the continuous flow type, a similar system utilizing a succession of enclosed lamps suspended in the solution is often used. Where gases or fluids are to be carried through the irradiation area in transparent glass pipe, the flow may be arranged around the lamp. Here the lamp is provided with a continuous flow of clean cooling air and the electrical system is protected from fumes because the reagents are completely enclosed.

RAYS ARE REFLECTED — In all enclosed photochemical systems, especially where the reagents are contained within clear glass enclosures, the radiations which pass completely through the reaction area should be reflected back and conserved. Aluminum reflectors are generally recommended. If the reflector enclosure has appreciable width, it should be provided with a top and bottom reflecting surface. The single lamp with a surrounding reacting chamber is a very efficient arrangement because it utilizes the radiations directly with a minimum of loss in reflectors and glass. It can be provided with temperature control by water baths and, of course, an appreciable amount of pressure control is also practicable.

Water may be used effectively to surround the reaction tube because light and ultra-violet rays pass through water with little loss. A temperature controlling water bath of clean tap water transmits practically all radiations but the infra-red or heat rays. In fact, the losses of photochemical energy through

water layers up to several inches thick are far less than through ordinary glass pipe.

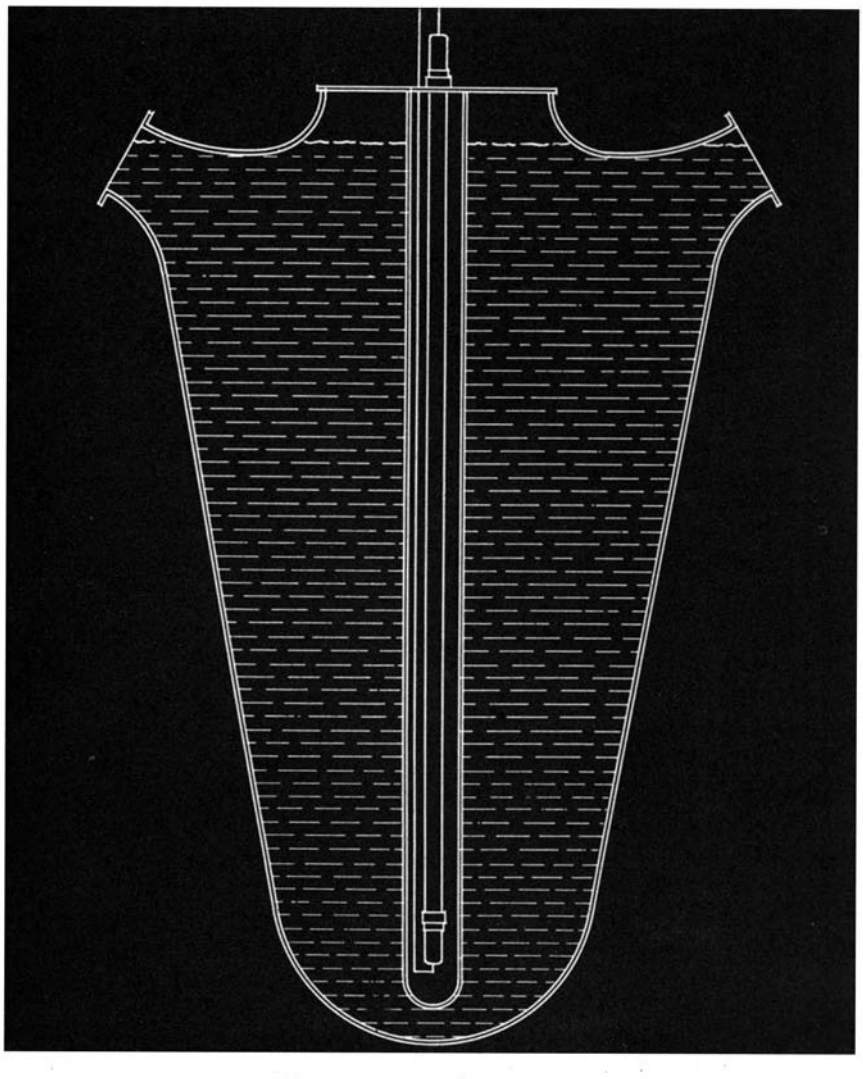
Most of the representative installations described above find their widest use in chlorination reactions. They are also suited to reactions involving other halogens and to reduction processes. For polymerizing reactions and the irradiation of films and coatings, a different treatment is required. Sometimes the film is treated alone and sometimes it is treated as a coating on paper or fabric or on many types of solid objects.

Photography and the photographic arts are all basically photochemical. In fact, except for photosynthesis in plants, photography is the most widespread and important photochemical process. Blueprinting, photolithography, photocopying and similar operations in this field require the same general equipment and technique as photography. Light and ultra-violet rays fall on coated paper or plates and cause the desired reaction—generally the recording of an image for reproduction in printing. If it is to be a blueprint—or the more popular "black print" or "brown print"— the original and the printing paper are pressed together and the radiations react on a special coating to develop a reproduction. This generally requires a long tubular source of light of a length appreciably greater than the print. The lamp is ordinarily mounted in the center of a rotating drum, which revolves at a steady rate to give the print a uniform exposure and thus even density.

Where a photoprint is to be used in photolithography, the picture is generally mounted on a frame and photographed. Here the intensity of radiation must be high and uniform. For such an operation, individual high-powered mercury vapor lamps may be mounted in portable units directing their [illegible] picture from both sides. A more [illegible] is to mount two or four long tube [illegible] the photograph with light. The [illegible] mounted so they are in front of the [illegible] ture sufficiently to provide brilliant yet uniform illumination.

All of these considerations in photochemistry apply forces which are not completely familiar to the chemist. In conclusion, a brief discussion of the basic principles of using radiation and electricity in photochemistry may make the processes described previously even clearer.

RADIATION — Radiant energy involved in photochemistry ranges from about 10,000 to 1,000 Angstroms and includes visible light from about 4,000 to 7,000 Angstroms. All of these radiations are reflected, refracted, transmitted, diffused and absorbed



Sectional drawing of a single 3,000-watt lamp mounted in a glass tube and penetrating deep into the solution in the photochemical reacting kettle

like light. The rays travel in a straight path until they are redirected or absorbed. In an open space the intensity of the light or radiation decreases as the distance between the source and the surface irradiated is increased. With concentrated light sources the intensity reduces rapidly—that is, with the square of the distance. With elongated sources where the surface is quite close to the source, the intensity drops off about in direct proportion to the distance.

Almost complete absorption of all radiation takes place when the rays strike a rough, dark surface. Partial absorption takes place when the rays strike a colored object or pass through a colored solution. For example, red rays are absorbed by a blue paint or blue solution, and blue rays are absorbed by red paint or a red solution. Certain colorless materials absorb infra-red and/or ultra-violet. For example, window glass absorbs ultra-violet and clear water absorbs infra-red. A solution of chlorine in benzene absorbs practically all rays in the near ultra-violet —from just beyond the visible violet to about 3,000 Angstroms in the erythemal band of the spectrum. Quartz transmits almost all radiations from 1,850 to well beyond 10,000 Angstroms.

Reflectors are either polished (specular) or diffusing (matte). Rays that strike a polished reflector "bounce" off at a definite angle like a ball from the cushion of a billiard table. Rays that strike a diffusing reflector are reflected in many directions and diffused. Most reflector materials reflect all visible and infra-red wave lengths well but only a few also have a high reflectivity in the ultra-violet. Aluminum has an excellent reflecting power for all wave lengths, including ultra-violet down to 1,850 Angstroms. Alzak finished aluminum is the recommended type because this finish retains its high reflecting efficiency under adverse treatment.

Transmission and absorption are, of course, optical opposites. Distilled water and clear "tap" water transmit almost 100 per cent of the light and near ultra-violet rays if the water layer is only a few inches thick.

Refraction or bending of light rays as they pass through lenses or prisms is only occasionally involved in photochemistry. The laws of optics that apply to visible light also apply to photochemical radiations. The rays are bent as they pass through the prism or lens and thus can be concentrated or spread as needed. Generally photochemists need diffused and uniformly distributed energy. Therefore lenses are not often necessary. This is also true of specular reflectors, particularly if they are bent into parabolic or elliptical forms. These and lenses may develop local "hot spots" or high concentrations of

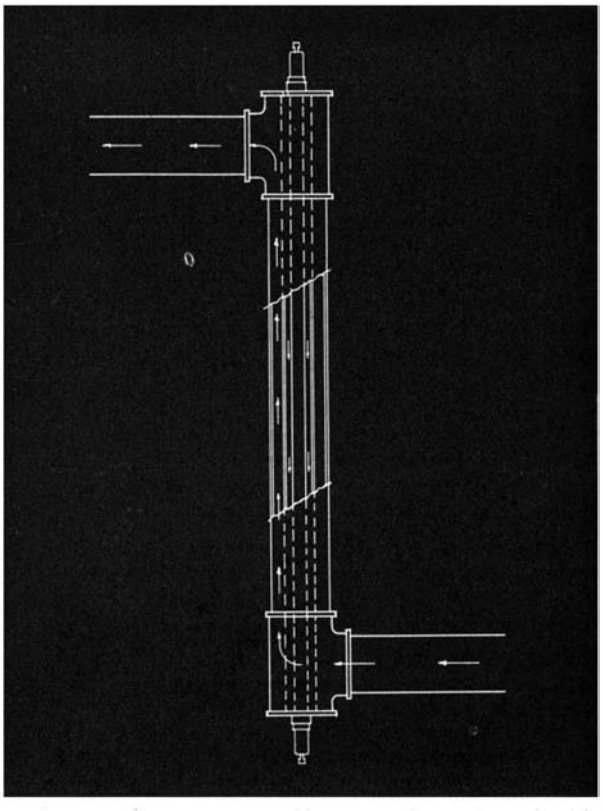
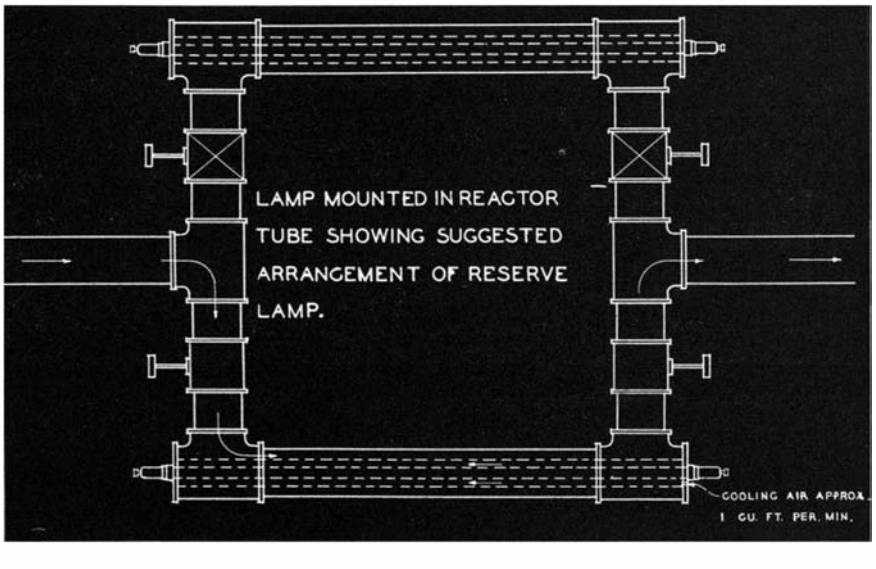


Diagram of a typical installation for the irradiation of a liquid or a gas. Tubular lamp is shown in dotted lines



By equipping the photochemical reactor tube with such a reserve lamp arrangement, the necessity of interrupting the process to replace a lamp is eliminated

energy which may have an undesirable effect on the chemical reaction.

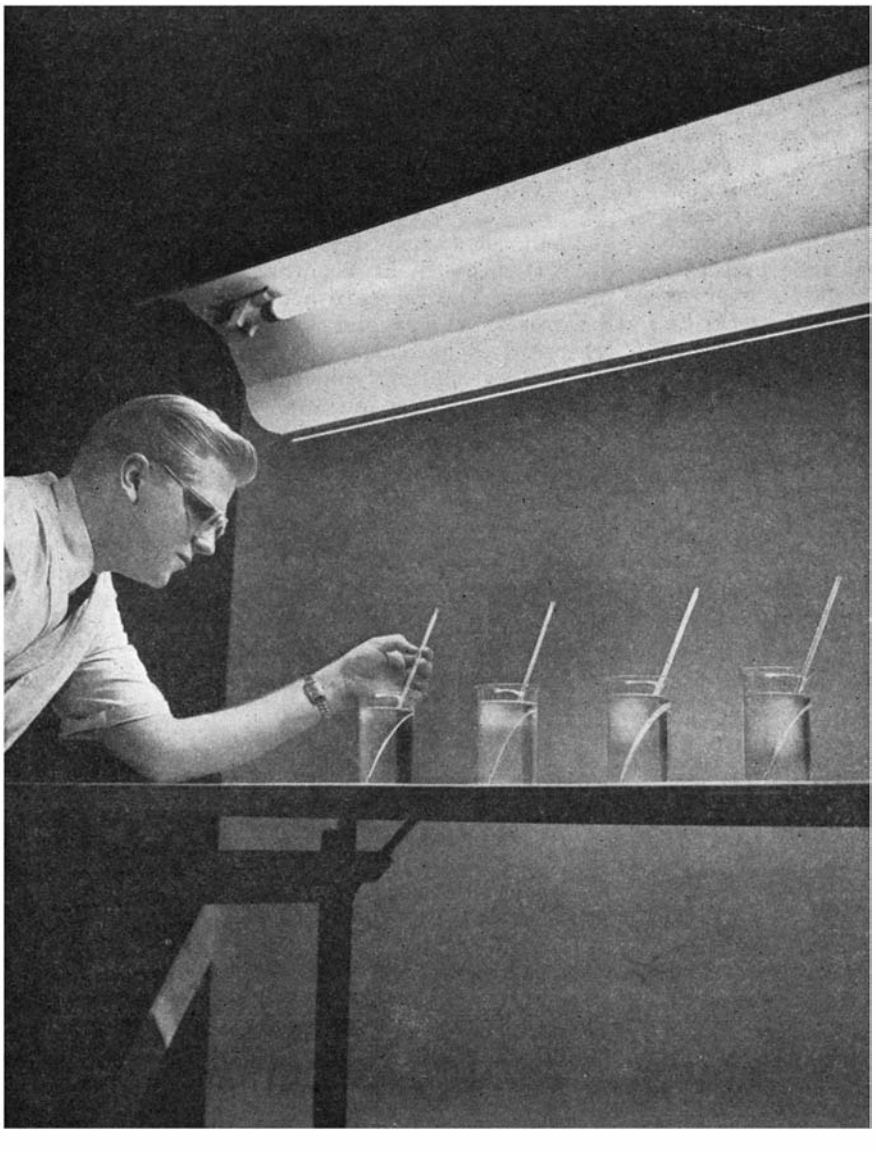
ELECTRICITY AND HANDLING OF LAMPS — The photochemical lamps mentioned above are all standard types for which ballasts, transformers and sockets are generally available. All that is required is to provide the proper transformer, connect it to the line and the lamp socket and then insert the lamp. There are, however, a few precautions that should be borne in mind.

First, the electrical system must be dry. Waterproof wiring and water-tight connections and fittings are generally recommended.

Second, all metal parts of the electrical circuit must be protected from corrosive fumes. All lamps have terminals or screw bases which must make good contact in the sockets or the parts will overheat and fail. If possible, these parts should operate in clean air. If this is not possible, they should be cleaned frequently and, in some cases it may be necessary to enclose them completely in rubber or a similar protective material to guard against damage by corrosion.

Third, the lamps must be handled with reasonable care. They should be operated on transformers designed for them. They should not be overheated. In most chemical operations, the enclosure does not run hotter than an ordinary enclosed lighting fixture which often runs almost hot enough to boil water. Where the lamp is surrounded with air at high temperature, however, some special cooling may be needed. The single tube type of lamp needs special care. At full operating temperature the glass tube is almost red hot and will crack if splashed with water. In handling, care should be taken to keep the arc tube clean. Grease from the fingers bakes in it and may develop a weak spot in the tube.

All this knowledge has helped photochemistry come into its own. Powerful, efficient, long-lived lamps are ready at hand with simple, dependable auxiliary apparatus to operate them. During recent years knowledge of the many uses of radiant energy to catalyze or generate chemical action has been accumulating with rapidly accelerating speed. One of the most important new forces in the field of chemistry is electromagnetic radiation for tomorrow's new, better and cheaper chemical products.



Left to right, beakers show the progress of a toluene-chlorine reaction in one, two, three and four minute exposures. The radiant energy from the 3,000-watt photochemical lamp overhead accelerates the reaction to 10,000 times the normal speed in total darkness

WHAT TO LOOK FOR IN FM

Manufacturers Are Getting Into Large-Scale Production of Sets
First of Two Articles Appraising Their Necessary Qualities

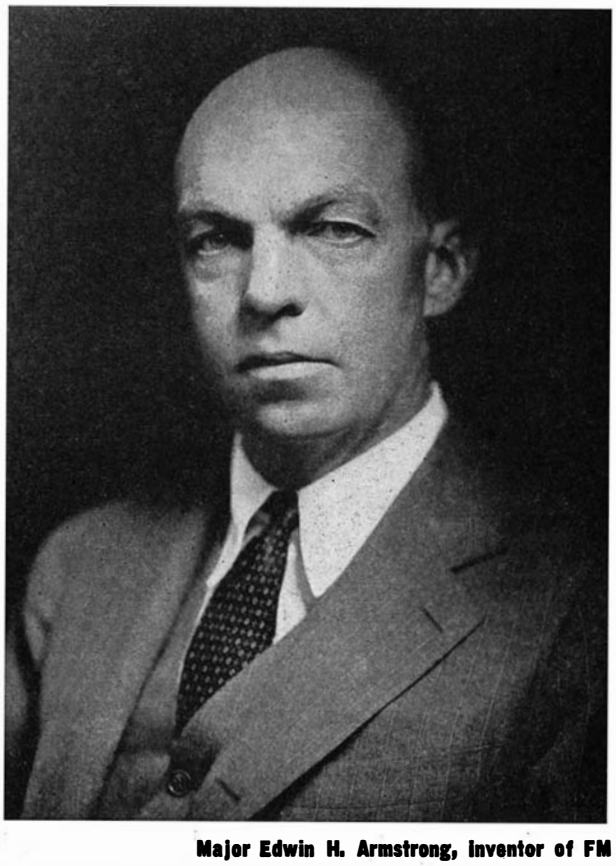
By David F. Armstrong

While post-war radio has not been all it was quacked up to be, FM and Television are two significant developments on the horizon. Television is still in its early stages of development and is so expensive as to be in the luxury class, but FM is now coming into its own. One large-scale dealer is now advertising a portable model FM-AM receiver for $54.95, which brings this kind of radio reception down to the prices the average man can afford to pay for this superior kind of radio reception.

A person who is interested in an FM radio should consider such a purchase only if he lives in an area served by an FM transmitter. There is a definite limit to the distance over which FM signals can be satisfactorily received. If you have any doubt as to whether your area is served, or is likely to be served, by an FM station, the Federal Communications Commission, Washington, D. C., will send you a list of stations and their locations. This picture is becoming brighter all the time. Former Chairman Charles Denny of the FCC predicted that there may be as many as 700 FM transmitting stations by the end of 1947. This will lead to a public demand for FM receivers and the Klondike in FM will be on.

In November of 1935 Major Edwin H. Armstrong announced the development of Frequency Modulation to the radio world. It was the end result of ten years of research and experiment to develop a system of radio communication in which a sending station would impress upon a radio carrier wave an electrical characteristic not present in static, and in which the radio receiver would eliminate the reception of all electrical impulses except the particular electrical characteristic the FM system was designed to accommodate.

To use the words of the inventor of the system: "In the course of years of experiments I discovered that there was one wave characteristic not found in natural and man-made disturbances—the wide frequency swing. It was that which led me to the basic FM invention, the essentials of which are a transmitter that will produce this characteristic and a receiver that will respond to it and that will reject all minor frequency ariations and all variations of amplitude."



Major Edwin H. Armstrong, Inventor of FM

FM went through a long and arduous struggle for recognition in its early days. There were "five years of continuous effort to overcome those tangible forces which exist in every industry and which have their basis in the characteristic resistance of human nature to change." But the fight was finally won in May of 1940, when the FCC recognized FM as a definite radio service and assigned it the 42-50 megacycle band, subject to certain rules and standards.

During the war and until 1946 the FCC forbade manufacturers to produce FM receivers. Then there was a new FM band assignment, the 88-108 mega-

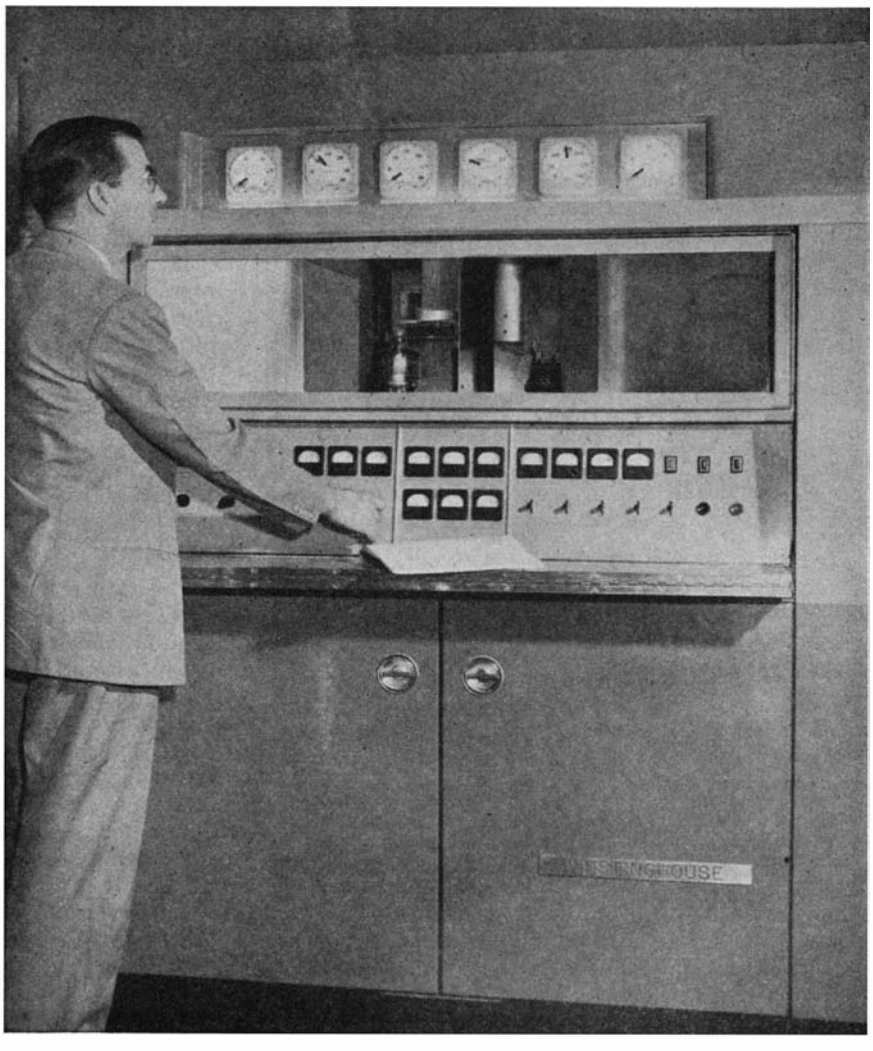
cycle band, which will eventually make the 42-50 megacycle band obsolete. Manufacturers were forbidden to make sets for both bands; it was either one or the other. But now there is a green light for the production of FM radios capable of receiving all the FM signals the FCC will permit to be transmitted in these two bands.

HIGHEST DEVELOPMENT — FM now stands as the highest development of radio communication. Transmitters and receivers are now available to serve the public with high fidelity, natural quality, and staticless reception in both music and voice programs. There is a misconception that FM is only for highbrow music lovers. Few beliefs could be farther from the truth. FM does improve the quality of music programs because it brings in the full liquid tones of the flute, the basso profundo of the 'cello and all the mellow cadences of the violin. It has the additional advantage of making the speaking voice more intelligible and sonorous to the individual who pays attention to intonation and innuendo. When you first hear the warm tones of genuine FM reception you will agree that the costly and complicated pioneering efforts that went into the engineering of FM are well worth while.

In the days of trying to sell AM radios no salesman liked to demonstrate a receiver during an electrical storm, but in selling an FM receiver the salesman welcomes the electrical storm because he knows it will offer concrete evidence of the ability of the FM receiver to eliminate static. The writer was present at a demonstration where the thunder accompanying the storm made the customers jump, but the music came in as clear as a bell. Again, FM is a real boon to dealers in areas where the AM band is so crowded that good reception is practically impossible. Here salesmen like to play FM and AM radios together to help the customer decide whether FM gives superior program reception.

Frequency Modulation is a serious challenge to the entire radio industry. It is now far beyond the theoretical and experimental stage and in time it may even make obsolete the radio programs based on Amplitude Modulation. But bear in mind that FM is high quality stuff. It is partly the responsibility of the manufacturers to make certain that the sterling advantages and the excellent quality of

A typical Frequency Modulation console model. This set contains both AM and FM receiving circuits and a record player with an automatic changer



Control panel of a Frequency Modulation transmitter. The large-face eye-level meters have pointers which move in recesses in the dial faces to eliminate the variations in readings due to parallax

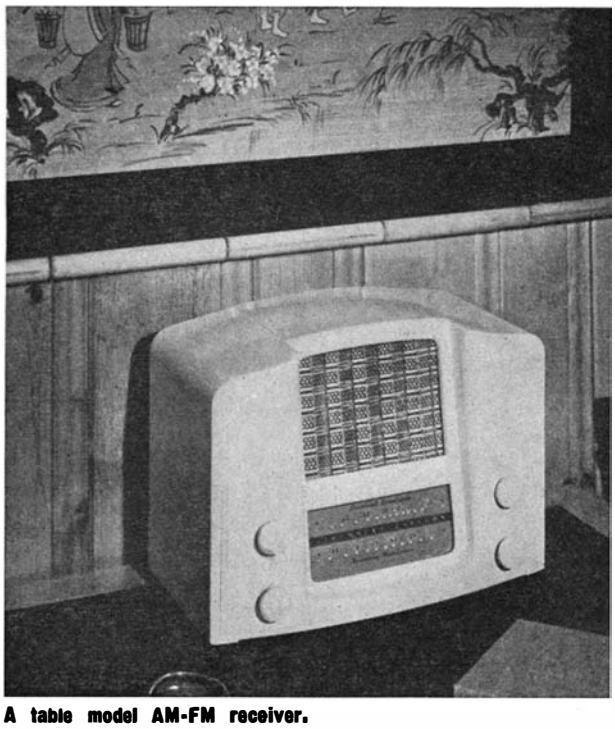
FM circuits are built into every piece of transmitting and receiving equipment sold. Human nature being what it is, it is also partly the responsibility of the purchaser to recognize the earmarks of the best quality so that he may purchase most wisely. Major Armstrong's comment on this point is significant: "FM has been pioneered, proved and is now in mass production. We have entered the FM era of radio. The public is entitled to the best from FM from the beginning."

DIFFICULT PROBLEMS — There have been some difficult problems to solve in connection with shifting the FM band from 42-50 megacycles to 88-108 megacycles. The necessity for redesigning sets and making experimental models to iron out the bugs at high frequencies plagued the manufacturers and slowed down production until very recently. Obviously the cost of all this design engineering will be borne by the present purchasers of FM. Later, when these costs have been absorbed, the price of FM can and will come down. The radio market has always been one of vigorous competition and FM will be no exception. At the present time there are about 30 leading radio companies licensed to build radio receiving sets in which the genuine Armstrong system of Frequency Modulation is utilized.

The production of FM receivers for 1947 is estimated at approximately 2,000,000. This compares very favorably with approximately 180,000 FM receivers for 1946. This has been achieved in spite of difficult engineering problems. FM-AM combinations are much more difficult to manufacture and assemble than either straight AM or straight FM. The combination jobs have more parts, the parts are more critical with respect to placement in the circuit, the permissible tolerances in FM components are small, the assembly operations are complex and the alinement of the completed receiver is a ticklish problem.

The extent of the FM manufacturing problem may be guessed from the confession of a vice president of one of our largest manufacturers. "It took bitter struggle over a period of many weeks to get 150 sets per day past inspection, and we were building three sets for every two we shipped . . . Today the same line . . . has no trouble knocking out 500 chassis a day of much higher quality than the early models. After more than a year we are doing the sort of job we thought we could do from the very first."

A short time ago one could say with conviction:



A table model AM-FM receiver. It is only recently that such models have come on the market

"It is conservative to estimate that the average retail price of 1947 FM receivers will approach $200, which is too high for the mass market. To the best of my knowledge, no manufacturer has yet begun to market any FM-AM set priced much below $100. We don't know how to build an acceptable FM portable, or an acceptable FM auto set."

Conditions change so rapidly in this industry that it is now becoming possible to produce table model FM receivers that have the same selectivity and sensitivity and tone quality as console models. If the circuit is carefully engineered and designed a table model can have just as much ability to limit static interference as a console model. The chief differences lie in those tone quality characteristics that depend on speaker size and the baffling of the speaker. These, of course, are limited in a table model.

FUNDAMENTALS OF FM — In any discussion of FM, it is valuable to review the principles upon which the system is based. Without becoming too technical, modulation refers to the changes that take place in a radio wave as it is made stronger or weaker when sound waves are converted into electrical impulses. If the frequency of the radio carrier wave remains constant and the height of the wave changes according to the variation of the voice or music sound waves, we have what is known as Amplitude Modulation (AM for short). This is the ordinary broadcast wave. It is also possible to transmit and receive sound waves by converting them into electrical impulses where the height of the wave does not change at all, but the frequency of the wave changes many times per second in accordance with the strength or weakness of the audio signal. This is Frequency Modulation, or, more commonly, FM.

People who bought FM receivers for the 42-50 megacycle band in 1939, 1940 and 1941 now have very few stations to listen to. There were 35 separate and distinct channels in the 42-50 magacycle band and this band is now obsolete. Stations now operating in the obsolete band may continue to transmit, but no new assignments will be made in it. It seems undesirable, therefore, to buy a receiver that includes this band.

In the new 88-108 megacycle band there is room for 100 channels. Each of these channels is 200 kilocycles wide (this is 20 times the width of the channels in the AM broadcast band, where the channels are only 10 kilocycles wide). These wide channels will eliminate station interference. Moreover, because of the short range over which an FM transmitter is effective, it is possible to duplicate channels and wave lengths all over the country. The FCC will probably permit this for stations which are located 200 miles or more apart.

The future in broadcasting probably lies with FM because of the general advantages of program reception and because of the economies possible in broadcasting. An FM station with an output of a few hundred watts has more power than an AM station of several thousand watts. The FM station does not require program monitoring to amplify low-volume sounds and flatten out the loud passages, it is free from static, it has a short range which eliminates station interference, it does not have a 5,000 or 6,000 cycle per second audio frequency cut-off and it reproduces the whole range of the sound spectrum from sixteen to 16,000 cycles per second with high fidelity.

From what has been said it should be clear to the layman that a receiver designed to receive AM signals will not receive FM signals. The average listener must therefore be concerned with the relative merits and drawbacks of each kind of radio program and how each affects his present radio use, his listening pleasure, his pocketbook and the next radio he has been thinking of buying.

Do not expect that *any* FM receiver will reproduce with all the fidelity sent out by a high-fidelity FM transmitter. Receivers vary in quality depending on the engineering skill that went into their design and construction. Moreover, not all FM broadcasts are high-fidelity programs. Some of them are "platter programs" and no greater fidelity will be transmitted from the station than was originally in the phonograph recording. But with FM a wide range of overtones can be reproduced with such remarkable clarity that the timbre of voice and music programs will be duplicated with extremely high fidelity.

The letters FM are coming more and more to mean: superior reception without static; elimination of all undesirable electrical interference; full dynamic range of tones for both music and speech; highest possible fidelity with minimum distortion; absence of background hum and noise with signals reproduced aganst a backdrop of silence. When the letters also mean Finest Made the listener is in for new auditory sensations.

Editor's Note: Mr. Armstrong's article will be concluded in the April issue of the Scientific American.

INVESTMENT CASTING

An Ancient Technology, In Which the Hardest Metals Are Poured Accurately in Ceramic Molds, Is a Growing Modern Business

By Edwin Laird Cady

EARLY in the war a need was found for parts made of metals which could not be forged, machined or cast on a production line by any ordinary method. A desperate search for means to make these parts was instituted. The trail led straight to precision investment casting.

Precision investment casting is a new process which has roots deep in the past. Hundreds, if not thousands, of years ago men realized that an object could be made of wax and the wax surrounded or "invested" with a ceramic material which would harden like concrete. The wax could then be melted and volatilized out of the ceramic investment and the cavity thus produced used as a mold for casting metal. For a long time the wax replicas and the resulting castings were made one at a time. Then, a few years ago, a method was found to mold the wax so many pieces and castings could be made from one model.

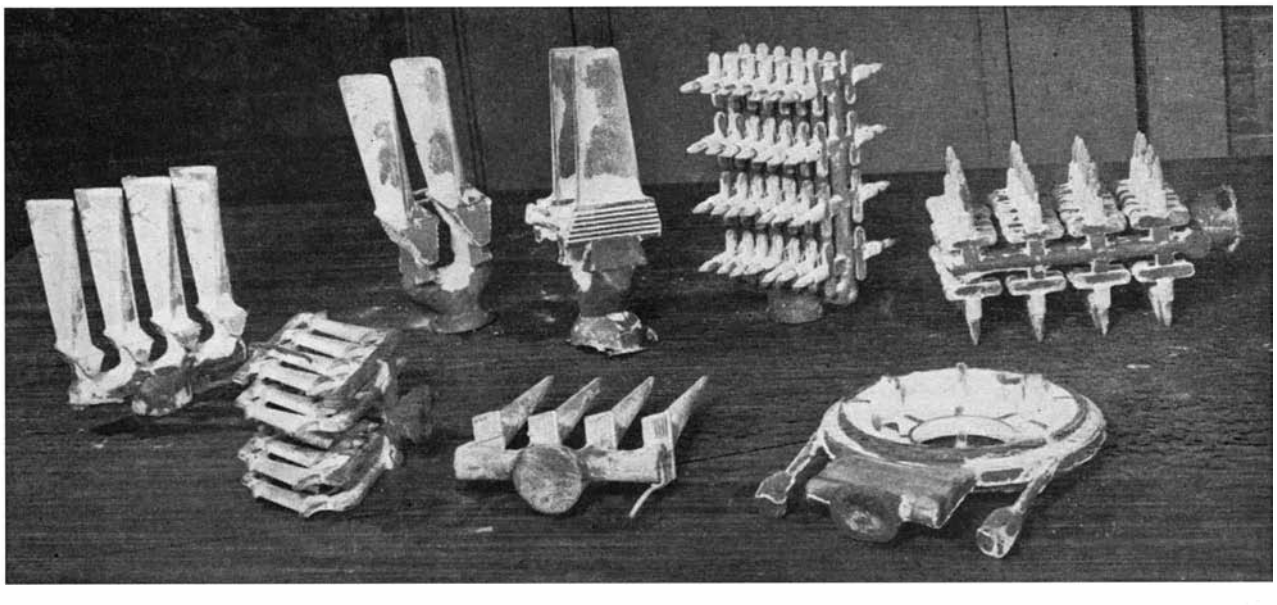
This step changed an ancient art into a modern precision process. Before the war the process was in use mostly for jewelry and for dental and medical products. Then the war industries picked it up, thereby making the turbosupercharger, jet propulsion, the gas turbine, some developments of radar and other war products possible.

When peace arrived nearly every factory management and engineer who had used the process during the war determined to continue with it. The advantages were obvious. Sand casting could not handle all of the alloys usable in precision investment casting, and could not approach the accuracy of its control over metallurgical qualities and dimensions. Die casting might be better for large runs of parts which could be made of extremely low melting point alloys such as zinc or aluminum, but it could not touch an enormous field of metals with higher melting points.

MISCONCEPTIONS — There were, of course, misconceptions. One was that precision investment casting required very little operating capital. The truth is that it needs as much fixed and operating capital as any other metal fabricating process. Another was that it needed little skill or experience. Actually it needs more of more different kinds of technical knowledge than other processes. A third was that it could achieve almost its full precision at equal cost, in spite of the age-old industrial experience that accuracy is directly related to costs.

These false ideas about invested capital, engineering knowledge and cost might be construed as three strikes against the precision investment casting proc-

A group of precision cast parts ready to be cut from the sprues and runners



ess. As a matter of fact, nobody knows what the complete score is. But out of every 100 companies which went into the field before 1946 at least 85 had left before 1947. And the end of the casualty list is not yet.

In spite of this, precision investment casting is a growing, healthy and prosperous business. It has plenty of room for companies which follow its present trends and operate with wisdom.

One line of development is the casting of alloys which resist forging unless their temperature is held within a narrow range and are impossible to machine. These alloys are used in jet propulsion machinery, in gas turbines and for other extremely high-temperature, heavy-duty work. This line, however, may be followed only by shops which know all of the complex techniques of the process, have wide experience and specially trained metallurgists. Nearly all of the shops engaged in this work began it during the war when research funds were easy to obtain, and have continued with its development.

Cobalt alloys such as Stellite are easier to handle than the forge-resistant metals, but are by no means the easiest. They are precision investment cast very largely because they can be machined or ground only with great difficulty. If accurate and intricate contours can be obtained by casting, costs can be considerably reduced. Some parts made at low costs could not be made at any practical cost by other processes. But since precision investment casting is used principally to make parts with accurate contours, the greatest skill and experience are needed to operate successfully in this field.

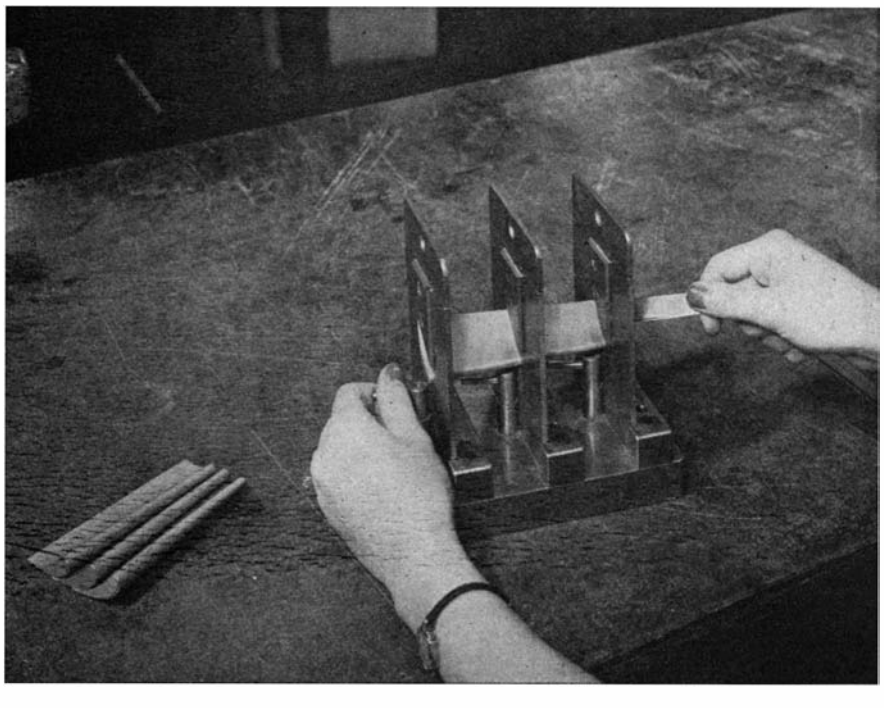
SALES ENGINEERING — As the alloys used in precision investment casting become easier to machine, and perhaps easier to cast, sales engineering increases in importance. The application engineering service given by the casters of the unmachinable alloys to consumers involves mutual scratching of expert heads to solve extremely difficult problems by any means whatever. The sales engineering service on the less difficult alloys must provide a choice of the greatest economy in a field where there are many production methods available.

Stainless steels are examples of alloys which benefit by such sales engineering. There are only a few types of stainless steel which can be bought in any desired sizes of wrought forms (such as bars, sheets and tubes) in small quantities. The other types must be had in cast forms. For this reason a great many stainless steel precision investment castings are made.

Stainless steels of the more common types are "different" rather than "difficult" to machine. But this kind of machining may require a steadier flow of heavier power than many machine tools can supply. Some stainless steels, moreover, are difficult for any machine tool to handle at high production rates. Sales engineering must therefore consider the machine tools available in the shop of the castings consumer and the type of stainless steel to be machined. On these two factors a decision is made as to which contours of the finished piece should be generated by casting and which by machining.

If the decision is in favor of considerable machining, a type of stainless easier to machine but lower in corrosion resistance and in physical strength may be decided upon. If, however, more of the contours are to be cast to size and shape so that the cost of casting is higher, the stainless steel should be more shock-resistant, durable under abrasive wear, dampening to vibrations and resistant to corrosion.

Precision investment casting sales and application engineering thus must be capable of dealing with the economics of product design as well as with production problems. The engineering is made easier by the fact that alloy ingredients make very little difference in the cost of metal for this process, although the costs of casting are higher for some combinations than for others. Thus, given a metallurgist who knows his job, the ability of a precision investment casting



Small investment-cast pieces are being inspected for dimensional accuracy by means of a jig. With the investment casting process very close tolerances can be held

house to sell by means of sales and application engineering is excellent.

Monel metals, stainless steels and other highly durable alloys have been put by this sales engineering into parts for sewing machines, printing presses, fishing equipment, business machines, thousands of devices needing highly accurate, intricate parts.

WITH MACHINABLE ALLOYS — When alloys are quite easy to machine another factor in sales engineering becomes important. There is no problem common to sand casting which does not also exist for precision investment casting. Shrinkage, warpage, hot spots, hot tears, segregations—all can add to casting costs. The usual expedients of fillets, ribs, gradual junctioning of thin with thick sections and mild radii rather than completely flat contours are useful solutions of these problems. Parting lines and needs for drafts are not so severe as in sand casting, but do appear as problems to the precision investment process.

In a highly machinable alloy these strategems can be used with the intention of machining the unwanted fillets or ribs from the casting, or of machining drafted contours or slightly curved ones to the desired straight line or other shapes. The cost of castings is greatly reduced thereby.

This balancing of casting costs against machining costs to obtain the highest value in finished products has enabled precision investment casting to make bronze, brass, beryllium copper, 1020 steel, gray iron and other machinable alloy parts for electrical, radio, surgical instruments and for many other uses.

One of the most interesting developments is the carving of single pieces of pattern material in order to make castings for tools, molds and experimental parts for machines. This appears to be a return to the old days before the process had been developed into a repetitive precision one. Actually there is little relation between the original use of pure beeswax and the modern hard waxes, the very hard and completely machinable plastics such as Lucite, the building-up of shapes by the use of modern adhesives and similar improved methods.

Dies are being precision investment cast for plastics molding, rubber molding, die casting and metal stamping. Tools and tool parts for metal cutting and for woodworking and similar operations are being cast. The development and experimental costs of thousands of products are being reduced

It is in the casting of alloys for which sales engineering can be most widely applied that precision investment casting is making its most rapid strides. These alloys, plus tools and experimental parts casting, offer the most practical opening for any company which wishes to enter this field.

Also inviting to the newcomer is the fact that firms which make pattern materials, investment materials, and the various production machines, have developed a high degree of sales and application engineering skill. Materials and equipment are becoming more standardized. But even with these advantages the "three strikes" must be avoided. Precision investment casting always will need adequate capital, know-how and common sense.

Risers are being attached to wax pieces to be used in the casting of parts for B-29 manifolds

INDUSTRIAL CONSULTANTS

The Laboratory Problems Which Are Involved In Practically All Manufacturing Processes Are Frequently Too Big For One Business To Handle Alone. Result: Foster D. Snell, Inc. Is Ready To Take On a Little of Everything

By D. H. Killeffer

HUNDREDS of dolls came back to the factory, bloated, their original beauty faded to an ashen gray—not in the least the lovely creatures that had gone out earlier to gladden the hearts of little girls. But the doll maker could find nothing wrong; the dolls seemed to suffer from some new and terrible doll disease.

High quality slate became scarce and expensive, and a maker of school blackboards and children's writing slates feared he would be put out of business by cheap, inferior substitutes.

A chemical manufacturer making several different kinds of synthetic resins learned that one of them might be good in a paint of the odorless, quick-drying, water emulsion type, but he had among his people no one who really knew what painters and paint makers want.

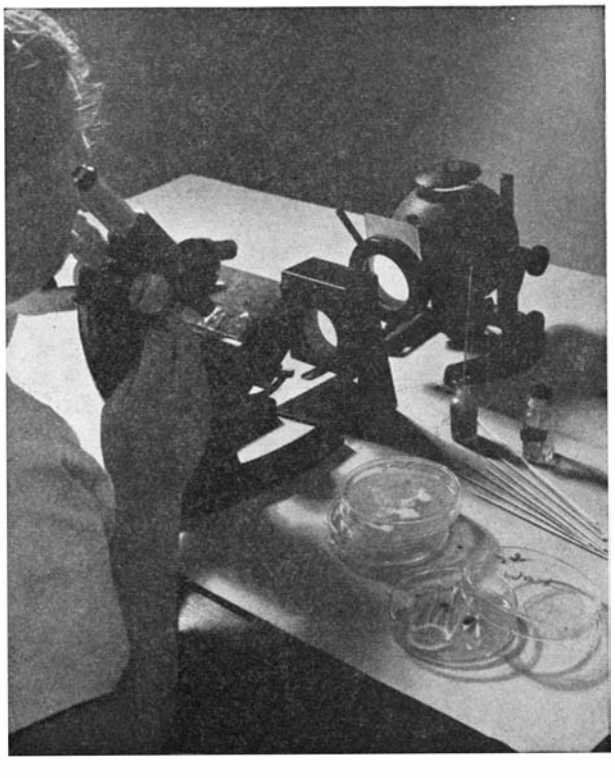
A department store manager planned to put out a wax polish under the store's own name, but could not choose between five different waxes offered him by as many manufacturers at different prices.

A shaving cream that had wide popularity suddenly began to come back to the maker. Complaint was that the stuff turned brown or even black in the tube when any jackass knows that shaving creams should be white. Yet the factory had done nothing at all different from its long habit.

A company had been buying large quantities of refined corn oil over a period of time and seemed likely to continue to do so. The manager found that the price of raw oil was so much lower than that of this particular grade of refined oil that he believed he could profitably buy the cheaper stuff and refine it himself, provided of course that he could find a suitable process and an engineer to design and install the equipment.

The waste of a manufacturing operation contained a small amount of acetic acid and the manager of the plant hoped that he could recover the acid and sell it. A survey of market and competitive conditions, a market research, gave him guidance to the proper answer: "No."

A technician counts and identifies microbes through the microscope

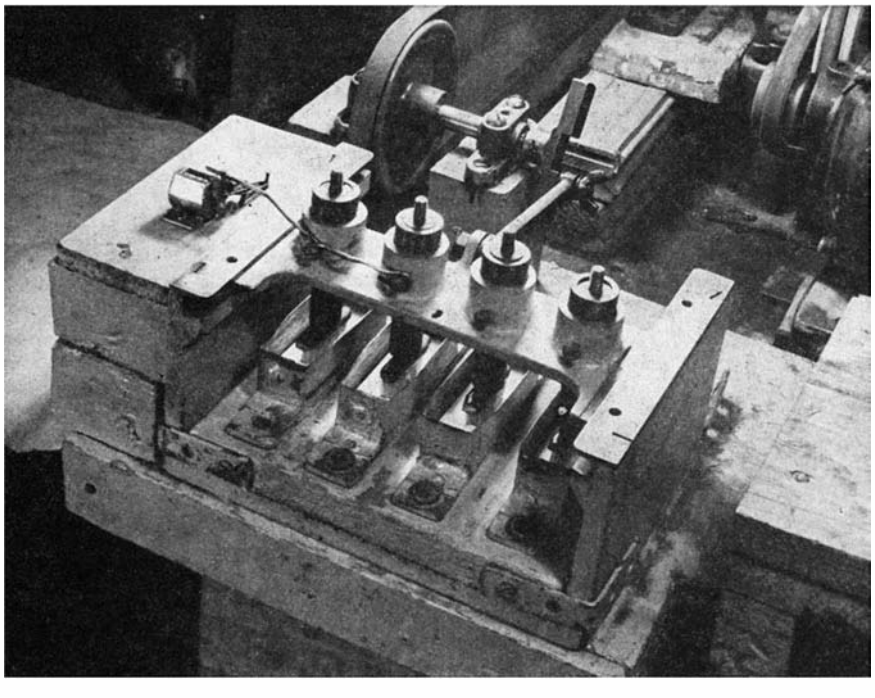


CHEMICAL CONSULTANT — A thousand problems like these continually plague the managers of businesses, large and small. They do not fit into any of the neat pigeon holes people usually set up to take care of their troubles and pass them on to a lawyer, a doctor, an auditor or a banker. They belong in quite a different class; and they can only fit if your set of pigeon holes includes one marked "Chemical Consultant."

Such people are becoming more and more useful in our world where science strides ahead, and where every bit we learn goes to work at once for all of us. Chemical consultants, both chemists and chemical engineers, give business and industry the benefit of our vast and growing store of scientific knowledge about materials. They turn dry scientific facts into solutions to industry's problems and they apply the scientific method of theory and experiment to find the answers to baffling questions of business. They often go further than that and discover, invent and develop entirely new phases of businesses—such as rayon, nylon, plastics and vitamins—that even change our habits and our ways of life.

Big business have so much use for this sort of thing that they save by maintaining their own staffs of scientists. These are well versed in the problems

The industrial consultant compares the interior structure of various loaves of bread with the standard during research on baking methods and materials



With this ingenious set-up the consultant measures the life expectancy of a toothbrush or the effectiveness of toothpaste

that a particular business is likely to have. They also know about the new directions it may take in growing. But at times strange problems, quite outside the company's usual ones, must be solved. Even the largest companies must go to someone outside who is expert at the particular problem in question. We have noted an example of this above: the large company which had skill in making resin but not in making paint. This problem was taken to a qualified chemical consulting group who had the required knowledge and ability. By coöperation, the manufacturer's scientists and the independent consultants solved the main problem and most of the lesser ones quickly and ably. Now the paint is ready to go to a paint maker who will soon supply it to all of us. It will be a radical innovation in paints. You will be able to paint a room or an apartment with it in the morning and occupy the space again in the afternoon without the disagreeable smell that usually clings for days to newly painted rooms. Because of this and because it can be used out-of-doors, the new paint will be handy for a great many uses. It may work a minor revolution in the painting of homes.

In contrast to this case, small businesses don't need scientists often enough to employ their own. They may not even know when a scientist could be useful. A great many try to get along without any

scientific help when they could use it profitably. This, of course, is a serious mistake when independent consultants are ready to help in the same manner as a lawyer or an accountant.

The problem of the deadly disease of the dolls that began this article was a problem of a small business. It was solved quickly and economically by a chemical consultant and the puzzled small business is now fast growing into a larger and prosperous one. The trouble turned out to be that the dolls were spoiled when the little girls who owned them lived in damp and humid regions. When the chemist found that out, it was a simple matter to change the formula for making the dolls heads to a composition that would not be injured by dampness.

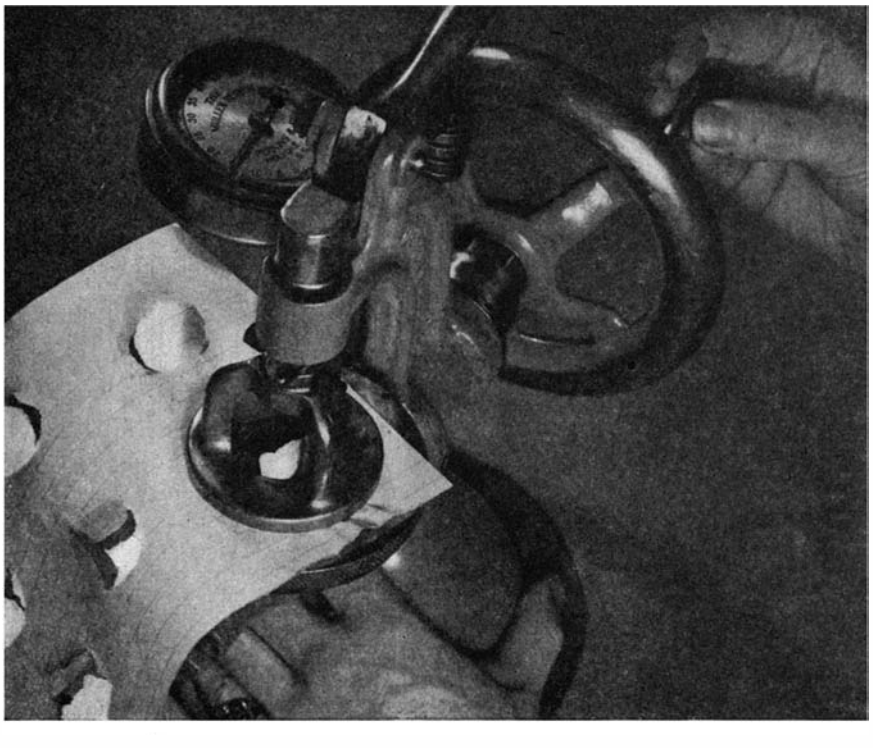
NEW KIND OF SLATE — The slate manufacturer saved his business much trouble, if not actual bankruptcy, by having an independent consultant develop for him a totally new kind of "slate." This was made by mixing fine sandy grains of a synthetic abrasive with molten glass so that the sheet glass product had a surface very like that of slate itself. The rough surfaced glass developed to solve this problem actually possesses advantages never found in natural slate and is becoming an important commercial product.

Tests by a chemical consultant of the waxes offered the department store mentioned above showed that the best was not the most expensive, as the buyer feared, but that a wax at a lower price was actually better for the purpose than the more expensive ones.

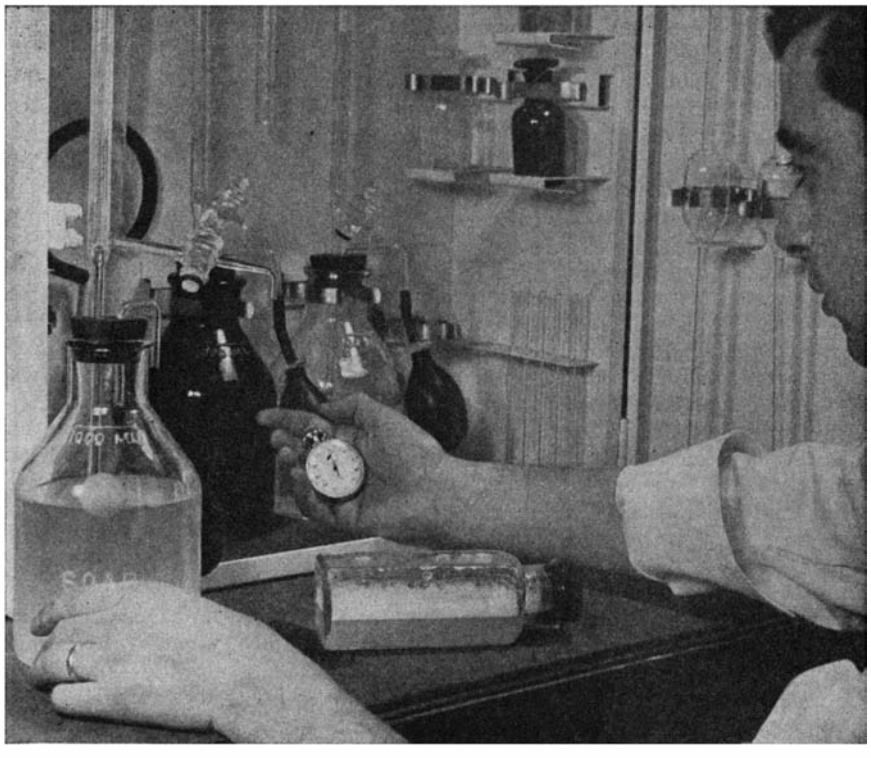
The discolored shaving cream was a much harder nut to crack. Chemical analysis showed that the color came from the tin of the tube and some sulfur compound in the cream itself. But nothing going into the cream was different from the materials that had for years made white cream that stayed white! It would unduly prolong this story to no good purpose if we went through all the steps taken to track down the trouble. After much searching, the chemical consultant found that the maker of the alkali used in the cream had supplied its producer with what he thought was a better-than-usual grade of alkali. It was better alkali for most purposes but it was fatal for shaving cream in tin tubes. It seemed that a faint trace of free chlorine in the alkali had been neutralized by putting in a small amount of photographers' hypo. This had become a sulfur compound of a kind that would discolor tin and hence shaving cream in tin tubes. Once the trouble was traced to its cause, the remedy was simple: the old, lower grade alkali was used.

These instances show a variety of troubles which business men may meet and some of the ways to cure them. In every case the chemical consultant was able to find the cause and to suggest its remedy at a cost trivial compared with the loss which the trouble was causing the business. The basic fact is that independent consultants have the skill and equipment necessary to give business the benefit of science in a form fitted to business requirements. They are also prepared to do this at a cost that is economical for the services rendered.

A laboratory manned with skilled people and equipped with the apparatus they need to work effectively represents a major investment which is not to be undertaken lightly—especially when ready-made facilities exist to find out whether such an investment is economically practical. A company which feels it may have to establish a laboratory can make sure by going first to independent chemical consultants. The consultants have a variety of services for every laboratory. Even independent consultants must limit themselves and cannot become



The Mullen tester. With this device the industrial consultant determines bursting strength, one of the most important of paper's physical characteristics



The industrial consultant performs many delicate chemical tests to evaluate the physical qualities of a great variety of substances. Here the stop watch reveals the hardness of a small sample of water

experts in everything. A look into the ten-story laboratory of Foster D. Snell, Inc., in midtown Manhattan, will suggest something of the character of consultation. This organization has grown up primarily by helping small businesses to solve their problems.

A laboratory such as this is a small business in itself. This one employs nearly a hundred people, most of them college graduates and specialists in some phase of the organization's work. It must therefore have the facilities usual for carrying on any business: offices, reception rooms, storerooms and the like.

MICROBE-FREE LABORATORY — It also must have several kinds of work rooms, each fitted and equipped for its particular job. One of the Snell laboratories, for instance, is devoted to bacteriology. The researchers went to great pains to design a special room for this purpose. They had to be certain that its walls, ceiling and floors were free from resident or floating microbes that might accidentally spoil tests. Nothing in the room can interfere with the bacteriologist's planned experiments. Even the air coming into the room must go through a filtering process to be sure that it carries with it no germs or dust from the outside.

The air in rooms set aside for tests of another kind is washed and treated for different reasons. When chemists want to calculate the strength of paper, for instance, they are careful to be certain of the exact temperature and humidity of the testing space. The reason for this is that they cannot account for the behavior of paper unless they consider these two important characteristics of weather at the same time. Everyone knows that even the size of a sheet of paper is larger when he measures it on a wet day than on a dry one. This is also true of the careful measurement of other values of paper, cellophane, rayon, and even many kinds of cloth. And this is the reason that one of the test rooms in the Snell laboratories has washed air pumped to it at painstakingly controlled temperature and humidity.

Another job for the consultant grows out of the chemist's need to call upon chemical engineers to make their laboratory experiments into factory processes. This means still another kind of work room, in itself a miniature factory. Actually the chemical engineers who work in it are continually rebuilding and rearranging this pilot plant. As soon as they have learned the effect of one change in process or equipment, pilot plant operators have thought up another change to do the job better. At the Snell laboratories, this work room looks like a small-scale chemical plant. There is, however, one big difference: everything in the pilot plant can be quickly taken apart, moved about and put together again.

This is the kind of establishment where consultants mentioned earlier tried out the chemist's ideas about how to make a paint out of resin. Everything in the chemist's experiments was worked over in an effort to find how engineers could operate a full-scale plant to make the new paint. In running their tests in such a pilot plant they followed the classic advice of Leo H. Baekeland: "make mistakes on a small scale so you can make profits on a large one." This, then, is a necessary part of the work of chemical consultants.

A chemical consultant must also devote a good part of his time to chemical analysis and physical measurement. These two services are basic to the solution of almost any problem. They make it possible for investigators to get back of surface appearances to the real facts about materials. Analysis not only detects impurities, like the sulfur in the shaving cream

mentioned before, but it often gives the expert an indication of the way a product was made, and how and where to look for the source of any trouble with it. Physical tests are designed to measure, for purposes of comparison, the properties—strength, gloss (as with the floor waxes we mentioned), life in service, and others—which relate to the value and life of the product being studied.

SURFACE PHENOMENA EXPERTS — Besides these quite general activities, each consulting group has its own specialty at which it is particularly expert. At Foster D. Snell, Inc., for instance, a special field is what scientists call "surface phenomena" and "surface-active agents." We need not here try to define these terms exactly, but rather let us say roughly that they have to do with the ability of liquids (particularly water) to wet things such as other liquids, solids and even gases. The most familiar examples are: soap, which helps water wet and clean our bodies in spite of our natural thin oily film; such commodities as salad dressing and dough for baking where we must mix those two proverbially unmixable substances, oil (or shortening) and water; and many other materials and operations (like making the resin-water paint) where you must mix together in one product substances of quite different, even antagonistic, natures. This includes, of course, the paradoxical "wetter water" of the headlines and the equally paradoxical "soapless soaps."

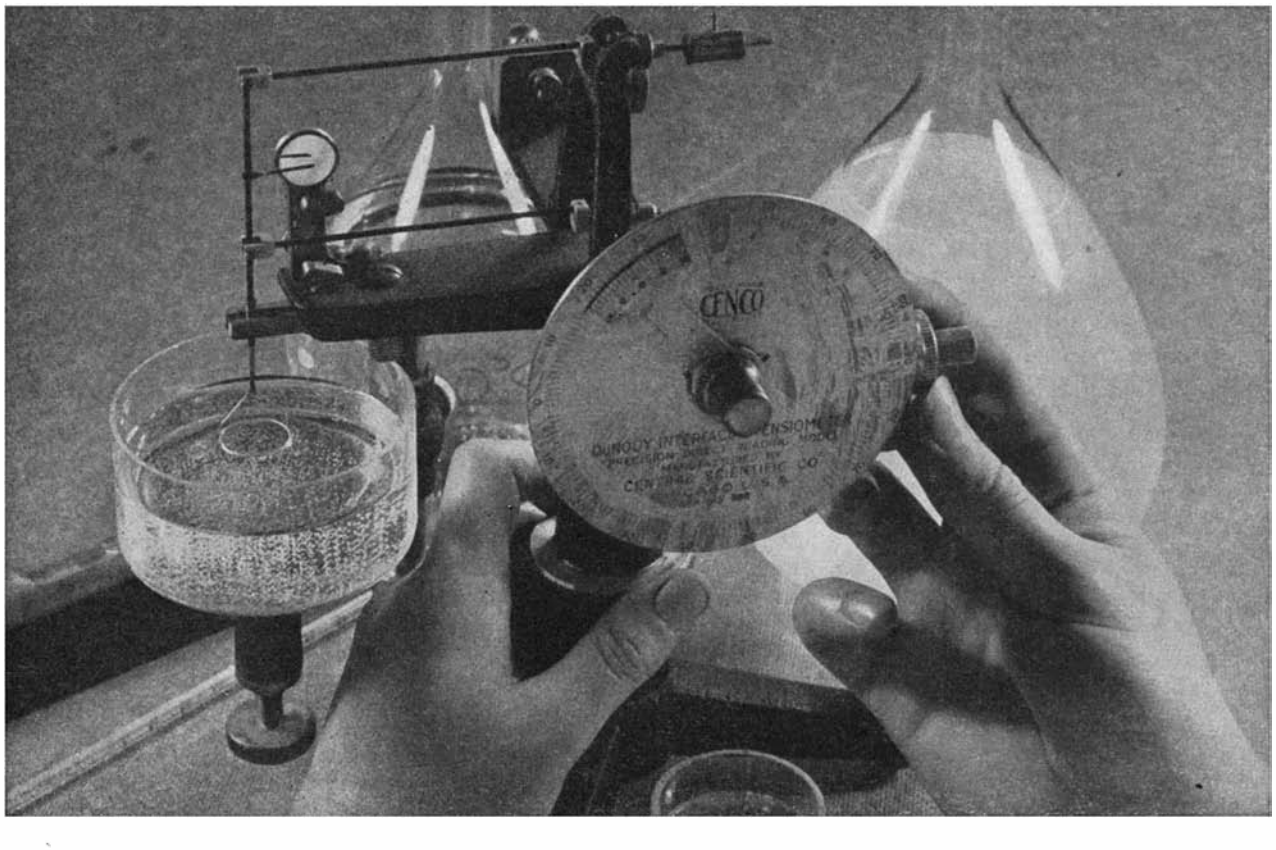
This work naturally spreads throughout all the ten floors of the Snell laboratory and into each of its departments. Here, for example, are washing machines that day in and day out work on small pieces of cloth that have been identically dirtied, called "standard soil." There is a great deal of difference between a washing machine and these launderometers, with their standard soil specimens in rows of glass jars mounted on rotating shafts. The job is the same, but the launderometer does it measurably and more accurately.

In another Snell laboratory, chemists measure the qualities of soap foam by blowing air through a solution in strangely shaped glass bulbs. A still different instrument (invented by Lecomte du Nouy, who wrote a current best seller "Human Destiny") measures surface tensions. This is the strength of the film which always surrounds liquids and which separates them from each other or from other substances. Researchers in surface activity are principally interested in controlling the strength or weakness of these films to suit their purposes.

Still other investigations in the laboratory seek improved ingredients for bakers to use in their dough and for compounders of plastics and rubber to include in their products. These researchers appear to casual observers as very different from the operations of the launderometer but actually all are a part of the same general problem: surface activity and its control.

From visiting the domain of a group of chemical consultants, one gets the impression that such consultants must know a lot about a great many different things. Above all they know how to solve the problems that vex all kinds of businesses, and how to do so economically. They give businesses a new but not untried kind of service to help keep them moving forward.

By measuring surface tension this instrument determines the strength of a soap bubble



SCIENTIFIC AMERICAN'S Industrial Digest

INDUSTRIAL ADHESIVES

Junctures Can Be Stronger Than The Joined Materials

INDUSTRIAL adhesives are rapidly reaching the point where they can join anything other than the strongest metals with junctures stronger than the materials themselves. The adhesive selection problem is becoming that of finding the one which will only slightly exceed the strengths of the joined materials and which can be applied with the greatest satisfaction at the lowest cost. Thus the adhesives industry which only a few years ago could hope to join only the weakest materials such as paper, leather and wood, is beginning to solve thousands of problems of the stronger materials. And 1948 seems destined to be the year in which industrial product designers begin most serious studies of what adhesives can do for them.

CARBIDE BORING BARS

Greater Accuracy and Efficiency At Reduced Cost is Reported

BORING bars made of solid cemented carbide are reported to be reducing costs, improving accuracy, increasing tool life and controlling surface finish in many production operations. The high degree of rigidity possessed by these carbide bars—2.8 times greater than that of steel—makes possible the precision boring of holes having a relative length up to eight times the hole diameter. The greater stiffness of the carbide bars keeps the boring tools from backing away from the work, and prevents the bars from "winding" up in the holes. In addition, the carbide absorbs and dampens vibration, resulting in longer tool life and better control of finish. Another benefit is that it enables the use of more wear-resistant grades of carbide for the actual cutting tool than is possible with the less rigid steel boring bars, thus still further increasing tool life.

These characteristics of cemented carbides have been effectively used, for instance, in designing—around such carbide boring bars—a new and completely automatic machine for the boring of wrist pin holes in cast aluminum pistons.

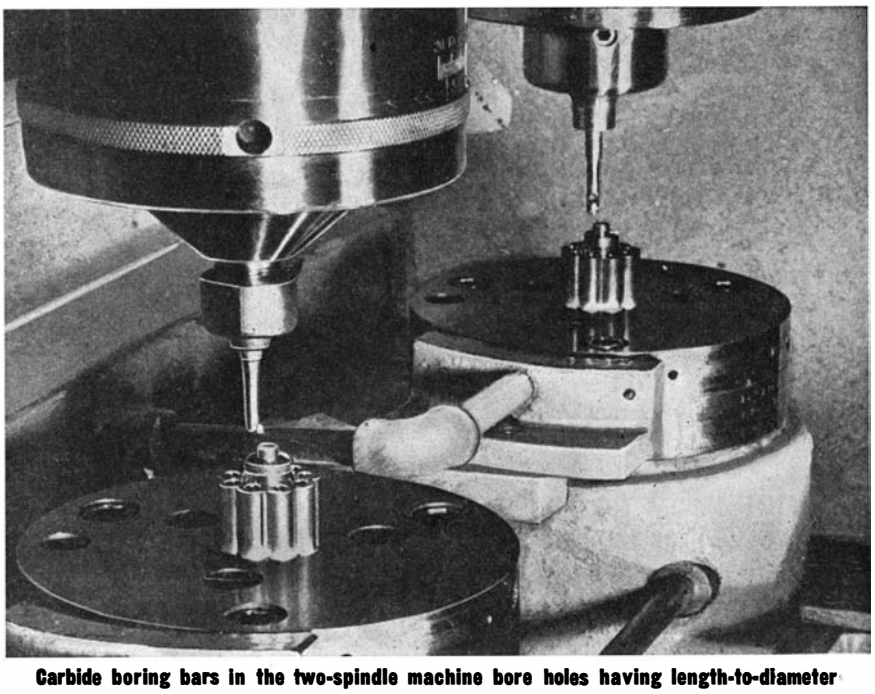
The total length of the hole in these particular pistons—that is, through both bosses—is 5.8 times the hole diameter. Formerly, it was necessary to drill the holes and then precision bore on double-end multiple spindle machines. Carboloy cemented carbide boring bars now permit "through" boring from one side only. Spindle and tool maintenance have been reduced by 50 per cent over methods used in the past.

The machine, of two spindle design, turns out 288 pistons an hour and approximately 2,300 per eight-hour shift. Cutting speed is 980 feet per minute. Floor to floor time is 25 seconds for every two pistons. The ability of the combination of carbide bar and carbide tool to hold size and surface finish over long runs has eliminated time lost in tool change shut-downs.

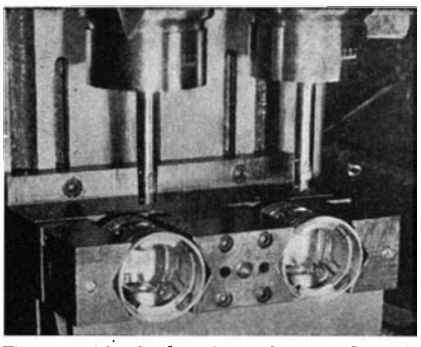
There was no change made in the grade of carbide used as a cutting tool.

Another typical application of the Carboloy boring bar is the boring of cast iron automotive valve guides having a ratio of length of bore to bore diameter of 7.3 to 1. Former practice was to drill, ream and "bearingize" the cast blank, following which the outside diameter was ground concentric with the hole. These holes are now bored in one pass (the out pass) with a solid carbide boring bar. Holes are straight, round and concentric with the outside diameter to a tolerance of .0002 inch. The operation has been in production for some months and has consistently produced 2,400 guides per eight-hour day. Tool life is between 12,000 and 18,000 bored pieces per grind.

Another manufacturer was experiencing difficulty in holding a .0002 inch tolerance when boring 3/16 inch cylinders in the bronze body of hydraulic pumps. The holes had a length-to-diameter ratio of 6 to 1. Primary cause of the trouble was chatter which resulted in tool failure, tapered holes, and excessive down time. This was due to a lack of sufficient torsional rigidity in the steel boring bars. A solid Carboloy cemented carbide boring bar, in-



Carbide boring bars in the two-spindle machine bore holes having length-to-diameter ratio of six to one in the hydraulic pump bodies, holding a .00005 inch tolerance



The carbide boring bars bore wrist pin holes in 288 aluminum pistons per hour

stalled in one spindle (finish boring) of the two-spindle machine solved the problem. The parts as inspected at the machine were consistently being held within a tolerance of .00005 inch.

Carbide boring bars are also being used to bore aircraft engine valve guides which are made of a bronze tube soldered on a nickel steel collar. When a steel bar was used, chatter caused rapid tool failure since the ratio of length to diameter of the bore is 5.5 to 1. Two cuts were made with the boring tool on each valve guide, after which the piece was pull-reamed to produce a hole that would pass inspection. To meet production schedules, two boring machines were used and two turret lathes were set up to perform the pull reaming. Some 45 pieces were produced per tool grind, and tool changes were made as often as six times per hour.

Using a solid Carboloy boring bar—shrunk into the spindle nose adapter of the boring machines—the holes are now being finish bored in one cut. The hole thus produced meets all inspections, including that for surface finish. Between 475 and 500 pieces per tool grind are now produced.

Consistent tool life can only be obtained by the duplication of the grind on the boring tool upon regrinding. This is particularly important in deep hole boring. Tool life may be quite erratic if care is not taken to duplicate the original grind.

The machine must be in condition in order to take advantage of the increased rigidity of the carbide bars. Spindles must be in good repair to use either a steel or a carbide bar.

ALCOHOL FROM ROSIN

Versatile New Material Is Commercially Available

Low-cost resin alcohol made from rosin has potential application in a wide number of industries including textile, rubber, adhesive, detergent, paint, varnish and lacquer. Called hydroabietyl alcohol, it is the first commercially available primary alcohol to be developed from rosin, one of the cheapest organic acids available. Hydroabietyl alcohol is a viscous liquid at room temperature. It is colorless, tacky and not miscible with water, in contrast to more commonly used alcohols. Of all rosin derivatives, it is the most resistant to discoloration and degradation by light or air.

The similarity of the properties of hydroabietyl alcohol to the properties of other high molecular weight alcohols, plus the fact that it is resinous in nature and low in cost, indicates a wide variety of industrial applications.

Like other high molecular weight primary alcohols it is subject to esterification with both organic and inorganic acids, and etherification. It is miscible with alcohols, ketones, esters, ethers, hydrocarbons and chlorinated hydrocarbons, and is compatible with many film-formers and resins used in protective coatings, adhesives and other products.

For many years the published research of laboratories both in America and Europe has disclosed a wide variety of valuable products that may be derived from hydroabietyl alcohol such as: resins, foamers, detergents, wetting agents, emulsifying agents, plasticizers, corrosion inhibitors, antioxidants, parasiticides, bactericides and compounds highly stable to ultra-violet light. Full investigation of these compounds has awaited the commercial availability of this unique resin alcohol.

Hydroabietyl alcohol can be used without further chemical reaction as a modifier for chlorinated rubber, polyamides, hydrogenated oils, textile sizers, rubber compositions and essential oil vehicles. Commercial production of hydroabietyl alcohol will be carried out by the Hercules Powder Company.

AIRCRAFT AUTOPILOT

Small Light-Weight Device Is Not Affected By Rapid Maneuvers

Unlike the majority of aircraft automatic pilot devices, a new midget autopilot recently developed by the Westinghouse Electric Corporation is virtually unaffected by rapid maneuvering or high rates of acceleration. Similar to the gyroscopic stabilizers used during the war for tank guns and airplane gun turrets, this midget pilot weighs only 35 pounds and will maintain control of a plane through loop-the-loops, barrel rolls, or great bursts of speed.

Dr. Clinton R. Hanna, associate director of the Westinghouse Research Laboratories, revealed that the new autopilot already has been put through more than 3,000 miles of banks, turns, dives and level flight while the human pilot and engineers "sat by" as observers.

Describing the autopilot as "the speediest and most sensitive ever developed," Dr. Hanna declared:

"This unit is about half the size of most automatic pilot devices. It reacts to the human pilot's signal, or to unwanted motions of the plane, in one-tenth of a second, then flashes its message to the control mechanism even while such motion is just beginning to take effect.

"Even the biggest plane can be put through its paces by the twist of a knob on a small control box within easy reach of the pilot. To dive or climb, he merely moves the knob in or out; for turns, it is rotated right or left. In level flight, the pilot can sit back and relax while the plane flies itself."

The unflustered nature of the midget pilot suggests that such a device, radio-controlled, might serve to direct the flight of guided missiles and pilotless aircraft.

Source of its "mechanical composure," Dr. Hanna explained, is a compact metal case containing three spinning gyroscopes. These gyros, spinning at approximately 12,000 revolutions per minute, are "locked" to the plane and follow it during all maneuvers without any possibility of tumbling. They differ in this respect from the ordinary "position gyro" which is not locked to the plane and hence stubbornly resists any effort to change its direction of motion. As a result, former gyros were sensitive only to changes in angle of the plane, whereas this midget pilot equipped with "rate gyros" responds both to changes in angle and to the rate at which such changes take place.

Although still considered to be "in the experimental stage," the midget pilot is expected to be applicable to light commercial and private planes as well as military craft.

CUMENE HYDROPEROXIDE

New Catalyst Makes Possible Cheaper, Better Rubber

Stronger and less expensive synthetic rubbers are promised by the development of a new chemical which can cut production time of rubber to 1/16 of that now required. In addition, the production of synthetic rubbers at temperatures as low as 40 degrees, F. is made pos-

sible by this material. Cumene hydroperoxide, as the new chemical is called, is a catalyst and is a development of the Hercules Powder Company of Wilmington, Delaware.

The great drop in production time made possible by cumene hydroperoxide will mean a considerable increase in plant output, not to speak of a lowering of production costs.

The chief advantage of manufacturing synthetic rubber at low temperatures lies in the fact that generally speaking, the lower the temperature during production, the stronger the rubber. Under present manufacturing methods, a temperature of approximately 122 degrees, F., must be employed, and the process stops at lower temperature.

The new chemical is being produced only on a pilot-plant scale so far, but it is expected that in the near future it will go into full-scale production.

A large number of other uses for the new chemical are foreseen. Laboratory tests indicate that cumene hydroperoxide will speed the production of many plastics.

Besides being less expensive than most peroxides, cumene hydroperoxide is safe to handle (as a rule, peroxides are unstable and often must be handled as carefully as explosives). This cuts shipping and storage expenses considerably.

UNDERPASS GEAR CUTTER

Curve Shaving Machine Ups Output With Less Operator Effort

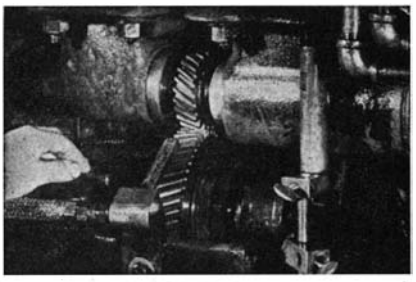
CAST iron crankshaft timing gears are now being shaved at the Rouge Plant of the Ford Motor Company at a rate of 1,684 per eight-hour shift with less actual effort on the part of the operator who formerly shaved 920 gears in eight hours by the old method. This has been achieved by a combination of the use of the higher production "underpass" machines, as produced by Michigan Tool Company, Detroit, plus semi-automatic air-operated loading for the gears. With this combination, the operator is no longer required to load the gears on arbors and insert the arbors in the machine, and he is easily able to take care of the output of two "underpass" shavers.

The gear is simply placed on the fixture in the shaving machine, and a flick of an air valve control lever closes the fixture, thereby clamping the hobbed gear securely in place. The operator presses the start button to start the automatic underpass shaving cycle, then steps to the second machine to unload a finished gear and repeat the loading process there, while the first machine is completing its shaving cycle.

The former method required the operator to mount a hobbed gear on an arbor and also dismount the shaved gear from the arbor while the single shaving machine he was operating was completing its automatic cycle. Time was also lost and extra effort involved in mounting the arbor and gear between centers with the hand screw method that was customarily employed.

The Michigan underpass machines automatically crown all gears by "curve-shaving" them during the finishing process. This is made possible by having the reverse crown ground into the cutter.

Average tool life with the underpass machines is 14,000 gears per sharpening. Since the shaving cutters, according to Ford, may be sharpened an average of seven times, total life per cutter including the initial 14,000 gears shaved before sharpening, is 112,000 gears.

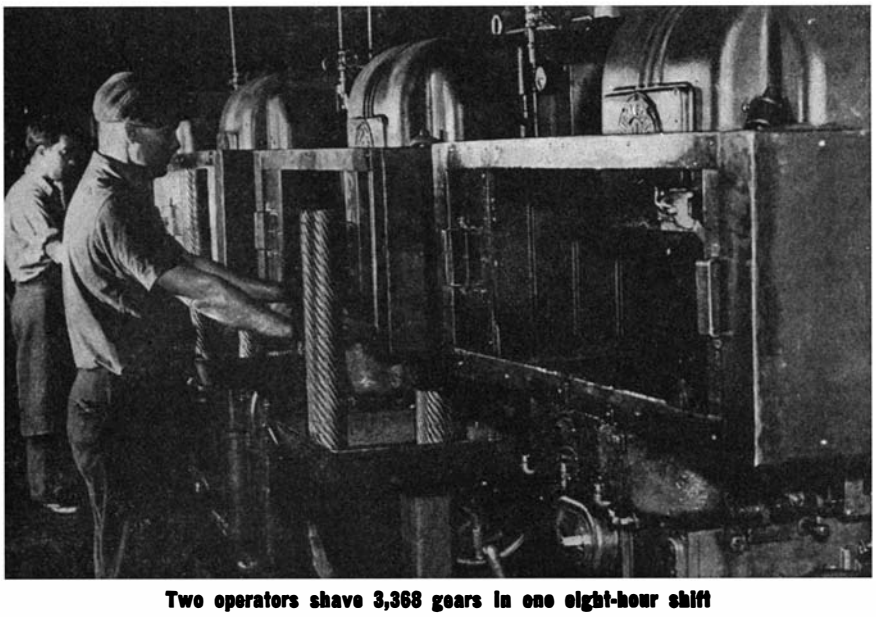


The cast iron gear mounted, ready to start the underpass curve-shaving cycle

The cast iron crankshaft timing gears have a face width of one inch, 24 teeth, pitch diameter 3⅜ inches, and are eight diametral pitch. In clamping the gears in the fixture there is a slight amount of "backlash" between the green gear and the underpass shaving cutter, with the gear and cutter at crossed-axes to each other.

When the machine cycle is started, cutter and gear rotate in mesh, with the cutter driving the work. The cutter feeds tangentially beneath the gear until the gear is again in "backlash" with the cutter on the opposite side. Direction of rotation is then reversed and the cutter is fed tangentially back to its original position.

This method eliminates the upfeed plus a "rocking" motion frequently used on crowning shaving machines and is said to contribute both to the shortening of the time required for shaving and to increasing the life of the cutter since the wear is distributed across the entire face of the cutter. The cutting fluid used in the underpass shaving machines for these cast iron gears is kerosene.



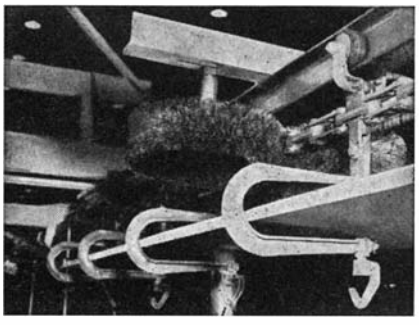
Two operators shave 3,368 gears in one eight-hour shift

DESCALING CONVEYOR CHAIN

Simple Power Brushing Set-Up Cuts Maintenance Costs

DESIGNED to combat the scale which formed on a conveyor chain that passed through a rust-proofing solution, a novel power brushing arrangement has resulted in a substantial reduction in the cost of chain maintenance and has given the efficiency of the process a noticeable boost.

This brushing set-up which was installed in the refrigerator plant of the General Electric Company at Erie, Pennsylvania, operates in conjunction with the plant's new conveyor assembly. Two circular wire brush sections, 15 inches in diameter and containing .014 wire, are mounted on each side of the conveyor chain to contact it just after the chain emerges from the bonder-



Revolving brush cleans conveyor chain

izing bath. Not only does the brush clean off the scale deposits, but it also removes excess grease, oil and dirt which accumulate in regular service.

This plant's conveyor chain is one of the longest in service in this country and travels at the rate of 27 feet per minute. Prior to the introduction of the brushing method of descaling the chain, it was necessary to halt production periodically, remove the chain from the conveyor and clean it in a caustic solution.

One of the unusual features of this new brushing operation is that no special power mechanism is required to operate it. The brushes revolve with the chain, cleaning it continuously as the production line moves.

The installation was designed jointly by engineers of The Osborn Manufacturing Company, of Cleveland, and the General Electric Company.

COLOR MICROSCOPY

Particles Viewed in Various Colors Without the Use of Dies

MICROSCOPY in color, without the use of dyes or light filters, has become a reality with a new microscopy technique. Developed by Germain C. Crossmon, Bausch and Lomb Optical Company scientists, this new technique, provides a speedier, more accurate identification of a wide range of colorless, transparent substances, including drugs and minerals. Dr. Crossmon terms the technique "dispersion staining." Only standard microscope equipment is required to turn transparent, colorless objects to bright colors. By choice of the correct immersion liquid which is placed over the sample, each different material appears a different color.

The method by which white light on a colorless object produces color is briefly this: The light from the microscope lamp is passed through a dark-field substage lens to strike the sample at a high angle. The sample is covered with a high-dispersion liquid that matches the light-bending ability of different materials in the sample at different portions of the color spectrum. Each material then scatters some of the colors present in the white light into the microscope where they are seen by the observer while other colors pass directly through the sample at such a high angle that they do not enter the microscope.

The new technique is expected to increase use of the microscope in checking foods or drugs for adulteration or contamination, testing minerals or ores for impurities and textiles for fiber identification. Crime laboratories can be expected to try dispersion staining to decide if microscopic fragments of materials are identical. Its use is also foreseen in medical microscopy for studying the relative refractive index of body tissue structures.

Use of dyes to stain tissues or bacteria probably will not be supplanted, Dr. Crossmon states, in those cases where absorption of the dye is a specific chemical identification of the material.

SWARF ELIMINATED

Magnet Removes Metal Particles From Grinding, Cutting Oils

ONE OF the major problems of metals cutting and grinding has been the swarf, or extremely fine metal particles inclusions which become entrained with cutting oils, grinding coolants and lubricating oils. The particles may be only of colloidal sizes, but since oils tend to hold particles in solution by peptization, they may be much larger than colloids. They pass through fine screens, refuse to settle out and are so small as to be work hardenable to the greatest abrasive hardnesses which metals of their alloys can assume. Therefore they can do rapid damage to tools and to machine parts.

Permanent magnet machines operate continuously to remove these particles and deliver clean oil to the work points. The first result is conserving of oil. But the important results are prevention of spoiled work, prolonging of tool lives and protection of machine bearings.—*E.L.C.*

PORTABLE PLANETARIUM

Small Instrument Reproduces Sky Over Any Part of Earth

A COMPACT unit, three feet high and weighing about 25 pounds projects on any surface the images of all stars down to the fourth magnitude—most of those that can be seen with the naked eye. Constellations are immediately recognizable and the illusion of the sky may be reproduced as it appears from almost any location on the face of the earth.

This portable planetarium turns on its polar axis at the rate of one revolution every four minutes. One complete revolution shows the rising and setting of the Sun, Moon, planets and stars.

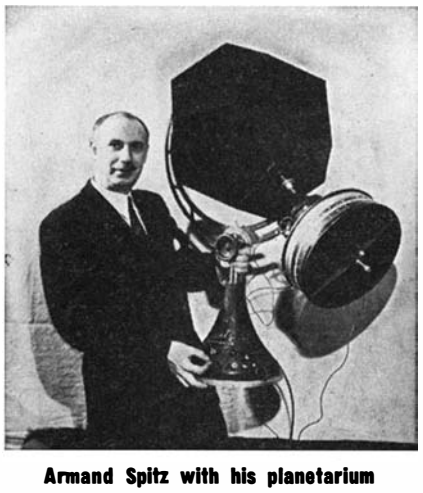
The projection medium of this instrument is a dodecahedron housing composed of rigid sheets of the Bakelite Corporation's Vinylite. Each of these twelve sheets is punched with openings so that illumination, produced by a special bulb inside the housing, sifts through in proportion to the relative sizes of the stars and their position in forming the constellations.

Vinylite was chosen because it is non-warping and has maximum rigidity for minimum thickness, drills easily and cleanly, is easily cemented and stands vibration and occasional hard usage without denting and deformation.

The device was designed and developed by Armand Spitz, Director of Museum Education at Franklin Institute, Philadelphia, after a decade of experimentation.

Study aids, such as a light-pointer for directing attention to a particular star or constellation in a darkened room, and current star charts are furnished with each planetarium to assist users in demonstrations and teaching. Portable domes, which give the instrument greater fidelity of reproduction than it is possible to attain on a flat surface, are also available.

Auxiliary projectors showing constellations, coordinates, eclipses, cloud formations and other such phenomena can be used in connection with this new portable planetarium.



Armand Spitz with his planetarium

New Products

POWER RECORDER

Instrument Automatically Computes Engine's Total Power Output

To ELIMINATE guess work in the measuring of engine usage and wear, a device called Power-Recorder, has been developed which records the cumulative power-hour units turned out by an engine, thus providing a measurement of total engine wear. This instrument promises to be of great value to all commercial airlines as a practical means for determining the time for servicing of the engines and thus increasing operating efficiency and economy in maintenance.

In aircraft engines the Power-Recorder, which is manufactured by the Square D Company, Elmhurst, New York, computes the total power-hours produced by continuously measuring the engine speed, manifold pressure and atmospheric pressure. Power data are obtained in accordance with the engine power curves for all throttle and propeller pitch settings and altitudes. The rate at which the power units are registered is directly in proportion to the power-hours delivered by the engine. The results are given in terms of equivalent hours at cruising power, thus registering 100 units per hour if the airplane is flown at normal cruising power.

Two types of Power-Recorders have been developed, one with a flexible shaft connection to the engine tachometer outlet, and another, a remote operating type which is electrically driven by a tachometer generator mounted on the engine tachometer outlet. For uses other than aircraft, the device can be calibrated in any convenient units, such as horsepower-hours.

The Power-Recorder prints the cumulative power units and the engine identification number in the manner of a timeclock so that the record can be filed for reference. It can also be supplied with a visual counter-type indication in the place of the printing mechanism.

DECADE SCALER

Self-Contained Unit Will Count Up To 130,000 Pulses per Second

SPECIFICALLY designed for radioactivity measurements, a new decade scaler is a completely self-contained instrument. It has an input sensitivity of 0.25 volt and is equipped with three scale-of-ten counter decades, a four digit mechanical register, control for a clock timer and an adjustable high-voltage regulated power supply for the operation of Geiger-Mueller tubes.

The three plug-in counter decades are used to provide a convenient decimal scale registration of each count. A selector switch is provided for the selection of a scale of 10, 100 or 1,000 in driving the mechanical register located on the front panel. This decade scaler, which is a product of the Potter Instrument Company, Inc., Flushing, N.Y., will resolve two pulses which are five microseconds apart and will count continuously with absolute accuracy at rates up to 130,000 counts per second.

The high-voltage power supply is adjustable from 600 to 1,500 volts. The simplest circuits are used throughout the instrument, and it is claimed that it requires absolutely no adjustments.

ELECTRON DIFFRACTION INSTRUMENT

Pattern On Photographic Plate Aids Study of Surfaces and Films

A NEW research tool designed to aid in the observation and measurement of surface conditions of metals, ceramics and plastics, is valuable in the investigation of problems associated with corrosion, catalysts, lubricants, metallurgy, pigments and surface deposits. This electron diffraction instrument, as it is called, differs from the X-ray diffraction instrument, which analyzes thick specimens, in that the new instrument shows the crystal structure of surfaces and thin specimens to 500 Angstroms.

To operate, a beam of electrons is directed at the specimen being tested, and any resulting diffraction pattern is photographed. The pattern consists of rings whose diameter, intensity and orientation provide information for determining composition, orientation and size of the crystals present.

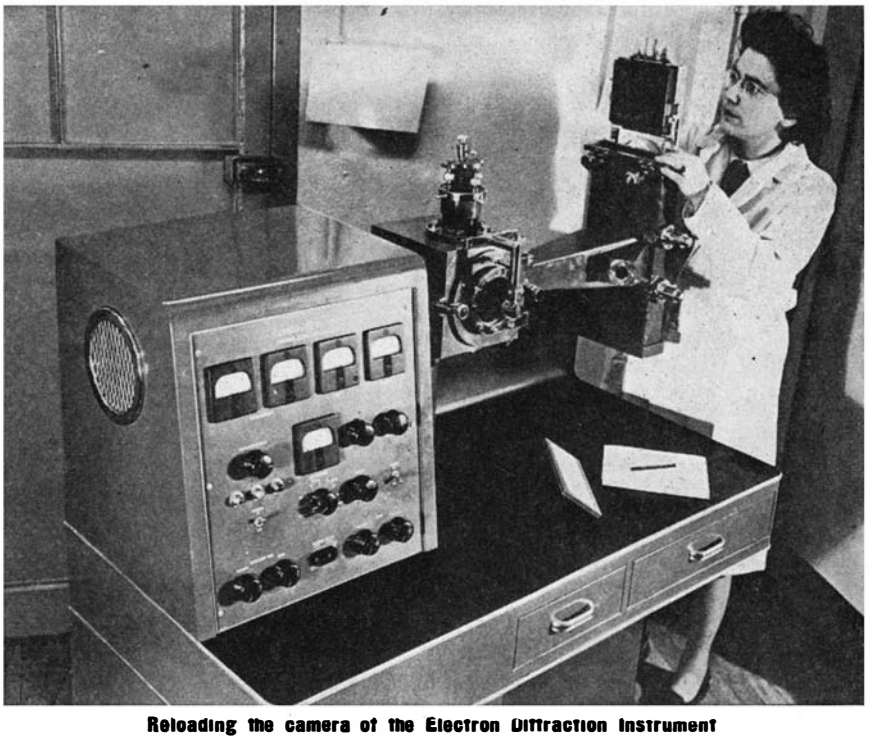
The instrument, which is a development of the General Electric Company's General Engineering and Consulting Laboratory, Schenectady, New York, consists of one unit containing vacuum chamber with specimen manipulator, visual and photographic recording camera, electron gun and beam focusing elements, regulated high-voltage power supply, and complete vacuum pumping equipment.

The specimen chamber permits examination of specimens ranging from 0.1 to four inches in diameter. In many cases, the instrument will detect and help identify the very first chemical changes before they are visible under a microscope or are otherwise detectable.

DEWPOINT APPARATUS

Moisture Content of Gases Is Easily And Accurately Measured

A NEW dewpoint apparatus is intended to meet the need in industry and in research for an inexpensive device to measure the moisture content of gases at approximately atmospheric pressure. Results obtained with this new apparatus are said to compare satisfactorily with those obtained by more complicated and more costly



Reloading the camera of the Electron Diffraction Instrument

The apparatus determines dew points at temperatures as low as minus 76 degrees, C.

methods. In addition, this device, which is produced by the Pittsburgh Lectrodryer Corporation, Pittsburgh, Pennsylvania, is claimed to be less subject to error, particularly at dewpoints below zero degree, C., than are units operating on the wet and dry bulb principle.

This apparatus consists of an outer container with inlet and outlet connections and a window; an inner container with a highly polished outer surface that is visible through the window; and a thermometer.

In order to determine the dewpoint temperature of a gas, a small sample is passed through the outer container of the unit while a mixture of crushed dry ice and acetone is stirred in the inner container. The stirring is done with the thermometer. As the temperature drops as a result of the stirring, the polished surface of the inner compartment is closely observed through the glass window. At the first indication of dew or moisture on the polished surface of the inner container the temperature is read from the thermometer. This dewpoint temperature is a reasonably accurate indication of the moisture content of the gas or air under test. Use of the acetone and dry ice mixture makes possible the checking of dewpoints as low as —76 degress, C.

SHORT-HAUL CARRIER

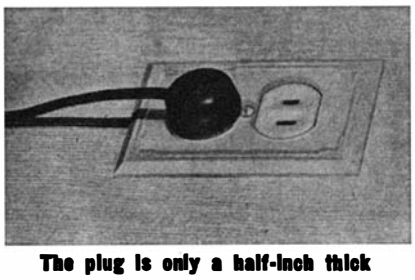
Three Channel System Operates On Open Telephone Line

DESIGNED to answer the needs of many organizations requiring wire transmission facilities over lines of moderate length, a small, three-channel short-haul carrier has been developed which will operate an open telephone wire for distances up to 150 electrical miles. This system, which is designated FTR 9-H-1 by the manufacturer, the Federal Telephone and Radio Corporation, Newark, New Jersey, occupies only seven inches of vertical rack space per channel and weighs only 35 pounds. The transformer, coils filters and capacitors are hermetically sealed and mounted on the rear of the panels. According to the manufacturer, the use of this system to extend communication facilities results in a very substantial saving over the cost of installing a new line on existing poles.

ELECTRIC CORD PLUG

Wire Enters at Side of Flat, Rubber-Covered Plug

REPRESENTING a departure from conventional electrical plugs, a new Neophrene-covered plug is so designed that the cord enters at the side rather than at the front. Thus when the plug is inserted in a baseboard socket, the cord keeps flush against the wall, eliminating much of the hazard and nuisance of loose, tangled wires. In addition, the plug itself is flat, extending barely a half inch from the outlet and



The plug is only a half-inch thick

so it is far less an obstacle than is the conventional plug.

This plug, which is designated Neoplug 100 by the manufacturer, Neoline, Inc., Los Angeles, California, is entirely encased in Neophrene and has no metal parts exposed. The plug will fit all standard electrical outlets and is available in standard colors.

MULTIPLE-LINE STAMP

Monotype Marks Several Lines of Copy In a Single Operation

FOR MULTIPLE straight-line stamping of letters and figures, a new device has been developed which can machine-stamp in a single operation complete instructions for the use of a tool, complete name plates and so forth. This versatile marker manufactured by New Method Steel Stamps, Inc., employs interchangeable type which is set in the marker's type holder just as type is set in a printing shop. Each individual piece of type is slotted so that the entire row of monotype and spacing slugs can be held in place with a flat locking pin.

The retainer of the multiple-line type holder has a hardened steel anvil for the type to bottom against. The outer case of the retainer is of hardened and tempered tool steel for long service life even under severe operating conditions. All insert monotypes are hardened and then ground to a standard size and length for accurate alinement when the type is assembled in the holder.

The marker can be used in the regulation mechanical marking machines or in a variety of punch presses, and is available in various sizes and type capacities.

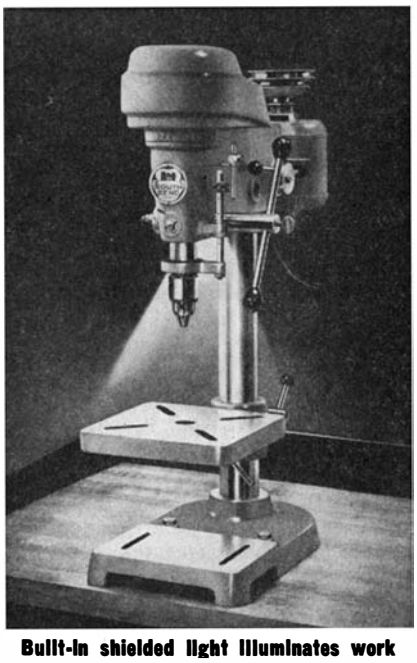
The multi-line stamp can be used in regular marking machines or in punch presses

PRECISION DRILL PRESS

Tool Features Built-In Light and Simplified Speed Change

A NEW 14-inch precision drill press introduces several original features which add considerably to convenience and ease of operation. A built-in light with an independent switch provides shielded illumination for the work area, eliminating the necessity of installing a separate lighting fixture. A quick-acting belt tension release lever simplifies changing the spindle speeds and returns the vertical mounted motor to its original position after each change, thus maintaining the same belt tension for each of the four cone pulley steps.

The spindle has a maximum travel of four inches, with spindle speeds of 707, 1305, 2345 and 4322 revolutions per minute. The free-floating spindle design prevents misalinement, side thrust and whip. The depth gage is graduated in sixteenths of an inch, and has adjustable collars to control both the depth of feed and the length of the return stroke. Two precision ball bearings carry the drive unit load and two



Built-in shielded light illuminates work

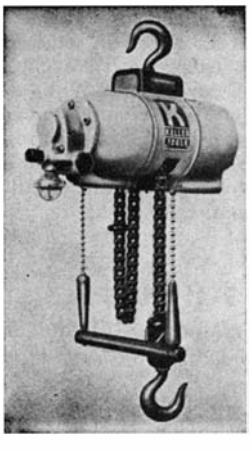
additional ball bearings carry the spindle, which is spline driven. All ball bearings, being pre-lubricated and sealed, require no oiling. The spindle quill bearing has adjustment to compensate for quill wear.

A full-tilt table, with 10 by 10 inch precision ground top surface, has slots for clamping fixtures or work. An improved type of double plug binder is provided for locking the table quickly and securely in any position on the 2¾ inch diameter column. Both bench and floor models are available. The drill press, a product of the South Bend Lathe Works, South Bend, Indiana, is supplied with or without motor, as desired. A 1/3 horsepower, 1725 revolutions per minute vertical mounting motor is recommended. An on-off switch, motor line connection cord, V-belt, motor pulley, and 0 to ½ inch capacity chucks are standard equipment.

AIR HOIST

Variable Speed Unit Has One-Ton Capacity

COMPACT and ruggedly built, a new air hoist having a capacity of 2,000 pounds features variable speed which gives the operator full control over positioning, raising or lowering the load at any desired speed from creep to 17 feet per minute. The standard length of lift is eight feet. The hoist, designated Model 86-2V20 by the manufacturer, the Keller Tool Company of Grand Haven, Michigan, is equipped with safety stops. The roller chain is of high-grade alloy steel and swivel hooks are drop forged. The hoist is powered by a vertical piston air motor, and the entire unit weighs only 75 pounds.



The speed of the air - powered chain hoist is variable from creep to 17 feet per minute. The entire hoist weighs only 75 pounds

BEARING CLEARANCE GAGE

Width of Flattened Plastic Gives Accurate Measurements

A QUICK and simple method of checking engine bearing clearances is reported from the Perfect Circle Corporation of Hagerstown, Indiana. With this technique a length of round extruded plastic is employed to give the measurements. This piece of plastic is packaged in an accurately graduated envelope. To check a bearing's clearance the bearing cap is removed and the piece of plastic is laid on the bearing shell. The bearing cap is then retightened on the crank, flattening the plastic. The cap is again removed and the width (not the thickness) of the flattened plastic is measured with the scale on the envelope. The clearance is read directly in thousandths of an inch.

HIGH-SENSITIVITY THERMOCOUPLE

Indicator Gives Accurate Reading In Hot Reducing Atmosphere

HIGHLY SENSITIVE, a new nickel-nickel molybdenum thermocouple will stay on calibration in reducing atmospheres at temperatures as high as 2100 degrees, F. Applications for the new thermocouple, product of the General Electric Company, include measuring temperatures in protective atmospheres in the heat-treating of steel and malleable iron, and in copper brazing.

The thermocouple element, supported by ceramic insulators, is sheathed in a special alloy protection tube which is welded at the hot end to make it air tight. To assure rapid response it makes physical contact with the end of the tube. A special glass seal was developed to make the terminal end of the assembly air tight.

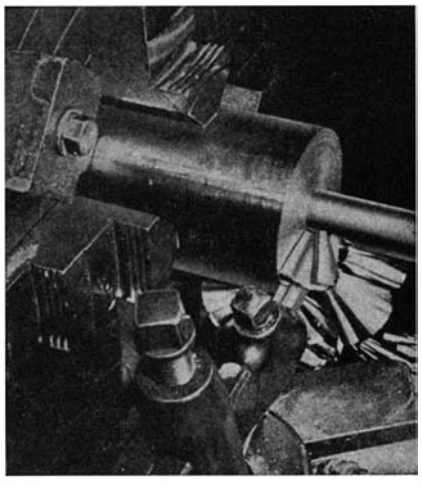
A gas-tight adapter is welded to the alloy tube at the terminal end. The adapter screws onto a one-inch pipe which is welded to the steel furnace casing to make a gas-tight connection with the furnace. Thus it is not necessary to pack the thermocouple or to use a junction box. The addition of a terminal connector with a die-cast housing completes the thermocouple assembly.

Before the thermocouple is assembled in the alloy tube, the nickel and nickel molybdenum wires are butt welded together, forming a strong joint that is free from foreign material. Standard chromel-alumel thermocouple extension lead wire is used for connecting the thermocouple to the temperature indicating instrument, as this wire matches the characteristics of the thermocouple.

SHEARCUTTING TOOL BIT

Molecular Cleavage Reduces Time And Cost of Production

OPERATING on the principle of molecular cleavage, a new pre-sharpened shearcutting tool bit is said to take cuts two to three times its normal size, thus greatly reducing production time and cost. A product of Shearcut Tool Company, Los Angeles, California, this bit cuts metal with a knife-like action instead of chiselling it off by the common metal-rupturing method that is employed with conventional bits. Savings in production time of as much as 50 per cent, and savings in power consumption of over 70 per cent through the use of this new bit have been reported. Other advantages claimed for the new tool bit are faster cutting speed; less heat generated by the cutting action; and less wear on machine tools.



Tool bit cuts by molecular cleavage

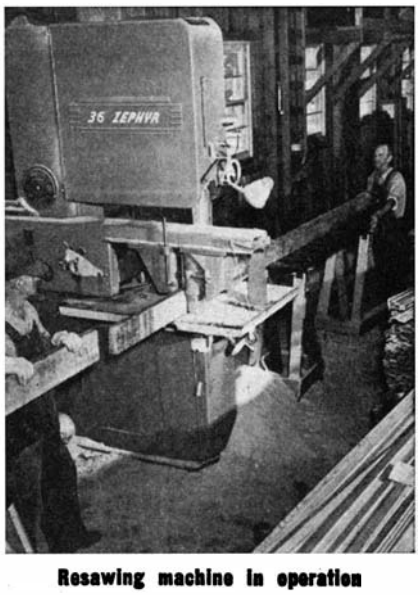
Precision tolerances may be held with the bit, and it is said that finishing cuts may often be eliminated. The tool may be used on copper, brass, bronze, plastics, cast iron, steel and other ferrous and non-ferrous alloys.

RESAWING MACHINE

Dual Purpose Unit Also Performs Regular Bandsaw Operations

A NEW COMPACT resawing machine features space and blade economy with accuracy and fine finish. This machine is designed for use by prefabricators, store fixtures, furniture, sash-door and other manufacturers who require special board sizes. With this new resaw, lumber can be purchased more economically by buying in odd lot sizes and then resawing to requirements. This further saves lumber storage space and enables a manufacturer to get a wide variety of wood sizes on short notice.

This unit, produced by the DoAll Company, Des Plaines, Illinois, is a



Resawing machine in operation

two-purpose high-speed band-sawing machine constructed especially for resawing but can be used for the usual band-sawing operations. The resaw mechanism, hinged to the machine column for quick positioning on the 36 inch square table, consists of a frame enclosing four sprocket and chain driven feed rollers, the one half horsepower drive motor and the variable speed unit. A spring tension adjustment accommodates variations up to a half inch in width of lumber passing through the rollers and a fixed scale with movable pointer insures positive dimension control of boards that can be cut from lumber up to 13½ by 15 inches.

The DoAll resaw achieves improved resawing efficiency by providing control of feed rate (10 to 60 feed per minute) with stepless variable speed drive. Balanced 36 inch drive wheels, automatic blade tensioning and heavy welded steel frame construction assures excellent blade life and vibrationless sawing accuracy.

Adjustable high-speed roller guides mounted above and below the table furnish the rigidity of back-up and blade control for accurate sawing—either straight ripping or for precision scroll work when the resaw carriage is swung aside off the table. The upper guide is mounted on a heavy post adjustable to height of material passing through the blade which is fully enclosed to point of work by a heavy steel telescoping guard for operator's safety. An automatic cut-off switch that shuts off the machine in case blade breaks is an additional protective feature.

The machine is sold fully equipped with 10 horsepower drive motor, blading and fixed speed selected for optimum sawing in either hard or soft woods. Regularly furnished with two-inch swaged tooth blade for top production, narrower buttress blades can be used in the interest of finer finish and less sawdust from high-grade lumber.

BRINELL TESTER

Machine Checks Hardness of Up To 800 Parts Per Hour

A BRINELL testing machine which is capable of checking up to 800 pieces per hour can test parts varying in diameter and thickness as much as ¾ inch without requiring adjustment of the elevating screw. This machine, a product of Steel Testing Machines, Inc., Detroit, Michigan, is identified as model KDR. It is motor driven and hydraulically operated. The tester is so constructed that it is impossible for the operator to remove the specimen being tested before the full load has been applied to the penetrator. The load is held for a predetermined length of time (adjustable from 2 to 15 seconds) after which the penetrator automatically reverses itself to starting position, ready for the next test. Specimens or parts which are of the same thickness or diameter—or within ¾ inch of that—are tested without moving the elevating screw with a resultant saving in time. This machine is equipped with a comparator indicator which eliminates the necessity of using the Brinell microscope on production testing. The machine can be furnished with a foot or knee starting switch. The throat opening is six inches and the maximum vertical opening is 14 inches. Standard equipment includes both flat and V-type anvils.

MIDGET POWER DRILL

Low-Cost Palm-Sized Electric Tool Is Announced

A LOW-COST midget power drill has been announced by Wolfson and Fairclough Manufacturing Company. This

Power drill takes bits up to ¼ inch

new device, called the King Midget Power Drill, is equipped with a geared-head motor, a trigger-finger control and it has a body of polished aluminum. The pistol-grip drill operates on standard 110-volt, 60 cycle A. C. at approximately 600 revolutions per minute, and takes bits up to ¼-inch.

DIELECTRIC HEATER

Simple, Low-Cost Unit Is Announced

FEATURING low cost and simplicity of operation, a new dielectric heater has been announced by the Radio Frequency Corporation of Boston, Massachusetts. This unit which operates at 30 megacycles per second, has no dials to set nor meters to watch. The inexpensive heater is applicable to drying, gluing and sealing operations and t the heating of metals and plastics. It is supplied complete with foot switch and electrode oven section, and a timing device is available as optional equipment.

ANGLE INDICATOR

Spirit Level Has Dial To Give Readings in Degrees

COMBINING a conventional bubble spirit level and an angle indicator, a new device called the Anglevel quickly determines slopes, pitches and inclines with a high degree of accuracy. In addition to four spirit vials (two vertical and two horizontal) the instrument is equipped with a dial indicator which is

The dial is calibrated in degrees

calibrated in degrees and gives an instant and exact reading of the angle being measured. The tool, a product of the R-D Company, Flint, Mich., has a frame of heat-treated aluminum and is 16 inches long 3 inches wide and ¾ inch thick. The entire unit weighs approximately one and one half pounds.

SINE WAVE CLIPPER

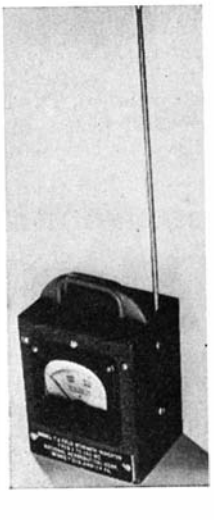
Test Signal Aids In Analysis Of Audio Distortion

A NEW sine wave clipper provides a test signal particularly useful in examining the frequency response and transients of audio circuits. Designed to be driven by an audio oscillator, the device provides a clipped sine wave. By feeding this output into the audio equipment under test, and in turn feeding the equipment's output into an oscilloscope, the servicer may quickly view and analyze distortion introduced by the amplifier. This sine wave clipper, a product of Barker and Williamson, Upper Darby, Pennsylvania, saves considerable time in engineering or repair work, since with the device the effect of making changes in the circuit may be seen instantly.

FIELD STRENGTH METER

Portable Unit Measures Output of Aircraft Radio Antennas

SIMPLE to operate, a self-contained field strength indicator is designed for instantaneous testing of the antenna output of aircraft radios. The portable unit weighs only one pound and consists of a small box and a telescoping antenna. Known as the Narco T-1, it



The portable field strength meter is completely self-contained and needs no external connections

contains a broad band untuned crystal detector coupled to an output meter measuring the relative power of transmission. It responds to all frequencies between 100 kilocycles and 150 megacycles making it possible to check antenna output on both low-frequency and VHF transmitters.

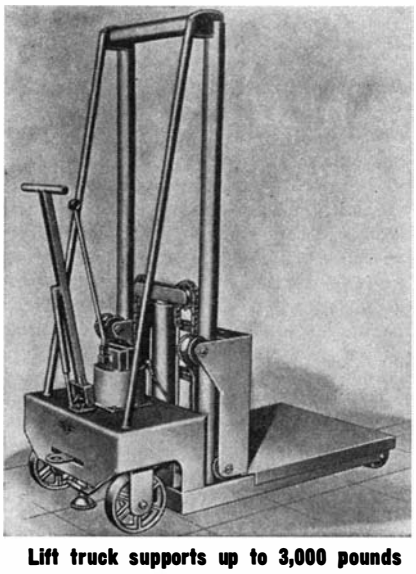
In operation, the Field Strength Indicator, manufactured by the National Aeronautical Corporation, is placed on any convenient external surface of the airplane whose transmitter is to be tested—normally on the cowling in front of the windshield so the mechanic can read output signals on the meter while operating the radio from the cockpit. The unit is particularly useful for tuning a transmitter for maximum output. The Narco test set is said to be one of the first made available which does not require batteries or an external connection of any kind.

HYDRAULIC LIFT TRUCK

Maneuverable Vehicle Eases Heavy Lifting and Stacking Operations

HAVING a capacity of 3000 pounds, a new hydraulic lift truck can simplify heavy, clumsy lifting, transporting and stacking operations. This truck, the latest addition to the line of hydraulic lift trucks produced by the Lyon-Raymond Corporation, is a mobile, easily operated unit that lifts and transports loads up to 3000 pounds. It may also be used to support heavy overhanging work and it can serve as a feeding table for heavy operations. The new truck simplifies and eases the handling and positioning of dies and other tools and fixtures, and it is a great aid in tiering skid loads and in the stacking of materials.

The forked tubular frame construction of the truck combines structural strength with light weight. Lifting power is furnished by a two-speed hydraulic hand pump which is mounted on the truck frame. A motorized pump that is powered by a ¾-horsepower motor can be furnished as optional equipment. The platform, which measures 30 by 36 inches, has a range of elevation of from six inches (lowered height) to 54 inches (maximum elevated height). The overall height of the uprights is 83 inches. The truck is equipped with two ten-inch front wheels and two five-inch rear wheels, all of which are equipped with roller bearings.



Lift truck supports up to 3,000 pounds

PACKAGED GENERATOR

Factory Assembled Unit Features Built-In Voltage Regulator

DESIGNED for use in engine-generator sets, a new packaged generator unit includes a revolving-field generator, a direct-connected exciter, an automatic voltage regulating circuit, meters and a selector switch for pre-setting the voltage. The only external connections needed for this compact, factory-assembled unit are leads to the generator switch. The built-in automatic voltage regulating circuit operates on the electrical resonance principle and has no moving parts. It requires virtually no maintenance and is designed to hold the terminal voltage to within 2 per cent of the selected voltage at any load or power factor within the generator rating.

The generator, which is a product of the Electric Machinery Manufacturing Company, Minneapolis, Minnesota, is available in standard voltages at popular 60-cycle ratings and with 0.8 power factor.

CURRENT BULLETIN BRIEFS

(The Editor will appreciate it if you will mention Scientific American when writing for any of the publications listed below.)

CARBOLOY GENERAL TOOL CATALOG GT-200 supersedes Catalog 175R and its various supplements. Among the new products shown are solid boring bars; solid carbide face mill blades; solid carbide disks, disks with holes and solid carbide strips, and many others. An outstanding feature of the catalog is the 12-page section devoted to wear-resistance applications. Small line sketches show typical applications of standard carbide tools and suggested uses for various shapes of standard carbide blanks. Presented for the first time is a full-page chart showing where to use the various grades of Carboloy cemented carbide. Although Carboloy's line of standard single point cutting tools has not been changed, the tool order numbers have been changed to conform to the standards of the Carbide Industry Standards Committee. *Carboloy Company, Inc., Detroit 32, Michigan.—Gratis. 65 pages.*

THE ROMANCE OF NICKEL. This new brochure traces the history of nickel through the ages and describes the methods by which the ore is wrested from the earth and smelted and refined into usable metal. The research surrounding these uses and how such research is being applied to the development of future applications are described. Included is a general listing of alloys using nickel and other metals, as well as chapters detailing present uses of nickel and how these uses were developed. *The International Nickel Company, 67 Wall Street, New York 5, N. Y.—Gratis. 60 pages.*

PLATING BARRELS—MERCIL TYPE. Bulletin PB 107. This catalog covers a wide range of plating barrels, from the small single-unit jewelers' apparatus to the large multiple-unit production installations. New developments include a pumping apparatus for circulating the solutions, Merlon cylinders for resistance to a variety of solutions, and the new sizes of barrels for which are given inside measurements as well as styles having outside measurements. *Hanson-Van Winkle-Munning Company, Matawan, New Jersey.—Gratis. 17 pages.*

SUCCESS WITHOUT SOIL. A practical easy-to-read manual on Hydroponics, or soilless growing, makes it clear that it is not necessary to be a highly trained chemist to grow plants successfully without soil. Outlined are instructions on how to get started, the advantages of mixing one's own formulas vs. the use of prepared formulas, and the chances of success in commercial hydroponics. *The Chapman-Gilbert Company, Inc., 830 West Ivy Street, San Diego 1, Calif.—Gratis. 16 pages.*

ALLIS-CHALMERS PRE-ENGINEERED TEXROPE DRIVES. More than two-thirds of this new indexed catalog is devoted to a systematic listing of pre-engineered Texrope drives for all applications from one to 150 horsepower. Indicated are motor speeds, ratios and driven speeds according to horsepower. Where it is possible to fulfill the requirements of a drive from stock sheaves and belts, the most economical and best drive from an engineering standpoint can be easily and quickly selected from the new catalog. New pitch diameter sizes of B and C Magic-Grip sheaves are used in many of these drives, greatly increasing stock drive selection possibilities. *Allis-Chalmers Manufacturing Company, Milwaukee 1, Wisconsin.—Gratis. 144 pages.*

RAYON MILE BY MILE . . . PERFECT INCH BY INCH. Depicts and explains the Continuous Process whereby rayon yarn is spun, washed, bleached, treated, dried and twisted as a single thread in one continuous sequence of operations. The booklet is illustrated with photos and flow charts. Textile and tire production scenes are included showing how inch by inch perfection means better production in plants using continuous process yarn and tire cord. *Industrial Rayon Corporation, 500 Fifth Avenue, New York, N. Y.—Gratis. 24 pages.*

HEATING FOR METALS. The equipment and the processes illustrated and described in this bulletin apply to every step in the processing of metals from the time the ingot solidifies until the final operation is completed on the finished piece. Covered are one-way fired soaking pits; slab and billet heaters; normalizing and annealing furnaces and covers; furnaces and atmospheres; direct-fired production heat-treat furnaces; standard rated furnaces; inspirating systems and burner equipment. The bulletin also discusses in detail the science of gas chemistry for heat treatment. *Surface Combustion Corporation, Toledo 1, Ohio.—Gratis. 31 pages.*

HOW TO RUN A LATHE. 45th edition includes changes in text and illustrations since 1944 edition. The book covers the operation of the lathe units, grinding cutter bits, making accurate measurements, plain turning, chuck work, taper turning, boring, drilling, reaming, tapping, cutting screw threads, and so forth. Included are reference tables and over 365 illustrations. *South Bend Lathe Works, 388 East Madison Street, South Bend 22, Indiana.—Paper cover copies, $.25 postpaid; leatherette cover copies, $1.00 postpaid. 128 pages.*

LASTING PROTECTION FOR METAL SURFACES. This illustrated booklet presents comprehensive data on Dum Dum, the new tough but pliable and elastic water-repellent coating that protects metal structures against deterioration due to outdoor exposure. Properites, advantages, typical uses and application directions are included. *The Arco Company, 8301 Bessemer Avenue, Cleveland 4, Ohio.—Gratis. 12 pages.*

Books

THE BOOK DEPARTMENT of Scientific American is conducted, with the cooperation of the Editors, to make available for you a comprehensive book service. Each month the Editors select and review in these columns new books in a wide range of scientific and technical fields. In addition, they are ready at all times to advise you regarding the best available books on any subject. You are invited to use this service freely. Tell our Book Department what kind of books you want and you will be furnished with the names of available books, including prices. When inquiring about books, please be specific; remember that we can be of the greatest help only when you tell us just what you are looking for. Books listed in these columns may be ordered from our Book Department. Add 25 cents per book for mailing outside U. S. All remittances are to be made in U. S. funds. Prices given are subject to change without notice.

CALCIUM AND PHOSPHORUS IN FOODS AND NUTRITION

By Henry C. Sherman

A BOOK by Sherman on any aspect of nutrition is an event, but one on the role of calcium and phosphorus possesses great significance since these two elements have received his special attention throughout a long and active life. In the present volume, the essential material on this subject (single from a nutritional viewpoint) is condensed in 115 pages. This material is amplified by a sixty-five page bibliography of selected items noted only by full titles. Every student of nutrition will necessarily include this volume in his working library and its contents in his knowledge. The treatment is rather condensed and is unlikely to interest lay readers. (176 pages, 5 by 8½ inches.) —$3.10 postpaid.—*D.H.K.*

THE HELICOPTER ADVENTURE

By Alexander Klemin

DR. KLEMIN, long a contributing editor of Scientific American, has created a truly unusual book for young boys. This is the tale of a former Naval flyer and his younger brother who together buy a helicopter and establish the "Harding Brothers Helicopter Service." There follows a series of wonderful adventures in which the boys with their helicopter rescue men from a vessel stranded off the coast of Maine; fly to the aid of a forester over a roaring forest fire; photograph the crater of the Mexican volcano, Paricutin, from the air; and find gold in the wilds of Northwest Canada. How the boys escape the dangers to win fame and fortune makes a yarn that is custom-built for the adventure loving youngster. (216 pages, 5½ by 8½ inches, illustrated.)—$2.85 postpaid.—*N.H.U.*

MIND AND BODY: PSYCHOSOMATIC MEDICINE

By Dr. Flanders Dunbar

PSYCHOSOMATIC medicine is the area in which the interaction of the mind and body is involved. When an old-fashioned doctor tells you your ill is "only in your mind" he is correct. Yet, since your mind *is* a true part of you, and since the notion that may be in it is doing actual harm, the ill is after all as much a reality as a broken leg and calls for as serious a treatment. This book mainly contains case histories of people whose minds have injured their bodies, and makes very human reading. Lacking, however in enough interpretation of each case, as if the average lay reader were a psychiatrist, the book fails in contributing a deeper understanding of the people one lives with and regards as normal. To commit an illogical bull, most of us aren't. (263 pages, 5½ by 8½ inches, unillustrated.) —$3.60 postpaid.—*A.G.I.*

CHEMICAL PROCESS PRINCIPLES
Part II—Thermodynamics

By Olaf A. Hougen and Kenneth M. Watson

PART TWO of the three part work, "Chemical Process Principles," this volume deals with the thermodynamic problems of the process industries, with emphasis on the practical methods of process design and analysis from a minimum of experimental data. New generalizations are presented for approximating thermodynamic properties from molecular structures. An advanced and comprehensive text. (804 pages, 6 by 8½ inches, with tables and graphs.) —$5.10 postpaid.—*N.H.U.*

HYDRAULIC MEASUREMENTS

By Herbert Addison
Second Edition

TEACHING hydraulics at Fuad I University, at Giza on the Nile, Egypt, Professor Addison has an unhampered perspective from which to write a handbook on the confused and contentious topic of measuring the flow of liquids. This is his second edition, with additions intended chiefly for the users of various sorts of liquid meters. The main trouble with hydraulic metering is that it is as much an art as a science, depending upon the experience and trustworthiness of the individual who does the measuring. That this factor of the personal must give way to complete objectivity becomes more and more essential as industry more and more adopts flow techniques in transmitting materials. It must do so despite the inescapable fact that most flow is turbulent. In reaching such goal this book is a useful milestone. (327 pages, 5½ by 8¾ inches, illustrated.)—$5.10 postpaid.—*M.W.*

VERTICAL FLIGHT

By Parlee C. Grose

A COLLECTION of interesting and highly readable articles on helicopters. Articles are entitled: Further Notes on the Problem of Vertical Flight; The Prime Functional Essentials of a Vertical-Flight Craft; Beedynamics; The Rotary Wing; and The Magnus-Effect Rotor Lift. (18 pages, 9½ by 12 inches, illustrated. Paper covers.)—$1.10 postpaid.—*N.H.U.*

PYROTECHNICS

By George W. Weingart

THIS second edition of Weingart's Pyrotechnics follows the pattern of the first, with some amplification. It is primarily an instruction book for the maker of fireworks of various kinds and it emphasizes the types of material that form the principal pieces of fireworks exhibitions. The instructions and recipes given are practical and to the point, but they are clearly intended for the professional and are not the kind of thing one would expect to do for pastime. The obvious dangers inherent in the handling of explosive and highly flammable materials require that these be kept out of the hands of the unqualified and the careless. Although the author emphasizes safety precautions, he is clearly not writing for the idly curious or the amateur, who are likely to endanger themselves as well as others if they undertake such matters. Military aspects of the subject are suppressed to give emphasis to decorative and amusing fireworks. (244 pages. 5½ by 8½ inches, illustrated.)—$7.10 postpaid.—*D.H.K.*

EARLY WORK OF WILLARD GIBBS IN APPLIED MECHANICS

Assembled by L. P. Wheeler, E. O. Waters and S. W. Dudley

THE FOUNDATION of modern physical chemistry and the great impetus to thermodynamics was Josiah Willard Gibbs' treatise *On the Equilibrium of Heterogeneous Substances.* That Gibbs (1839-1903) climbed to that apex of mathematical thinking from his early studies in applied mechanics is scarcely known. Indeed, his Ph.D. thesis is published for the first time in this small book. Its title: "On the Form of the Teeth of Wheels in Spur Gearing." While he was still a tutor at Yale he was granted (1866) a patent on an improved car break. His patent attorney was Munn & Co., publishers of the SCIENTIFIC

The Editors Recommend

Best Sellers in Science and Technology

PHOTOGRAPHIC GIANTS OF PALOMAR — By *J. S. Fassero and R. W. Porter.* Twenty full-page drawings of the 200-inch telescope by Porter showing the big telescope and such details as observers coop, the 36- by 51 inch elliptical coude mirror and its crane and R.A. drive and computer. Also eight full-page astronomical photos. Detailed explanations face each illustration. **$1.60**

GUIDE TO THE LITERATURE OF MATHEMATICS AND PHYSICS — *By Nathan Greer Parke III.* A guide for self-directed education in both mathematics and physics. The major part is a classified list of books in each sub-class of both subjects and in related engineering subjects **$5.10**

HIGH FREQUENCY INDUCTION HEATING — *By Frank W. Curtis.* Answers many questions concerning induction heating and its utility in industrial processes. Thoroughly practical in scope. **$3.10**

MUSICAL ACOUSTICS — *By Charles Culver.* Textbook for college students majoring in music. It is essentially physics throughout. Covers all important phases of acoustics of music. **$3.10**

PLASTICS — *By J. H. DuBois.* Third edition, again revised and enlarged, with two four-color plates. This is an important book on the whole general subject of plastics, plus much brand new material on synthetic rubber, manufacturing processes, and plastics moldings. **$5.10**

NORTON'S STAR ATLAS AND TELESCOPIC HANDBOOK — *By Norton and Inglis.* Tenth edition of a standard work, with main charts redrawn for epoch of 1950. Standby for amateurs past the cradle roll. **$5.35**

THE MEANING OF RELATIVITY — *By Albert Einstein.* Second edition with added chapter describing advances since publication of first edition some 25 years ago. Requires knowledge of advanced mathematics and physics; not a popular exposition. **$2.10**

THE SCIENTISTS SPEAK — *Edited by Warren Weaver.* A review of recent advances in all of the sciences and a wide-ranging discussion of the meaning of science in the modern world. This book brings together the 79 "science talks" by 81 distinguished scientists which were broadcast at the intermission of the New York Philharmonic Symphony Sunday afternoon concerts in the 1945-46 and 1946-47 seasons. **$3.85**

RAW MATERIALS FROM THE SEA — *By E. F. Armstrong and L. M. Miall.* The potential value of the ocean as a source of minerals is surveyed and several important industries employing sea water as a raw material are described in some detail **$3.85**

SOILLESS GROWTH OF PLANTS — *By Carleton Ellis and M. W. Swaney. Second edition revised and enlarged by Tom Eastwood.* A practical "how-to-do-it" book for those who want to make money out of soilless farming. **$4.85**

MACHINERY'S HANDBOOK — *13th Edition.* "Bible of the mechanical industry." 1911 pages of latest standards, data and information required daily in shop and drafting room. **$7.10**

PROCEDURES IN EXPERIMENTAL PHYSICS — *By John Strong, Ph.D.* A wealth of useful data of a practical kind for the constructor, experimenter and skilled craftsman. **$7.45**

EXPERIMENTAL SPECTROSCOPY — *By Ralph A. Sawyer.* Covers theory and types of spectroscopes and spectographs, mounting and use of gratings, determination of wavelengths, infra-red spectroscopy, spectrochemical analysis and so on. Somewhat elementary, but requires knowledge of physics and some physical optics. **$5.10**

TIME, KNOWLEDGE, AND THE NEBULAE — *By Martin Johnson.* Discourse on physical notions of time and limitations of profitable contact between physics and philosophy, analysis of Lorenz-Einstein interlocking of time and space observations, and similar physical aspects of time. **$2.85**

HEAT PUMPS — *By Sporn Ambrose and Baumeister.* Presents the basic facts on the design, operation, installation and maintenance of heat pumps for either heating or cooling in domestic and industrial applications. **$3.85**

PRINCIPLES OF PHYSICS, VOL. III—OPTICS — *By Francis Weston Sears.* One of the most modern works on physical optics available today. At college level, it covers the subject with emphasis on physical principles rather than practical applications. **$5.10**

IF YOU MUST GAMBLE—*By Maurice Lenihan.* Statistical safety, as practiced by insurance companies, applied to bridge, dice, roulette, horses and so on. No guarantee of successful "systems" but sound advice lightly handled. **$2.10**

LUMBER — Manufacture, Conditioning, Grading, Distribution and Use — *By Nelson C. Brown.* A complete analysis of manufacturing techniques, conditioning, grading and so on, with stress on efficient and economical production. **$4.35**

FUNDAMENTALS OF OPTICAL ENGINEERING — *By Donald H. Jacobs.* This work starts with the fundamentals and is mainly non-mathematical. It is probably the best suited of all existing books as an introduction to optical design. Author is a physicist at Bureau of Standards. **$5.60**

THE HOME FREEZER HANDBOOK—*By Gerald J. Stout.* Detailed instructions for building and operating home free ers, large and small, that are low in first cost and economical to run. Section on preparation of foods for freezing. **$4.10**

YOUR HOME AND HOW TO BUILD IT YOURSELF — *By Wayne C. Leckey.* A comprehensive volume covering the entire process of house building from the preliminary layout through excavation and masonry to framing, sheathing, plumbing, wiring and the thousand and one little details that go into house construction. **$3.10**

AN OIL BURNER HANDBOOK—*By L. J. Whelan.* How oil burners work, how to get the greatest efficiency from them, how to conserve fuel and what to do about troubles, are all told here in simple, understandable language—for home owners or technicians. **$2.50**

(The above prices are postpaid in the United States. Add, on foreign orders, 25¢ for postage on each book, except as noted. All prices subject to change without notice. Books listed are offered for retail sale only, not to the trade.)

For Sale by: **March, 1948**

SCIENTIFIC AMERICAN, 24 West 40th Street, New York 18, N. Y.

I enclose $..... for which please forward at once the following books:

Book .....**Author** .....

Book .....**Author** .....

Name .....

Address .....

Write us for information on books of any subject. We can supply any book in print

AMERICAN. He also designed a governor for steam engines. But, according to Dr. Wheeler, one of the three compilers of this memorial, Gibbs lacked the money and time to exploit the device. (78 pages, 6¼ by 9½ inches, three illustrations.)—$3.10 postpaid.—*M.W.*

FLYING MINUTE MEN

By Robert E. Neprud

PEOPLE smiled at the Civil Air Patrol uniform with its curious red tabs, and thought its pronouncements flamboyant. If such people on the basis of these two minor elements thought the war work of CAP to be of little value, they were wrong. The CAP grew into a voluntary, yet well disciplined army of 100,000 civilians who, with little put-puts or Cubs, patroled our borders, discovered submarines, rescued airmen at sea and in many other ways made history and a name for themselves. Mr. Neprud has succeeded in setting down an accurate historic record and writing a fine, stirring, human story that will appeal to every American whether or not his interests lie primarily in aviation. (243 pages, illustrated with cartoons by Jack Mosley and photographs.)—$3.10 postpaid.—*A.K.*

THE WATER-SOLUBLE GUMS

By C. L. Mantell

SINCE Biblical times great numbers of the water-soluble gums of trees and sea weeds have been important articles of commerce, and like many other ancient arts, this one is far ahead of its scientific treatment and explanation. Dr. Mantell has assembled in a single volume a great mass of information about the sources, preparation, characteristics and uses of these valuable and ancient materials. The breadth of the field is surprising to one accustomed to think of the water-insoluble resins as the principal products of plants. The broad uses of gum arabic are extended by such important commercial products as agar-agar, karaya, ghatti and the various lichen gums. The result is that the subject matter of this book goes into many diverse and apparently unrelated industrial fields: paper, cosmetics and foodstuffs, for instance. A valuable compendium. for instance. A valuable compendium.—(279 pages, 6 by 9 inches, illustrated.) —$6.10 postpaid.—*D.H.K.*

HIGH VACUA

By Swami Jnanananda

A NEW BOOK in this restricted field is an event. This one covers kinetic gas theory in high-vac work (74 pages); pumps, all types (78 pages); measurement of pressures nearly all types of gages (92 pages); high vac technique (28 pages); preparatory work (13 pages); physical chemical methods (13 pages). Written for other physicists—the author being at the University of Michigan—this book does not take the non-physicist by the hand and baby him through the difficult art. Yet anyone attempting high vacuum work will be many times its value behind the game.

WANTED...

Men who want Higher Salaries!

Recent Survey Shows That Less Than 3% of U.S. Families Have Annual Incomes of $7,500 and Over*

Year after year, good jobs seek good men! Today is no exception, as the statistics in this message prove. (And these figures cover total income, not merely salaries.)

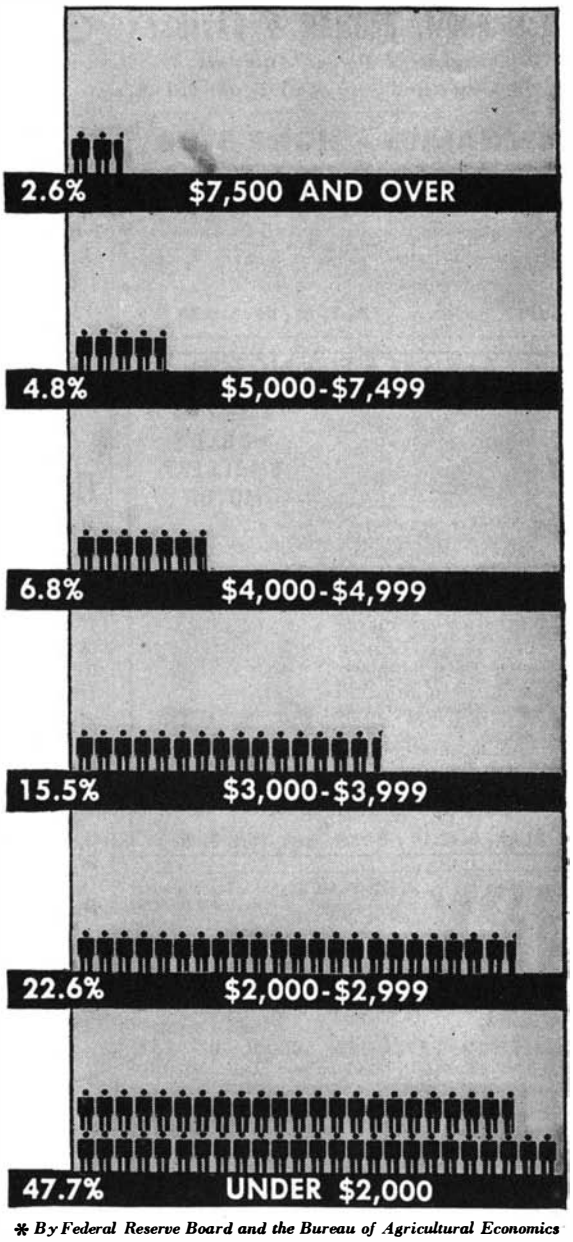
The greatest opportunities in business are at the high income level for this simple reason: Top-flight positions demand men who have a thorough and broad understanding of business fundamentals. Executives must know the inner workings of the entire business structure —Production, Marketing, Accounting and Finance.

It is not enough to be an expert in one or two departments; the demand is for "all around" men with a sound knowledge of underlying principles. They, alone, are able to shoulder the responsibilities of important administrative jobs.

How to Reach the Top

The Alexander Hamilton Institute was founded in 1909 to help fill the unending need for executive talent. Since that time, more than 430,000 men have availed themselves of Institute training in their spare time. Today, many are among the foremost executives in this country and Canada.

The Institute's Modern Business Course and Service covers all four basic departments of business. It is a systematic, time-saving method of bringing to any man's home or office the understanding of business principles which he needs, but which he cannot acquire through his own experience within a reasonable time.



* *By Federal Reserve Board and the Bureau of Agricultural Economics*

Send for Descriptive Booklet

The Institute's Executive Training program is fully described in its stimulating 64-page book, "Forging Ahead in Business." If you are on the outlook for a better understanding of business principles so that you may advance yourself and increase your income, "Forging Ahead in Business" will prove a real source of help to you. A copy is offered, free and without obligation, to anyone who is interested. Simply return the coupon, and it will be mailed to you promptly.

ALEXANDER HAMILTON INSTITUTE
Dept. 35, 71 West 23rd Street New York 10, N. Y.
In Canada: 54 Wellington St., W., Toronto 1, Ont.

ALEXANDER HAMILTON INSTITUTE
Dept. 35, 71 West 23rd Street, New York 10, N. Y.
In Canada: 54 Wellington Street, West, Toronto 1, Ont.
Please mail me, without cost, a copy of the 64-page book— "FORGING AHEAD IN BUSINESS."

Name.....
Firm Name.....
Business Address.....
Position.....
Home Address.....

if he does without its help, even though it is no more than 98 per cent up to date. The data are compact, systematically organized and the author's name as given is *not* a misprint. (310 pages. 5½ by 8½ inches, 134 illustrations).—$5.60 postpaid.—*A.G.I.*

FLAMEPROOFING TEXTILE FABRICS

Edited by Robert W. Little

ONE OF the American Chemical Society's Monograph Series, this book contains contributions from some 17 men, all of whom were actively engaged in wartime research on the flameproofing of textiles. The book is divided into three parts—Fundamentals, Methods and Applications—and contains the result of the three years of research by the contributors. An excellent work, but one obviously designed for professional readership. (410 pages, 6½ by 9¼ inches, illustrated.)—$6.85 postpaid.—*N.H.U.*

APPLIED ARCHITECTURAL ACOUSTICS

By Michael Rettinger

BASED on geometrical rather than physical (wave) acoustics, this is a thoroughly practical handbook specifying the best size and shape for sound studios and motion picture theaters, together with data for insulative, absorptive and reflective materials and construction to reach the best acoustices in such enclosures. The author, a Hollywood engineer for the Radio Corporation of America, includes stimulating advice for maintaining good acoustics in churches and other large rooms, and for quieting noises in hospitals. (189 pages, 5¾ by 8¾ inches, charts and illustrations.)—$5.60 postpaid.—*M.W.*

FUNGI

By Wolf and Wolf

READERS searching for the right book on fungi should study the following wording closely. This is not your book if you are looking for a fieldbook on how to know the mushrooms from the toadstools; or how to identify fungi on the run; or for lively, entertaining reading; or for any kind of popular treatment. It may be your book if you have worked your way through books like the above and want something more solid, a textbook and reference for those who have already studied it (a poor reference for those who merely pick it up); if you don't seek the charm of nature writing; and if you want to be as nearly professional a mycologist as an amateur can be. For such it is a meaty work deserving of much respect. The illustrations are scientific, not decorative. (Two volumes, 438 plus 538 pages, 5½ by 8½ inches, 235 illustrations).—$12.70 postpaid.—*A.G.I.*

PLANTS AND ENVIRONMENT

By R. F. Daubenmire

SERIOUS, studious readers willing to dig will get from this (or any) textbook of autecology (study of interrelations between plants and environment, subdivision of ecology) an appreciation of plant life utterly incomprehensible to a person not thus trained. Autecology is a study of those phases of geology, soils, climatology, zoology, chemistry, and physics relating to plant welfare. This is a young science making rapid headway today, though relatively few are aware it exists or of its deeply significant content. (424 pages, 5½ by 8¼ inches, 87 illustrations.)—$4.60 postpaid.—*A.G.I.*

YALE SCIENCE THE FIRST HUNDRED YEARS 1701-1801

By Louis W. McKeehan

YALE University is celebrating the centennial of its Sheffield Scientific School. This led Professor McKeehan to look into the teaching of science during Yale's own first hundred years. There was mighty little, and what there was was in the beginning merely by-play to the theological studies for which Yale was founded. As an epitome of how mankind's propensity to talk slowly gives way to skill in observation, this little book is a pleasant pocket piece. (82 pages, 5 by 7½ inches, two facsimiles.)—$2.60 postpaid.—*M.W.*

ELEMENTARY NUCLEAR THEORY

By H. A. Bethe

SELECTION of topics within the theory of atomic nuclei, treated in an elementary way—for physicists. Many others probably would not find it anything like elementary. Emphasis is on nuclear forces, the central problem of nuclear physics, and on beta disintegration. Author is a member of the Los Alamos Staff and professor of physics at Cornell. (147 pages, 5½ by 8¼ inches, 17 illustrations.)—$2.60 postpaid.—*A.G.I.*

ACHIEVEMENTS IN OPTICS

By A. Bouwers

NOW IT comes out that in Nazi-dominated Holland the author early in the war invented and with Dutch official connivance secretly patented a variety of telescope systems practically the same as those Maksutov published in 1944. A non-concentric system, a concentric system, a corrected concentric system, a mirror microscope, an improved Cassegrainian, a remarkable binocular, a very fast camera, a television projector, other uncommon things. On the basis of the evidence in this little book, the first 65 pages of which describe these things up to a point, some think the Maksutov telescope should now be called the Bouwers or Bouwers—Maksutov. Advanced amateur telescope makers will find the evidence of interest; beginners may flounder a little. Remainder of book pertains to diffraction and aberration researches of less interest to telescope makers. (135 pages, 5¾ by 6¼ inches, 64 illustrations, paper covers).—$2.60 postpaid.—*A.G.I.*

Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

Editor of the Scientific American Books "Amateur Telescope Making" and "Amateur Telescope Making—Advanced"

IMAGINE yourself high aloft in the small round prime focus cage of the 200" telescope privileged to be present at the final climax of 20 years' effort when the mirror was given its first tests with a knife-edge and eyepiece in its mounting. Imagine the suspense! An air letter from Russell W. Porter:

"I'm just off Palomar Mountain and have had a look at the 200" mirror at the prime focus with a knife-edge, using a 9th magnitude zenith star as light source, a sight never to be forgotten. Its image was so bright and appeared so real that one felt he could take it with his fingers and feel it.

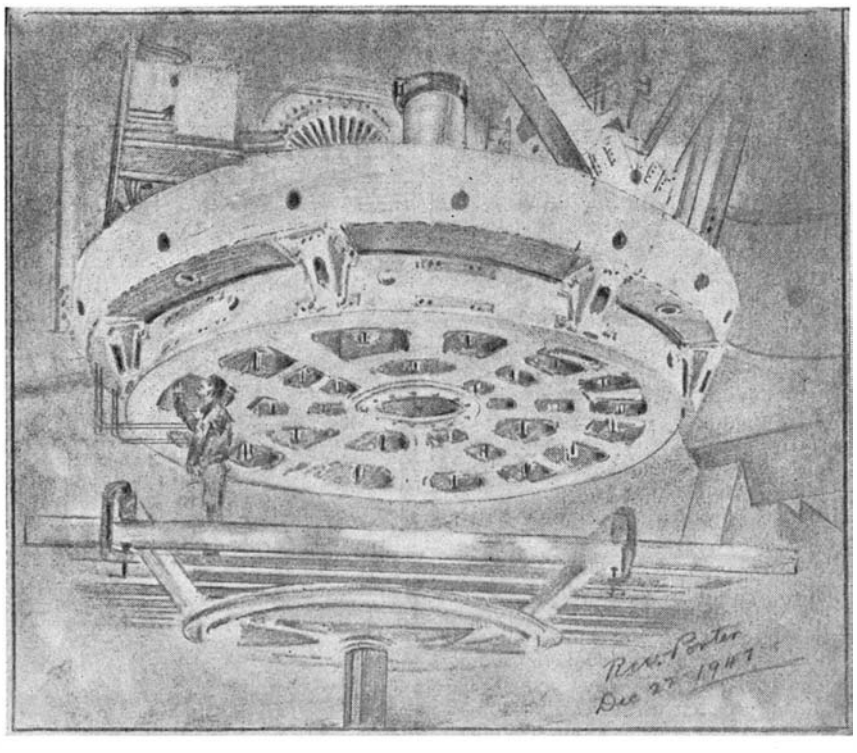
"This was the first time I had ever seen the Foucault shadows from a large mirror with light coming through our atmosphere from a star. The seeing was about 2 on a scale of 5 (so Humason estimated) and showed up remarkably the turbulence of our atmosphere. I would liken the appearance, when the star's light was about half cut off by the knife-edge, to reeds or eel grass in a rapidly flowing river, weaving back and forth in the stream. This shredded appearance of the atmosphere was thought by Dr. Anderson to have its origin about two miles up.

"Later in the night the seeing improved. *The Foucault shadow darkened uniformly all over the mirror with the cut-off from any direction.*

"With an eyepiece the image widened, inside and outside focus, in perfect circles.

"All the men who understand mirror testing—Bowen, Anderson, Hubble, Brown—were highly elated at the mirror's figure.

"The sketch I enclose was made the second day and shows the lower end of the telescope tube, looking up under the cell that supports the mirror. In the many openings at the bottom of the cell may be seen traces of the supporting levers. It was below freezing and this drawing was made in a hurry. After about an hour my hands got so cold I couldn't hold my pencil—poor ol' arctic explorer."



To telescope makers these results sing! Interpreted for others they mean:

As the mirror maker works he stops often to test, throwing on his mirror the light from a tiny illuminated pinhole in a distant screen (artificial star). The rays return to his eye and are examined (1) with a telescope eyepiece (low-power microscope) inside and outside focus (2) with the eye by skillfully cutting them with a knife-edge. The first gives qualitative overall tests, the second highly precise

quantitative tests of all areas. Finally the mirror is similarly tested in its telescope on an actual star. "Perfect circles" and "darkening uniformly" mean success. Astronomers celebrate with expansive grins.

Later information: The mirror tests satisfactorily in all positions.

UNCOMMON optical grinding and polishing materials is the subject of the following discussion by John M. Holeman, 305 Thayer Drive, Richland, Wash., continued from last month.

At present, the "Diamond Dust" sold by lapidary supply houses costs $2 a carat, but one carat is enough for quite a few experiments. This material is a by-product of the diamond cutting business and can be seen under the microscope to consist of white flakes of all sizes from powder to fairly large pieces. This is the cheapest way to buy diamond but, naturally, such a mixture cuts and polishes at the same time and leaves the work more or less scratched. To get the fastest cutting or to produce a smooth surface it is necessary to have the abrasive graded into at least coarse, medium, and polishing sizes.

In grading diamonds the larger pieces are broken up in an Abich mortar. These can be obtained from scientific supply stores or easily made after an illustration such as the one in Orford's "Lens Work for Amateurs." The reduced material is then levigated in the usual manner, except that oil is used instead of water. Of course it is impracticable to levigate a small amount, also the presence of the oil makes the whole thing very messy. Diamond dust is perhaps easier to buy prepared than to make. The Elgin National Watch Co., Aurora, Illinois, sell well-graded material mixed in a jelly for easy handling. Needless to say, the finer grades, which are comparable to rouge in particle size, are more expensive but will put a beautiful polish on diamonds, quartz, glass, Stellite, Carboloy, or almost any hard substance.

The following method was used for rapidly making several 1" diameter lenses from a very hard substance. By the process described it takes about two hours' total time to shape and polish one side of a lens having hardness 9.

First, however, before starting to use diamond the optical worker should be warned of diamond poisoning. If a single flake of this very hard material lands on a smoothing tool or metal lap, the tool will probably have to be remade or thrown away. Unlike softer abrasives it seems never to break down on glass and will continue to scratch as long as the tool is used. Diamond dust on machines and shelves will do wonders in wearing and scratching. Once anything is contaminated with it, it seems impossible to get rid of it. For this reason diamond dust is always kept wet with oil to reduce its tendency to fly about. With proper care it can be used like any other material but carelessness may result in a situation so bad that the easiest thing you can do is to abandon your shop.

To make the lens mentioned above a concave lap of the proper radius is

cut in soft annealed copper. The lap is then mounted on the spindle and, while slowly rotating, a few drops of olive oil containing a few grains of diamond dust (lapidary grade) are applied with a stick. The diamond powder is then rolled into the surface of the lap with a specially made tool consisting of a handle with a forked extension between whose tines is mounted at right angles a barrel-shaped roller about ½" long and 3/16" in diameter turned out of a drill rod. This is drilled axially with a 1/16" hole for its bearing in the implement. It is then polished, hardened as hard as possible, and repolished with crocus paper. The convexity of the barrel-shaped surface of the roller should be slightly greater than that of the lap, so that the barrel will roll on only a small area. The completed roller should turn freely on its axle and have a polished surface.

When the roller is first applied to the rotating lap it can be felt to roll over the gritty diamonds, but as it is worked all over the surface several times the abrasive sinks in and the rolling action becomes smooth. With a lap of the size described this should take only a minute. The amount of pressure to be used on the roller is difficult to specify. It should be great enough to embed the abrasive but not great enough to deform the lap.

Once the lap is charged it should cut for a long time without any attention. Whenever it seems to be dull it can be recharged in the same manner.

The lens to be shaped is fastened to a handle, pressed against the rapidly rotating charged lap, and worked with the customary motions. For this small size the lap speed can be several r.p.m. The lap must be kept lubricated at all times with oil, preferably olive oil, applied a drop at a time with a stick. It is important that the pressure used on the work be correct, but a feeling for this soon comes naturally. If the pressure is too light the work will skate over the lap with no abrasive action, but if it is too great the abrasive particles will be dug out of the lap and it will need to be recharged.

The lenses that were shaped by the above processes were semi-polished but remained covered with fine scratches from the unsorted diamond material used. These scratches were removed with fine emery on a brass lap. Polishing was then done in the usual manner. If finer grades of diamond had been available, fine grinding and polishing could have been accomplished using additional identically curved laps. It is not feasible to change grit on the same lap, as is done with Carbo, because with this type of charged lap the abrasive remains embedded in the metal.

Rouge: It is generally conceded that no substance puts a better polish on glass than plain red iron oxide rouge. There is, however, considerable variety in the quality of rouges, also several means for refining it when the need arises. Some workers remove the larger particles with a bruiser, working a thin red paste between two glass plates and forcing the big grains to the edge

where they are broken down and lost. Others levigate rouge with dispersing agents and flocculate the suspended material as was described by Parsons in the wartime Roof Prism Program letters. Almost everyone who does careful work washes rouge in some way, even if only to stir it up with water and pour off for use the part that doesn't settle in a given length of time.

Rouge may be used to polish almost any material except metals, many of which are stained by it.

Cerium Oxide: Long in use in France, this material came into widespread popularity during the late war. Pale pink and much cleaner to handle than rouge, it does not "stain" glass and it polishes much faster—some say two to three time faster. In 1947 cerium oxide cost $2.75 a pound in small quantities, which makes it a good deal more expensive than rouge, but the quantity an amateur would use makes the difference inconsequential. Some mirror-making kits now contain this new abrasive and it is preferred by many hand workers because of its greater speed, though they may go back to rouge for figuring because the latter is easier to control.

Barnesite: During the war this mixture of rare earth oxides was used by many large plants. It contains a large percentage of cerium oxide and has many of the same properties. Most samples are dark brown and have a peculiar soft feel. It is claimed that Barnesite polishes almost as fast as cerium and produces as good a surface as rouge. Further, it absorbs water, does not dry out rapidly, and needs less attention on the machine. At present the cost is less than that of cerium.

Putty Powder: This is the lapidary's name for tin oxide, the white, powdery material that Newton used for polishing his metal mirrors. It is also used for polishing petrified wood and agate specimens and is still the best polishing agent for many metals—Stellite, for example, being polished on a beeswax-coated pitch lap with tin oxide. Due to the shortage of tin, putty powder has been hard to get for some time.

Titanium Oxide: So far as I know, no one else uses this substance, which is generally classed as a paint pigment. The duPont grade Ti-Pure R-200 (available only in 50-pound bags) is pure white, easily dispersed, and extremely fine. It does not stain most metals, will polish glass, quartz, and harder gems, and has no peer for polishing plastics.

Finally: Some metals are very difficult to polish and in desperation such unorthodox stuff as lampblack has been successfully used. If you have a grinding or polishing problem you may be forced to discover something new. This list makes no attempt to include even all the commercially available possibilities.

End of article by Holeman. A note on Barnesite, crowded out by the happy report on the 200", will appear later.