CHEMISTRY'S INEXHAUSTIBLE STOREHOUSE . . . Page 196

SCIENTIFIC AMERICAN

MAY • 1943

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A Plastic From Coal for Safety Glass . . . See page 193

Wanted: MORE EXECUTIVES!

To help win the war!...and the peace to follow!

Every great crisis produces new leaders. This war is no exception. It has created as great a crisis for business as for our nation, and new leaders are rising to the top every day.

Right now, companies are searching high and low for men of executive ability and training to manage the different departments in new and expanded plants. The war and its demands for production, and *more* production, has thinned the ranks of executives to the danger point. The country needs men of executive ability just as it needs production workers and men for the armed forces.

Where will it find them? Ordinarily there would be enough "officer material" right in the ranks . . . men who had been learning by experience, slowly but steadily advancing in the companies which employed them. That is one way of doing it—the hard way, the slow way. But now time is pressing. Such men are needed not two years from now, but *today* and *tomorrow!* Where will they come from? Those men will have to be trained, *and the smart ones will train themselves—now!*

How can they do that? Through the Alexander Hamilton Institute's intensive Course of Executive Training.

This executive training, which is described in a book called "FORGING AHEAD IN BUSINESS," can help you to accomplish in months what would otherwise take years—if you could get it at all. It is valuable to men in different lines of business because it covers the fundamentals of *all* business—production, marketing, finance and accounting. It is equally effective for the college graduate or the business man who only finished grammar school.

More than 400,000 men have enrolled for this training and every day reports come in of their promotions, salary increases, new and better positions. Many of these men have become so famous that you will recognize their names instantly when you see them in this booklet.

Send for "FORGING AHEAD IN BUSINESS"

The facts about this executive training are given in the book "FORGING AHEAD IN BUSINESS." This 64-page book has inspired thousands of men. Many say it started them on the road to real business success.

A word of warning. If you are *not* interested in executive training, don't send for this book. But if you *are* interested in this way to better your position and increase your earning power, then we want you to have a copy of "FORGING AHEAD IN BUSINESS" with our compliments. Simply fill in and mail the coupon, and the book will reach you by return mail.

SEND FOR THIS FAMOUS BOOK TODAY

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73 West 23rd Street, New York, N. Y.

Please mail me without cost a copy of the 64-page book—"FORGING AHEAD IN BUSINESS."

Name ....

Business Address ....

....

Position ....

Home Address ....

ONE of the long list of products derived in part from coal is "Butacite" polyvinyl acetal resin, used as an interlayer in laminated safety glass, shown here as a continuous sheet passing through an air-cooling process. The story of coal as an industrial raw material is told on page 196.

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SCIENTIFIC AMERICAN

Owned and published by Munn & Company, Inc., Orson D. Munn, President; I. Sheldon Tilney, Vice-President; John P. Davis, Secretary-Treasurer; all at 24 West 40th Street, New York, N. Y.

NINETY-NINTH YEAR — **ORSON D. MUNN, Editor**

MAY • 1943

SCIENTIFIC AMERICAN, May, 1943. Vol. 168, No. 5. Entered at the New York, New York, Post Office as second class matter June 28, 1879, under the act of March 3, 1879, additional entry at Orange, Connecticut. Published monthly by Munn & Co., Inc., 24 West 40th Street, New York City.

Subscription rate $4.00 per year. Canada and foreign $5.00

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed From Issues of May, 1893)

WIRELESS—"The Edison method of telegraphing from moving trains is probably the best known practical application of electrical oscillations in air to commercial practice. Bett's method of telegraphing between ships at sea . . . depends upon the transmissibility of electrical oscillations through water. Although these methods are far from perfect, the end seems not distant, and we can confidently expect that in the near future we will be able to telegraph on land and sea without wires with great ease by means of electrical oscillations."

ANIMAL SOUNDS—"An organist says that a cow moos in a perfect fifth octave, or tenth; a dog barks in fifth or fourth; a donkey brays in a perfect octave; and a horse neighs in a descent on the chromatic scale."

SHOCKING—"A dynamo attachment for a rocking chair, designed to send a mild current of electricity through a person sitting in the chair, such current being generated by the motion of rocking . . . has been patented . . . The dynamo is connected by wires with electrodes on the arms of the chair, or with hand pieces, which may be held by one desirous of receiving the current, or with metal foot rests, so that one may by either means receive a mild current of electricity. The dynamo, which may be of any usual type, is fastened on the under side of the chair seat . . . and is driven by a belt from a shaft journaled in hangers on the chair bottom, the shaft being operated by a belt from one end of a lever . . . The lever is pivoted . . . and its rear end is a caster or roller which runs upon the floor."

PHONES CHANGE—"The Bell Telephone Instrument patent expires and becomes public property in 1894. The Bell receiver is in some respects a superior transmitting instrument, so the *Electrical World* says, to any of those especially designed for the purpose, in that it introduces no local disturbances, such as are inseparable from variable contacts."

SPECTRUM—"From experiments recently performed in electrical oscillations, the conclusion that light and electrical oscillations are identical is very strongly substantiated. The principal parts in which they practically agree are the velocity, rectillinear propagation, laws of reflection, interference, refraction, polarization and absorption by material substances. In fact, the sole certain difference appears to be the wave length."

RAIL SPEED—"The New York Central engine No. 999 . . . drawing a regular train of cars on the track of the New York Central road has surpassed the speed of any object propelled by man short of a projectile. The speed of the wind in the most powerful gales has been equaled, and the flight of the swiftest bird through the air has been surpassed. The mile record for a locomotive engine on Tuesday, May 9, was reduced by it to 35 seconds . . . On May 10, between the cities of Batavia and Buffalo, a new speed test was made. Batavia was passed at a speed of sixty miles an hour. This was increased until a mile was run in thirty-five seconds, and soon after a mile was made in thirty-two seconds."

TALKIES—"Edison's Kinetograph in its complete form consists of an optical lantern, a mechanical device by which a moving image is projected on the screen simultaneously with the production by a phonograph of the words or songs which accompany the movements pictured. For example, the photograph of a prima donna would be shown on the screen, with the movements of the lips, the head, and the body, together with the changes of facial expression, while the phonograph would produce the song . . . In the picture as exhibited in the Kinetograph, every movement appeared perfectly smooth and natural."

COLUMBUS—"The cost of discovering America by Columbus, says Prof. Ruge, in the *Globus,* was 1,140,000 maravedis, or about $7,296 of our money . . . Of the sum named, Columbus received an annual salary of $320, and the two captains each $192 per year. Each sailor, in addition to his subsistence, received $2.45 per month, or one ducat."

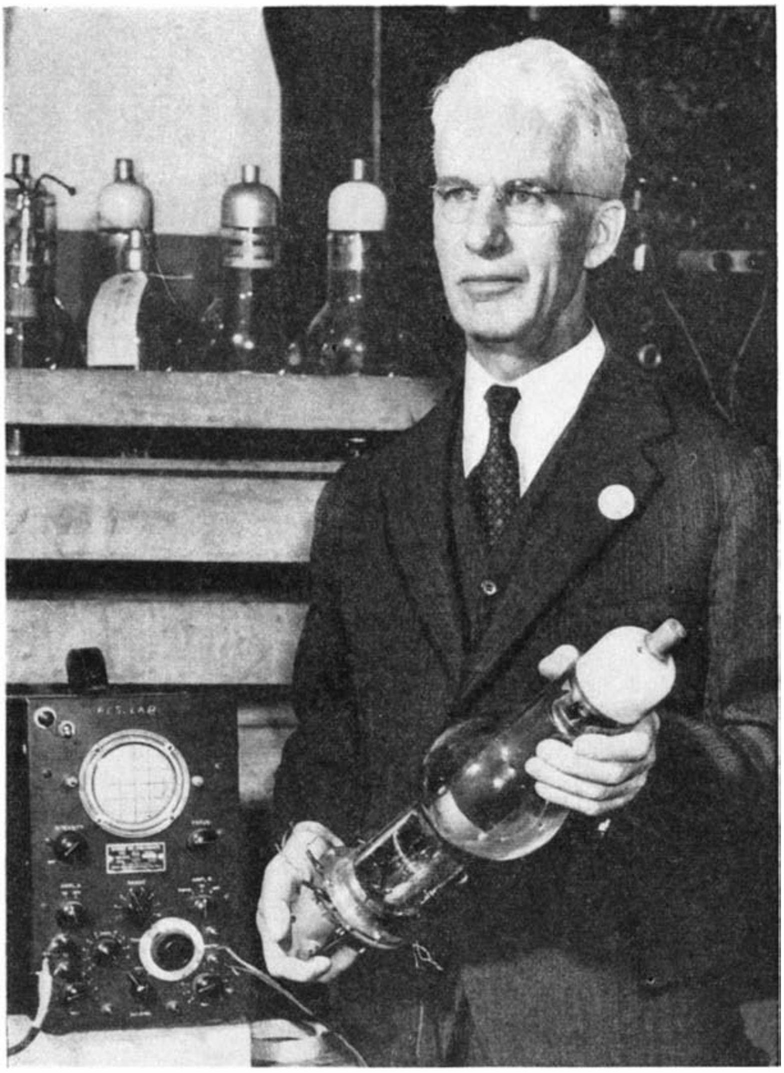
CATHODE-RAY TUBE—"Hertz has shown that the rays which proceed from the cathode of a Geissler tube, and are capable of exciting phosphorescence, will permeate thin metal . . . This idea has been realized by Dr. Lenard by means of an ingeniously arranged apparatus and a hammered aluminum plate 0.003 millimeter thick. This plate forms in the apparatus in question a shutter which Dr. Lenard calls the 'window,' because while quite impermeable to air and light, it allows the rays from a cathode at a distance of 12 centimeters to penetrate it freely . . . Substances capable of phosphorescence, if held near the 'window,' shine with their peculiar light on the side nearest to it. All the phenomena of phosphorescence cease if a magnet is so applied to the discharge tube as to repel the cathode rays from the inner side of the 'window.' The atmosphere is a dull medium for the cathode rays to penetrate."

FROZEN MUTTON—"Some idea of the gigantic proportions which the Australian frozen mutton industry has attained may be gathered from the fact that one of the establishments alone, the Australian Chilling and Freezing Works, at Aberdeen, on the Great Northern Railway, 162 miles from Sydney and some 87 miles beyond Newcastle, can freeze 850 and chill 1,500 sheep daily. The vessel load at Newcastle, a special train conveying the mutton to that port, where as many as 6,000 sheep have been loaded in one day. The steamers carry their cargoes to England. The vessels are provided with refrigerating machinery and deliver their cargoes in frozen condition."

BARRELS—"The manufacture has been commenced, at Barrow, of steel barrels for the carriage of petroleum in the place of wooden casks. The barrels are made in halves by means of dies and compression while the thin plates of steel are hot. These halves are welded together by means of electricity."

LIQUID AIR—"The essential difference between a liquid and a gas of identical composition is illustrated by the behavior of atmospheric air. Air liquefies as a whole with the usual proportions of oxygen and nitrogen. But when liquid air is allowed to boil the nitrogen distills off first, showing no appreciable admixture of oxygen until half the liquid has evaporated. Liquid air behaves in the magnetic field and in the spectroscope like dilute oxygen and the color is simply a more watery blue."

Personalities in Science



DR. ALBERT W. HULL

SINCE this has very properly been called "a physicists' war," the President of the American Physical Society occupies a position even more important than usual. Dr. Albert W. Hull, who has recently been elected to that post, is right in the front line of the scientific war. Indeed, the reason this is a physicists' war is principally because of the variety of electronic tubes that are being used for a host of important, though secret, applications; and the development of new types of tubes has been Dr. Hull's major work.

A real Connecticut Yankee, he was born in Southington, Conn., on April 19, 1880. He was the second oldest of eight boys, all of whom are still living and healthy. Science seems to have held an appeal for the family, for five chose technical careers: physics, bacteriology, metallurgy, forestry, and engineering. All five went to Yale.

As an undergraduate at Yale, Hull majored in Greek, taking prizes in Greek and mathematics, and worked with a carpenter gang during vacations. He now looks upon this summer experience as one of his assets, and incidentally profited by it when he built his own summer camp at Sacandaga Lake. Graduating in 1905, he spent the summer in Germany and returned to teach French and German at the Albany Academy.

With ths diverse background he finally chose physics for a profession, and has never regretted it. Perhaps this experience accounts for the advice which he invariably gives young men, that it is more important to find the right job than to get a high salary. Receiving his Ph.D. degree from Yale in 1909, he first taught four years at Worcester Polytechnic Institute before Langmuir and Coolidge discovered him and invited him to the General Electric Laboratory for the summer of 1913. This taste of research proved infective; after finishing the year of teaching he returned to Schenectady, never to leave. Though several universities have endeavored to tempt him away, he has remained loyal to General Electric. In 1928 he became assistant director of the Research Laboratory.

Alert, scholarly, incisive, Dr. Hull is the creator of a greater number of new types of electron tubes than any other man, and an important contributor to the fundamentals of physical science as well. To him have been due such important developments as the screen-grid tube which was the first practical means for efficient amplification of radio frequencies and which is now used in all modern radio receivers; such new types of tube as the dynatron, magnetron, and thyratron; and special alloy glass seals which made possible metal receiving tubes as well as large metal-glass junctions for power tubes.

The magnetron has had many important applications. It depends on the fact that electrons can be altered in their path by a magnet. In ordinary electron tubes, the flow of electrons from the filament to the plate is regulated by the charge on the grid. In the magnetron there is no grid, but the tube is in a magnetic field. As its intensity increases, there comes a stage at which the electrons are curled back to the filament, and never reach the plate. At this critical point a very slight change in the field produces a large change in the current carried by the tube, and it has proved especially valuable for producing high-frequency oscillations used for generating ultra-short waves.

Many honors have come to Dr. Hull, such as the Howard N. Potts Medal of the Franklin Institute, given in 1923 for work on X-ray crystal analysis; the Morris Liebmann prize of the Institute of Radio Engineers in 1930 for his work on vacuum tubes; and an honorary degree of Doctor of Science the same year from Union University, and in 1931 from Middlebury College.

The honor which he prizes most, however, is the love and esteem of his associates, especially the younger men under his direction.

Though fond of sports, he has little time for them. His favorite pastimes are golf, bridge, and rock architecture at his Adirondack Camp. His hobby is his profession.

99TH YEAR **SCIENTIFIC AMERICAN** MAY 1943

LONG IS THE LIST . . .

Coal, a Plentiful Raw Material, Fills Many Needs of War and Peace

DR. JAS. K. HUNT
E. I. du Pont de Nemours and Company

RECENT announcement by the Carnegie Institute of Technology of an arrangement with a group of the sponsors of the Coal Research Laboratory for an investigation looking toward the development of commercial methods for manufacturing organic acids from coal, focuses attention anew on the use of bituminous coal as a chemical raw material.

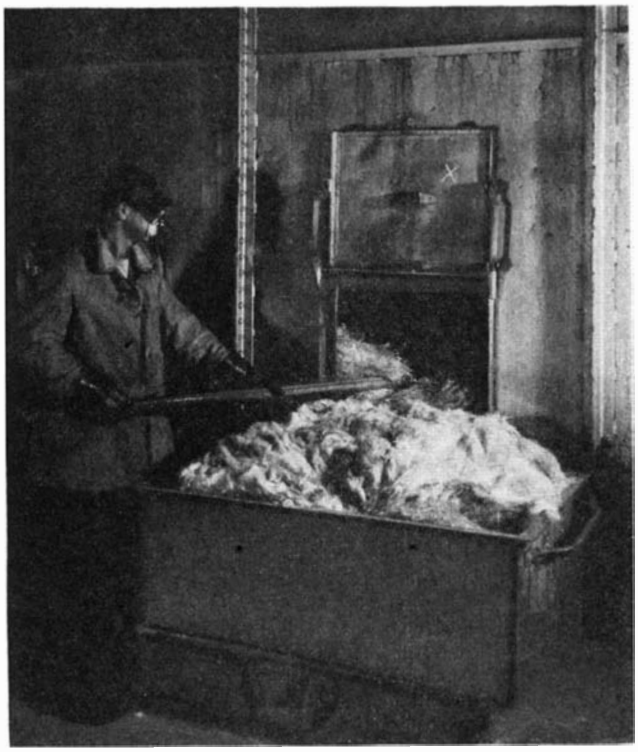
According to Bituminous Coal Research, chemists at the above laboratory "have developed and patented methods of producing from coal a series of aromatic acids such as phthalic and mellitic, with substantial amounts of oxalic acid as a by-product." It is stated that $40,000 has been appropriated to cover research expenditures on this project during the next two years.

In spite of the fact that coal has been known for at least 2000 years—having been used by the blacksmiths of Greece and Italy some 300 years before Christ—only within comparatively recent years has it found application other than as a fuel. But now that products derived from bituminous coal have found so many important applications, its use as a chemical raw material has expanded to previously undreamed-of figures. It is not possible to say exactly how much is used for strictly chemical purposes, but if we include in this category all the coal that is coked, it appears that some 100 million tons may be chemically utilized in 1943.

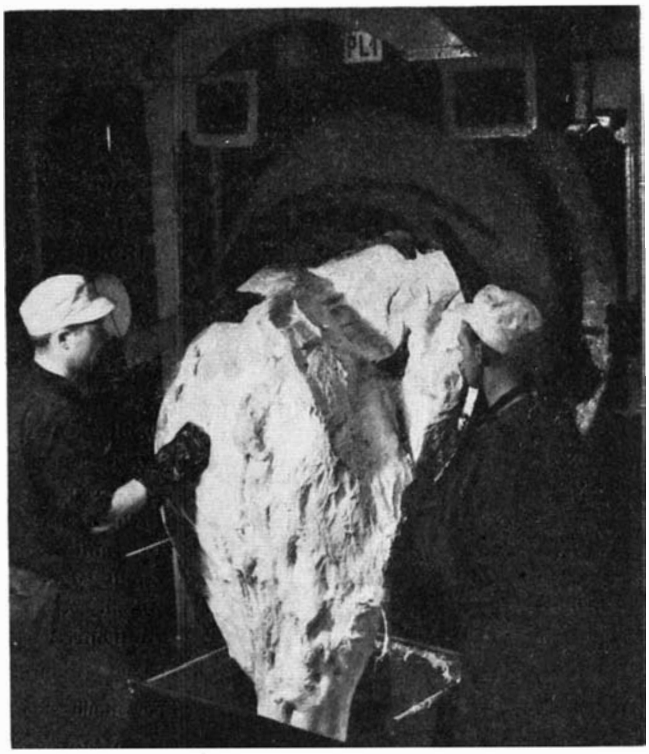
Known to most persons simply as a fuel, coal is, nevertheless, a well-nigh inexhaustible storehouse of chemicals used in the synthesis of hundreds of products, vital alike in peace and war—products which in many cases had to be imported until critical shortages during World War I indicated the necessity of chemical self-sufficiency.

One of Nature's most plentiful raw materials, bituminous coal is potentially richer in rubbers than the islands of the Far East; more bountiful in fibers than all the Japanese silkworms; possessed of more colors than the rainbow; and abounding in curative medicinals.

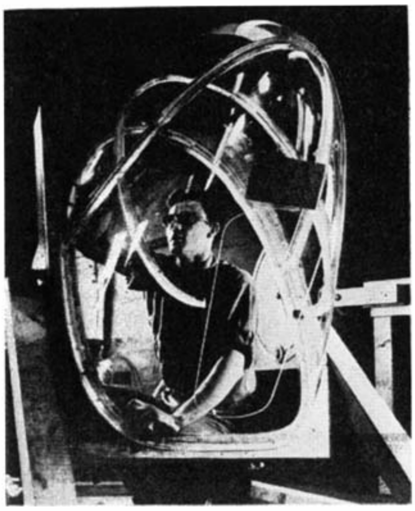
Ordinary bituminous coal supplies the constituents of explosives for bombs, shells, and torpedoes; plastics of many types, including those of crystal clarity; solvents; food preservatives; insecticides; fertilizers; lacquers; "soapless soaps;"



Removing crude phthalic anhydride from a condensing bin. This chemical, made by oxidation of naphthalene, which in turn is derived from coal tar, is an important intermediate in manufacture of smokeless powder, dyes, and certain resins



Neoprene coming from the polymerization kettle. With coal, limestone, and salt as basic raw materials, this synthetic rubber has been referred to by the Baruch committee as the one full equivalent of natural rubber for heavy-duty tires



Lucite, stemming from coal, has many military uses. Here is shown the crystal-clear nose of a bomber—one of the largest pieces of plastic ever manufactured on a production basis

literally hundreds of things vital to total war.

But coal is not just poured into some giant bubbling test tube, over which a white-robed chemist waves a wand and adds air and water at intervals, and out of which comes neoprene synthetic rubber, nylon, fast dyes, TNT, crystal-clear plastics, and sulfapyradine. It's not that simple.

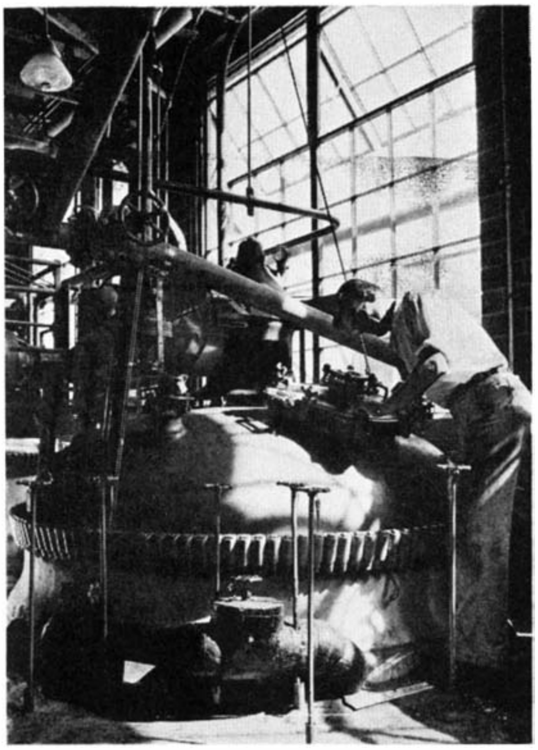
"Made from coal" really means that one or more of the intermediates used in making a product is in turn made from one or more of the several derivatives of coal.

Since William Perkin, a young British chemist, made the first "coal-tar dye" 87 years ago, chemists and engineers have expended untold energy, initiative, imagination, and funds in probing the chemicals derived from coal and in developing the processes and equipment necessary to their manufacture into useful products.

Bituminous coal heated in an enclosed vessel gives off volatile products and leaves coke as a residue. Both coke and the volatile products—such as coal gas, ammonia, benzol, and toluol—today are used to make war necessities for many of which we formerly depended on foreign countries.

About 1.1 pounds of coal, for example, are chemically utilized to make each pound of neoprene, America's first general-purpose synthetic rubber-like material. Neoprene is so essential to our war effort that it was one of seven materials, and the only non-metal, placed on the original priority list in 1941. Today it is carefully apportioned for tires on military vehicles, barrage balloons, airplane parts, shipboard cables to protect ships against certain mines, and other necessities. This product of coal, limestone, and salt is more than a synthetic rubber; it is a material containing rubber's desirable qualities and, in addition, desirable properties of its own.

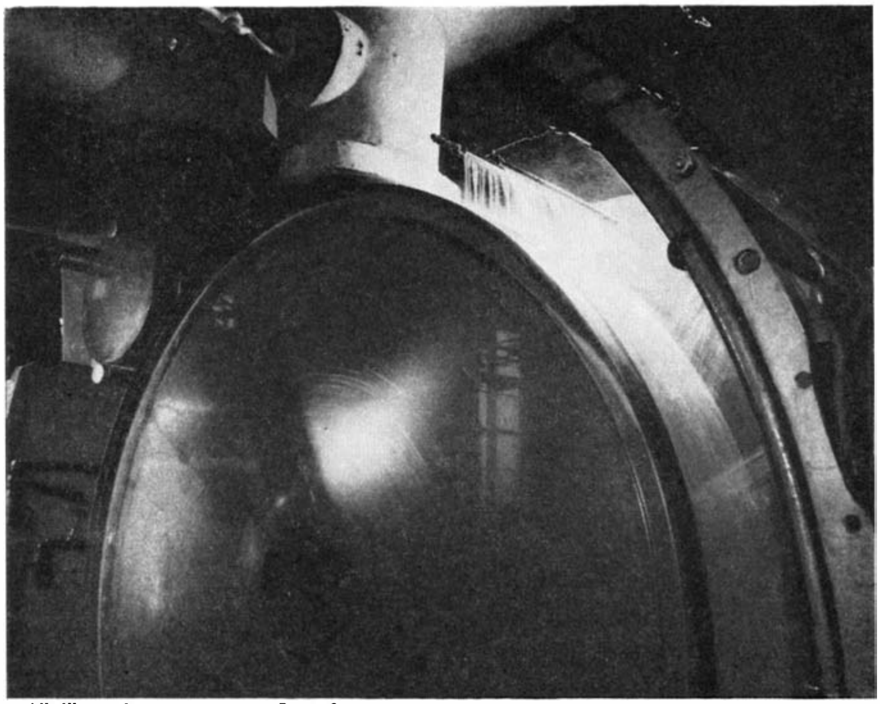
Nylon is derived from the elements of coal, air, and water. Having higher combined strength and elasticity than any natural fiber, it has been used only for military purposes since February, 1942. Parachutes and canopy cloth, tapes, shroud lines, and certain parts of the harness webbing and belting for parachutes take great quantities. Nylon rope is superior to any fiber rope on a basis of strength, lightness, and durability. Exceptionally tough tire cords of this synthetic now are made experimentally. Tapered paint brush bristles, the first satisfactory ones ever made by man, and bristles for essential industrial and toilet brushes are of nylon. They replace natural bristles formerly imported from the Far East. All nylon is needed for war now, but with peace there will come not only sheer stockings, but a host of new products fashioned from this versatile member of coal's family.



Kettle used in one of the steps in manufacturing Butacite polyvinyl butyral used in making safety glass "sandwiches" and as a rubber "alternate"

Although the 18-year old Perkin produced the first coal-tar dye in 1856, America still was importing more than 90 percent of all its colors when World War I started. Our infant dye industry of 1918 now is a vigorous adult, furnishing to our armed forces fast dyes that will stand up under severe weathering and repeated washings. These dyes help to make our fighters the best-dressed in history, and help camouflage man and munitions. From the American pioneering work with synthetic dyestuffs, beginning in the period 1914-18, has sprung the organic chemicals industry in which ordinary coal is one of the indispensable raw materials.

The pharmaceutical industry is to a large degree predicated upon coal-tar chemicals. The sulfa drugs are an outstanding example. Among the most notable and helpful contributions to medicine in a century, today they are invaluable aids in decreasing fatalities among those injured in war. Their use on burns at Pearl Harbor, against streptococcic infection, and against pneumonia and other diseases has already saved an incalculable number



All illustrations courtesy Du Pont Company

Nylon, the principal intermediates of which are derived from coal-tar chemicals through a complex series of chemical operations, first sees the light of day when it is extruded in a molten condition on this huge casting wheel and sprayed with water

of lives. Atabrine, vital substitute for quinine in treating malaria, is another coal-tar derivative. Improved antiseptics and anesthetics are also made from coal-tar chemicals.

"Lucite" methyl methacrylate resin, the crystal-clear plastic for transparent portions of military airplanes, stems from black coal. This is only one of the light but strong plastics, of which so much is expected, that come from coal and its derivatives. Another is polyvinyl butyral, formerly the plastic interlayer in laminated safety glass for automobiles, but now the coating for Army raincoats, hospital sheeting, drinking-water bags, and other war products. This plastic is replacing tons of precious rubber.

Originating in bituminous coal also are the phenol-formaldehyde and the urea-formaldehyde plastics. These plastics' war roles range from adhesives on plywood trainer planes and torpedo boats to soldiers' bugles, from insulation on electrical wiring to gunstocks and radio antennas on airplanes.

Military explosives utilize coal. Toluol, an ingredient of TNT for shells, bombs, and torpedoes, comes either from coal or petroleum. Methanol, derived in part from coal, is a necessary raw material for the manufacture of certain military explosives, and coal is the source of aniline, needed for making the tetryl used as a "booster" in high-explosive shells.

Long is the list of products partially or wholly derivable from coal and essential in the war. It includes:

Solvents, such as trichlorethylene, now used to clean metal parts of ordnance quickly and efficiently, and formerly available as odorless, non-flammable, dry-cleaning fluids.

Anti-freeze to protect the motors of airplanes, tanks, and trucks the world around, and of automobiles and trucks needed on the home front.

Flotation agents which lift invaluable copper, zinc, lead, nickel, tungsten, chromium, and other strategic metals from low-grade ore deposits.

"Zelan," a durable water-repellent textile finish, which remains effective on Army field jackets, ski troop uniforms, and other military clothing, despite weathering and repeated laundering.

A new flame-proofiing agent—ammonium sulfamate—used to treat clothes of workers in munitions and aircraft factories and foundries, and also to flame-proof insulating materials on ship's cables.

Acetate rayon, a useful war fabric, is made from cellulose and acetic acid, now derivable from coal. Lacquers, mildew inhibitors, leather cloth, moth repellants, fluids for hydraulic brakes, gum inhibitors for gasoline, wetting agents to facilitate scouring, bleaching, and dyeing operations.

Such are the diversity of products originating in coal.

Vital as these coal-derived products are to us in modern industry, modern living, and modern warfare, they are only indicative of what is to come. The full chemical possibilities of coal are yet to be realized. Research and development intensified by the urgency of war already have uncovered new synthetics that are helping our armed forces. These, and still more chemicals-from-coal, will be ready for the better world envisioned after peace returns.

• • •

ELECTRICAL PROGRESS

Engineers Work for Present, Plan for Future

American electrical engineers facing the problems of war production are accomplishing near miracles to aid in the manufacture of record quantities of the highest quality electrical equipment ever built, according to Harold S. Osborne, President of the American Institute of Electrical Engineers.

"Through electrical communications, electricity provides the nerve system of the war machine, and through its power applications it supplies part of the muscle," he says. "The fact that engineers are trading technical information and production shortcuts has played no small part in the 200 percent increase of electrical equipment production since 1940.

"During the last two years also, power output has been boosted 31 percent and messages over long distance telegraph and telephone lines have increased 30 percent.

"These quantity figures are even more impressive when it is realized that the industry's products are of highest quality despite war shortages and represent many new types and designs to meet special war requirements."

Mr. Osborne, who is Assistant Chief Engineer of the American Telephone and Telegraph Company, emphasizes the need for post-war planning on the part of technical men as well as statesmen. "Looking ahead," he says, "the Institute sees a continuing need under war conditions for its main function, namely, the interchange between engineers of information regarding technical matters of vital interest. This will include due emphasis on the problems of post-war planning—how increased knowledge, increased facilities, and increase in skilled personnel can be used to bring about a higher standard of living."

COLD CONQUEST

Research Keeps Military Motors Running

On the Russian front, in Iceland, Alaska, and in the frigid substratosphere, the motorized war machines of the United Nations are reaping the rewards of research conducted in the laboratory cold-rooms of the automobile industry. This sidelight on winter warfare was reported recently in the publication, *Automotive War Production.*

Continuing the peacetime research which released the tea-kettle and the tow-rope as standard winter equipment for American motorists, automotive engineers have developed countless methods for improving the operation of mechanized equipment in sub-zero temperatures. The industry's engineers pooled their knowledge for the solution of problems which Army observers have brought back from the Russian front, and the team of cold specialists thus formed under the supervision of the SAE War Engineering Board devoted all of its talent to the refinement of methods designed to combat the effects of extreme cold on engines, batteries, starting and ignition systems, steering mechanisms, and cooling and lubricating equipment.

After months of work in laboratory cold-rooms, some of these engineers are now conducting field tests on trucks and tanks at a winter base established by the United States Army in one of the coldest areas in Canada. Supplied with equipment like that of an Arctic expedition, these men are testing theories that have survived the punishment of laboratory temperatures ranging down to 60 degrees below zero. Among the most difficult problems under investigation is that of lubricating both engines and chassis in cold so extreme that ordinary lubricants no longer flow.

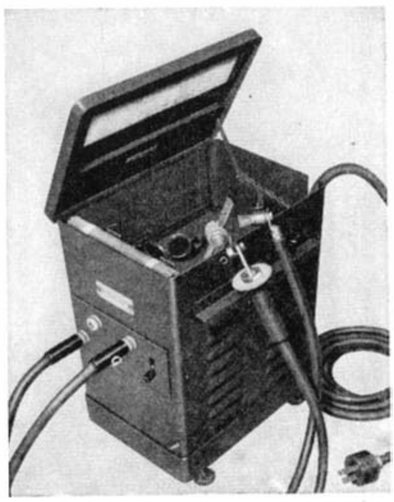
The industry's cold-research is also proving its value in the tropics, where warplanes, taking off in midsummer heat, quickly climb to heights where Arctic cold imposes opposite problems. For the solution of such aircraft problems, it is pointed out, recent refinements of techniques which produced car heaters for American motorists in peacetime have proved extremely valuable.

It is not at all a remote possibility that such research will, with the return of peace, produce undreamed-of advances in that contest which mankind has waged with his climatic environment ever since the first primitive human huddled around a bonfire.

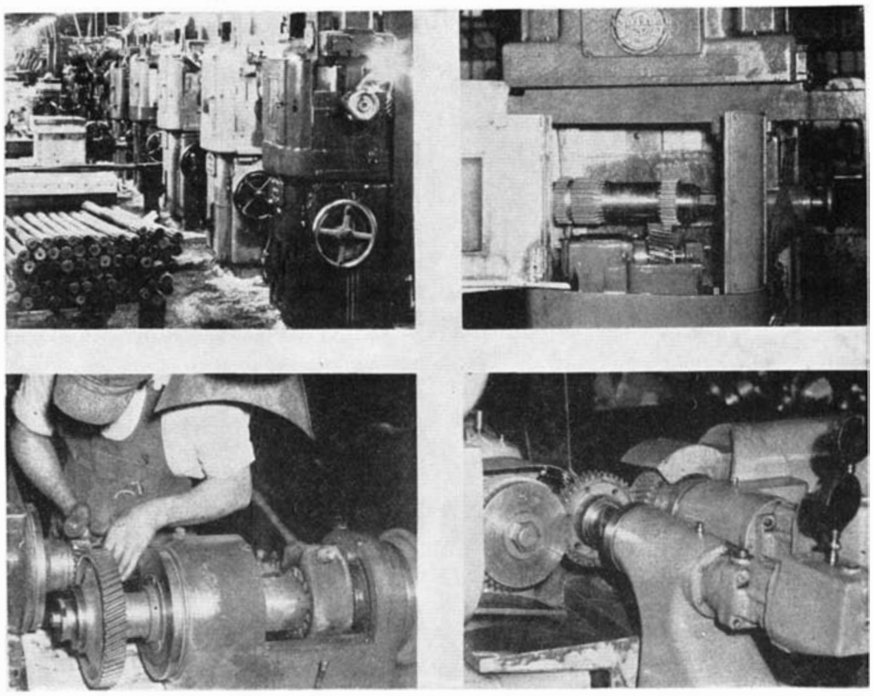
BONDING

Surface Prepared by Electrical Fusing

When metal surfaces are to be coated by that metallizing process, the surface of the base must be prepared for the



To provide an adequate bond



Upper left: Battery of gear finishers used in tank gear plant described. *Upper right:* Close-up of gear finisher with extension head, being used for precision work on transmission shaft splines. *Lower left:* Removing burrs, prior to lapping. Gears are here run in both directions to check contact area. *Lower right:* Lapping a tank gear

process so that an adequate bond will be provided. This preparation may now be done electrically by means of the Metco Fuse-Bond unit illustrated in these columns.

Operating on any 110 or 220 volt, single phase power line, this equipment fuses a rough deposit of electrode metal into the surface to be metallized. Electrodes are applied to the work with a special holder which uses up to six electrodes at a time, depending on the size and nature of the part to be prepared. Small parts may be prepared with this equipment as easily as large shafts, since there is no excessive heating of the base metal, or disturbing of its physical characteristics.

GEAR PRODUCTION

Reaches High Precision

on Standardized Equipment

WIDELY regarded as a "pilot" plant in the mass production of the specialized precision gears required for military combat vehicles— particularly tanks—the gear department of the Mack Manufacturing Company is also notable for its adaptation of well-known automotive mass-production equipment to its specialized problems.

Even though the accuracies required in gears for such vehicles far exceeds normal requirements, as in trucks or automobiles, it has been by production control and correlation of equipment rather than by new production processes that the desired results have been achieved. The net result was not only a minimum of delay in achieving large scale production, but also an exceptionally high degree of consistency in operating results.

The general process in producing gears at Mack starts with rough forming the blanks—usually using Carboloy cutting tools. Internal splines in gears are produced by broaching. For this purpose two types of machines are used. For smaller gears a horizontal machine is used, while for the larger ones a pull-down type of machine is employed. The advantage in the latter case is that the extremely long and heavy broach required for the larger gears is less liable to sag on a vertical than on a horizontal machine.

Wherever possible, gears are hobbed. This is done in two steps—rough and finish hobbing, leaving about 0.035 to 0.040 of an inch for finish hobbing and about 0.001 of an inch after finish hobbing to be cleaned up by shaving.

Some types of gears not lending themselves readily to hobbing are finished by shaper cutting. This includes, particularly, herringbone types—although some others are produced on shapers. Wherever possible, shaper-cut gears are subsequently finished by crossed-axis shaving.

Finishing of gears is carried out on a battery of Michigan 860 type rotary gear finishers, some of these being equipped with special extension heads for shaving of gears on relatively long shafts. In general, gears are held to 0.0002 of an inch as they come off the finishing machines and before heat-treating.

Included in the gear checking equipment provided is a Michigan "Sine-Line" involute checker, but the latter is used mainly when trouble develops and it is necessary to locate the source of the difficulty. Thus the lead-checker is used as a production control instrument, while the function of the involute checker is largely a laboratory one. Approximately 5 percent of all gears are machine checked in production.

The entire Mack set-up is extremely flexible in character and is so designed that lots of gears of different kinds can follow each other through. Each time the set-up is changed, it is accurately checked as the first gear goes through.

Pilot machines of the entire line are the lappers. Here a close watch is kept for tooth contact and any deviation is immediately traced down to its source.

Before assembly all gears are pin-checked, while there is also a 100 percent check of gear pairs for correct center distance, and so on.

COKE PLANT

Supplies Steel Mill,

Salvages By-Products

THE FIRST metallurgical coke plant on the West Coast is made up of two batteries totaling 90 Koppers-Becker coke ovens of the latest design and includes equipment for recovery of all usual by-products. Built in the San Bernardino Valley for the Henry J. Kaiser Company, Inc., the ovens will furnish more than 900 tons of coke daily for the blast furnace of a steel mill on the West Coast.

Construction began on a site formerly occupied by a pig farm and a grove of walnut trees and surrounded by nut, fruit, and eucalyptus trees. Wherever possible concrete and wood were used in the construction, with a consequent saving of steel. The by-product equipment provides for recovery of tar, ammonium sulfate, benzol, toluol, xylol, solvent naphtha, and phenols, including the extraction of phenol from waste liquors by the Koppers dephenolization process. This chemical equipment was erected outside wherever possible and was arranged so that it may be readily expanded with additional units if desired.

VITAL METALS

Being Developed from

Domestic Sources

LONG BEFORE this nation got into the present war, our government began making plans to find other sources of supply or suitable substitutes for the raw materials normally imported from foreign countries. Dr. R. R. Sayers, director of the Bureau of Mines, United States Department of the Interior, writing in *Chemical Industries,* tells how his department accomplished the job of getting "Strategic Metals from Low-Grade and Complex Domestic Ores."

Faced with the task of investigating and exploring domestic mineral deposits and developing or improving metallurgical processes for using low-grade ores which were to be found in our own country, the Bureau of Mines set to work. Specific duties were assigned to it by Congress.

Relying upon the experience of more than 30 years in the conservation and development of the country's mineral resources, the Bureau of Mines did its work well, employed some of the exploratory and metallurgical methods evolved over the years, developed new methods and processes.

In the case of manganese for example—a vital metal in the manufacture of steel—the production of a ton of steel takes about 12 pounds of manganese and it is used in larger quantities for the manufacture of special steels. The Bureau's work disclosed the existence of large deposits of manganese-bearing ore in several states. Early in 1942, the Department of the Interior, through the Bureau of Mines, established 11 beneficiating plants of different types in eight separate states. It is believed that enough manganese can be produced to make the United States entirely independent of foreign imports.

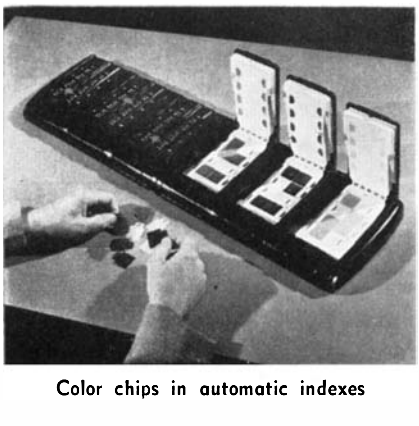
And so it is with other metals. Tungsten—long an imported metal to us—was found by the bureau of Mines near Yellow Pine, Idaho, in 1941. It was the largest and most important discovery of tungsten ore in the history of the United States. Chromite exploration, too, turned up many tons of usable ore. And added to the list, the Bureau found antimony, mercury, and nickel—all in sizable quantities.

Also, states Dr. Sayers, many experiments have been conducted in the laboratories of the Bureau of Mines for the utilization of low-grade ores. The Bureau of Mines, he says, has shown the nation the way to self-sufficiency in strategic metals. Not for long will we have to depend upon foreign sources for many of our vital supplies.

COLOR CHIPS

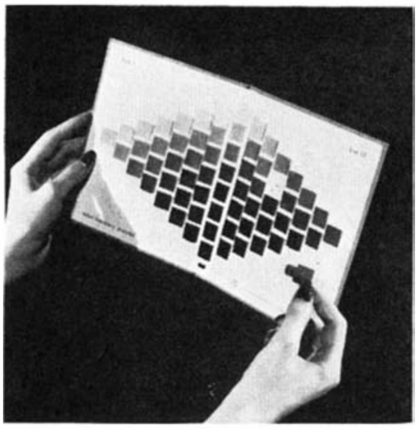
Assist in Comparing Colors in Industry

We live in a world of color. Men wonder if they are wearing the right ties, women strive to achieve certain effects with dress accessories. But far more important than these everyday decisions are the uses of color in industry. It is here that the Color Harmony Manual and the Color Harmony Index, recently introduced by Color Laboratories Division of Container Corporation of America, are proving valuable. The advertiser who must select the colors for his next catalog, the interior designer who must decide on the color of a rug for a particular room, the paint manufacturer who must have definite and accurate standards to go by—all welcome these attractive and simple presentations of the Ostwald system of comparing colors.



Color chips in automatic indexes

This first American color standard reproduction was developed by Carl E. Foss from colorimetric specifications in accordance with standard procedures through the use of spectrophotometric measurements. The Manual consists of 12 book charts, providing 680 colors in the form of small cellulose acetate chips which have been sprayed with color. The chips are removable, and so may be compared easily with each other or with fabrics, papers, paints, and so on. The Index is especially useful in laboratory work, as each of its 680 chips is 1 inch square, fitting the usual photometric instruments. Instead of being arranged in book form, the chips are visible in a series of six Bakelite indexes. Simply touch a button and there is your color.



One of the 12 color book-charts

What color is mauve? Moss green? Burnt orange? No two people would agree when confronted with such subtle variations of hues. In the Ostwald system, symbols instead of names are used for the colors, and thus all confusion of terminology is eliminated. The symbols may be communicated verbally or by wire. The colors are fade-proof and virtually indestructible.

The Ostwald system does not specify the colors to be used; rather it assists in selecting the most effective and harmonious ones according to the purpose at hand, and eliminates all guesswork as to whether certain combinations "match" or "clash."

ROSIN IN SOAP

Contributes Many Desirable Properties

Research in the use of rosin in soap manufacture, especially in spray-dried or powdered soaps, indicates that when the right choice of rosin is used as a part of the soap stock, and in proper proportion to other soap stocks (in the range of 3 to 30 percent rosin), certain definite advantages are gained while no worthy soap qualities are lost. Spray-dried soap can be made with 15 to 20 percent rosin.

The extensive research program on soap making was undertaken by Hercules Powder Company's chemists to determine the true place of rosin in soap, about which there had been much difference of opinion. Rosin was first used in soap manufacture in the middle of the 19th Century, when it was used largely in high-tallow content soaps; its use improved water solubility and sudsing. For many years most soap makers have held to the theory that rosin has only limited value in soap manufacture, primarily as a filler or extender.

The results obtained so far in Hercules research show conclusively that the proper use of rosin imparts desirable properties to all types of soap. In addition to the low price and large volume available, rosin can impart to bar, spray-dried, or built soaps, quick and lasting suds; improved solubility; and reduced dusting of spray-dried soaps and flaked soaps.

Detergency also can be improved by proper use of rosin, the data indicate. Spray-dried and flaked soaps containing rosin have no unsatisfactory aging or odor characteristics. Discoloration on aging in bar soap is in proportion to the grade and amount of rosin added.

CRACK DETECTOR

Uses Ultra-Violet, Also Detects Contamination

In many industries it is imperative that a rapid and positive visual means of examining metal surfaces be available for the detection of cracks and surface faults. In other industries it is required to have definite knowledge of the cleanliness of the surfaces so that applied plating will bond permanently.

No such method of determining these conditions existed until it was discovered that the principle of fluorescence may be applied. A high pressure quartz mercury vapor arc, fitted with a special filter which transmits only the ultra-violet rays necessary for causing fluorescence, has proved to be satisfactory equipment for either application. Fluorescence analysis has been known and used for the examination of many substances for years past. It is an inexpensive method, quick and positive. No special skill is required for its use, although practice does make possible greater speed.

In the detection of surface faults, a fluorescent solution, such as fluorescein, is flowed over the face of the metal and then thoroughly wiped off with a cloth. In the event that the face contains irregularities of a surface nature, some of the fluorescent material will be retained in the fault. This can be easily seen under the filtered rays of the ultra-violet lamp. Internal structural faults cannot be detected by this method; this usually requires X-ray examination.

Where metal surfaces are being prepared for plating it is of the utmost importance that all foreign matter be removed. Oil is probably the most frequently present contaminant. Fortunately, it is brilliantly fluorescent and its presence can be detected with ultra-violet light, even though it is there in very small quantities. This is also true of most other lubricating products commonly used in machine shop procedure.

INDUSTRIAL TRENDS

AIRCRAFT THAT HOVER

MOST INTRIGUING form of air transportation, to both the lay mind and the aeronautical engineer who is not too hide-bound by tradition, is the true helicopter, a conception of many years standing which has reached a practical stage only relatively recently. Foremost advocate of this form of heavier than air ship is Igor Sikorsky, aeronautical pioneer, who has recently dramatized the possibilities of the helicopter by doing things with his latest model that have never been done before with heavier-than-air craft. For example, Mr. Sikorsky has demonstrated the abilities of the helicopter to make vertical landings in enclosed areas, to fly backward and forward and sideways, to hover, and to deposit packages on and receive them from an inaccessible place while hovering near the spot.

Predictions for the post-war decade were recently made by Mr. Sikorsky, based upon the two principal objectives for travel by air: High speed, and the ability to reach any spot on the surface of the earth or sea even though surrounded by obstacles. The modern airplane, of course, has fulfilled the first of these objectives, but requires large landing fields; in fact, the higher the speed the larger the required fields. These great landing areas have necessitated the location of airports at considerable distances from the centers of most cities. Until the advent of the helicopter, the second objective of air travel has thus been impossible of realization.

With the progress which has been made in the field of the helicopter during the past few years, it is entirely possible that, as Mr. Sikorsky predicts, it will become one of the popular aircraft types of the not too far distant future.

To appreciate fully the possibilities of the helicopter and thereby be able to project future trends of this phase of aeronautics, it would be well to review here the fundamental idea of the helicopter. In its usual form the helicopter has a simple overhead rotor which might be likened somewhat to a large aircraft propeller turning in a horizontal plane. Thus the impelling force of the propeller is directed in a vertical direction. Such rotors, according to Mr. Sikorsky, revolve at a much lower speed than does the airplane propeller, the power loading does not exceed about 10 to 12 pounds per horsepower and the disk area loading is about two to two and one-half pounds per square foot.

Many difficulties have stood in the way of successful vertical lift flight, and vastly more research work must be done before Mr. Sikorsky's predictions are realized. However, such problems as those concerning rotor vibration, torque counteracting, control of the direction and speed of the ship itself, and similar technicalities have been satisfactorily solved in a practical manner. An extension of the present research will undoubtedly open up vast vistas for the helicopter.

In a recent discussion of helicopters, Mr. Sikorsky revealed that his present model has flown at a maximum speed of 80 miles an hour, has carried two people, and has extreme ease of control and smooth riding qualities. He feels that a popular three- or four-place ship could probably have a maximum speed of 130 miles an hour and that a 2000-horsepower helicopter weighing about 10 tons and carrying 20 persons is entirely feasible for short-range commercial use in the future.

In the matter of first cost and upkeep, Mr. Sikorsky has estimated that during early production of helicopters the price would probably be comparable to that of a medium-priced airplane; in quantity production the cost would undoubtedly approach that of a medium-priced automobile. In the matter of economy he believes that a two-place ship would average about nine miles per gallon of fuel, a four-place ship about six miles per gallon, and that the cruising range would be from three to four hours at 100 miles per hour.

On the question of safety, Mr. Sikorsky explains that the helicopter can be automatically converted to the autogyro principle by simply changing the blade angle, thereby allowing safe controlled landings even after motor failure.

If the predictions which we have briefly outlined above emanated from any other source than Mr. Sikorsky, they might well be viewed askance. With the background of theoretical and practical knowledge which he brings to the subject, however, there is every reason to feel that they are based on sound and fundamental principles. In any event, whether or not there be one million helicopters produced during the first decade after the end of the war, as Mr. Sikorsky also predicts, there are going to be a lot of them in the air. How they will ultimately place in competition with the conventional airplane is a question which will be avidly discussed by aviation enthusiasts for some time to come. In the final analysis there will be ample space in the air and in industry for both types; each will ultimately find its own possibilities and limitations.

WHEN CARS COME BACK

PREDICTIONS are rampant in many quarters regarding the possible appearance, performance, and efficiency of the motor car of the future—when it finally emerges from plants re-converted from the toil of war to peacetime production. Fantastic, indeed, can be these predictions, if the mind wanders at will, but equally practical are they when kept under control by the trained mind of the engineer. Even though the day on which automobiles will start to pop off the assembly lines for civilian use is still very far in the unseeable future, it is refreshing and stimulating to view future trends as based upon present accomplishments.

It is in this vein that a well-known engineer in the aluminum industry recently predicted that the automobile of the future will be lighter and more economical than any heretofore produced. It will probably use a much smaller and a higher performance engine than the finest power plants so far conceived.

The general public, however, cautions this engineer, must not expect completely new designs immediately upon the cessation of hostilities. Some manufacturers, no doubt most of them, will first offer for sale motor cars nearly identical to those sold before the war. There will, of course, be a two-fold reason for this: First, the designs are available and production of proved types can be started with little loss of time. Second, the buying demand will be so insistent that production must be started with a minimum of delay. As soon as manufacturers get into the swing of production, however, radically improved designs built around new and superior metals and techniques will be the order of the day. Possibly within two years after the end of the war the motoring public will be able to avail itself of those technological developments which have come about directly and indirectly as a result of intensive war-inspired research.

To hark back to our metallurgical engineer: He believes that at least one automobile will be placed on the market with the motor located in the rear and that radical changes in body design will appear rapidly as post-war production hits its stride. Looking into the fields of aluminum and aluminum alloys he predicts that as much as a 30-percent weight reduction can be realized in the average automobile with new applications of aluminum and a more careful design study. Improvements in alloys will permit a more extensive use of aluminum in future designs and secondary aluminum alloys will appear largely in such parts as cylinder head and block castings. With careful engineering of such alloys it should be possible to bring down the weight of the post-war engine to as low as five pounds per horsepower.

In these latter respects the automotive industry will in the future offer an outstanding outlet to the raw materials of the aluminum industry. With our aluminum capacity built up to the point which it will have reached by the war's end, millions of pounds of the light metal are going to be looking for non-military applications. The automobile is going to furnish, in many ways, these needed applications. If the aluminum industry in general and foundries in particular can be operated efficiently enough to meet the price competition of iron and steel, the general public will be the beneficiary in that they will have available post-war automobiles which are light in weight and hence economical in consumption of fuel, oil, and rubber.

—*The Editors*

A Hobby Goes To War

Scientific American's Amateur Telescope Makers Find Their Peacetime Optical Skills are a Wartime Asset

ALBERT G. INGALLS

"DESPERATELY—that's how badly they are needed."

It was a year and a half ago and the Army procurement official spoke in a suddenly lowered voice.

The thing so desperately needed, a need now no longer desperate, was something you may never have heard of—roof prisms.

Essential part of telescope sights for field guns, anti-aircraft guns, tanks. Little pieces of crystal-clear optical glass the size of your thumb, sparkling like cut gems, two of their facets sloped like the sides of a roof. Worked to a geometrical nicety within two millionths of a circle in exactness of angle between the facets.

Among those supreme tasks which are tackled only with deference by precision optical workers, almost none calls for greater skill of hand, and eye, and brain than making roof prisms. Commoner kinds of prisms there are, but roof prisms are precision royalty. A good roof prism maker is the equal in military value of a whole company of soldiers.

A year and a half ago there were not in these United States as many as a score of precision opticians who could make these prisms. In peacetime one or two men could easily supply the normal needs of all the military services, and roof prisms had not been used for other purposes. Suddenly a nation's new armies needed thousands of them. Without its roof prism a gunsight, and therefore a gun, could not function. The Army procurement official's depiction of a desperate situation, therefore, was no empty piece of dramatics.

Some of the few who could make roof prisms had long been employed at Frankford Arsenal. Consequently, to that institution were sent the ablest artisans, picked men, from the precision optical industries—those that in peacetime make scientific instruments—to work by the side of its experts and take home their secrets to impart to new workers.

If this skill-multiplying process were as simple as it sounds, there would have been roof prisms, easily and early, but it wasn't simple at all. Suppose that Stradivarius had been called on to increase his production of violins a hundred fold within months. It was more like that. Men don't learn such minutely exacting arts in a day—not even professionals who have done other kinds of precision optical work for years.

There was, however, another group of men in this country who likewise for years had been doing precision optical work, though as a hobby—the amateur telescope makers. Among these 20,000 followers of a scientific sport there are many who have developed skills in making lenses and concave mirrors for telescopes demonstrably equal to those of professionals. Could some of these eager, patriotic amateurs, working at home in their cellar and attic shops, help relieve the Army's roof prism need?

Preceptor of the American amateur telescope making hobbyists is Russell W. Porter. Early in the century, during a dozen years as astromoner and surveyor

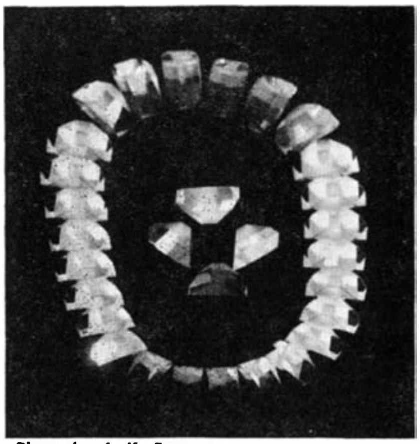


Photo by J. K. Fogarty
A garland of gems—roof prisms

with several arctic expeditions, Porter dreamed of owning his own astronomical telescope. Cured at last of his "arctic fever" he returned to New England and there in his cellar shop he made a telescope of the reflecting type, a type which he called "the poor man's telescope," because its simple materials cost less than those for the more familiar kind having a large lens.

LATER he taught the same art as a hobby to a group of average members of his home community. These amateur telescope makers organized a club, and on the top of a neighboring mountain they built a clubhouse-observatory, naming it "Stellar Fane"—shrine to the stars. Today Stellar Fane, or Stellafane, is the mecca of American amateur telescope makers, and the club that Porter started is the prototype of 60 similar clubs all over the nation. Porter, after making many more telescopes, was called to California to help design the great 200-inch reflector which will remain unfinished until after the war.

In 1925 I visited Porter and Stellafane, and there I became inoculated with the virus of the telescope making itch and went home to make my first telescope. Here, as it proved, was a real hobby, a tough one. By hand, and using loose abrasive grains with plenty of elbow-grease, you ground a disk of thick plate glass or Pyrex the size of a butterplate to a concave curve. Next you polished it with optician's rouge on a layer, or lap, of pitch. Then, by rubbing it locally, you shaped its shallow depression everywhere within two millionths of an inch of a parabolic curve. To accomplish this was a fight, but a fight that was fun Finally, you silvered your disk and set it in a tube on a home-made mechanism and found the statement true that with such a telescope you could do serious astronomical work. It would magnify 100 times and reveal the polar caps of Mars, four of the satellites of Jupiter, the rings of Saturn, countless celestial suns and universes.

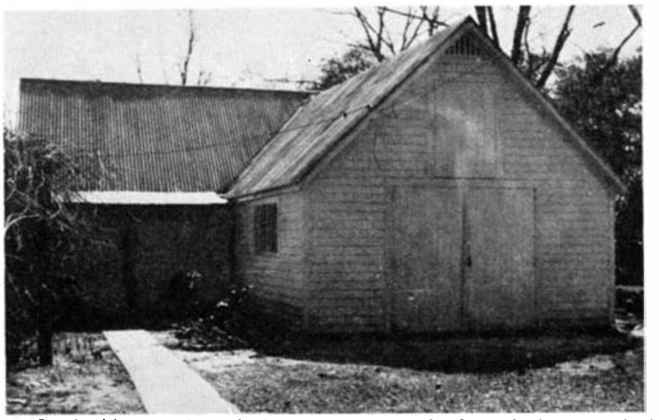
After Porter had helped me fight out the final curve of my first telescope mirror, we sat in a New York chop house from six till twelve one night, sketching telescopes on a tablecloth and hatching a conspiracy to start germ warfare. With his greater experience in telescope making and my access to the pages of Scientific American, we would expose men of amateur scientific turn of mind all over the nation to the contagious bug of the telescope disease. Porter prepared articles which I expanded into a book.

IT PROVED that the bug would take, and would even spread without promotion. As soon as a man made a telescope and his townsmen saw it over the fence, they came down with the same itch and set eagerly to work in their garage, attic, or cellar shops. Some would finish their first telescope six inches in diameter and hanker for one eight—finish that and begin one twelve. Club groups made large telescopes for community use. An Indianapolis group made a three-ton reflector three feet in diameter. Telescope making as a hobby became epidemic and still is. Wives saw their husbands dive into cellar shops after supper or without it, and come up only after midnight or when hungry. The long-suffering, deserted ladies called themselves "glass widows." One, in revenge, bolted her spouse downstairs in his shop all night. Another, in California, sued for divorce and won it.

Scattered over the nation are thousands of these enthusiasts. By mail they scrape mutual acquaintance and become fast friends who have never seen one another, never heard one another speak.

Throughout the 18 years of this hobby's career Russell Porter has been its father—my part more motherly, having to do with the homelier conduct of the central clearing house for news and ideas.

While not all amateurs' telescopes are quite Grade A, many are easily as precisely made as those that professionals produce, and some are even better. For this apparent anomaly there is a reason that seems to make sense. The amateur can work on and on till every last detail is perfected, even if it costs him a year of spare time, but the professional must count his time or else lose money. The



Sandy MacTavish and the unpretentious back-yard shop in which he and Pavel Uvaroff produce pretentious roof angle prisms. On the bench are two 97-prism polishing matrices and a flat for testing them by interference fringes (light source above)

word "amateur" means one who does something for the love of it and not for gain. But, because some who make no gain are also inexpert, the ill-starred word has also acquired the meaning of bungler and dilettante. During more than a century of the telescope making art the ablest and most famous professionals have been men who began as amateurs, and then actually beat the professionals at their own game. For this there are parallels in other hobbies and in sports. Such men never fall out of love with their work. Though professionals, they remain amateurs—devoted lovers—in outlook.

Many of the amateurs not only refused to stop work after making a single telescope, but at one kind of telescope, and even at telescopes. With a loose foot and a roving eye they explored the diverse side-roads of optics. They made unusual and uncommon telescopes and domed observatory buildings in which to house them; sun clocks, camera obscuras, spectroscopes. They also made optical test planes, called flats—glass planes that deviate from absolute geometrical flatness not more than one millionth of an inch anywhere over a surface the size of a dinner-plate. Flats have many uses in precision optics and as final controls of all measurements, in industry. The amateurs not only made these things, but often the same men made the tools with which to make them. As they worked, they also pored over profound books, largely mathematical, on optical theory and design.

IN LONG periods of years—five years, ten years—a hobbyist often learned more about precision optics than he sensed. This background of experience was destined to prove an asset when the United States Army needed roof prisms, and that is the other part of this story.

In 1937, when this nation was seen to be headed for war, a hint was thrown out among amateur telescope makers who read Scientific American that, if war came, the widespread reservoir of precision skill among their personnel might do its bit to help win it. One far-seeing amateur who thought often about this was Alex MacTavish. He foresaw that war would call for roof prisms for gunsights and he correctly reasoned that, because this particular variety of prisms was the hardest thing in optics, they would prove to be needed the most. This acted as a challenge to his nature and, as he went about his vocation, his mind dwelt often on roof prisms. Strongly encouraged and in many ways aided in this by Porter, in 1940 MacTavish had already quit his business, built his shop, designed and constructed his machines and testing equipment, and ferreted out a procedure for making roof prisms. Thus he had gained a head start over the other amateur telescope makers, and when these later tackled roof prisms he was best qualified to be the technical advisor of the group of those who today are successfully turning out a sizable share of the roof prisms needed by the Army.

TO FRANKFORD ARSENAL, then, a year and a half ago, went Porter, MacTavish and I—three musketeers in quest of an arrangement by which other amateurs could try making roof prisms and, if they succeeded, produce them regularly in their spare hours as a contribution to victory. Would the quest prove quixotic? Would the Musketeers be laughed at—amateurs, of all people, aspiring to make roof prisms, of all things! Why, being amateurs, didn't they tackle something relatively simple—perhaps the easy Porro prisms used in binoculars. Some people, in fact, said they were just a bit crazy, but sometimes it's an advantage to be crazy.

If any official at Frankford Arsenal thought such things, his exterior remained impeccable. How can an official judge in a jiffy whether he is listening to wild men or passing up a good bet? And there was also that desperate need, so . . .

Had the amateurs been making roof prisms? Yes and no—MacTavish had, but the others hadn't tried it yet.

What, then made them think that the amateur telescope makers could manufacture these especially difficult prisms? The fact that they had made other difficult precision optical things. MacTavish, for example, before tackling roof prisms, had made small lenses, three telescopes, three flats.

Had they come to ask for a big contract? No. Only for the simple assurance that if the amateurs tooled up and made sample roof prisms, these samples would be officially tested and rated for quality; and that small trial contracts would then be given those who showed promise. A small amount of optical glass with which to make samples was also asked for.

Frankford Arsenal bet 24 two-ounce pieces of optical glass and later, when the amateurs still seemed serious, 100 more pieces. Optical glass then was scarce—it always is a treasure. In fact, this exquisite substance truly merits a name wholly distinct from the commoner word, glass; just as roof prisms deserve a name distinct from the word prism; and the precision opticians who work in millionths of an inch on optical glass should have their own separate designation. Here our language lacks three words.

The glass was to be distributed by me, two blanks to a man, to those of the advanced amateur telescope makers, wherever they lived, who were known to have outstanding skill. On behalf of Scientific American I agreed to co-ordinate the group of about 80 candidates scattered over the nation, transmit their sample prisms to the Arsenal for test, and sift out the men who made good, turning them over to the Arsenal as contracting producers. This made of me a sort of old mother hen for the venture.

HOME went three musketeers, well enough satisfied. You couldn't expect an arsenal to go way overboard at once on amateur stock. It now was up to the men.

A "Roof Prism Program" was organized, but, since amateurs are a clubby, unconventional lot with no leanings toward the pretentious, the movement was called simply "The Gang," which sounded less like Washington. The participants were mature, middle-aged men with established vocations. A sampling of the Gang runs like this: a metallurgist, a biologist, a steel worker, a cabinet maker, two physicists, two chemists, a candy manufacturer and a gravestone manufacturer (who work as partners), several engineers, an accountant, a physician, dentist, decorator, geologist . . . A group in one community comprised a microscopist, teletype engineer, telephone engineer, paleontologist, and a herpetologist (snakes)—all working in spare hours.

Practical instructions for making roof prisms were the most immediate need. Alas, none had ever been published. Only a writer who had made roof prisms with his own hands, but no mere sideline observer, could properly qualify to write such instruction, and none of the few who had done so had ever gone literary.

Among professionals there also was an old tradition that the subtleties of the higher precision optical skills were too elusive to capture and put into writing. This rationalization had never been accepted by the amateur telescope makers, because daily for 15 years they had been doing exactly that. True, it required painstaking description—precision language to explain precision optics. Books, articles, and long letters, all written by amateurs for other amateurs, had been almost the sole transmission lines for the amateur's working techniques of telescope making.

INSTRUCTIONS for making roof prisms, so far as the instructors' incomplete knowledge permitted, were therefore prepared.

Porter, in California, wrote a booklet in which he embodied the data which he had garnered about testing prisms—for it is essential that the angle between the rooflike facets be square within two seconds of arc, or 1/1800 of a single degree. How infinitesimal such an angle is would be shown if you could see a man at 30 miles. Light rays coming from his left and right shoulders to your eye would then make that angle. Bringing the roof angle by hand retouching to this high precision—far too fine to be measured with any kind of mechanical gage, and measured instead with long pointers of light that amplify the errors—and at the same time keeping the determining surfaces flat—is the chief reason why roof prisms are far more difficult to make than ordinary prisms.

Because nobody had ever taken the trouble to write a treatise on the roof prism art, MacTavish had been forced to invent, all over again, what may have been known 50 years before and largely lost. All that he had thus painfully learned he at once put into writing and gave to the others freely, through mimeos issued with chipped-in funds. This patriotic gift enabled them to start close to the stage which he had currently reached.

Herschel Ice, an amateur who had worked professionally for six months at Frankford Arsenal, remained faithful to the spirit of his antecedents, by writing out for the Gang all he could glean there about prism work.

A mimeographed, monthly Gang newsletter also was begun. Its purpose was to remedy an existing fault—that these men could not, at this uncertain stage, quit their regular vocations to come together at any central point to work, as otherwise would have seemed logical. The newsletters brought the men together once a month in a sort of town meeting. Through them, every scrap of knowledge about the technique of roof prism making which any one Gang member discovered and sent in could be passed to all the others.

Between the issues of these monthly Gang gossip sheets there came to my desk a daily blizzard of letters—trouble letters, rejoicing letters from men who had found new ways to do old things; letters from those who couldn't buy this or that tool because they lacked priorities; letters, letters, letters. These many, many missives were answered—let bureaucrats and red tape winders brace themselves—with entire informality on common postalcards, but on the day of receipt and generally in the same hour. The same letters were then bundled up each day and sent around the nation-wide triangle—MacTavish, Porter, and back—so that the other two musketeers could keep in close touch with the activities and contribute their helpful comments to each inquirer's problem. "If all these letters could be put end to end," Porter's secretary grinned, "they would paper a path to the Moon."

TOOLING up for roof prism making cost only one or two hundred dollars because the men already owned part of the equipment. They had used it in telescope making. All were natural mechanics and could make the remainder. For example, professionals usually purchase the grinding spindles they use, but amateurs could roll their own from junk. The spindle made from junk was as good as the one that looked like a standard catalog machine, except that it lacked paint and polish. The required optical flats, or test plates for glass, were no great problem for men who had years before learned to make them accurately to a millionth of an inch or better. Did the complication of obtaining a priority seem to block the hope of acquiring a necessary high-precision square or gage? Then make it yourself. Did James Fogarty have to buy a saw for sawing glass when he could crush a black diamond and arm the edge of a brass disk with its powder? Did one man in the Gang feel uncertain about the metal he used for a fine tool? Very well, the Gang included a metallurgist who knew the answer. Did the metallurgist want to make his own rouge, but feel uncertain about chemical details? The Gang contained chemists and one man's letter could be passed on to another.

Jim Fogarty hand-correcting in his cellar shop. No frills

After the start there were a few weeks of suspense. One morning came a big box. Lovingly protected at the center of about a cubic yard of packing was a sparkling, transparent roof prism of water-clear optical glass. They're common now, but the first one seemed like a maharaja's gem. In a mountain village, Pavel Uvaroff, to whose door people had previously beaten a path even from China for special jobs on telescope mirrors, had labored a hundred aching hours on this one prism; though today, as a veteran of a year, he'd do it in an hour. The elaborate packing bespoke the pains it had cost him.

UVAROFF'S prism—the first to come in—was forwarded to Frankford Arsenal for test and the report showed that the roof angle—most critical of numerous details that had to be right, or else—exceeded the desired right-angle by several times the permitted tolerance. Yet for a first shot this was excellent shooting, easily on the target, and it didn't take Uvaroff long to begin hitting the bull's-eye.

Within the next fortnight three more men had sent in their long-labored-over first samples. Impatient, I put these in my pocket and went to the Arsenal to see them tested. I was apprehensive, since first impressions count and a bad showing now might prejudice the amateur's future. The foreman, 30 years at Frankford Arsenal and a master optician, tested. Would such a man be scornful of the amateur? His sunny demeanor said no, as the prisms were placed on the test stand. He squinted through the eyepiece of the apparatus.

First man's prism: Angle error five times the tolerance. That wasn't too reassuring.

The second man's prism was nicked and scratched like the chin of a New York commuter after his hurried morning shave; perhaps, therefore, it would prove to be good in its more essential characteristics—like a plain wife with a wonderful disposition. Alas, the angle was a whole thirtieth of a degree from square —60 times the tolerance—and the facets were far from optically flat. Such a prism would give only blurry definition if used in a gunsight. Amateur stock was falling fast.

Third man's prism—Jim Fogarty's. Test. Suspense. Foreman: "Good prism! Definition fine—*very* good. I *know* this man knows what he's doing—he won't have any trouble reducing his angle to two seconds." The Arsenal gave Fogarty a trial order for 50 roof prisms and when he completed it, 47 of them proved to be acceptable. Fogarty's average on the hundreds of prisms he now makes runs much higher than this—higher, in fact, than that of many professionals, as does the average of others of the amateurs.

This gave the program three men who could make roof prisms.

Robert Gray sent in samples. Since he had previously made several telescopes, including a trim one-ton reflector 20 inches in diameter, his work on prisms obviously should shine from the start. At first it proved to be only fair. Not much later, on his trial order, he made a 100 percent score of acceptance. This caused an official to comment that Gray had been thrown clear out of the amateurs and into the professionals, but he refused the intended honor. An amateur is an amateur forever, he commented. Hobbies engender strong loyalties. Today, Gray turns out roof prisms by the peck.

By summer several more men had qualified by showing promise in their sample prisms. An official remarked that the amateurs were beginning to produce results that none had expected. Oho! Results that none had expected! So now the cat was out of the bag. Yet, in all fairness, no amateur had ever expected anyone to expect, since no amateur had himself felt sure, until the test had been made, that amateurs could make roof prisms. So the Gang members only chuckled and worked on. For Frankford Arsenal had been fair and square, its personnel invariably courteous. It is, of course, a fact that judicious co-operation with civilians is no more than the plain duty of a government arsenal. That is, in time of peace to keep alive a spark of certain rare skills, and in time of war to disseminate those skills among the people whose taxes support the public institution. Yet this overlooks traits in human nature which could easily have supervened had these officials been small, but which did not because they were large.

How are roof prisms made? Are they molded, or sawed, or blown, or ground, or what? From thick slabs of optical glass they are sawed roughly to shape with circular saws whose microscopic teeth are fine abrasive particles. Sometimes, instead, they are molded to a rough outline. Next, numbers of the rough blanks are cemented to iron plates and together ground more closely to the desired size. Groups of these are then cemented into V-shaped grooves in prepared plates of steel and ground still more closely, more delicately, to size. The prisms are then polished in groups with pitch laps, using optical rouge, and their facets made optically flat. Each step is carefully gaged to bring the prisms ever closer to the ultimate shape and size. On each prism during these processes at least 50 accurate measurements must be made. The final stage, or "hand correction," is done by rubbing off glass freehand on a rouged pitch pad, at less than a millionth of an inch per rub, with fingers so practised that the optical flatness already gained is not lost while the angle is being corrected. This calls for supreme skill.

To the Gang came jolts as well as joys. Men became over-confident and received sudden heavy rejections. Men who had started off with a bang slumped. A number of new men failed from the first. But Daniel Widdicomb sent four samples, all of which proved to be acceptable, and he, today, is a producer of roof prisms and has a shop in his cellar, employing two assistants. No imposing factory facade is necessary in work like this—only simplicity and the essential skills. You can't bluff an inspector's testing apparatus with an embossed letterhead.

Some members of the Gang combined. Thus, Strong and seven nearby amateurs worked together in one little shop, so packed with tools and work that a man would pop out the walls if he took a deep breath. Five men, led by George Ellis, co-operated in one shop. Dakin combined with Sloane. Uvaroff, whose superb workmanship soon brought him a larger order for 300 prisms, worked as a partner of MacTavish, whose second order was for 1700. Together these two work in a temporary barn-like building near MacTavish's residence, their combined orders for several thousand roof prisms now nearly complete, and with an exceptionally high acceptance of better than 98 percent.

Just exactly why were these amateurs making roof prisms? Patly put was Fogarty's answer to this question: Patriotism, pride, profit—and profit last. "My main ambition," wrote Hartshorn, "is to get something made with my own hands into U. S. fire control equipment and doing things to Berlin and Tokyo. If I can accomplish this, I'll feel well repaid for my work, and to Hell with the money." I could quote nearly every participant in this romantic quest in a similar vein.

Pavel Uvaroff, who corrects 55 roof prisms in a single day

A second motive was pride—the very challenge of the difficult roof prism. Over-compensation for being amateurs? Quite possibly. Naturally this hit the amateur harder than the professional, since many of the latter had never tackled roof prisms, and some who did failed dismally.

In the third motive—profit—there is no moral crime, but one member of the Gang, who can make roof prisms and makes hundreds, succeeded in getting himself suspected of some hidden mysterious motive when he tried to donate his profit to the war effort. The officials are still in a swoon.

Throughout the whole period the members looked mainly and often to MacTavish for sound advice about the working technique. This dynamic (red-headed) overcomer of obstacles has the most roof prisms to his score. If discouraged, he smiles. If worse discouraged, he grins—and works. Things gravitate to such people.

Late last summer ten of the Gang took a day off and met in Frankford Arsenal, most of them seeing one another's faces for the first time, though all were old friends by mail. By then the period of tiny trial orders was past and Frankford knew that amateurs could make roof prisms. Half a ton of optical glass was being shipped to eight of the ablest men. These soon made it into roof prisms and asked for more.

Did the amateurs find roof prisms more difficult than telescope making? Much more so. From first to last there were troubles, and heartaches, and headaches. There were cycles of elation and depression which chased one another down the keyboard like fugues, and they still chase. About them a whole book could be written and that book would not be fit to print. At least one fat chapter would be about Washington-inspired red tape. But who among readers cares about tales of woe? Such troubles, when philosophically looked at, are only a part of war, and war is Hell.

Thus the Musketeers' original purpose—to sift a carefully selected group of the abler amateur telescope makers, in the hope of finally sifting down to a smaller number who could and would make prisms toward Victory, and who together would contribute a volume of roof prisms comparable with the production of one of the professional plants—had justified itself.

It is suspected that Scientific American's Amateur Roof Prism Program and its Gang must have caused Frankford Arsenal almost as much trouble as an equal number of large manufacturers—or as a hen with a hatching of ducks. That the Arsenal, after all its patient dealings with the amateurs, still stands solidly on the banks of the Delaware, and still can function, clearly establishes its toughness and indestructability. From its officials there came recently to Scientific American the following communication:

"In the Fall of 1941 this Arsenal became interested in a group of amateur telescope makers sponsored by your publication. Since this time, a good many of these amateurs have developed into qualified optical workers. They have turned in roof angle prisms which meet the very high quality of performance required by military instruments. Several of them have gone into this work on a full time basis, and have established shops capable of turning out precision optical elements in commercial quantities. They are able to compete with larger organizations both on a quality and cost basis.

"The development of this whole program is much more a result of the work of your publication than of this Arsenal. The instruction of the amateurs was almost wholly accomplished through the medium of the mimeographed booklets prepared and issued by members of your staff. You have at no time received any financial gain from this work, but have offered your services simply as a contribution to the war effort. This Arsenal, therefore, takes this opportunity to thank you for the interest you have shown, and to express its hope that you will continue this work."

The work does continue and runs now on its own momentum, each member of the Gang an independent producer and no longer in need of assistance. The wartime fulfillment of a peacetime hobby!

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For technical details see page 238.

OUR *Point* OF VIEW

HAS TELEPATHY EVER OCCURRED?

TELEPATHY, according to recent comments in *The Truth Seeker,* is just another delusion foisted on a gullible public and in the same general class of belief as witchcraft; a fraud. Yet this respected superstitution is accepted by certain persons who scorn astrology, numerology, palmistry, and tea-leaf reading. The telepathists quite evidently have little faith in their own system, for they still use the telegraph, the telephone, the mails, and their vocal cords. The telepathist who decides to put his beliefs into practice should be watched for additional signs of insanity.

Scientific American's editors do scorn astrology, scorn numerology, scorn palmistry, and have never gone in for tea-leaf reading.

They believe that fraudulent telepathy has been and often is foisted on a gullible public.

They are aware that many who apparently accept a wide variety of claims for telepathy also do incline to accept various forms of occultism—which tends to prejudice the question.

Coming closer to their own psychic investigations, at least four of the editors remain wholly unconvinced, as yet, that any of the category designated as psychic phenomena of the physical type occur at any time.

In their general outlook on the philosophies, the editors as a whole belong in the category of the tough-minded rather than the tender-minded.

Yet a majority of them are tentatively convinced that at times telepathy occurs.

Are they prepared to establish this tentative conviction by actual proof? They know of no present way to prove telepathy, and will not try. The Scientific American tests of 1933 were favorable to telepathy but did not prove it. Proof, incidentally, is a strong, heavy word—a ten-ton word. To it there are two degrees of strength or weight. There is the proof that suffices to satisfy one individual; this is perhaps a way of describing what is called personal conviction. And then there is the kind of proof that all can and must recognize. We think that only the latter deserves to be called proof in connection with a question like telepathy.

It is found that four of Scientific American's editors owe their tentative conviction in favor of telepathy largely to individual, personal experiences. Since these experiences cannot in logic carry weight with others who did not experience them, they cannot be said to have general validity in proof of telepathy—they tend to prove it to one person alone.

J. B. Rhine, of Duke University, a contributing editor to Scientific American, once had personal experiences that convinced *J. B. Rhine* that telepathy sometimes occurs. He clearly saw, however, that these could not carry conviction to all, and therefore designed the now-famous extra-sensory perception (ESP) tests. Because their evidence is tangible, and therefore available to all, these tests would bridge the gap between us all. Several years ago the public heard a great deal about the Rhine tests. At that time the atmosphere surrounding them became emotional, to the detriment, so far as that factor extended, of sound objective science. Now that this objectionable emotion has calmed down, what is the present status of the ESP tests?

Late last year that status was summed up in *The Journal of Parapsychology,* of which J. B. Rhine is an editor. The active period of the tests began in 1934. The boom of criticism came in 1937 and continued into 1938. The critics who wrote articles were almost without exception from the psychological profession, though they did reflect pressure from arising public interest. There were condemnation and increasing irritation. The criticism took a mathematical phase, having to do with the statistical interpretation of the many tests, but did not come from the mathematicians—it came from the psychologists. As a whole the mathematicians, when appealed to, found that if the Rhine investigations were to be fairly attacked, they must be attacked on other than mathematical grounds. Today the critics have come mainly to silence, with some shifts toward favorable, or at least neutral, attitudes and an element of restrained but persistent die-hard rejection. There is fairly widespread recognition of the scientific character of the research and an increased respect for the way it is being done.

Obviously, the Duke University researches have not proved telepathy. Yet they have advanced its status and cleared the way for a less emotional and calmer continuation of the work.

These tests are the classic example of an attempt to reduce a former loose methodology to scientific control. The tests of telepathy can be and are empirical only, since if telepathy exists, science has no idea of its nature (and in the lack of such a comprehension the common use of the word "force" carries little force). Compared with the numerous personal experiences which sometimes bring conviction to individuals, the Rhine tests are rather dull and routine but, so far as they go, they are a net gain. More interesting, as reading, are personal experiences —even though, as already stated, these cannot be pinned down to a satisfactory basis for all.

Many persons have experienced little incidents that seemed telepathic. For example, things that cause comment like this: "How remarkable! I was thinking of that very subject when you spoke of it." Unfortunately, in a large proportion of such instances there is a precipitating cause for each of the two persons' similar thoughts—not often an obvious one, but get-at-able if the participants are willing to risk spoiling the incident by really digging for it. Something that happened an hour or a day before is often the true trigger. Will this cover all cases, or does telepathy occur? There is as yet no final answer.

An odd case of apparent spontaneous telepathy occurred several times to the writer. Sometimes, when the telephone rang in his office, he knew before removing the receiver who was calling up. Simple, if it had been his wife or an old friend or someone else whose call was even remotely expected. It always (in a total of about four instances) was the same person, a very casual acquaintance of a business sort who called up every few weeks or months for no very specific purpose. An odd complication was that this man's office looked down on the writer's across an open space of 550 feet. But there was no collusion—as yet no possible reason for any, since by the time the incidents had begun to make enough impression to lead to thoughts of conducting tests, the man had left town. Even his name now is forgotten. Was it telepathy? No outright claim is made that it was.

If telepathy is something like a sense, there are literally thousands of opportunities every day for those who can practice its use to do great good (and harm): to reveal criminals' secrets, catch criminals, nip plots, win business deals—the possibilities are endless. In the competitions of life a person who could read minds as he reads a book would as easily run down the field through the opposition as the Invisible Man, and soon could have control of all the money and power. Or he might, as a simpler test, tell us Hitler's plans—or tell Hitler ours. Aye, there's the opportunity—why aren't the ablest mind-readers attached to the general staffs? Something must be wrong.

Something obviously is: telepathy, if it occurs, is a pretty poor, frail sense—not a sense at all, compared with normal senses. Spontaneous in most instances. Erratic. Undependable.

Thus, as *The Truth Seeker* says, we still use the telegraph, the telephone, the mails, our vocal cords—with this statement we have no quarrel. Our question is whether telepathy ever occurs, and it hasn't yet been answered by anybody—not in the final sense that science calls proof.—*A.G.I.*

The Betatron

World's Most Powerful X-Ray Machine Holds Vast Possibilities for Medicine, Industry, Research

A. R. WILDHAGEN

FROM the physics laboratory of the University of Illinois has come a new machine which is the most powerful X-ray apparatus in the world, and in the field of atomic physics is considered the most important development of a decade. The machine is the betatron, developed by brilliant young Professor Donald W. Kerst, a device for accelerating electrons, which emerge from it with a speed of more than 185,000 miles per second and an energy of 20-million electron volts. Twenty-million-volt X-rays are produced by these electrons.

The speed imparted to the electrons by the betatron is only 0.03 of 1 percent less than the velocity of light—the highest velocity ever produced by any machine. The effect of these electrons is equivalent to 1800 grams of radium, four times the world's present $15,000,000 extracted supply of the substance.

The betatron's place in the scientific laboratory is alongside the cyclotron, the "whirligig atom-smasher" developed by Professor E. O. Lawrence, of the University of California. In the work they do, the betatron and the cyclotron complement each other: The cyclotron accelerates protons, the heavy particles from the nucleus of atoms; the betatron accelerates electrons, the light satellite parts of atoms. A proton is 1800 times as heavy as an electron and the two kinds of particles have opposite electrical charges. Because of these differences, the betatron, with its high-speed electrons, has opened entirely new opportunities for atomic research.

While both betatron and cyclotron electrically accelerate atomic particles, the similarity ends there. Operation of the two instruments is entirely different. The cyclotron accelerates protons by giving them repeated "kicks" as they spiral around in a vacuum chamber. The betatron gives one continued "push" to the electrons spinning in its vacuum tube. The cyclotron, such as one now being completed at the University of Illinois, weighs 60 tons, and with its shielding and auxiliary apparatus takes up more space than a two-car garage. The betatron, including all equipment, weighs less than four tons, is itself smaller than an office desk, and even with auxiliary apparatus, control panel, and shielding, requires little more space than a large closet. Operation of the cyclotron requires 150 kilowatts of power, while betatron operates on 30 kilowatts.

The 20-million-volt betatron at the University of Illinois has been in operation for a year, revealing the scientific importance and practical possibilities of this type of machine for medicine, industry, and research. For medicine, the high-voltage X-rays, and to an even greater extent the high-speed electrons, may make the betatron a very important weapon for use against malignant tissues in the human body. For industry, the powerful X-rays from the betatron may have important applications. For research in atomic physics, the betatron is a powerful new "atom-smasher," of special importance because its output can be precisely controlled and because it accelerates the light-weight electrons to speeds no other machine can approach. These electrons are 1800 times lighter than the protons accelerated by the cyclotron type of atom-smasher.

IN PENETRATING ability, the 20-million-volt X-ray beam produced by the betatron far exceeds the 400,000-volt X-rays now used for therapy in hospitals. Preliminary tests have revealed that the powerful X-rays from the betatron have the special advantage of producing their greatest effect about 1½ inches below the surface of the body. With X-ray therapy as used up to the present time, the effect is greatest on the surface, and decreases with depth. The tests with the betatron indicate the possibility of concentrating more treatment upon deep tissues with less effect to the skin and fatty tissues just under the skin.

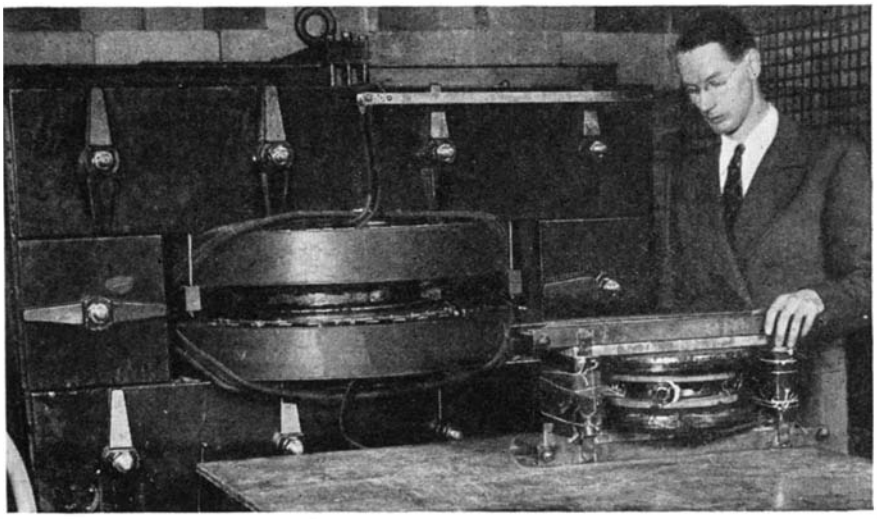
Direct use of the high-speed electrons from the betatron may be even more valuable than use of the X-rays. Most of the X-rays continue beyond the point of treatment to pass entirely through the patient. The electrons would not do this. At 20 million volts they will penetrate as far as four inches, and no farther. The region of maximum effect should be about three inches beneath the surface, according to calculations by Philip Morrison, of the University of Illinois physics staff.

Professor Kerst states that: "Sending the accelerated electrons directly into the patient is the most promising way to use the betatron for therapy." He suggests that 25- or 30-million-volt betatrons would be ideal for medical use. Their electron beams could penetrate more than halfway through a patient to reach any desired point in the body without effect beyond that point.

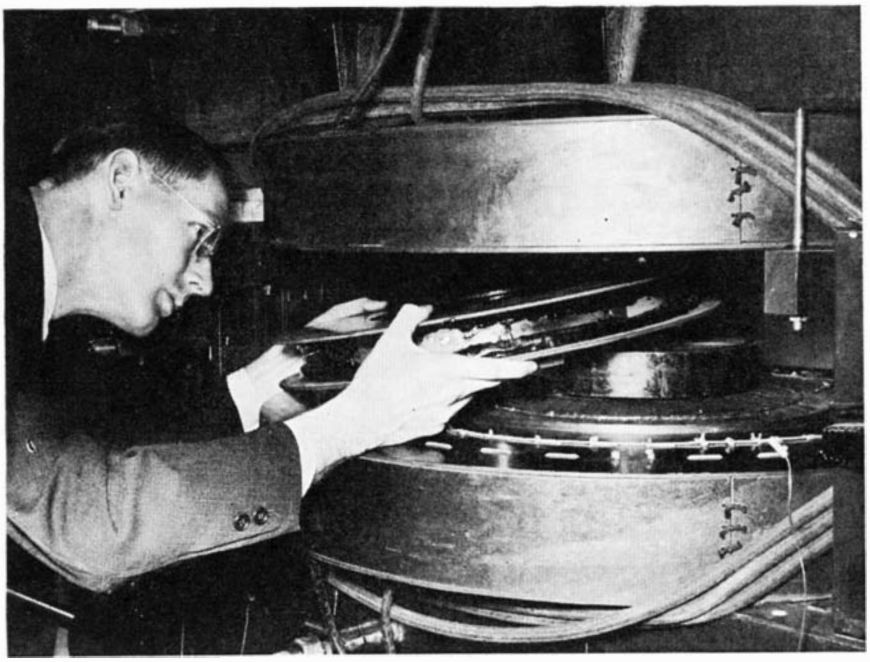
HOWEVER, the machine is not yet available for medical use. The only betatron in operation is that at the University of Illinois, where tests of its possibilities for therapy have been made by using a "phantom" made up of slabs of cellulose material having X-ray absorption equivalent to live tissue. Clinical tests of the betatron as an instrument of therapy are yet to be made. While the X-ray beam coming from the instrument is all that could be desired, the electron beam, with its greater possibilities, is not yet as compact as would be necessary for therapy. This difficulty soon will be overcome, according to Professor Kerst.

While industrial uses for the betatron may develop, the nature of X-rays is such that, beyond a certain energy, voltage increases do not increase penetration of the rays. This fact was verified by G. D. Adams and R. K. Clark, graduate students working with the 20-million-volt betatron. They showed that above three million volts further voltage increases reduced, instead of increased, the penetration of X-rays into lead, the standard substance for blocking the rays.

This result checks closely with theoretical calculations about the transformation of energy into matter. According to



Professor Donald W. Kerst with the first betatron, having 2.5-million volts output energy, on the table and the 20-million-volt machine alongside. The circular vacuum tube of the large unit can be seen in place in the center of the betatron, between the pole faces of the 3½-ton magnet. The larger betatron is only three feet high



The top half of the magnet of the betatron has been raised a few inches to permit insertion of the doughnut-shaped vacuum tube between the circular magnet poles

theory, such transformation begins at one million volts, where the X-ray energy is just sufficient to be converted into matter in the form of positrons and electrons. This conversion process increases at higher energies, with the result that beyond a certain voltage the X-ray penetration decreases as the X-ray energy increases.

THE X-RAY energy output of the betatron can be very precisely controlled. This feature has been utilized in research at Illinois by G. C. Baldwin, H. W. Koch, and L. W. Phillips. They investigated the exact amount of energy necessary to "smash" the atoms of various elements. Among their findings was that 11 million electron volts energy is necessary to disrupt the nucleus of copper as compared to 19 million volts for carbon. These are the first such precise measurements ever made at such high energies.

The betatron also may open the field of cosmic ray effects for laboratory research. Professor Kerst has plans for a 100-million volt betatron. Energies of this magnitude would be far beyond any needs or practical applications in medicine or industry at present, he states, but would have tremendous importance for science by producing cosmic-ray effects at will in the laboratory. Now the only source of cosmic rays is from interstellar space, and scientists studying these mysterious rays go to the tops of high mountains where the air screening them from the earth is thinnest, or send instruments into the stratosphere attached to free-flying balloons. What could be learned, and what applications might develop if cosmic-ray effects could be produced in a laboratory are subjects about which scientists cannot even conjecture as yet, when they know so little about the cosmic rays.

Professor Kerst's betatron is an entirely new scientific instrument which uses the increase of a magnetic field to accelerate electrons. It consists essentially of two parts—an electro-magnet and a doughnut-shaped vacuum tube. With these there is auxiliary equipment such as a motor-generator, condenser bank, control panel, and so on. The magnet of the 20-million-volt instrument is five feet long, three feet high, and is placed on a pedestal to bring its central opening to a convenient working height. The magnet weighs three and a half tons. It is laminated from 17,000 pieces of silicon steel. The faces of its poles are each 19 inches in diameter.

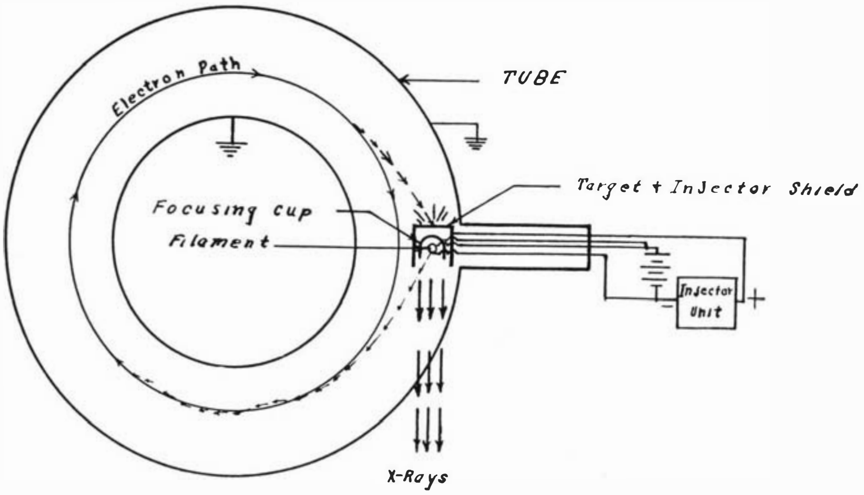
Between these poles is the doughnut-shaped vacuum tube, 19 inches in diameter on the outside, four inches wide, and two inches thick. The central opening is 11 inches in diameter. The inside of the glass is silvered and a stem projects from the tube at one side. Through seals in this stem wires lead to a filament, focusing cup, and shield, which form an injector unit located just inside the outer radius of the tube. The shield also serves as an X-ray source. (See the simplified diagram below.)

Professor Kerst describes the action of the betatron as being similar to that of a step-up transformer, with the electrons inside a doughnut-shaped vacuum tube replacing the secondary coil. A step-up transformer consists of an electromagnet with two windings: A primary of a few turns of wire through which an alternating current passes, and a secondary of many turns in which magnetic induction from the iron transformer core builds up a voltage proportional to the ratio between windings of the secondary and the primary. As current enters the primary, magnetic flux of the iron core builds up quickly from zero to full strength, inducing a corresponding surge of power in the wires of the secondary.

IN THE betatron, where the circular vacuum tube is between the magnet poles in the place of a secondary, the surge of magnetism whirls electrons around inside the tube, where they have been released by a heated filament, just as electrons are released by the glowing filament in a radio tube. A pulsating voltage on the injector propels the electrons into the tube in pulses or "bursts" at the rate of 180 bursts a second. The current through the coil of the magnet is alternating at the same frequency of 180 cycles per second.

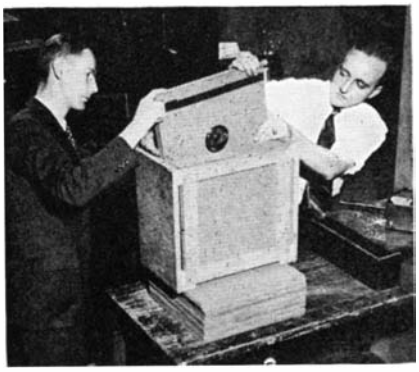
Each burst of electrons is released when the current in the coil is at zero and about to begin a cycle. As the flow of this current increases, the strength of the magnet also increases, and the electrons are whirled about inside the vacuum tube by the increasing magnetic field. The field is circular, corresponding to the pole faces of the magnet, and the electrons follow a circular path within the vacuum tube just as they would follow the wires of a coil.

The field pattern has been carefully planned to hold the electrons in a path which will keep them from striking the injector. Centrifugal force cannot cause the orbit to enlarge because the pole faces have been so designed that the increase in the magnetic field counterbalances any force tending to deflect the electrons from a compact stream. Instead of circling in



Path of the electrons in the vacuum tube of the betatron is shown in this drawing. The electrons coming from the filament of the injector are concentrated into the electron path by a magnetic field set up by the large magnet. After acceleration the electrons strike the injector shield which acts as a source of high-voltage X-rays

a wire, the electrons are spinning within the vacuum along a magnetically controlled path, at the same time being accelerated by the magnetic flux just as if they were following wires for every one of the 350,000 times they spin around inside the doughnut in the 1/720 of a second while the magnetic field is building from zero to peak in one polarity. Each revolution is equivalent to one turn of a secondary. In that 1/720 of a second the electrons travel a total distance of 250 miles, reach a speed of more than 185,000 miles per second, and gain an energy of 20 million volts.



Equipment used to test penetration of high-voltage X-rays when studying therapeutic possibilities. The frame contains a cellulose material which has X-ray absorption properties equivalent to those of living tissue

At the peak of the magnetic cycle, the balance of forces is disturbed, the electrons swing out of their fixed orbit, and strike the injector shield, producing an intense beam of 20-million-volt X-rays. The electrons also scatter out through the walls of the vacuum tube at their high speed.

Professor Kerst, the developer of the betatron, became interested in electronics through an interest in amateur radio. He attended the University of Wisconsin, where he graduated in 1934 and received his Ph.D in physics in 1937. He spent the next year in industrial development work. While in this, he became acquainted with the published reports of attempts to accelerate electrons by use of magnetic fields. The reports tell of attempts since the early 1920's by German, English, and American physicists. Kerst analyzed the idea in his spare time at home, and became convinced that the method was feasible. He took the suggestion to his employers and asked to be allowed to work out the idea. They said it couldn't be done.

The 27-year old physicist left his commercial job and joined the University of Illinois faculty, where Professor P. G. Kruger, acting head of the physics department, encouraged him. Theoretical details were worked out with the aid of Professors Robert Serber and H. M. Mott-Smith. Dean R. D. Carmichael of the Graduate School, and the Graduate Research Board, promised full support to the project because of the benefits to science if it succeeded.

During the next year, while teaching classes in physics, Kerst spent all his spare time in designing and building his first betatron. It was completed July 15, 1940, and operated without difficulty. An X-ray beam of 2.3-million electron volts energy came from the device. Kerst immediately began plans for a 100-million volt betatron. He pointed out that the device had "many practical possibilities," and listed "among them: an X-ray machine useful in all the many ways in which X-rays are useful and in some others because of the high energy and greater penetration; the high-speed electrons could be withdrawn out of the machine and used for electron therapy of malignant tissue inside of the body; various electric apparatus which requires a high-speed beam of electrons could possibly use a small betatron of the proper energy."

To speed the construction of a larger instrument and at the same time stimulate industrial interest in the production of betatrons for general practical use, Kerst obtained a leave of absence from the university and took his plans to the General Electric Company. The company entered into an agreement to provide the facilities of its laboratories for the production of a large betatron. As an intermediate step towards the 100-million volt machine, the 20-million volt betatron was built under Kerst's direction.

This instrument, when completed, was brought to the University of Illinois, where laboratory space was provided in the new Abbott power plant. It has been in operation there for more than a year. A betatron of 100-million volts output, following Kerst's design, is being constructed by the General Electric Company.

The name "betatron" was selected by Professor Kerst as a general term to indicate a device for accelerating electrons by means of a magnetic field. The name is from the Greek letter "beta" used by scientists to indicate high-speed electrons, and the Greek suffix "tron" meaning "an agency for." Translated, the betatron is an agency for producing high speed electrons.

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COLOR AND HEAT—In a study of gasoline storage tanks, the U. S. Bureau of Mines found that a red tank had an evaporation loss of 3.54 percent (over a period of four and one-half months) as against 1.4 percent for white.

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T V ARCHEOLOGY

Indian Kitchen Middens in Tennessee Excavated, Flooded

OVER an area of 75 square miles, now mostly covered by a great artificial lake, archeologists of the Tennessee Valley Authority found remains of an ancient river folk whose shell mounds reveal a progressive evolution from a pre-agriculture and pre-pottery stage to a fairly high level of primitive culture.

When plans were made to build a dam across the Tennessee River at Pickwick Landing, near the Shiloh battlefield, it was realized that an area of considerable archeological interest would be flooded. Scattered over the region were large mounds, composed principally of shells of river mollusks. These had formed the chief food of the primitive inhabitants and the shells were the debris from their "kitchens" over many centuries.

The archeologists worked to get as complete a record as possible of the ways of life of this ancient people before all traces were destroyed by the flooding of the area. Excavations were conducted under the direction of William S. Webb and David L. DeJarnette, of the Tennessee Valley Authority staff.

It was soon evident that the roots of the shell mounds were buried deep in prehistory. The builders had vanished long before the first white men came into this part of the continent. Undoubtedly Indians, that had settled along the river because of the wealth of shellfish—clams, freshwater snails, and the like—which it afforded them for food.

There is no evidence that they used the bow-and-arrow, although artifacts were found which suggest they were familiar with the atlatl, or throwing stick, as a weapon to kill mammals, fishes, and occasionally each other. They were not, to any great extent, fishermen. Some remains of both fish and mammals are found in their shell heaps, but on the whole they seem to have been contented with the easily gathered mollusks.

As the mounds grew in height, clay floors with fire hearths were built, and there are to be found zones containing great quantities of river pebbles broken by fire, together with much ashes and charcoal. These findings seem to indicate that they had started cooking on hot rocks. Clambakes became numerous, and in some cases quite elaborate.

Later, but before the advent of clay pottery, large vessels were cut from chunks of sandstone and soapstone and undoubtedly were used in cooking.

"It seems possible to discern in these shell middens," the archeologists report in a detailed account of their work published by the Smithsonian Institution, "a gradual development of the processes of cooking."

Presumably few primitive peoples were better in touch with the outside world. The river was always a great highway and they lived "by the side of the road." The evidence shows that most of the improvements in their way of life came from outside.

Primitive as they were, the shell-mound builders appear to have had one domestic animal, the dog, which entered in some way into their religious life. Skeletons of dogs are found in the graves with evidences that they had been buried with considerable ceremonial.

The early culture complex, Webb and DeJarnette say, is very different from any others known to exist in the southeastern United States. It contains no evidence of agriculture, although there is some indication of the use of storage bins. Nuts, roots, and seeds may have been gathered to supplement the shellfish diet. They had few, if any, textiles, so far as the evidence goes. These are so perishable, however, that failure to find them means little. There is no evidence of even semi-permanent house structures.

Nature's Cross-Word Puzzles

Typical Examples of a Kind of Indoor Sport Indulged in by a Few Astrophysical Fans: Simple Arithmetic

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REFERENCE has often been made in these columns to spectral lines which originate in an atomic state of low, or of high, energy; but the way in which it has been found that this is true has never been described. Yet the method by which spectra are analyzed is the simplest thing, in principle, in modern physics. It depends first of all upon very accurate measurements but, in working these out, it uses no more complicated mathematical processes than simple addition and subtraction. The actual working has a curious, and almost uncanny, resemblance to the solution of a cross-word puzzle—and exercises the same fascination upon the dozen or so physicists and astronomers who are its devotees. The writer, being one of the original "fans," ventures here to describe how it is done, in the hope that readers who like puzzles may be interested. The principles involved must, of course, be taken on trust here—this is a magazine article, and not a text-book on spectroscopy. They are simple.

Whenever an atom (or, for that matter, a molecule) emits or absorbs a spectral line, it makes a transition from one to another of the numerous sets of "energy states" in which it is capable of existing. When it unloads energy, it gives out light; when it takes it up, light is absorbed. In either case, the number of waves per second (or per centimeter) characteristic of the light is exactly proportional to the amount of energy emitted or absorbed—that is, to the difference between what the atom has in the two energy-levels.

Why this is true, no man knows; it is part of the mysterious set of quantum laws whose operation determines the kinds of atoms that can exist, and their properties, and gives us a universe in which things have definite size, form, and characteristics.

The more complicated atoms—iron, for example, or chromium—show thousands of lines in their spectra, and must have hundreds of different possible energy states. If we had a complete list of these states, with their energy measured in proper units, the wave-number (number of light-waves per centimeter) of each line would be the difference of the "levels" of a pair of these states. To find these energy-levels, given the wave-numbers of the lines, is the puzzle.

It would often be a hopeless puzzle, from its mere complexity, if we did not have some clues. One of the most important of these is furnished by comparison of the spectra of the same element emitted from sources of different temperature.

In a cold gas practically all the atoms of a given kind will be found in states of low energy. The classic example is the excessively rarefied gas in interstellar space, in which all the atoms are in the "ground state" of lowest possible energy. At temperatures of a few hundred degrees, Centigrade, where the most volatile metals begin to evaporate in a vacuum, most, though not quite all, of the atoms are in these low states. As the gas gets hotter, more of the atoms get into the "excited states" of higher energy, until at 3000 degrees—about the highest temperature available in an electric furnace—they are fairly well populated. In the arc, and above all in the spark, the atoms are much more highly excited, but mainly by electrical processes. In the furnace, the current is used only to heat the tube within which the metal under observation is placed, and temperature alone is effective. Now some of the lines emitted from the metallic vapor arise from transitions from high energy levels to those part way down, and others from transitions from lower levels to those at the bottom. In a hot furnace, lines of both types will appear; but, as the temperature is lowered, the number of atoms in the high energy states shrinks to practically nothing, and the lines produced by transition from them fade out. There will still be atoms, though not so many as before, in the states of intermediate energy, and transitions from these will still give observable lines, though fainter than before (which can be met by longer exposures). Evidently, at low temperature, only the transitions which end upon states near the bottom will show up; and it is thus possible to select from the great mass of lines in a complex spectrum a related group small enough for successful study.

The temperature classification of spectra in this fashion has been the life work of a single investigator, Dr. A. S. King, who, in the past 30 years, has studied almost all the known metals. A single element may demand an enormous amount of work—a paper on gadolinium, for example, lists nearly 6000 lines, and gives not only the temperature behavior, but new and highly accurate measures of wavelength. The enhanced lines, emitted by the ionized atom, are separated from the arc lines due to the neutral atom. Each set presents a quite independent problem of analysis.

With this preliminary, let us take up an actual example of one of Nature's spectroscopic puzzles.

Before the beginning of the modern physical interpretation of spectra in 1914, King published a temperature classification of the lines of chromium, including 670 lines, from the red at λ7000 to the near ultra-violet at 3500. Of these only 73 appeared in the spectrum of the furnace at the lowest temperature (about 1750°) at which enough chromium vaporized to show anything.

Here we should have a selection of the transitions down to a few of the lowest of the energy-levels. A list of these lines, with wave-numbers and intensities, is given in Table I. (It may be remarked that wave-number 13000 corresponds to the deep red, 16000 to the orange, 19000 to the green, 22000 to the blue, and 25000 to the violet.) A few other lines which will be discussed later, are added at the end of the list.

THIS list constitutes our puzzle. We have to find a set of numbers representing energy-levels, such that the differences between pairs of them shall give the observed wave-numbers. We dare not hope to get every one, for our list is short, and for a thorough analysis we should have data for the rest of the ultra-violet, the infra-red, and for a host of faint lines not listed here—but let us see what we can do.

To get a start, we look for "constant differences," on this principle: Suppose that there are two energy levels near together, separated, say, by 15 units. Transitions from any other level to these two will give a pair of lines with wave numbers differing by 15, and if there are several such pairs of transitions, we shall get several pairs of lines, with just the same separation.

There is a group of three strong lines

W. N.	Int.	W. N.	Int.	W. N.	Int.
27935.26	80	22972.72	25	19633.61	3
27820.20	100	22931.30	20	19517.74	3
27728.80	70	22870.19	20	19512.62	4
27649.73	3	22859.80	6	19208.74	50
26796.26	8	22798.75	20	19203.13	60
26787.46	8	22763.57	6	19194.29	75
25744.08	10	22657.83	6	19051.17	20
25731.31	8	22231.52	25	18991.14	20
25720.92	8	21991.43	20	18985.45	12
25673.05	7	21897.23	12	18874.49	20
25614.61	4	21827.69	20	18868.85	25
25613.01	5	21773.79	20	18860.02	12
25576.37	10	21729.51	20	18762.37	6
25527.47	6	21670.07	15	18701.06	30
25508.48	12	21657.09	25	18692.20	20
25496.36	9	21610.03	20	18479.88	40
25446.95	10	21517.07	40	15793.18	50
25363.96	10	21493.44	20	15711.83	30
23498.79	250	21489.40	30	15377.51	10
23386.33	200	20227.07	10	15291.09	15
23305.01	175	20135.67	8	15209.79	12
23047.95	20	19907.23	4	15078.87	20
23037.94	20	19801.36	3	11095.85	100
23036.52	12	19789.03	6	11087.08	75
23011.12	25	19725.04	3	11081.41	50
22976.52	15	19707.03	6	15191.27	20
				29824.69	20
				29584.59	20

Table I

in the green, with wave numbers 19208.74, 19203.13, 19194.29 and differences 5.61, 8.84. Not far away we have another group, 18874.49, 18868.85, 18860.02, and differences 5.64, 8.83. One of these coincidences might be due to chance, but hardly both. Not far away we find a pair of lines 18985-91 with difference 5.69, and on the other side 18692-701, difference 8.86. This *must* be significant, and it is evident that there are three energy levels separated by the amounts 5.65 and 8.84 (taking the mean of the three values found above). In the ultra-violet we find 26787-96 with difference 8.80—a further check.

The small differences between these values correspond on the average to only one part in half a million in the wave-numbers—indicating that the measures (which are taken from the great list compiled at the Massachusetts Institute of Technology) are very precise.

WE HAVE now another question. Does this triplet of lines lie at a higher or lower energy than the others with which it "combines"? Nothing in our main list helps to answer this; but from a general list of the lines in the chromium spectrum (which a serious investigator would have completely prepared in advance) three strong lines are found in the infra-red, 11095-87-81, with the differences 8.77, 5.67. But here the larger difference is from the middle to the larger wave-number, while in the other triplets it is from the middle to the smaller. This clearly means that the new level which we have found lies on the *opposite side* of the group of three from the other two. Hence the triplet group having levels a good way on each side of it cannot be one of the lowest in the atom. We must place it in a middle position, with the levels first found lower down, and the last one higher up by amounts equal to the wave-numbers of the lines. The lowest level (so far as we have gone) is evidently the one which is 26787 units below the middle member of the triplet.

Let us now arbitrarily call this level 0, and start to work out the others. This is best done on a diagram (Table II).

Here is our cross-word puzzle. The numbers in italics along the rim represent the energy levels—those inside the wave-numbers of the lines. From the pair of lines in the ultra-violet, we locate the levels a and b, then from the triplet in the green, we find two values 7593.17 and 7593.13 for the level B, take the average and find C. The next set of three lines gives level E (we shall see later why we placed it here) with decimal figures .37, .41, and .40. The two pairs of lines with separations 5.69 and 8.86 give us D and F in a manner which should now be obvious, and the three infra-red lines determine H, the three values agreeing within 0.04.

We have now done all that we can with the differences a-b and b-c; but we have something more to work with, for E-D=116.51 and F-E=167.84. The first of these differences appears between 21493 and 21610 and gives us the level d and the differences B-d then gives another line, at 21827. The identification of levels e and f is made in the same way.

	A_3	B_2	C_0	D_1	E_2	F_3	G_4	H_2
	0.00	*7593.15*	*7750.76*	*7810.88*	*7927.39*	*8095.23*	*8307.60*	*37883.32*
a_3 *26787.46*	26787.46	19194.29			18860.02	18692.20	18479.88	11095.85
b_2 *26796.26*	26796.20	19203.13		18985.45	18868.85	18701.06		11087.08
c_1 *26801.89*		19208.74	19051.17	18991.14	18874.49			11081.41
d_1 *29420.87*		21827.69	21670.07	21610.03	21493.44			
e_2 *28584.59*	29584.59	21991.43		21773.79	21657.08	21489.40		
f_3 *29824.68*	29824.69	22231.52			21897.23	21729.51	21517.07	
g_2 *23304.97*	23305.01	15711.83			15377.51	15209.79		
h_3 *23386.36*	23386.33	15793.18				15291.09	15078.87	
i_4 *23498.83*	23498.79						15191.27	

Table 2

The "combinations" between A and these new levels give lines beyond the lowest of King's original paper; but from a later list of his, two low-temperature lines (given at the end of Table I) are found in exactly the right positions. The combination with H gives lines in the unobserved infra-red.

We may now try something new. There is an unclassified line at 19051, distant 60.03 units from 18991. The line 21610 has a similar position in the other group we have found, and 21670 is 60.04 from it. These two lines locate the level C, and a similar process at the other corner of the figure finds D. Both levels are confirmed by lines in other parts of the spectrum.

NOW try something else. There are three great lines at 23305-386-498, with separations 81.32, 112.46. Hunting with the first of these we find 81.25 between 15711 and 15793, and then note that the differences between this pair of lines and the big ones are 7593.18 and 7593.15, exactly equal to A-B. The levels g and h can immediately be added to our array; and transitions between these and E, F, G account for four other low temperature lines in the red.

The third line of the big triplet suggests the level i, and a line not given by King, but in the M.I.T. tables, agrees so well with G-i as to confirm this—which is abundantly assured by other lines not in the present list.

The cross-word scheme is now visible in all its glory—and it may fairly be claimed the analogy has been made good.

At this point we may stop showing how to work the puzzle and leave the further solution to the reader—remarking only that 30 of the remaining lines in Table I can easily be fitted into the diagram by the same methods that have already been illustrated. The solution will be given next month.

The example given here is a fair one, for nothing which might confuse the solver has been omitted; but there are few, if any, instances in which a list of so few lines would contain within itself the full data for its analysis.

The result is, of course, only the nucleus of a very much bigger rectangular array—or matrix, as it is technically called—of levels and wave-numbers. Once such a scheme is started, it grows at the edges until it may take a sheet a yard square to write it on. As with a cross-word puzzle, every new gain opens the way for another one (as is illustrated above by the successive discovery of d, e, f, and then of C and G).

Once in a while there is an unkeyed letter in a puzzle; and there are unkeyed levels in spectra, which can be placed only by a general knowledge of the rules of the game.

For there are plenty of rules. The present simple case has been presented as a diagramless puzzle, because, though the arithmetic behind the "square array" is very simple, the rules are complicated, and belong to the text-book and not to the article. One of these may, however, be mentioned. It is possible to assign to each energy level an "inner quantum number," J, such that line-producing transitions occur only between levels for which J differs by 0 or 1. These numbers have been written in Table II as subscripts to the letters, and the reader may see for himself how the rule is satisfied. Moreover, there are two kinds of levels, called by the simple arithmetical names "odd" and "even," and lines arise only from transitions between odd and even levels. In the present case A, B... are even, a, b... odd. Transitions between two levels of the same "parity"—both odd or both even—are "forbidden"—they are less than a millionth part as likely as the permitted kind.

When once a spectrum has been analyzed, all sorts of important applications may be made. Even the little beginning we have made in analyzing the chromium spectrum illustrates the point—when it is first stated that a detailed analysis shows that the energy level here called A is actually the lowest in the neutral atom.

The transition from A to B is forbidden, but might imaginably happen in a nebula if there were chromium atoms in it. It would give a line of wave-number 7593.15 or wavelength 13166A. This is much too far in the infra-red to be observable in faint objects like stars or nebulae, so the knowledge is of no practical use to the astronomers.

On the other hand, if there are enough neutral chromium atoms in interstellar space, they should absorb the lines corresponding to transitions from the low state A and those above. The strongest of these is at wave number 23498.79 and wavelength 4254.35. This is in an easily observable region. It has not yet been observed; whence we may conclude that there is not much chromium in interstellar space. It may yet be found if observations can be made on more distant stars.—*Mount Wilson Observatory, February 23, 1943.*

Who Were Our Ancestors?

The Strange Tale of an Ancient Skull that Baffled a Committee of Experts Appointed to Investigate it

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THIS is an odd story. It is odd because it is an account of what paleontologists cannot do with a single bone—or even two. It is a striking refutation of the fallacious popular belief that an anatomist can always reconstruct an entire skeleton from a single fragment. Moreover, this is a mystery from far away and long ago. Two great glacial advances have flooded down over Europe and melted away through millenia of summers since the Swanscombe skull was carried on a body that walked upright and was alive in the England of the middle Ice Age. The ancient fragments portrayed upon these pages hold a mighty secret—but they hold it well indeed; so well, in fact, that learned and distinguished men meeting in solemn conclave over the remains have each time shaken their heads dubiously and emerged "by the same door wherein they went." Measurements have been taken. Anatomical points have been argued pro and con. But the mystery remains—and in that mystery lies shrouded the secret of our own antiquity as a species as well as the key to our evolutionary line of ascent.

The period immediately preceding the last decade had resulted in the development of two major theories in regard to human evolution, both based on the information accumulated up to that date. One regarded the line of ascent to ourselves as running more or less directly through a series of big-brow-ridged, massive-skulled types characterized by jaws lacking the chin eminence so typical of modern man. The face was large in proportion to the brain case, the nose was broad, and the teeth and dental arch larger than in *Homo sapiens.*

This type, whose earlier stage was regarded as represented by Pithecanthropus, the original Java Ape Man discovered by Dubois in 1891, was followed on the time scale by the classical Neanderthal type so long known from various sites in Europe.

Between the specimens, variations in the brow-ridge, the appearance of an incipient chin, and more elevated brow in some individuals, led to the suspicion that at some time during the middle third of the Würmian glaciation—the last glaciation to cover Europe—this type had evolved into our own progenitors on the European scene.

The second line of thought upon the subject of human evolution, a theory ardently supported by, among others, Sir Arthur Keith, the distinguished British anatomist, viewed this big-brow-ridged form of humanity quite differently. *Homo sapiens,* it was argued, was much too distinct in type to have been so rapidly derived from Neanderthal man in the closing Ice Age. Instead, supporters of this theory maintained that Neanderthal was already specialized away from the main line of human ascent to ourselves; that he was, in fact, a sort of collateral relative—human, of course, but not our immediate progenitor. This school expressed the view that our type was older in Europe than has been suspected and perhaps had followed a different line of development than the big, brow-ridged forms.

Giving weight to this view was the famous Piltdown skull, the vault of which was sapiens-like in structure, with reduced brow-ridges. It was accompanied by a very chimpanzee-like jaw, thus suggesting a more primitive lower face associated with a skull already essentially similar to our own. The marked dissimilarity of jaw and skull in this early Ice-Age fossil led to suspicions that the jaw and skull might have become associated through pure chance. (Some students regard the skull as an acceptable early fossil but would ignore the jaw.) Many arguments and much intensive research failed to quite clear away a pervading shadow of doubt which grew more intense as later finds, such as that at Peking, did not disclose any specimens similar to this strange and anomalous fossil. So dawned the last decade. What was it to reveal?

THE commercial gravel pits of England, unlike those of the United States, teem with the flint relics of man's Ice Age handiwork. As a result, they have been watched by collectors, amateur and professional alike, since the closing decades of the 19th Century. Unfortunately, however, although many thousands of implements had been collected, no authenticated discoveries of actual human remains, with the dubious exception of the Piltdown skull referred to above, had been found associated with the worked flints of the earlier Ice Age in Europe. It was obvious, of course, that man of some sort had existed, but what was he like? On this point knowledge failed us.

This is not to say that discoveries had not been made. They had. In fact, that is one reason why suspicions began to arise that there might be more than one possible line of evolutionary ascent to modern man. Curious stories could be told about some of these finds, most of them early and tainted with inevitable doubt as to the circumstances of discovery of the layers from which they may have been derived. There is the strange tale of the Foxhall jaw which was eventually brought to America, following which both owner and mandible disappeared. There is the story of the Galley Hill skull from the hundred-foot terrace of the Thames—a find to which Sir Arthur Keith, devoted some attention in later years.

All of these peculiar and doubtful discoveries had one curious thing in common. They were purportedly derived from deposits representing, not the closing Ice Age when we know that our own species was already in existence, but those lower and more deeply buried horizons representing either the earlier ice advances or the long interglacials between them. They were thus old, which would not have been amazing in itself, but, paradoxically, save for minor hints of primitiveness such as unusual skull thickness, they were modern in type! Obviously such reversals of the "orthodox" line of human ascent would need strong confirmation from more scientifically authenticated sources before acceptance. Ironically, when it came, the evidence was to prove, in some degree at least, as capable of double interpretation as the cryptic prophecies of a Greek oracle.

MR. ALVAN MARSTON, dental surgeon and amateur archeologist, made the discovery of the first fragment of the Swanscombe skull in June of 1935. It was that rare and almost never attained combination: a significant discovery made by a man gifted enough to appreciate instantaneously the value of his discovery and to obtain immediate confirmation by witnesses of the location of the remains and all pertinent geological information relating to the site. The find was made in the Barnfield Pit at Swanscombe, near London, to a depth of 24 feet beneath the surface.

The bone, a complete human occipital, including the foramen magnum, or spinal opening, at the base of the skull, lay in a stratum which, geologically and in terms of the implements found there, is assignable to the Second, or Mindel-Riss, Interglacial Period. Within that period we know that some type of man chipped oval flints which were apparently unhafted, but instead held in the hand and used for cutting and chopping purposes. Possibly they may also have been utilized for digging up succulent roots and tubers. These implements can be roughly termed "hand axes." Various styles and refinement of workmanship permit their assignment to different periods and hence they are valuable for dating purposes. The Swanscombe skull is thus older than the known remains of Neanderthal man in Europe, being associated with that phase of the hand ax cultures of the Lower Stone Age known as Achuelian. It is, moreover, the first entirely authenticated example of human remains to be recovered from an Acheulian horizon. By the glacial time clock that human fragment lies two glaciations, one interglacial and a half away from us, a time, perhaps, no less than 400,000 years as the living measure such things.

By dint of tireless application and persistence, Mr. Marston made one additional discovery. Nine months later, in the same layer, but lying a little distance away, he located the left parietal bone of the same skull. Since that time nothing else has been reported. We are thus left with the cranium featured in the drawing: the base and back of the head and part of the side. The face is completely missing, along with the lower jaw. At this point we must turn to the anatomist for aid. It may be that he can tell us something as to the physical type of the early flint chippers who worked beside the Thames.

Without entering extensively into the tedious detail of anatomical analysis, the following facts may be noted: First of all, although lying, in point of time, very close to the period of the small-brained Peking and Java types, the skull under discussion possesses a cranial capacity around 1935 cubic centimeters. It thus falls well within the modern range of female brain capacity —and the Swanscombe skull is believed to be that of a female. Casts of the interior of that portion of the skull available to us reveal a richly convoluted and ad-

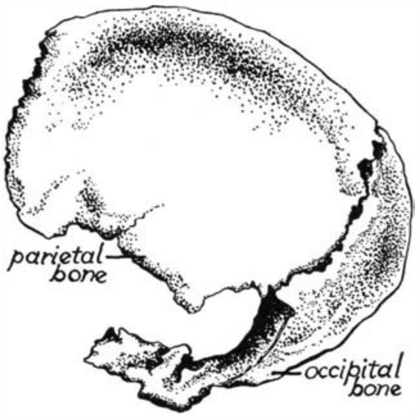
All drawings by Ann Murray
Rear view of Swanscombe skull

vanced type of brain. In the words of the British anatomist, Le Gros Clark: "the main point of interest of the cast is the indication it gives that in early Paleolithic times the human brain had already acquired a status typical of *Homo sapiens.*"

The occipital bone is broad and more massive than the average female skull of to-day. Its thickness is also exceptional and is shared by the accompanying parietal bone. Beyond this massive quality, however, (and we know from the Piltdown example that this need not imply heavy brow-ridges) there is nothing which will surely distinguish the cranium from that of existing man. In one or two measurements, such as involve the breadth at the back of the head, the skull is unusual. It does not lie far enough outside the modern individual range, however, to enable us, on that basis alone, to reject the likelihood that the Swanscombe individual was essentially a slightly more primitive replica of ourselves.

An extended analysis of the measurements of typical Neanderthal skulls by the English scientist, Morant, has shown that, so far as the big-brow-ridged, heavy skulled, "classic" Neanderthal type is concerned, the latter *can* be definitely distinguished from modern man—even when only such bones as confront us in the Swanscombe example are at hand. If it had not been for one peculiar discovery on the European continent, it is possible that the Royal Anthropological Institute committee which met to consider the Swanscombe skull might have been inclined to come out boldly and assign the Swanscombe fragments to our own species. Things in the earth, however, have a way of confounding us all. It was so in this case.

Two years before the Swanscombe discovery a Neanderthal skull had been found in the gravels of the river Neckar, near Steinheim, Germany. The Steinheim cranium is much more complete than the Swanscombe skull. Strangely enough, since it is quite possibly as old as the third, or Riss, glaciation, this individual, in some characteristics, is more modern



A side view of the same skull

in type than the later Neanderthals, most of whose recovered remains date into the first phase of the last, or Würmian ice.

Though the brow ridges are still heavy and pronounced, the back of the Steinheim skull is nicely rounded and completely unexceptional. It lacks both the great breadth and the bony ridge for heavy muscular attachments so characteristic of the later Neanderthals. The skull, instead of being low and broad, carries its capacity on a more vertically arranged plan, as in modern man, though it must be noted that the Steinheim cranial capacity is considerably less than that of Swanscombe. In the words of Morant, however, the Steinheim skull, so far as its parietal and occipital bones are concerned, is "even less peculiar than the Swanscombe." This fact, of course, so long as the Swanscombe face is missing, must inevitably introduce the possibility that the fragments we have been considering may have belonged to a human type with a face more primitive than our own. For this there can be no answer until further discoveries are made.

Nevertheless, when all due allowance is made for this possibility, the Swanscombe skull seems clearly to suggest that our previously mentioned Acheulian hand-ax makers, in several major characters at least, were more closely related to modern man than the huge-browed anthropoidal Neanderthalers, whose bones rest in the European caves immediately below those

The Steinheim skull. Note the rounded and sapiens-like curve of the skull vault at the back of the head

of our own ancestors of the closing phases of the last glaciation.

The Swanscombe skull clearly demonstrates that a higher form of man than the small-brained Pithecanthropus type was in existence in Europe in times early enough to approach, if not to overlap completely, upon the antiquity of that extremely primitive Asiatic form. Our search for human origins is thus complicated by the possibility that a varied assemblage of human types simultaneously existed in the lower (earlier) Ice Age. Which of these types is truly ancestral to modern man? Or have several played their part and was *Homo sapiens* from the start something of a mongrel breed?

To none of these questions can science as yet provide an exact answer. But the bones from the Barnfield Pit at Swanscombe, if the rest are ever found, may indicate the solution to a major question in human prehistory: *Whether, that is, a form approximating our own species in appearance had attained such status far back in the dim vistas of the earlier Ice Age or whether, on the other hand, we, as individuals, derive from a big-browed human line, like Neanderthal, which remained primitive in all its major aspects down into the period of the last ice advance.*

Human vanity, of course, will always tug toward the former explanation—and of human vanity one must beware in science. Yet the Swanscombe skull does suggest, and other evidence accumulated from Palestine in recent years is not contradictory, that if the line leading to ourselves attaches at some point to a Neanderthaloid form, that point of transition lies at an earlier period than the time of the "classic" late Neanderthalers who hunted along the European ice-front in the last oncoming cold.

Suddenly the Neanderthalers vanish. And into their former domain a new, lithe figure enters—our tall forefathers of the period of the dying ice. Did they really spring in so short a time from those rugged, little, beetling-browed men of the long cave darkness? It now seems doubtful—at least in terms of so short a period as a single glacial advance. But after perusing all the literature, examining the whole extensive controversy, we can feel sure of just one thing—that somewhere among the English gravels the answer is still lying quietly in the earth. Until those missing bones, or others like them, are found, science may guess and grope, but science will not know.

What About Vitamin Tablets?

What Can Science Say Today about the Desirability of Taking Supplementary Vitamins? Is it Good or Bad?

T. SWANN HARDING

CAN WE win the war with vitamins? If we don't it will hardly be our fault. To fill allied requests the Department of Agriculture bought nearly $3,000,000 worth of vitamins in October, 1942, alone —B_1 and C especially. Its total purchases of vitamins in the 19 months between March 15, 1941, and October 31, 1942, aggregated:

Twenty-one trillion units of vitamin A from fish-liver oil costing over $3,000,000.

More than eight tons of thiamin hydrochloride, or vitamin B_1, costing over $4,000,000.

Thirty tons of ascorbic acid, or vitamin C, costing $1,246,000.

Riboflavin (vitamin B_6) and others purchased in somewhat less imposing quantities.

All told, nearly $9,000,000 had thus been spent on vitamins up to November 1942. These vitamins went to our armed forces and to our allies.

But the enemy has not been caught napping. A correspondent in the South Pacific recently wrote about going toward the combat zone while chewing Japanese vitamin tablets—captured, of course—which tasted as if composed of equal parts peppermint candy and chalk. But they had vitamins A, B, C, and D in them, and this certified to the fact that the Japs have the same faith in vitamins that we have. This faith now amounts to an international religious belief.

Of course, commerce and trade cannot be said to have altogether overlooked the possibilities of this newer religious cult. An article in *Barron's* for February 10, 1941, pointed out these possibilities: Whereas, in 1929 our vitamin output was valued at only $4,500,000, and constituted but 1.3 percent of the total value of drug and medicinal products manufactured, in 1939 the corresponding figures were nearly $42,000,000 and 12 percent. Obviously, opportunity knocked.

The financial writer went on to observe that a government educational campaign was already under way to acquaint the people with the virtues of vitamins—as if they needed that! He added that doctors were getting interested, and that articles were appearing in popular magazines. Whereas only 10 percent of the population then was taking vitamins, many more soon would be, and foods would soon be loaded with them. Hence, he pointed out, this new field offered sterling investment opportunities. And so it came to pass—but all great religions have had some money changers in their temples from time immemorial, so let's not be cynical.

We do need vitamins, in some form or another. Lack of vitamin B_1 was largely responsible for the bothersome epidemics of beri beri in 1914-18, a disease characterized in its early stages by nervous debility and lack of energy. Today crystalline B_1 in 16-pound, waterproof containers should help prevent a repetition of that among our troops. Vitamin A (often jocularly called the anti-blackout vitamin because a deficiency of it causes night blindness) is now supplied in 55-gallon steel drums. The British mix fish-liver oil with their oleomargarine to get plenty of A. It is often issued in tablet form to members of our armed forces. Vitamin C, which prevents the occurrence of anemia and scurvy, is used increasingly on fronts where fresh vegetables and fruits are scarce. Aside from the tablet form, in which our armed forces often get it, crystals of C are sent to the Allies who mix it with food and distribute it for medicinal and civilian use.

IN THIS whole vitamin question, the difficulty boils down to finding out just how much is fact and just how much is fancy. Let us see whether it is today possible to strike a balance—freely confessing that science and medicine do not yet know everything about this big question.

Tests have pretty definitely proved that, when deprived of the vitamin B complex, both men and women tend to become irritable, unco-operative, forgetful, and low in stamina and energy. Even partial deprivation affects their working ability. Other tests have "proved" that vitamins prevent or cure colds and perform all sorts of other tricks, yet, in such instances it largely depends on what you call proof.

In reality medical opinions still vary about the efficacy of vitamin therapy. Probably the most reliable research of all indicates that taking vitamins prevents neither colds nor exhaustion, at least under ordinary conditions and when the subjects eat well-balanced meals. Incidentally, we do not yet know within 50 percent or more the true requirements of normal men and women for any vitamin, nor the effects of modes of life, habits, and activities on those requirements.

The best-conducted experiment so far made on the effect of vitamins in preventing or lessening the severity of colds was carried on in Minnesota with students of the State's university. The work was carefully controlled. Some tests were made with placebos (pills containing only milk sugar—inactive), some with vitamin C only, and some with multi-vitamin preparation containing vitamin A, thiamin hydrochloride, riboflavin, ascorbic acid or vitamin C, and vitamin D. An interesting finding was that every treatment, *including those with placebos*, reduced the number of colds. The general conclusion was: "This controlled study yields no indication that either large doses of vitamin C alone or large doses of vitamins A, B_1, B_2, C, and D, and nicotinic acid, have any important effect on the number or severity of infections of the upper respiratory track when administered to young adults who presumably were already on a reasonably adequate diet."

The decrease in the number of colds reported by the control subjects who got no vitamins was about the same—60 to 65 percent—as that for those who got vitamins. In the same way injections of sterile salt solutions as well as of vaccines will seem to prevent colds; starch tablets will reduce the number of colds about the same as orally administered vaccines; and capsules of liquid petrolatum do as well as vitamin concentrates. Here we are definitely in the precincts of psychology.

WHILE it is fairly certain that malnutrition, such as is connected with vitamin deficiencies, can cause lowered vitality, poor resistance to infection, and so on, under normal circumstances, a variety of other uncontrolled factors are in operation at the same time. These confuse the picture and make it less easy to evaluate this factor. There is no scientific warrant yet for mass-scale dosage with vitamins. For example, better attention to personal hygiene, or improved working and living conditions, are often in part responsible for the favorable effects often credited to vitamin dosage.

The War Department recently made prolonged trials at a Minnesota camp on soldiers of ages from 19 to 34 who got their regular rations and supplements of vitamins—B_1, C, the B complex—or a placebo for check. The conclusion reached was that vitamin dosage produced no increase in muscular endurance and no other measurable physical improvement. The tests covered many weeks of severe and prolonged muscular effort. That, itself, seems pretty conclusive with regard to supplementary vitamins.

The fact remains, of course, that *underfed* people in Nazi-dominated or Nazi-menaced countries do get insufficient vitamins, and doubtless do need supplements to their diets. But our Army is usually well fed, though in certain circumstances its diet becomes scant and vitamin concentrates are needed. Dried, canned, and dehydrated foods retain their vitamins well, and the Army's tests show little necessity for added vitamins under normal conditions.

Supplementary vitamins are simply important food constituents that have been isolated, concentrated, or synthesized. Certain restricted diets may lack the corresponding vitamins, and the resulting symptoms are varied.

The American Medical Association formerly denounced shotgun vitamin therapy without mercy. This it did, for instance, in September, 1935 but by July, 1942, it had decided that new factors demanded a reconsideration of its former position. In general, it felt that multi-vitamin mixtures would be acceptable to it, provided they met certain standards as to quantitative vitamin content.

Meanwhile, in late 1941, the food manufacturers announced a strong determination to wrest the vitamin business away from drug interests by seeking to increase consumer demand for protective foods. This was proposed as a long-term, not as a high-pressure program. The industry must first be educated. Consequently we soon had the packers advertising the vitamin content of meats on the raw basis, though meat is customarily consumed in cooked form.

The fact remains that we should do better to obtain our vitamins from foods, if possible.

Gordon and Sevringhaus said, in *Vitamin Therapy,* in 1940: "The body of man has not yet evolved so that he can function efficiently on tablets and food concentrates. His physiology requires the materials essential to health and well-being in the form of food. Synthetic tablets are not a perfect substitute. The ingredients of food purchased in the form of pills are wastefully expensive." Large doses of supplementary vitamins are wasteful, as the body excretes them unused.

IT IS, however, well enough to prescribe vitamin concentrates as drugs to overcome months of previous proved deficiency.

The public is often fooled by the labels of multiple-vitamin preparations. A dose of 10,000 to 20,000 units of vitamin A seems large, though the unit represents but 6/10,000 of a milligram. Yet such large doses would be required only in rare cases of extreme deficiency. On the other hand, some vitamin-B complex capsules contain too little vitamin-B complex to be beneficial. It is fair to say, however, that many are actually above standard.

Generally speaking, the advertisements tend to make us think we all need vitamin concentrates. This is the modern version of snake oil, a new therapeutic gospel of the shotgun prescription. Vitamins are added to milk and bread and are even added to soap, facial creams, pills, candy bars, toothpastes, and breakfast foods, and the vitamin business is a $100,000,000-a-year affair.

Actually the cornerstone of laboratory research on vitamin requirements has scarcely yet been placed; but, so far as scientists now know, the only people who really need vitamin concentrates are babies and young children, expectant and nursing mothers, persons recuperating from illness, or those temporarily on restricted diets. The last group always includes some of our armed forces.

The vitamin-containing foods are, primarily, eggs, butter, cheese, whole milk, cream, fish-liver oils, leafy green and yellow vegetables, fresh fruits, whole-grain cereals, legumes, peanuts, soybeans, green peas, green lima beans, pork, chicken, kidney, citrus fruits, tomatoes, salmon, whole-grain rice, liver, and so on. Daily consumption of a good serving of ham, a green vegetable, a glass of milk, a slice of brown bread, and an orange—all as one example—will supply sufficient vitamins. In short, vitamin troubles largely vanish if we include in the diet plenty of fresh green vegetables, fresh fruits, lean meat, animal organs, milk, butter, cheese, eggs, and whole-grain cereals.

Insofar as the diet is restricted by rationing or other conditions over which we have no control, the use of supplementary vitamins is warranted. Otherwise they should be used only when the doctor says—for the average person can get all the vitamins he needs from a balanced diet of carefully selected foods. Thus we have seen that:

Our government and those of our enemies are using vitamins, but there is a tendency among the people to exalt vitamin taking to the level of a religion—a tendency which some drug manufacturers have not omitted to exploit.

Nevertheless, we do need vitamins of one kind or another, natural or substitute.

Science cannot yet draw a sharp demarcation between fact and fancy in the realm of vitamins—our knowledge is still too imperfect. Medical opinion varies somewhat.

One piece of research reveals that taking supplementary vitamins does not reduce the number of colds we suffer. Another research shows that no increase in muscular endurance, or other measurable physical improvement, comes about due to taking supplementary vitamins.

Not all food manufacturers have told the whole, frank truth in their vitamin advertising.

Some doctors question whether synthetic vitamins are a perfect substitute for the natural ones in food.

Not all the supplementary vitamins sold to the public are up to standard.

One excellent solution of the vitamin problem is to eat a well-planned, well-balanced diet of foods. Where there is some special circumstance, supplementary vitamins are warranted on the basis of evidence as at present known.

Finally, science still has a lot to learn about vitamins—the research isn't finished. In the meantime, many wonder whether too many haven't gone off half-cocked. This may have something to do with a tendency on the part of doctors and scientists to be skeptical or at least cautious.

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IDEAL WEIGHTS

A Little Hunger May Improve the Nation's Health

ALL in all, longevity is probably the best single index of "ideal" weight. A large-scale study by the Metropolitan Life Insurance Company has shown definitely that at the young adult ages a moderate degree of overweight was beneficial, but that beginning at about 35, the advantage lay with women of average weight. In middle age and beyond, the underweights had the best longevity record.

Even in young people, the advantage of a moderate degree of overweight has been diminishing, because two important diseases—tuberculosis and pneumonia—which have largely accounted for the excess mortality among young underweights in the past, have been brought under control. Indeed, the advantage of overweight at the younger ages is so temporary that if the whole life span is considered, a moderate degree of overweight even at those ages is probably not desirable, because it often indicates a tendency to overeat, which is the basis of much preventable obesity of later life.

For adults, irrespective of age, the most favorable weights for health and longevity are probably close to the averages observed at ages 25 to 30.

Overweights with high blood pressure often get relief merely by reduction in weight. Another striking example, curiously enough, is connected with war. In some countries which have experienced severe limitation of food supplies, the death rates from diabetes and other chronic diseases associated with overweight have declined.

MENACE

Tropical Diseases Menace Us But Education Menaces Them

THE PARASITIC diseases of the tropics, including malaria and sleeping sickness, largely confined to those areas in the past, now loom as a potential menace to the health of individuals everywhere, Dr. James T. Culbertson of the department of bacteriology of the Columbia University School of Medicine declares in a book, "Medical Parasitology."

Americans in the armed forces whom global war has sent to the tropics and subtropics are especially threatened by animal parasites. Fortunately, according to Dr. Culbertson, specific drugs which lead to cure are known for most of the infections. Sometimes the cures are dramatic and prompt. Nor is it too much to hope that in time human beings will, through vaccination, be rendered at least relatively resistant to the effects of the organisms and possibly absolutely immune.

"All the parasitic infections now seem likely to experience a new and widespread distribution to fresh areas as a consequence of the rise in business and travel which, in large part, air transport has made possible," Dr. Culbertson says.

"The greatest hope of protection against these dread maladies will come through a more adequate diffusion of knowledge of the agents which cause them. Hitherto, comparatively little instruction upon the causes of these parasitic diseases has been offered in the medical schools of this country. It is now appreciated that in the past many cases of parasitic disease occurred among us but were overlooked because of our ignorance concerning them. However slow the progress, education is probably in the end the most effective method of prophylaxis, for without appreciation of both the danger of infection and also the advantages of freedom from it, the layman, in the temperate zone as well as in the tropics, will be slow to endeavor either to protect himself from animal parasites or to co-operate in affording protection to his fellow man."

Testing For Victory

Industrial Safety in All its Phases is the Direct Concern of a Unique Non-Profit Organization

ALVAH SMALL
President, Underwriters' Laboratories, Inc.

Now, more than ever before, it is necessary to uphold industrial safety, for those products which find their way into factories, warehouses, munitions plants, barracks, and transport facilities are an integral part of the planned production, training, housing, and transportation necessary for victory. Fires or explosions caused by their failure, injury to personnel, and other preventable accidents directly benefit the Axis.

Thus the use of science and engineering to safeguard lives and property, which has been the forte of Underwriters' Laboratories for nearly 50 years, has unusual importance today. The goal of this work has been reduction of losses from fires, accidents, crime, and related dangers. Today, as in World War I, the Laboratories' fund of information, and its technical services, built up through testing and research, are daily being tapped by many branches of the Government, armed forces, industry, and others, in order to speed the war effort with safety.

Test methods and performance standards, established by Underwriters' Laboratories, have existed for a large percentage of the problems which have arisen. In more than a few cases, however, test precedures and suitable performance characteristics have had to be decided upon on the basis of past experience with similar problems and products.

A non-profit engineering safety organization, the Laboratories was organized in Chicago in 1894 by the capital stock fire insurance companies of the National Board of Fire Underwriters, and now operates three testing stations. The main one, and largest, is in Chicago, while the others are in New York and San Francisco; there is also an explosion station at Lemont, Illinois.

The organization is self-supporting, its work being carried on by testing manufactured products sent by their makers to the testing stations for approval. This part of the work is paid for by the manufacturers on a time-salary-rate basis for each investigation. The investigations are conducted at cost.

Although more than 350,000 different products have been approved, about half of the products sent in for test fail on the first investigation to meet all of the safety requirements they must pass before they may carry the Underwriters' Laboratories' label. Subsequently the construction or performance of some of these products is modified in such a way that they pass the tests.

After the design, construction, and performance of a product has been found safe by test and investigation at one of the testing stations, the product is regularly and periodically inspected at the factory to assure continued conformance with the safety specifications or standards of Underwriters' Laboratories. This inspection work is paid for by the manufacturers, and, like the original investigation of new products, is done at cost; that is, at no profit.

To carry out this inspection work at factories, Underwriters' Laboratories has 187 offices in principal production centers in the United States and Canada from which inspectors (technical men trained by the Laboratories), regularly visit the factories to check and test the approved products. More than 66,000 inspections are normally (before the war) made at factories each year to assure the safety of some 500,000 products in more than 115 different industries. (Because of the curtailment of civilian products there has been some reduction in the total number of UL approved products being produced.)

Testing materials for extinguishing magnesium fires at Underwriters' Laboratories. Thermocouples are placed in the center of the pile of burning magnesium; temperatures are read from recording instruments in background. Efficiency of extinguishing material is determined by speed of reduction of temperature

The ways in which the Laboratories' services are being used during this war are many and varied, probably the most important and far-reaching activities having to do with substitutes for critical materials in many varied fields of endeavor.

When WPB limitation orders or other Government directives drastically reduce or completely cut off the amounts of copper, rubber, zinc, cadmium (to name only a few) which can be used in certain products, questions arise as to what can be used in place of these materials. It is natural that the answers to these questions should come from Underwriters' Laboratories, for approved devices of some 5000 manufacturers are on its lists of inspected products, and safety standards exist for these products.

Obviously, fire doors, extinguishers, fire hose, alarm systems, lighting fixtures, electric switches, roofing, and thousands of other products must be made in spite of war-caused shortages of certain materials. And they must be made so that they will perform safely and will not disrupt war production through failure. Under these circumstances, and in order to maintain as high a factor of safety as possible, Underwriters' Laboratories has issued Emergency Specifications covering many products. These specifications will be in effect only for the period of the war emergency; afterwards, the regular peace-time UL Standards will apply.

Before setting Emergency Standards for such products as fire hose, when the amount of crude rubber for hose linings was cut more than 50 percent by WPB, extensive test work was performed. As a result, specifications were developed which, when met, provide a safe, reliable, and satisfactory product; a method of checking so as to maintain this standard through inspection at the factory was also put into use.

Similarly, when brass was restricted for fire-hose couplings, it became necessary to work out a new design and new specifications employing less critical materials. A final design was eventually settled upon, consisting of malleable iron tail-pieces and a low-content brass swivel ring—the ferrous parts suitably protected against corrosion. Several thousand tons of brass have already been saved by this change, and the performance of the new couplings—from the Fire Department viewpoint—is entirely satisfactory.

In one year, the Electrical Department—to take just one of seven engineering departments at Underwriters' Laboratories—has issued 60 sets of Emergency Requriements. These cover such diverse subjects as the use of steel instead of copper for certain electrical current-carrying parts; the use of uninsulated neutral or grounded conductors in non-metallic sheathed cables; and enamel coatings as a corrosion protection on electrical conduit, in place of metallic galvanizing.

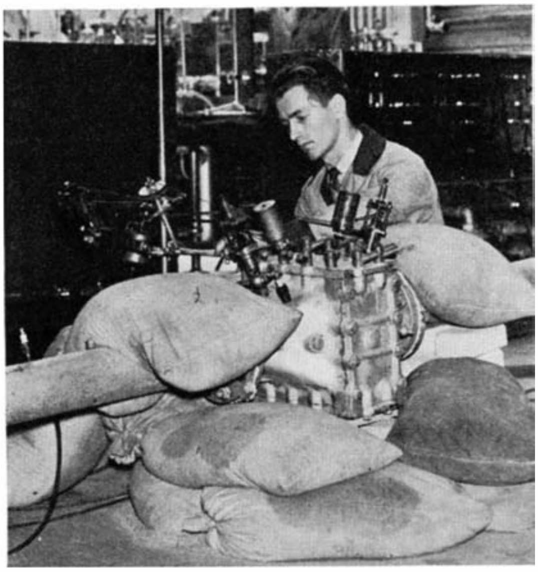
Because of the variety of conditions which must be met in the design and use of different devices, the suitability of this or that substitute must be determined individually for each type of product considered. Steel, for example, cannot be used as an electrical conductor in place of copper in all cases. Only where thorough testing shows that safety is not threatened, may it be permitted. Careful consideration of each such problem is essential and, for these reasons, such work has occupied much of Underwriters' Laboratories' time since Pearl Harbor.

The types of products mentioned so far may or not be purchased directly by the Federal Government. However, comparatively few of them are for civilian use as practically all of the manufacturers with whom the Laboratories deal are now 100 percent on war production. Most of the myriad of civilian products which Underwriters' Laboratories ordinarily tests, particularly those in the field of domestic electrical devices, are virtually not being produced today.

A torch attack on a vault door in which is installed a microphone burglar alarm intended to detect noise of such attacks and send an alarm. Underwriters' Laboratories has made a series of recordings of the noises made in carrying out various types of attacks on vaults. With these recordings many burglar-alarm systems can be accurately tested

Another wartime activity of Underwriters' Laboratories is the testing and inspection at factories of large quantities of various kinds of materials purchased by the different branches of the Government under Federal Specifications. This work is carried on readily by the Laboratories' staff of trained inspectors in offices located near centers of production in 187 cities.

Products which the Laboratories inspects for the Government are insulated safes, food-mixing machines, vegetable or meat-slicing machines, safety cans, explosion-proof motors, knife switches, synthetic-insulated wire, fire hose, fire extinguishers, watchmen's clocks, steel scaffolding, and a hundred or more other items.



Flame arresters for vent lines of oil storage tanks are tested with this equipment. The arrester is placed in the line shown and gas mixture introduced into each end. One explosive mixture is fired; a few seconds later the other is touched off. If the second one explodes, it proves flame from first did not pass arrester

As an example, several hundred miles of rubber-lined fire hose are delivered monthly to the Army and to the Office of Civilian Defense under Emergency Federal Specifications. The OCD has on order a large number of 50-foot lengths of 1½- and 2½-inch single-jacket fire hose. As of November 1, 1942, 30 percent of it had been tested at factories by Laboratories' engineers. The remainder is being tested as produced.

Still another way in which the Laboratories is contributing to the war effort is through the uses made of its engineering services and special-investigation facilities. Investigations have been conducted for the Army, Navy, Treasury Department, War Production Board, and for manufacturers supplying these and other Government branches. Typical problems are:

Fire and explosion hazards of butadiene and styrene used in the manufacture of Buna-S rubber. Effectiveness of methods and products for preventing the shattering of glass by explosions under air-raid conditions. Investigation of fire-retardant qualities of marine type bulkheads. Investigation of the effectiveness of electrically conductive flooring, conductive floor finishes, and conductive shoes for use in arsenals and munitions plants where accumulations of static electricity are a hazard. Determination of flammability of camouflage materials for gun emplacements, and for other protective concealments. Inspection of protective installations for safes and vaults for storage of securities, narcotics, medical supplies, secret codes, valuable documents, plans, and so on. Tests for tanks for hazardous liquids for use by the Army and by war plants.

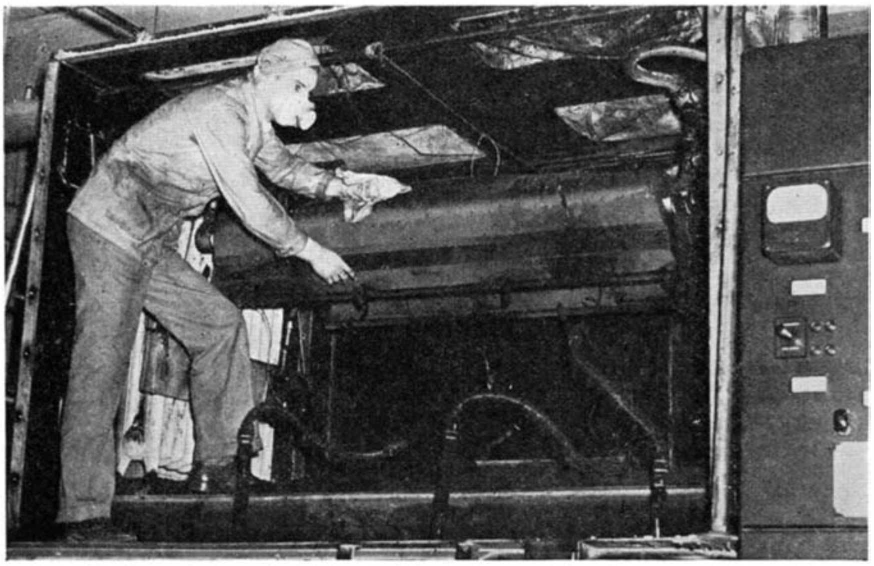
The exact results of these and many other investigations must remain shrouded in military secrecy for the duration.

Much of the work which has been cited here as examples of Underwriters' Laboratories operations has been performed under "rush" conditions. In fact, in some instances production at numerous factories has been held up pending the solving of the problems. Consequently, less important UL work has been pushed aside, engineers have been "borrowed" by one department from another where necessary, and all possible speed has been made in the completion of the investigations.

One more example of the war-effort activity of the Laboratories has to do with the protection of shell-loading and munitions plant from lightning. Specialists assisted in the drawing of Federal Specifications covering this subject. Contracts awarded for the "rodding" of these immense plants usually calls for inspection and test of the installations by Underwriters' Laboratories' engineers, and frequent inspections have been made at more than 30 plants in all parts of the United States.

It is difficult to appreciate the magnitude of this job without having seen one of these plants. Suffice it to say that the average plant probably occupies 30,000 acres, comprises several hundred or even a thousand buildings, and that the lightning protection system installed on each building is extensive.

Copper plays an important part in lightning protection. The recommendations made by Underwriters' Laboratories' engineers for changes in the methods of protecting certain types of buildings at the plants have resulted in savings of thousands of tons of this now precious metal, the greatest savings having been made in the rodding of igloos—steel-reinforced concrete buildings used for the storage of shells, bombs, and so on. Laboratories' engineers worked out a method of welding the iron reinforcing rods of these buildings into a continuous electrical system. This conducting network, with no parts left unconnected, is then connected to points, grounds, and down conductors where necessary. Before this method was put into effect, a great deal more copper was used to make a protecting network over the building. The present method has resulted in a con-



Lighting fixtures are tested for over-heating and dust-tightness in this dust chamber. Dust-tight fixtures are designed for use in hazardous locations in dusty factories where an exposed spark or flame may set off a disastrous explosion

siderable saving of copper. Savings of copper have also been made by modifying the protective system of other types of buildings.

Out of the imperative search for substitute materials in many fields may come surprising results: Many of the constructions which have been adopted to meet emergency specifications may result in products which are as good as, or perhaps even better than, products of conventional construction and materials which met pre-emergency specifications.

It is difficult, however, because it is still too soon, to cite any outstanding examples of products meeting emergency specifications which are better than those which met previous specifications. We are, however, constantly seeing improvement in some of the emergency products in which novel materials are being used. Certain synthetic rubber compounds used as insulation for electrical wires have properties which make them better under various conditions than rubber compound insulations made from crude rubber. Various plastics are also proving to be excellent insulators on electrical wires. Even wire with impregnated paper insulation is working out satisfactorily for the uses to which it is allowed to be put; and improvements are being made from time to time in this paper insulation.

Non-metallic reflectors (usually Masonite types of materials) are being used as reflectors for fluorescent and other lighting fixtures in place of the metallic reflectors which were previously required. This may be something which will last and which will work out to be an improvement.

Non-metallic material, such as asbestos-cement boards, has been approved for the housing of electrical busway systems. This is in place of metallic housings previously used.

There is another angle to this substitute-material problem which is rather interesting. Scarcities of some materials and restrictions of them for uses to which they were formerly put have resulted in the use, sometimes, of materials better suited for the purpose but which previously were too expensive to use. For example, there is the increased use of silver contacts in electrical devices in place of cadmium, chromium, or some other materials which were previously employed for this purpose. It is very possible that the more general use of silver in electrical equipment will be a common thing after the war.

From the work that has been done thus far under the stress of emergency it can be generally said that many things are being learned as a result of the enforced use of emergency specifications. Many new materials are being used in new ways, and out of this will undoubtedly come improvements which will be of lasting value, and products which will be better than any which we had before. All of this work, and much more, is part of the wartime activities of Underwriters' Laboratories. In other ways, also, which cannot yet be discussed, the Laboratories is working for Victory.

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ANTS

New Mexico Ants Help Man Mine Garnets

Ants have been mining garnets and peridots in New Maxico for centuries. Sometimes the stones have brought from $50 to $100 as gems, but most of them are worth only a few dollars. What might bring joy to the man with a pan, or a shovel and a soil sifter, is that the ants have been working for him, all these years, going down into volcanic soil and collecting the stones which abound in New Mexico ant hills of McKinley county, near Fort Defiance on the Navajo Indian reservation.

"Some of the finest garnets in the world have been collected from such ant hills there," says Dr. Stuart A. Northrop, head of the department of geology at the University of New Mexico, at Albuquerque, and author of a book of 387 pages, "Minerals of New Mexico," published by The University Press.

"The finest gem peridots known have also come from this region," he says, and his book is a mine of information for geologists, metallurgists, and corporations now striving to give to the United Nations all they can out of New Mexico's vast underground stores.

VISUAL PURPLE

Eye Uses 500 Films Every Minute

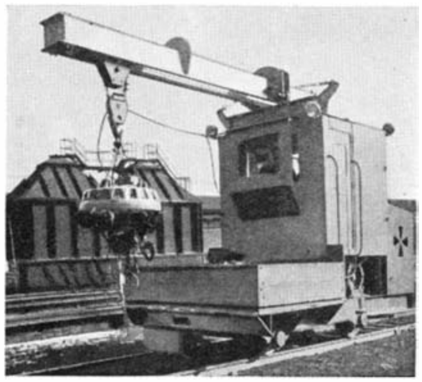
Every minute the human eye uses about about 500 chemical photographic "films" that it makes itself, according to the Better Vision Institute. Recent studies have disclosed that the eye is more like a camera than formerly was believed.

A remarkable photo-sensitive substance, known as the visual purple, in the eye is bleached by light in the seeing process, somewhat in a manner similar to the action taking place on the film in a camera when exposed to light. However, the human eye has the remarkable power to change back the photo-sensitive substance, after exposure, into its original form so that it can be exposed again. This substance in the eye is exposed and restored at the remarkable speed of eight to ten times a second, or about 500 times a minute. Experiments also show that the substance, if removed from contact with living eye tissue, will remain permanently in the exposed condition and will not return to its original form.

SCRAP PICKER

Does Work of Six Men, Faster

A self-powered magnetic scrap picker, designed and constructed by The Timken Roller Bearing Company from odds and ends, was placed in operation recently and is doing the work of six men gathering up scrap in the company's railroad yards.



A "bite" is 900 pounds

In two hours time, it does the work that three two-men crews formerly did in 24 hours.

Mounted on an ingot buggy, it is powered by a Hercules, Ford-V-8 diesel replacement engine that drives a 230 volt

D.C. generator which supplies power for the magnet and the electric motor drive.

The magnet is 39 inches in diameter, lifts 900 pounds of heavy scrap or 300 pounds of turnings per load. The box on the front of the picker holds about 1200 pounds of scrap. The boom has a 12-foot swing.

FLUTTER

Detection of Vibration Has Broad Implications

"DETECTIVES of flutter," they call them. They are tiny electric ears weighing no more than two ounces, but they have saved many a test pilot's life, many a million of dollars and man-hours tied up in the prototypes of new planes. They do it by running down to its various lurking-places that most deadly of aeronautical mysteries—flutter.

One of the electric ears used in the detection of aircraft vibration

Flutter, in engineer's language, is "a peculiar resonant condition of surfaces wherein aerodynamic energy is absorbed by the structure, resulting in larger and larger amplitudes of displacement until structural failure occurs." In plain talk, flutter is a vibration which increases in amplitude till such parts as wings or tail surfaces actually tear off in the air.

Back in 1936, when planes began to become bigger and faster, that was happening to big new experimental planes more often than anyone cares to remember. If the test pilot survived the experience—a few now and then did—he might be able to report: "I was making about 200 miles an hour when I felt the wings getting ready to go. I hit the silk."

That meant that about 200 miles an hour was presumably the critical speed at which flutter took place in the wings of the experimental plane, and so would take place in the wings of production models built from it. But engineers didn't like to deal with "presumable" figures, especially when those presumable figures were reached at the cost of a smashed plane and perhaps a cracked-up pilot.

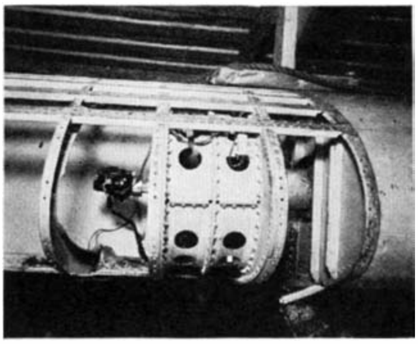
Glenn L. Martin Company engineers accepted the challenge by setting up a "vibration department," charged with the task of tracking flutter into its secret and innermost lairs. It was already known, of course, what causes flutter to appear. Take a wing, for example. A common cause of flutter in wings is the "getting together" of the vibration of the wing itself and of some part attached to it, say an aileron. Once the two vibrations got together—and in spite of very careful mathematical calculations they sometimes did get together—the wing was pretty sure to come off in midair with dramatic suddenness.

What Martin-devised equipment set out to do was to check the mathematically-predicted vibration of the wing and at the same time of the parts connected with it, and record their frequencies on graph paper. Back in the office vibration engineers studied those graphs, predicted at what point the frequencies would harmonize—in other words, at what speed the wing as designed would part company with the plane. If that speed was well above any speed the plane could possibly make, they knew the wing was safe.

Having verified by a combination of mathematics and testing the safety of that particular model of plane from the peril of flutter, the vibration engineers used their equipment to carry their testing a step further. By means of specially-devised vibrators placed inside the leading edge of the wings, they produced in normal flight artificial vibrations of an intensity that would be encountered up near the flutter speed of the plane.

While this was going on, they, of course, watched the oscillograph closely, and as soon as they saw flutter conditions approaching they shut off the vibrators. The records thus obtained they used to verify their mathematical calculations of the flutter speed of the plane, which information became valuable in the designing of even larger and faster planes.

As soon as the new equipment and methods had passed the acid test of proved accuracy, the vibration department made a major contribution to the aircraft industry by publishing its "Graphical Solution to the Phenomenon of Flutter." Shortly after that they were called upon by the Navy to apply their equipment and methods to the largest flying boat ever built—the Martin *Mars*. Equipment and methods came through again with flying colors.



A vibrator unit in an airplane wing is used to verify causes of flutter

Two other aspects of their equipment and method especially please these "Shake and Shudder Boys," as they are called around Martin's. One is their proved ability to measure "landing-shocks"—accelerations on nose-wheels of planes during rough landings. They can tell how many "G's"—multiples of gravity—are exerted on that critical part at the moment it touches the ground and in the moments which follow. By the same token they can measure the accelerations on the flying-boat tails as the ship hits the water in landing. They have been called in many a time as consultants, both by their own company and others, to prevent smashed nose-wheels or wrenched flying-boat tails.

The other aspect that pleases them is the use to which they foresee their equipment and methods being put when peace comes back and the country resumes building trucks, busses, automobiles, liners, and passenger coaches. In every case, they feel, they have contributions to make towards the lightness of the equipment and the comfort of the passengers.

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ZIRCONIUM—Beach sands along the northern coast of New South Wales, Australia, contain an estimated million tons of zirconium, probably the best deposit in the world, as well as titanium minerals and smaller amounts of monazite sand, according to reports to the Department of Commerce.

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SOYBEAN PLASTICS

Offer New Aid in Solving Shortages

NEW DEVELOPMENTS in the field of soybean plastics, which promise to augment the nation's limited supply of phenolic resins, are reported in *Chemical and Engineering News* by Dr. George H. Brother, of the United States Regional Soybean Industrial Products Laboratory, Department of Agriculture. Soybean protein can now be used in the production of laminated plastic material, or sheets of plastics, a new application of soybean protein which cuts down considerably on the use of high-priority phenolic resins in the preparation of laminated boards, according to Dr. Brother.

"It is possible to prepare a water solution of soybean protein in formaldehyde, which upon drying is a thermoplastic formaldehyde - hardened protein," Dr. Brother explains. "Fibrous material, such as sheets of unsized kraft paper, impregnated with this solution and dried, may be stacked between the heated platens of a press and united into a board with sufficient heat and pressure.

"The board has about the same flexural and impact strengths as phenolic laminated material, but, of course, less water-resistance. However, if single sheets of phenolic-impregnated paper are placed on the top and bottom of the stack of soybean-protein-impregnated sheets when they are introduced into the press, the resulting laminated board will have exposed phenolic faces and consequently the water resistance of phenolic plastic, except on the edges. This is not serious, because it is necessary to protect the edges of phenolic laminated board for maximum water resistance," Dr. Brother explains.

A second new development in soybean plastics is the formation of formaldehyde-hardened or tanned soybean protein which is completely thermoplastic, or capable of being made plastic by heat. "This development is of considerable fundamental importance," according to Dr. Brother, "because previously all protein materials had to be formed to shape in the unhardened condition and then treated with formaldehyde to render them as water-resistant and permanent as possible. That process was time-consuming and expensive, and of course made the preparation of a protein molding material impossible.

"The soybean protein-formaldehyde thermoplastic material is a molding plastic which comes finished from the die. This material alone does not completely meet the industrial plastics needs because it is not suitable for injection molding. However, it was found to be perfectly compatible with phenolic resin, with which it formed a new type of plastic material."

RUBBER RINGS
May be Replaced by Substitute for Jar Seals

A STEP in the interest of rubber conservation was taken by the Detroit Gasket and Manufacturing Company when they announced the development of a new product that may in the future prove to be the solution of food packer's problems. Created from by-products of the petroleum industry and the farm, of materials that are non-critical at the present time, the new "77 closure material," as it is called, may be of importance in replacing rubber canning rings, of which it is estimated some 27,000,000 gross will be used for home canning alone—with the commercial needs being many times that figure—for 1943.

The need for conserving tin has forced many food packers to consider glass containers for their products. The use of glass jars which require closures to protect the taste and quality of foods places a strain on the manufacturers of rubber rings, and adds to the over-all problem of rubber conservation.

Tests by the Department of Agriculture and by many responsible food packers reveal that this new closure material will do the job in every way as well as the vital rubber closures which it can now supplant; its performance has never failed, it is claimed, to equal the sealing quaities of the rubber canning ring.

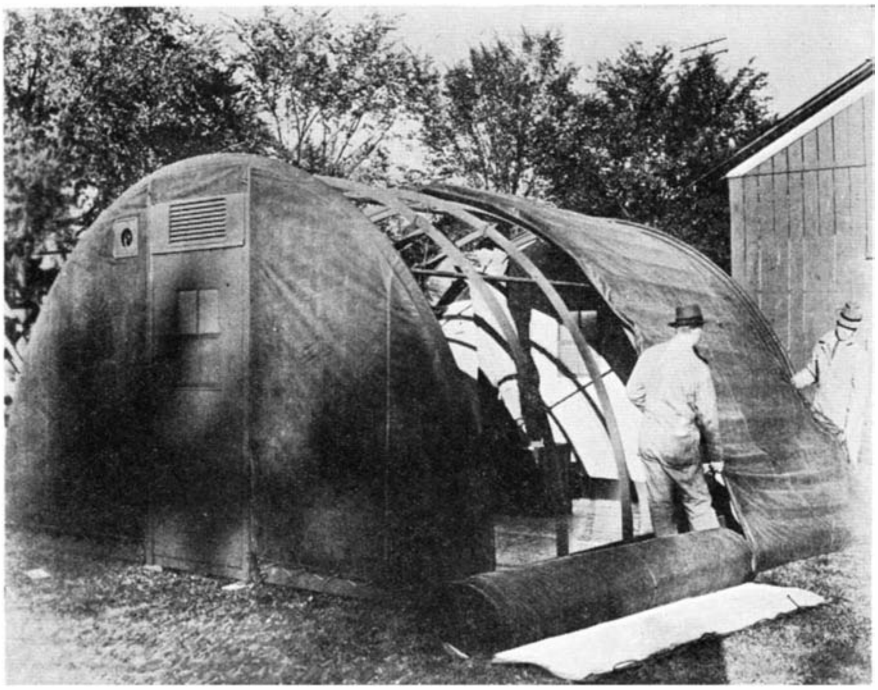
WOOD TREATMENT
Makes it Resistant to All Three of its Enemies

IMPROVEMENTS in the treatment of wood making it fire resistant and still paintable have helped to make forest products a major heavy construction material during the past year, according to W. F. Munnikhuysen, head of the Wood Preserving Division of Koppers Company. Such timbers were becoming more common in large buildings before the war, and because of shortages of other permanent construction materials their use was greatly accelerated in 1942.

"Fire-proofed timbers are reasonable in cost and speedy in erection," said Mr. Munnikhuysen, "and their employment in heavy construction will undoubtedly continue after the war. Special chemical pressure treatment now makes wood resistant to all three of its enemies at the same time—fire, decay, and termites."

One of the most important wartime uses of wood has been in construction of plants important to war production. In many instances this use of fire-proofed timbers has released critically needed steel for other purposes. In other instances the buildings would not have been erected at all because of steel shortages, or would have been delayed many months. Construction of warehouses, troop barracks, boats and barges, munitions factories, and war housing has been made possible by engineering improvements in utilizing wood, as well as by pressure treatments to make it a permanent construction material.

The already well established uses of treated wood in bulkheads, runways, bridges, culverts, railroad cars, railroad crossings, ties, piling, and telephone poles continued and expanded in 1942. Wood used for these purposes is being treated under several processes and with various chemicals, depending on the construction use that is to be made of it. For some requirements it is made resistant to decay, termites, and marine borers by means of creosote, which is a poison to fungi and hungry insects. For other requirements chemical salts are used. There are no



Glass-insulated portable shelter for army use in the Arctic

wartime shortages of creosote or of other generally used preservatives nor of plant treating capacity.

All preservatives in modern treating are forced deeply into the wood under elevated temperatures and pressures. The biggest advancement of the past year was in treating such wood with chemicals to make it resistant to fire and at the same time to give it a surface which will take paint as well as untreated wood.

ARCTIC SHELTERS

Designed to Save Critical Materials

IN LINE with its efforts to conserve critical materials and reduce demands upon shipping space, the Army Air Corps has awarded to the James Manufacturing Company a contract for an undisclosed number of a new type of light-weight, portable shelter for use by Air Corps personnel in Arctic climates.

The shelters are specifically designed to save weight, to occupy a minimum amount of space when packed for shipment, and to reduce the amount of fuel which must be shipped to heat them, by incorporating blankets of glass fiber insulation in the walls and flooring. When packed for shipment, they are sufficiently light and compact to permit transportation of the complete unit by air.

Of impregnated cotton fabric and laminated wood frame construction, the shelters, when erected, are 16 feet in width by eight and a half feet high in the center. They may be used in any eight-feet multiple of length and they will be heated by gasoline heaters.

While the Fiberglas insulation weighs only about 200 pounds total for a 16 by 16-foot shelter, it is estimated that it will reduce from 27,360 pounds to 6790 pounds the weight of the fuel that must be transported to maintain in each shelter, throughout the heating season, a temperature in which men can live comfortably. The total weight of each such shelter is approximately 1200 pounds.

A crew of four men can erect one of these structures, ready for use, in a minimum of time. It can be taken down for removal to a new location even more quickly. When packed, the complete unit occupies a space of less than 160 cubic feet. The longest dimension of the packed unit is 8 feet.

No metal, other than incidental hardware, is used. The side walls and roof of each 16 by 16-foot shelter consists of two quilt-like sections. These are composed of the glass fiber insulation, faced on one side with flame-proofed muslin, and then enclosed with cotton fabric treated with a plastic material which makes the fabric waterproof, rotproof, vermin proof, and fire-resistant. The glass fiber insulation is incombustible.

OIL SPRAYS

Insecticidal Value Related to Oil Composition

RESEARCHES into the chemical properties and the insecticidal value of so-called summer-type oil sprays when used against the eggs of the codling moth, the oriental fruit moth, and bud moth, conducted by scientists at the State Experiment Station at Geneva, New York, were singled out for national recognition by the American Association of Economic Entomologists as an outstanding accomplishment in 1942. The investigations were conducted by Dr. P. J. Chapman, entomologist, and G. W. Pearce and Dr. A. W. Avens, chemists, and are part of a comprehensive research program on the use of oils for sprays.

In their experiments, the Station scientists found that the efficiency of the sprays was directly related to the chemical composition of the oils. The oil that was most predominantly paraffinic in character, for example, was found to be six times more efficient than oils of the so-called napthenic type. Contrary to common belief, highly refined or white oils were more efficient than corresponding less refined oils, efficiency increasing with the removal of the aromatic constituents.

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LIGHTNING—Contrary to the old saying, lightning usually does strike more than once in the same place. Engineers recently took a photograph in North Carolina of a thunderbolt that consisted of 31 consecutive separate strokes, all occurring within six-tenths of a second.

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GLASS SHOWERS

Latest Application of Glass in the Home

MANY NEW uses of glass in the home have been introduced during recent years, and new homes have featured a variety of applications of glass. Large wall areas were covered with plate glass mirrors; Carrara structural glass formed the walls of kitchens and bathrooms; glass blocks were in great demand in many ways.

Recently Pittsburgh Plate Glass Company introduced prefabricated glass shower enclosures to meet a specific demand for a good, inexpensive shower that can be installed quickly and economically. A maximum of five or a minimum of three pieces of glass form the complete unit. The enclosures have been designed to meet the varying specifications of present-day housing.

Each glass shower enclosure is packed as a unit in one box and contains necessary glass and setting materials, mastic, caulking compounds, and installation screws. Also included are a recessed white china soap and grab, and a natural-finish wood shower curtain rod. The glass is fabricated with holes for plumbing outlets, drilled to specifications submitted with the order. A precast concrete shower receptor can be furnished as a part of the unit, but packed separately; however, because of savings in freight cost it is more desirable to have the receptor made locally.

FEED CONTROL

Improves Safety in Magnesium Plant

MARKED production speed-up, together with safeguarding of personnel and equipment, is resulting from the installation of automatic feeder control for the pulverizing equipment of a magnesium plant engaged in war work. Developed and built by Max Mosher, Ch. E., a specialist in grinding equipment who has already installed a large number of feeder controls in many industries, this automatic control is based on electronic tubes, circuits, and relays responding to the varying load placed on the driving motor and controlling the feeding rate accordingly.

In this magnesium plant the control regulates the rate of feed of magnesium shavings to the grinder, which in turn converts them into fine powder. For reasons of safety the feeder is housed in a separate building alongside the one in which the grinder is located. Chips are carried from feeder through a pipe by air suction. If the rate of feed is too great, the grinder can become clogged, resulting in possible burnout of the grinder motor and, worse still, the danger of explosion in the event of severe overheating If the load on the grinder is reduced below full load, the grinding equipment is not being used to maximum efficiency, and wartime production schedules suffer.

Attendant manpower is reduced to a minimum with this automatic control. The operator merely dumps magnesium shavings from a barrel into a hopper every half hour or so, while the hopper automatically feeds the grinder. In installations of this sort, it is claimed there is usually a 20 to 30 percent gain in output while safeguarding equipment, particularly the grinder motor, and the product itself, against damage.

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OIL-WATER—Oil and water *do* mix! A new oil paint—that thins with water—designed especially for use over wallpaper, is now available.

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MANAGEMENT PROBLEMS
Vastly Increased by Production Changes

A FOOTBALL team advancing toward the goal line, only to have the ball suddenly jerked back to midfield, has the problem of mustering the "try, try again" spirit instead of being demoralized by the loss. A similar situation exists when production teams experience set-backs in their schedules, *Automotive War Production* pointed out recently. Keeping morale high on the production team frequently requires a quality of leadership such as a Knute Rockne or a Bernie Bierman supplied to their champion football squads, the industry publication says.

A decision made thousands of miles away, resulting from an unpredictable shift in war strategy, may upset the best-laid plans of automotive organizations, it is explained. When drastic production changes come, it is a function of management to rekindle spirits, infuse new energy into the organization, and keep the men marching toward the new objectives, says the publication, citing the following cases:

One automotive company, working day and night to get into production on a new fighting plane, got a shock when the Navy requested the removal of two items from a major component of the ship. Making the necessary alterations required the change of 4000 production operations and 50 percent of the tools and jigs. But the organization picked up the specified change and converted its tools without loss of even a day on its promised production schedule.

Another company, starting out to build an experimental type of tank, received a seemingly endless number of design changes. After many months of intense work, the organization's spirit became keyed to a high pitch in the expectancy of seeing the first finished product roll out. Then a last-minute change came through which called for retooling of one of the major components. Informed of the news, the technical staff buckled down to months of additional preparatory work.

Having poured five months' time and energy into one type of aircraft engine, an automotive company was suddenly asked to stop all work and shift over to a different engine. Scrapping nearly a half year of work, including virtually all of its hard-to-get tools, the automotive organization undertook the new assignment. Instead of letting their morale sag, the managerial men put all their energy into the new task and infused so much enthusiasm into the organization that engine production under the new schedule was advanced four months.

One automotive organization manufacturing fighting planes has had to retool many of its operations twice and some of them three times to fit the new designs.

"The reshuffling of war contracts in the period ahead because of changing military needs will test morale time and again, putting additonal demands on managerial leadership," the publication predicts. "It will again make clear that one of the important functions of management is the power of example. By willingness to shoulder new problems and responsibilities, management sets the pace for the organization as a whole."

DYE
Made by Chemical Treatment of Sawdust

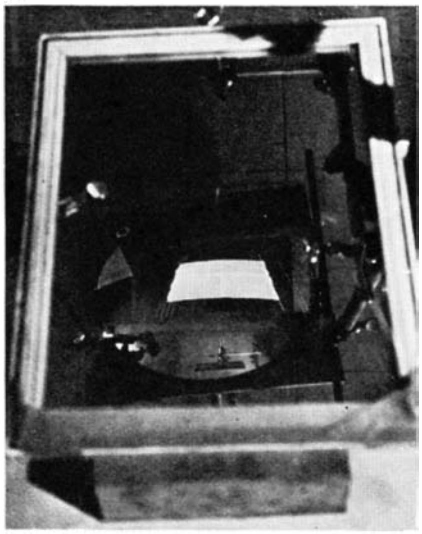
A SUBSTITUTE dye suitable for all commercial purposes may be made, according to *Chemical Age*, from sawdust and other waste from timber mills. It is treated with sulfur and caustic soda in a furnace; sulfureted hydrogen is liberated in large quantities, and the substance is rendered soluble in water, to which it imparts a strong color. This solution may be employed in dyeing and, when finally fixed by passing the material through boiling potassium bichromate, it yields colors hardly distinguishable from coal-tar dyes. Sawdust dyes, it is stated, do not fade to any great extent when subjected to strong sunshine, nor is the color affected by frequent washings.

MIRRORS DO IT

Armor-Plate Width Measured from a Distance

THE SAME fragile mirror that helps Milady mend her makeup can take on the grim wartime job of speeding armor plate production in giant steel mills.

This statement came recently from Dr. E. D. Wilson, a research engineer with



Experiment set-up of mirrors

the Westinghouse Electric & Manufacturing Company, who devised a system of mirrors to enable a workman to measure at a glance the width of yellow-hot steel slabs rolling shoulder high from the mill. In present plants the steel plates travel on a table just above the floor and can be measured with a long hand gage. In a new mill—now being built—the plates will come out of the rolls too high to use the gage.

"These plates, up to 13 feet in width, must be accurate to within one-half inch before they go to other rolls to be squeezed into long sheets," explained Dr. Wilson. "If the plate is too narrow, the sheet will be too narrow. And if the plate is too wide the excess must be cut off and scrapped, wasting vital material and production time."

Without a method of measuring the slab, the mill operator would put enough force on the roll to make certain that the plate exceeded the specified width. Such guesswork would increase the amount of scrap. Engineers designing the new plant brought this problem to the Westinghouse Research Laboratories and Dr. Wilson was assigned to work out some way of measuring the steel from a distance. In a few weeks he had the answer—mirrors.

With three mirrors, a pane of glass, several lights, and five white lines on a sheet of black paper, he rigged up an experimental system for measuring the width of the steel from a point 20 feet to the side of the rolls.

"A square of cardboard was painted red and covered with light to represent the glowing metal," Dr. Wilson said. "The black paper chart, with its white lines showing the proper plate width, was mounted off to one side. One set of mirrors was arranged to catch an image of the glowing 'steel' and a second set was aimed at the chart. Then both of these images were directed into a mirror so that the white lines were superimposed on the image of the steel plate."

In practice, Dr. Wilson explained, plates that fill the space between the lines would be sent on to be rolled into sheets. When the plate is too narrow, the rolling mill operator can easily estimate the amount of additional pressure needed to spread the plate to the required width.

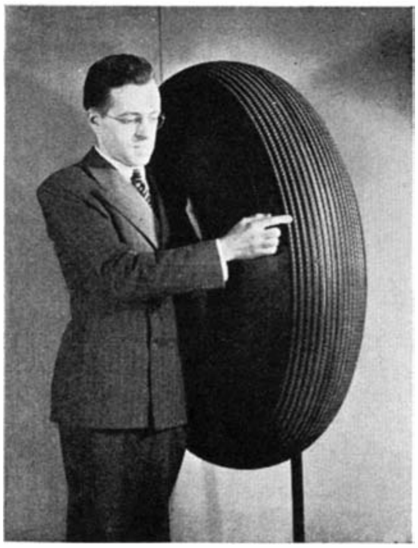
NON-SKID

Tire for Airplanes Has Wire Tread

DESIGNED to prevent skidding on snow and ice, a new type of airplane tire, whose tread comprises thousands of steel-wire spirals in each tire, was announced recently as being in production for United States Army planes, Goodyear officials disclose. Embedded directly into the tread of each tire, the wire spirals supplement the tread's non-skid function.

These tires are said to be especially adapted to high-speed landings of planes on small fields which may be covered with ice or snow. Similarly, they are particularly efficicacious for takeoffs from surfaces covered with glare ice.

In the first step toward producing a tire of this type, the wire coils are strung on steel rods to be transferred in parallel rows to rubber mats. The mats are linked together with cement into a strip long enough to cover the surface of a customary airplane tire carcass. Then the carcass



Wire spirals increase safety

is placed in a mold in the normal manner. As the tire carcass is vulcanized, the thousands of wire coils become integral parts of the tread itself, scarcely noticeable in the tread when the tire leaves the mold.

Extensive tests of the new tires have indicated their complete feasibility where protection against skidding is needed.

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RUBBER PLANT—Pingue or Colorado rubber plant has been found to have the highest rubber content of any native plants tested during the past several months by the Colorado State College experiment station. The roots of 10- and 11-year-old pingue contain from 4.5 to 5.9 percent rubber. The plant grows as a weed and is found most commonly in the mountainous counties of south-central Colorado. It is poisonous to livestock.

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SOUND-ON-FILM

New Recorder Operates For Eleven Hours

A DEVICE for recording and reproducing sound on film instantaneously and over long periods of time operates on the basic principle of indenting the sound

Sound is indented on film

track in the surface of the film. Thus the recording may be played back at once, without treatment or processing of any kind. The records so made may be reproduced hundreds of times, since pressure is put on the film only during recording; during play-back the stylus rides lightly in the sound groove.

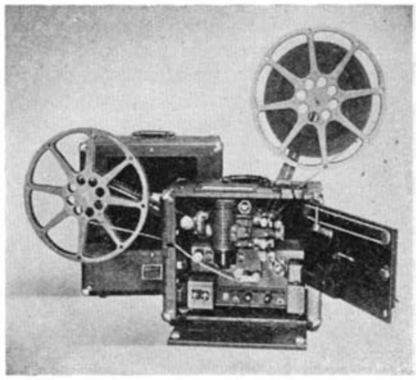
The accompanying illustration shows the newest model of the Filmgraph, as the device is known. The illustrated model uses continuous loops of film which are placed in the magazine and which are available in lengths that will record over periods of time ranging from 15 minutes to 11 hours. The loop moves continuously through the machine, no rewinding of the machine being necessary or possible. The recording head moves automatically from the first to the second track and so on until 50 tracks are indented across the width of the film. The track in use at any given time is indicated on a dial and any track may be played back at any time by manually moving the stylus by a control knob to the desired number.

The film used in the Filmgraph unit is ⅝ of an inch wide and .005 of an inch thick. A sapphire stylus is used for both recording and play-back. It is claimed that the stylus will give years of satisfactory operation without regrinding.

SOUND PROJECTOR

Uses Substitute Materials, Yet Retains Quality

STURDY, precision built, easy to operate, containing every feature essential to superb movie projection and film protection—and incorporating these features



A war-time movie projector

in spite of the fact that critical materials are restricted in its manufacture—the new Filmosound "V" projector has a sound head of welded sheet steel instead of the casting formerly employed. A carrying case of waterproofed fir provides the extra strength required for the slight additional weight of substitute materials. Die castings, formerly of aluminum, are now zinc. A larger carrying handle has been designed with an automatic spring to prevent the handle from resting over the lamphouse vent when the machine is in operation. A positive latch on the case door prevents accidental opening.

Gear case ventilation has been improved with the result that oil vapor is now exhausted through the cooling system to prevent the formation of oil film on optical components of the projector.

The new Filmosound is available now only to our armed forces—but it is indicative of the better "things to come" when peace is restored.

PRESERVATIVE

Increases Life and Use of Cotton Rope

A NEW product has been added to the list of test-tube developments by researchers who are chasing alternates for critical materials. This product is a toxic preservative for cotton rope.

Formulation of this preservative is important for three reasons: First, rope is vitally needed—by the Navy, for defense, and by the fishing fleets which must continue to operate to feed armed forces and civilians. Second, Manila and sisal rope, formerly used, are getting scarce because they have to be imported. And third, cotton rope, inherently a softer rope, should have a preservative before it can be employed for marine use. While cotton rope, for most purposes, has adequate strength, organisms in the sea water cause the rope to deteriorate.

This newly developed preservative toughens and stiffens the rope, gives it wear-resistance and firmness. It also reduces unwinding of the strands, and, in general, increases its efficiency.

The formula for this preservative was developed in the technical research laboratory of I. F. Laucks, Inc. It is a clear, liquid toxic in which the rope is dipped long enough for complete penetration, then dried. The treatment is relatively short, the time element depending, of course, on the thickness of the rope.

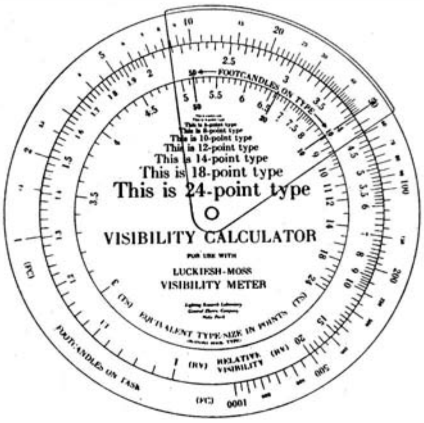
Because testing of a product is a part of its actual development, cotton rope which had been dipped in the preservative was placed on various fishing vessels where it received hard usage. After a period of six months the rope is still in use and standing up exceptionally well—showing no signs of deterioration.

VISIBILITY CALCULATOR

Based on Equivalent Type Sizes

An ingenious "Visibility Calculator" has just been developed by Matthew Luckiesh, contributing editor to Scientific American and Director of Lighting Research Laboratory at General Electric's Nela Park, Cleveland, and Arthur A. Eastman, laboratory expert.

The new device, designed for use with the Luckiesh-Moss Visibility Meter, permits quick and accurate determination of



Type-size visibility determiner

relative visibility of any visual task when amounts of light on that task are changed. In addition to simplifying calculations heretofore required, the calculator multiplies the number of advantages to be had from the Visibility Meter.

Consisting of two calibrated cardboard disks and a transparent sector element, the new calculator can be operated as readily as a slide rule or the dials of a combination safety lock. Only 6½ inches in diameter, it contains a wealth of pertinent information. Included on the front side of the device are nine examples of various sizes of type, by which the reader may translate relative visibility values into practical and understandable terms.

The new calculator, when used in conjunction with the Visibility Meter, permits the user, for example, to find the equivalent type-size of a certain eye task, say at a machine, or to determine the increase in relative visibility and in equivalent type-size when illumination is stepped up from one level to another, or to find how much more light is needed to improve visibility of a certain task equal to that of larger type over smaller type.

CORE BOXES
Wearproofed by Spraying With Metal Coating

Wearproofing wooden core boxes and foundry patterns against the abrasive action of sand by spraying the surfaces with a light coating of metal has been found to prolong the life of the patterns and to eliminate the necessity of frequent and costly rebuilding; it also permits worn wooden patterns or boxes to be completely renewed by the same means.

Employing a low cost, portable Alloy-Sprayer with suitable low temperature alloy, this work can be done at either a production rate or on an intermittent basis as required if the wood surface is relatively soft, the metal can be sprayed directly onto the finished wood surface without special preparation. If the wood is hard, a coating of shellac is applied and the spraying is done when the shellac is "tacky." In either case, the thickness of the coating is usually from .002 to about .005 of an inch. After the coating is sprayed, it is allowed to cool thoroughly and then is sanded down to the finish desired.

GLASS DISKS
For Use in Home and Commercial Sound Recorders

A new type of transparent recording disk for use in home and studio has been developed to replace the conventional disk formerly made from restricted materials. This glass disk, produced by H. & A. Selmer, is said to have a smooth surface which provides an extremely low scratch noise level.

The smooth surface of the glass-record groove keeps noise level low

CURRENT BULLETIN BRIEFS

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

CARBIDE TOOL GRINDERS is an eight-page illustrated catalog showing a complete line of carbide grinders including a combination chip breaker and a cup wheel grinder. Anyone concerned with carbide tool maintenance will find the text and illustrations to be of outstanding interest. Request Bulletin Number 201. *Hammond Machinery Builders, Kalamazoo, Michigan.—Gratis.*

RECTIFIERS FOR ELECTROPLATING, ANODIZING, ELECTROTYPING is a 12-page illustrated pamphlet dealing with copper-oxide rectifiers and their application to a number of electrolytic operations in industry. A question-and-answer section supplements the text. *Hanson-Van Winkle-Munning Company, Matawan, New Jersey.—Gratis.*

FILE FILOSOPHY is a 48-page account of the history, manufacture, variety, and uses of files in general. The latter section, showing applications for various purposes and materials, will be of outstanding interest to every user of files. *Nicholson File Company, Providence, Rhode Island.—Gratis.*

A COURSE IN RADIO FUNDAMENTALS, by George Grammer, is a 104-page paper-bound book designed as a radio training manual which contains those elements of a course of classroom study that lie outside the field of the textbook—study guide, examination questions, and laboratory experiments. For use in connection with home study and as a classroom guide. *The American Radio Relay League, Incorporated, West Hartford, Connecticut. —50 cents.*

MUSIC IN INDUSTRY is a four-page folder describing a successful method of improving employee morale, lessening fatigue, and speeding up production. *RCA Manufacturing Company, Camden, New Jersey.—Gratis.*

THE GAS MASK is a 20-page highly illustrated digest of the history and development of the military gas mask. *Office Chief Chemical Warfare Service, War Department, Washington, D. C.—Gratis.*

NODRIP HANDBOOK is a 32-page pocket size booklet describing methods of preventing condensation drip from metals, concrete, wood, plastic, and other surfaces through the application of a plastic cork coating. *J. W. Mortell Company, Kankakee, Illinois.—Gratis.*

TYPE S TEST-SET is an eight-page bulletin describing a general-purpose Wheatstone bridge with self-contained galvanometer and battery which is said to be simple in arrangement, easy to operate, and conveniently portable. This test set will be of interest to manufacturers of electrical equipment as well as to workers in laboratories, repair shops, and maintenance departments. *Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia, Pennsylvania.—Gratis.*

THE INSTALLATION AND LEVELING OF THE LATHE is a 20-page booklet which covers many of the points that must be taken into consideration when installing various types of lathes so that the most efficient operation can be obtained. Request bulletin H-3. *South Bend Lathe Works, South Bend, Indiana.—Gratis.*

FIRE-RETARDING COATINGS is a discussion of the properties of fire-retarding paints, including borax, sodium silicate, whitewash, synthetic resin, loose-texture formulations, and the new type of sodium alginate-base preparations. *United States Forest Products Laboratory, Madison, Wisconsin.—Gratis.*

INDUSTRIAL CRAYON GUIDE is a 16-page illustrated bulletin listing and describing a wide range of crayons for marking lumber, metal, leather, glass, and so on. *American Crayon Company, 942 Hayes Avenue, Sandusky, Ohio.—Gratis.*

EQUIPMENT FOR ACCIDENT PREVENTION is a 144-page catalog devoted to safety equipment of all types. Included are descriptions of protective apparel, safety tongs, gloves, goggles, respirators, and a wide variety of other products in the safety promotion field. *The Boyer-Campbell Company, 6540 Antoine Street, Detroit, Michigan.—Request this bulletin on your company letterhead.—Gratis.*

WATER TREATMENT WITH LIMESTONE, by Connell, Zeller, and Sorrels, is a 74-page description of a method for removal of carbon dioxide, iron, and manganese from water supplies. The method described may be applied on a economical and practical basis. Engineering Experiment Station Series No. 65. *School of Engineering, Texas Engineering Experiment Station, College Station, Texas.—Gratis.*

NEW DEPARTURE SHOP MANUAL is a 16-page booklet illustrating and describing approved methods for handling, mounting, and lubricating ball bearings. Photographs and cross sections of many types of bearings are reproduced. *New Departure Division, General Motors Corporation, Bristol, Connecticut.—Gratis.*

ARMSTRONG CATALOG is a 230-page book which describes and illustrates a complete line of high grade tools including bits, blades, cutters, ratchet drills, open end and socket wrenches, pipe-threading tools, and so on. *Armstrong Brothers Tool Company, 301 North Francisco Avenue, Chicago, Illinois.—Gratis.*

INDUSTRY'S WEAPON AGAINST WEAR is a fully illustrated brochure on the process of hard-facing of metals for solving problems of production, maintenance, and replacement of wearing surfaces. Gives compact details of a number of applications. *Stoody Company, Whittier, California.—Gratis.*

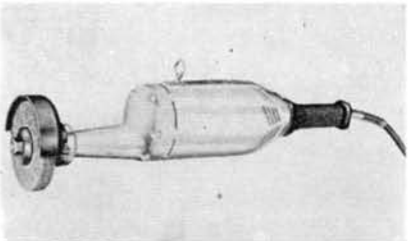
Industrial Growth

New Products and Processes That Reflect Applications of Research to Industrial Production

GRINDERS

In Portable Form, For High-Speed Production

ENGINEERED to meet today's high-speed requirements for grinding, brushing, and similar operations, two new portable grinders are now available in four-inch



For grinding, brushing, and so on

and five-inch sizes. These grinders, manufactured by Skilsaw, Inc., have been designed for adaptability to a wide variety of applications. The shaft is mounted on ball bearings; the commutator and switch are fully enclosed for protection against dust; straight-line ventilation blows grinding dirt away from the operator; a rubber sleeve handle provides a cool, non-slip grip; and a powerful universal motor assures full efficiency.

SANDER

Reciprocating Type Can Also Be Used for Polishing

MANY industrial processes today require sanding, rubbing, or polishing—processes that are usually done laboriously by hand. Now, however, there has been developed a reciprocating sanding machine which duplicates the back-and-forth motion of hand work, but at a speed of 3000 strokes

The rubbing pad is soft

per minute as compared with approimately 150 strokes by hand.

Because of the design of the bottom plate of the "Easy" electric sanding machine, it is possible to accomplish various types of rubbing and polishing operations on curved or flat surfaces. To the bottom plate is secured the felt, rubber, or composition pad to which the abrasive is attached or which does the actual rubbing itself. A variety of pad materials and sizes are available.

GAGE BLOCKS

Optically Checked for Accuracy

A STANDARD set of Doall Master Gage Blocks, designated as Set 400 and consisting of 81 blocks, is now being produced in quantity by the Savage Tool Company. The 81 individual blocks range in length from .050 to 4.00 of an inch. These precision gage blocks are produced in "AA" grade (accuracy .000002 of an inch), "A" grade (accuracy .000004 of an inch), and "B" grade (accuracy .000008 of an inch).

Miking a gage block

Each gage block, in addition to being extremely accurate in length, has its measuring surface lapped to a flatness of less than the quarter wavelength of light, and is produced with mirror finish. These two factors enable the blocks to be wrung together in combination, enabling the user to secure practically any dimension in steps of .0001″ from 1.000″ to 12.00″.

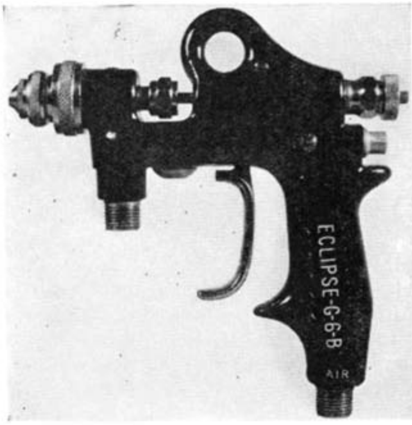
Precision optical measuring instruments are used to check the accuracy of every gage block produced, and this equipment is also available to users for rechecking their gage blocks after they have been in use. The used gage blocks sent in will be recalibrated and gages that have been worn beyond tolerance of the original set are replaced to maintain the required standards of accuracy.

It is said that World War I was fought in thousandths of an inch, while World War II is being fought in tenths of a thousandth. To maintain the accuracy of a tenth or half tenth on the precision fighting equipment being produced throughout the country, gage blocks are of prime importance.

SPRAY GUN

Plastic Body Gives Good Service

After many months of development and test under actual working conditions, spray guns with plastic bodies have proved their worth. The new black plas-



Plastic gun bodies weigh less than metal, have good chemical resistance

tic gun, as made by the Eclipse Air Brush Company, Incorporated, weighs a quarter of a pound less than the aluminum-body spray gun that it replaces—an important factor in reducing worker fatigue.

The plastic used in the body of this new gun has good chemical resistance and is said to be not affected by thinners, solvents, paint removers, and so on. The black surface is smooth and easy to clean and the plastic is strong. Priority assistance is required to obtain these guns.

WASHING MACHINE

Rapidly Cleans Small and Delicate Parts

Instrument mechanisms and other delicate mechanical parts may be thoroughly yet safely washed in the device shown in one of our illustrations.

The parts to be cleaned are placed in a

Metal parts are washed as well as dried in the reciprocating basket

basket which in turn is lowered successively into a cleaning solution and then into two rinse liquids. In a fourth position of the machine the basket is lowered into an electrically-heated blower-equipped drying compartment in which the cleaned parts are spun dry prior to removal.

CARBON MET.

Has Desirable Industrial Cleaning Characteristics

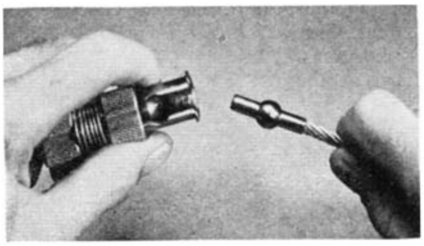
Developed as a substitute for carbon tetrachloride, now widely used for cleaning by war plants processing metal parts, a newly developed solvent is described as a volatile, water-white methalated hydrocarbon solvent which evaporates clean and is non-flammable and non-explosive, and which is characterized by its quick and powerful cleaning as well as dissolving action on gums, oxidized oils, burnishing compounds, and so on.

The new product, developed by The Curran Corporation, is said to be 14 times faster than naptha in cutting gummy and tarry dirt. Unlike the chlorinated solvents, it induces no corrosive or rusting tendency of ferrous metals; also, is much less toxic than carbon tetrachloride, which it is intended to replace. It is also said to be substantially lower in cost than carbon tet.

ROPE COUPLING

Permits Quick Joining and Parting of Ends

Designed especially for use in aircraft control cables, a new device makes it possible to connect or disconnect such



Spring-loaded collars hold the cable coupling ball fittings securely

cables rapidly and positively. The assembly of one of these devices, called Tru-Loc Quickies, is shown in the accompanying photograph. Each end of the cable is provided with a ball type fitting. The coupling consists of a cylindrical body, slotted to take the cable end fittings. On this body are two knurled collars, separated by a spring which holds them against flanges at the ends of the body.

When the coupling is to be used, one of the knurled collars is pulled back to expose the slot. The cable end is then inserted or removed and the collar released. Installation is complete when the two fittings are in place and the collars are over them, holding them securely against accidental uncoupling. These units are available in five sizes for use with cables ranging from 1/16 to 3/16 of an inch in diameter.

When Engineers Meet

Aeronautical Experts Contract a Sort of Mental Indigestion that is Good for the Whole Country

ALEXANDER KLEMIN

Aviation Editor, Scientific American. Research Professor, Daniel Guggenheim School of Aeronautics, New York University

The high point of the year in aeronautical technology is always the annual meeting of the Institute of the Aeronautical Sciences. To minimize travel the meeting was held this year in three places simultaneously: New York City, at Columbia University; Detroit, at Rockham Education Memorial; and Los Angeles, at the University of Southern California, and in many instances papers were delivered by proxies.

Naturally, the activities of aviation engineers at the present time constitute a vital element of the war effort. Therefore all papers had to be approved by the Army or Navy and read substantially as written, and all discussions had to be off the record. Furthermore, censorship restrictions prevented the disclosure of the most striking advances made during the year, whether in aircraft, engines, or instruments, but subject to these restrictions an immense amount of important technilogical work was disclosed, indicating that American aeronautical research is forging ahead to the utmost.

Great discoveries are being made in aerodynamics, but these were not discussed at the meeting, which, however, advanced the solution of one aerodynamic problem; namely, how it would be possible for our designers to predict the maneuverability of aircraft before the craft themselves were built. Johnny Good, Jr., of the Douglas Aircraft Company, discussed the subject in a paper that had the formidable title of "Maneuverability Criteria Through Turning Performance." Our fighter planes are almost as fast, and certainly as well protected and armed as any in the world, and are provided with every instrument, accessory, or gadget that it is possible to think of. These planes also are exceedingly robust—far more robust that the almost "delicate" Zero, for example. There has, however, been a tendency in American fighter design to use too much strength and weight, too many gadgets, instruments, and accessories, and finally, to load the wing, in pounds per square foot, to very high values. The result is they lack, perhaps, in maneuverability—the ability to roll, or to dive very rapidly when detaching themselves from the enemy. If Mr. Good's paper can help our designers to predict the maneuverability of their craft, they may possibly be a little more careful in piling on, even at the behest of Army and Navy, all those items which make our aircraft complete at every point, but detract from their handiness in the air and diminish their rate of climb to great altitude.

A vital problem of the day and one which is agitating both the fighting services and the public is the towed glider. The towed glider has been widely heralded as the solution to the military problem of landing men in restricted enemy terrain. It has also been hoped that the towed glider, or gliders, would act as a species of air train, bringing down the cost of carrying cargo by air to very low figures. The author of the present item, and W. C. Walling, of Lockheed Aircraft Corporation, discussed the performance problems of the towed glider. They had made a serious study of the problem and their views were somewhat deflationary. If great loads are to be carried slowly, it would appear, on the whole, more desirable to design and build special cargo airplanes. The towed glider, while it enhances the pay load tremendously, also decreases the cruising speed and hence increases the flying costs per ton mile. The glider is not suited for long range transportation, but appears to be well adapted for short operations, such as the Germans undertook in carrying soldiers into Crete, and possibly from Sicily into Tunisia.

Mr. Thomas D. Perry talked on "Progress of Aircraft Plywood." During the year the plywood situation in airplane construction has improved tremendously. Military and naval training planes of various types are made of wood and plywood covering. In the glider program almost all the framework of the glider is of plywood. Cargo planes are utilizing wood and plywood to a great extent, and even military or combat aircraft reveal a growing number of plywood members, such as doors, seats, floors, traps, rotors, and control surfaces. The new processes of molding plywood by the flexible bag method is apparently finding wide use in compound curved shapes, and more than 25 factories have such molding equipment. The demand for flat plywood in aircraft is taxing the capacity of nearly 100 factories. Also, there is coming to the fore a high density and impregnated plywood having almost the strength of steel and particularly adapted to places where there is great concentration of stress.

We used to think that anything was good enough for a man to fly in—an open cockpit or whatnot. Today, we find Albert A. Arnhym, of Pacific-Airmax Corporation, demanding from aircraft designers, in his address, "Comfortization of Military Aircraft," that they "comfortize" planes and protect the pilot from bad air, heat or cold, and effects of high

altitudes; that they give him good vision, ability to jump easily, and the like. The protective armor of military aircraft is a vital subject, and it seems that it is possible to do a great deal for our fighting pilots in protecting them against direct attack by putting plates close to the individual and by guarding instruments and accessories.

There is apparently one great step forward to be expected in the very near future, and that is pressurization of the passenger cabin. In the opinion of well-informed authorities, and as discussed at length by Charles W. Morris, of Air Research Manufacturing Company, it is absolutely imperative to maintain the cabin pressure at the equivalent of 8000 feet. Almost every air transport man of the day agrees with the view that some form of pressurization will have to be achieved.

Extraordinary interest attached to the session in which Army and Navy flight surgeons discussed airplane design from the point of view of the medical man. Gangsters who wish to stun or put their enemies out of action without killing them know how to cover a piece of metal with rubber as in the blackjack, and their brass knuckles are streamlined so as to stun without deadly injury, explained a naval captain. In the same way the plea was made that airplane designers should include as one of their great aims the construction of aircraft in such fashion that minor crashes would result only in injury and not in death. Projecting sharp edges of a compass at the level of a pilot's forehead, for example, is almost criminal negligence, and has killed many pilots who might have walked away after a bad landing.

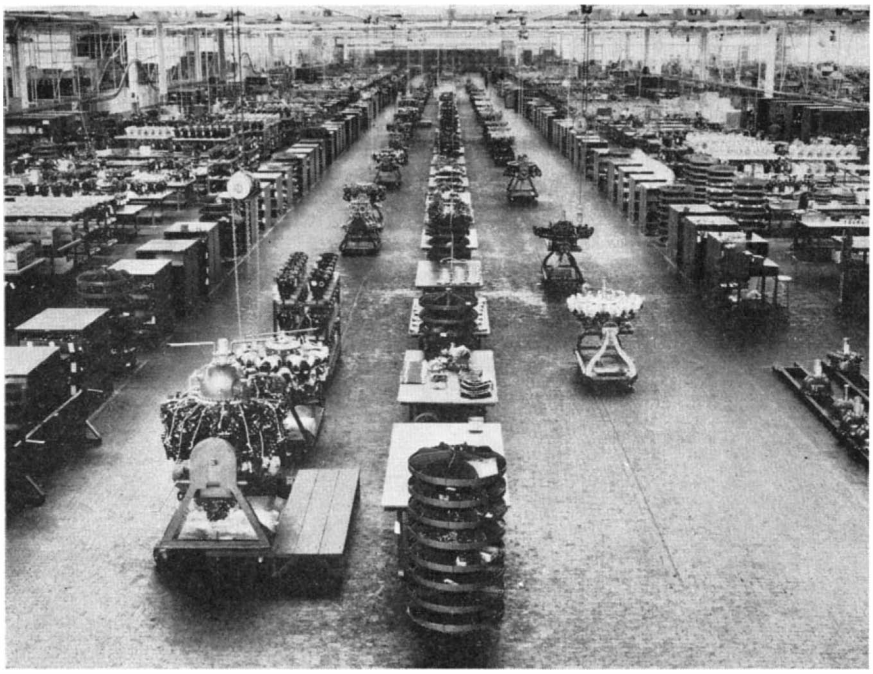
We wish that we could deal at equal length with many of the other splendid and informative papers presented, but space will permit only the mention of a few highlights. Magnesium, strong, and even lighter than aluminum, is apparently coming into its own in aircraft construction. Formerly it seemed to be used exclusively in German aircraft, and now methods of improved fabrication have brought it to the service of American designers. Propellers, power plants, superchargers, air transport economy, and the like gave those who attended the Institute meetings a species of mental indigestion. It is good for the country that there should be such mental indigestion, since this augurs well for the constant improvement of our military and naval aircraft.

ENGINE PRODUCTION

Speeded by Assembly-Line Methods

AMERICAN manufacturers, spurred by war-time necessity, have found ways of making the world's best airplane engines on a production scale which was undreamed of before the war. Now, straight-line assembly methods are being employed on a gigantic scale. In a United Aircraft factory, for example, there is a main-floor storage area, which is equipped with a splendid conveyor system. Then there is also a "green" or preliminary assembly line, shown in one of our photographs, where double-row engines are assembled on one side and single-row engines along the other side. Sub-assembly benches to the right and left of the two lines feed completed sub-assemblies into the single and double-row lines.

The endurance which an aircraft engine has to show is truly remarkable when we consider the enormous power which is crowded into such a compact and relatively light mechanism. It is not surprising, therefore, that, after each engine has been given an initial test, it is completely disassembled and all its parts are laid out on benches for minute inspection, before it is finally assembled and made ready for shipment.—*A.K.*



Marvels of assembly methods lay aircraft engines on the line

Our Book Corner

THE BOOK DEPARTMENT of Scientific American is conducted, with the co-operation 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.

MITCHELL, PIONEER OF AIR POWER

By Isaac Don Levine

General William Mitchell (Billy Mitchell, as he was widely known) had innumerable friends in and out of the service. He impressed all those who knew him by his energy, friendliness, ability, and his sincere and wholehearted love of military aviation. Had Mitchell's advice been followed, the whole history of American aviation would have been different. Mr. Levine has given us first a graphic and personal story which makes fascinating reading. But what is more valuable is the fact that the book recalls with perfect truth and impartiality how Mitchell's ideas on air power were neglected and should have been followed at various periods of our history. With a bibliography of Mitchell's own writing and with a fine index, the book is a definitive work on Mitchell and will become a valuable part of our aeronautical and military literature. (420 pages.)—$3.60 postpaid. —*A. K.*

CHEMICAL REFINING OF PETROLEUM

By Kalichevsky and Stagner

Theory and practice of the various chemical processes used in refining petroleum and its products are presented here in a form especially suited to the needs of petroleum technologists. (550 pages, 6½ by 9½ inches, a few drawings and photographs, and a comprehensive list of patents pertaining to the general subject.)—$7.60 postpaid.—*A.P.P.*

MODERN PULP AND PAPER MAKING

By G. S. Witham, Sr.

A technical discussion of the subject of the title, yet not so abstruse as to be beyond the grasp of the average paper maker, the text does much more than merely skim the surface. (705 pages, 6½ by 9½ inches, 319 illustrations.)—$6.85 postpaid.—*A.P.P.*

INSECT INVADERS

By Anthony Standen

No insect lover, no Fabre or Maeterlinck, no Teale, is this chemist author who writes: "I hate insects and my sole interest in them is to be able to destroy them." Chapters on what insects are, what their bodies are like, how they live and multiply, insects that harm man and animals, insects that eat our food and other things, good insects. Also on the balance sheet (damage data), insects out of place, insects kept in place, chemicals, and other tricks. Emphasis in this book is on the practical but it is not a conventional insect control book—much more readable and popular. (228 pages, 6 by 9 inches, 56 illustrations.)—$3.60 postpaid.—*A.G.I.*

RADIO—I

By Williams and Scarlott

A compact presentation of the essence of radio fundamentals written to conform to the pre-induction training course in the subject as prepared by the War Department. The text carries the reader from a general discussion of radio through the language and symbols of the science to a review of electrical theory and a discussion of thermal emission. (132 pages, 6½ by 9½ inches, nearly 100 illustrations.)—$1.10 postpaid.—*A.P.P.*

COMMON EDIBLE MUSHROOMS

By Clyde M. Christensen

Known to be edible since the days of Chaldea and Talmud, mushrooms growing wild have been shunned by many because of the belief that one must be an "expert" to distinguish between edible and poisonous varieties. Not so. With no more time or trouble than it takes to learn half a dozen flowers or trees, the amateur can identify an equal number of wild mushrooms. This book tells how to recognize, gather, and cook 45 varieties. Mushrooms, this year, can augment the food supply. This publication will help immeasurably. (124 pages, 5 by 8 inches, four color plates, 62 photographs.)—$2.60 postpaid.—*A.D.R., IV.*

WINGS OVER AMERICA

By Harry Bruno

The subtitle of this book, "The Inside Story of American Aviation," is very appropriate. Mr. Bruno, one of the Quiet Birdmen and one of the early American flyers, has lived through and participated in every great period of American aviation. His book is accordingly reliable as history, but vivid as the story of a participant in aviation history. The early days are described in a most interesting fashion. Then comes the story of early naval and military aviation with General William Mitchell coming to the front as one of the wartime flyers. In a graphic chapter, "The Eagle's Wings Are

Broken," Mr. Bruno tells the story of Mitchell's court martial and the defeat of a great military aviation pioneer. Little by little we see knowledge taking the place of daring alone and soon the great work of the airlines puts a seal on the achievements of aviation.

"The Boy Grew Older" is a sad recital of the later stages of Colonel Lindbergh's career. Harry Bruno loved Lindbergh, one can see from this book, and it pained him to see how Lindbergh—a splendid, capable, and brave flyer—succumbed to the adulation and clever efforts of the Nazis. It is true that no definite chronology or scholastic history is available in these pages, but Harry Bruno, beloved by many in aviation, has caught the very spirit of its magnificent history. (333 pages plus a 64-page picture section.)—$3.10 postpaid.—*A. K.*

MARINE DIESEL HANDBOOK

By Louis R. Ford, M.A.

A MASSIVE compendium of data on the design, construction, and operation of the marine Diesel engine, this volume is a compilation of material drawn from the best and most authoritative sources. The author is editor of *Motorship and Diesel Boating* and has been closely associated with marine prime movers for many years. The text has been prepared with an eye to simplicity, yet in no sense has accuracy and completeness been sacrificed to make for easier reading. Chapters cover applications, principles, types, fuel injection systems, lubrication, supercharging, and so on. Included is a chapter of questions and answers on practical operating problems. (896 pages, 6¼ by 9 inches, lavishly illustrated with diagrams, charts, tables, and photographs.)—$7.25 postpaid. —*A. P. P.*

WAYS OF THE WEATHER

By W. J. Humphreys

NOTED United States Weather Bureau meteorological physicist, author of abstruse literature on his science, translates this science into plain language for plain people; writing so good a book that it was made a Book-of-the-Month Club selection. After a lifetime on the receiving end of weather questions, Dr. Humphreys knows which ones most often puzzle people, and in this all-around book he answers them, scientifically, simply, and entertainingly—sometimes whimsically. A book of clear answers to "why." (400 pages, 6½ by 9¾ inches, 75 illustrations.) —$4.10 postpaid.—*A. G. I.*

GERMANY'S MASTER PLAN

By Joseph Borkin and Charles A. Welsh

THE STORY of Germany's industrial offensives under the octopus-like operations of I. G. Farben (Farbenindustrie) before and after World War 1, with emphasis on the cartel developments prior to this war, developments which sent crippling tentacles into America's preparedness. Architects of the "master plan" are named as the Junkers, the High Command, and the industrialists, all of whom

The Editors Recommend

Best Sellers in Science

thought their plan unbeatable and who placed Hitler in control of their fabulous power to unite the German people with his dynamic abilities. The authors believe Hitler struck too soon—that this and other German mistakes must be exploited, if we are to win. (339 pages, 5 by 8 inches, index.)—$2.85 postpaid.—*A.D.R., IV.*

FLYING HEALTH

By Dr. M. Martyn Kafka

SOMEWHAT more than a year ago a German booklet of medical instructions to pilots created a sensation by its completeness and its common-sense view and practical help to the military pilot. We believe that Kafka's book is still better, is more complete, more detailed, and of as much service to the practical flight surgeon as to the pilot himself. Doctor Kafka has not attempted to write a book on aviation medicine. He has simply recognized that the fighting pilot needs to be absolutely at the top of his form, both physically and mentally. There must be exercise, sports, and other considered factors, and these are well covered. Doctor Kafka, a former Army flight surgeon, has written what is in effect a practical common-sense guide to what the pilot must know about his health. (248 pages, illustrated.)—$2.10 postpaid.—*A.K.*

MECHANICAL DRAWING

By Kenison, McKinney, and Plumridge

COVERING the skills and technical knowledge which are needed in the specialized field of drawing, the text of this volume will serve as an adequate guide to the problems of the work. It covers thoroughly the subject of instruments and their use, provides drill exercises, and, in general, shows the student how to make neat and accurate drawings. (330 pages, 5½ by 8½ inches, a large number of drawings and photographs.)—$2.10 postpaid.—*A.P.P.*

PRE-SERVICE COURSE IN ELECTRICITY

By William C. Shea

FOLLOWING an outline of a basic course for pre-induction training in the fundamentals of electricity, the material presented in this text was drawn from technical and field manuals of the War Department. The purpose of this book, which is adequately fulfilled, is to provide those who are about to enter military services with a foundation of knowledge for future specialization. (276 pages, 6 by 9 inches, over 200 illustrations.)—$2.10 postpaid.—*A.P.P.*

MATHEMATICAL RECREATIONS

By Maurice Kraitchik

IN NO sense is this a book of instruction —it is a collection of intriguing problems for the already instructed. The author is an associate professor of applied mathematics and a former editor of the magazine, *Sphinx*, devoted to recreational mathematics. He has brought together a large assemblage of material which, to the lover of just such things, rates as entertainment, pure but not simple—

ancient and curious problems; problems that are freakish; problems depending on the laws of chance; magic squares; geometric recreations; permutational problems of the queens and knight; positional games in addition to checkers and chess; permutational games. The answers and demonstrations are stated. This book is based on a course of lectures. (328 pages, 5½ by 8⅜ inches, 181 figures.)—$3.85 postpaid.—*A.G.I.*

WEBSTER'S DICTIONARY OF SYNONYMS

ANSWERS a long felt need for a work devoted to synonymy that emphasizes discrimination among synonyms, and which offers accessory material in the form of word lists of various kinds. Not an assemblage of mere word-finding lists for consultants with only a vague notion of the sort of word they seek, but rather a work which provides a means of making clear comparisons between words of a common denotation, and definitions which distinguish differences in implications, connotations, and applications among such words, and of choosing for their purpose the precisely suitable word for any occasion. (907 pages, 6½ by 10 inches, thumb indexed.)—$4.10 postpaid.—*A.D.R., IV.*

ELEMENTARY PHYSICAL CHEMISTRY
By Merle Randall and Leona Esther Young

TEXT, REFERENCE, refresher course, for analysts, biologists, biochemists, engineers, geologists, and students without a teacher. The pages are reproduced from typescript by photolith. Authors are professors respectively in the University of California and Mills College. (455 pages, 6 by 9 inches, illustrated.)—$4.60 postpaid.—*A. G. I.*

SHIP STRUCTURE AND BLUEPRINT READING
By H. L. Heed

MATERIALS of Ship Construction; Plates and Shapes; Welding and Riveting; Combinations of Structures; Ship Layout; Arrangement of Ship Drawings; Ship Types; Dimensions; Framing and Structual Units; Appendages; Ventilation; Machinery; Piping; Lines of a Ship. Also contains handy tables, list of blueprint abbreviations, and glossary of shipbuilding. Thoroughly practical. (4¾ by 7 inches, illustrated.)—$2.60 postpaid.—*A.D.R., IV.*

WOLF-CHILDREN AND FERAL MAN
By Singh and Zingg

IN SCIENTIFIC AMERICAN, March, 1941, Professor Robert Zingg, an American anthropologist, told the salient facts about two human infants reared as animals by wolves in India till captured by Reverend Singh and reared as humans. In May, 1941, we reviewed in this department the book, "Wolf Child and Human Child," by Dr. Gesell, of Yale, a study of the same children. Now comes Reverend Singh's actual, detailed diary account of the whole nine-year episode, with less emphasis on psychology and more on general interest than the others. Second half of the work, by Zingg, gives details of 12 similar and earlier cases of feral children in India where wolves often steal infants; also, in Europe, the cases of Wild Peter and of infants reared by bears; grown children abandoned in the wilds by parents; and the long and remarkable account of a royal heir in Europe who was confined for 16 years in a living grave, then found and educated. This book is a round-up of widely scattered data on this subject. (379 pages, 5½ by 8½ inches, 35 illustrations.)—$4.10 postpaid.—*A.G.I.*

ARMY-NAVY GUIDE

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By Frederick P. Lowell

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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"

THE FOLLOWING notes in this month's Telescoptics department are an addendum to the general article on page 202, which should be read first. They are aimed at the reader who has made telescopes, but not roof prisms.

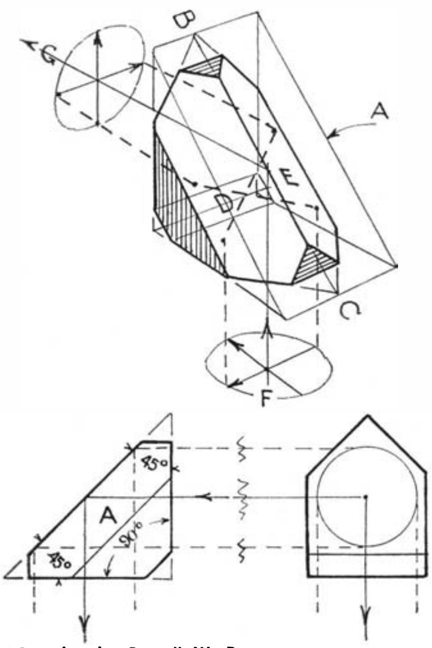
THE FAMILIAR right angle prism turns rays through an angle of 90°, inverts the image, but does not reverse it. The elbow telescopes of military gunsights, on the other hand, require a prism that will similarly turn rays through an angle of 90°, similarly invert, but will also reverse the image. In actual application, of course, such a prism is called on to normalize the already inverted and reversed image produced by the gunsight's telescope objective.

The common right angle prism can be modified so that it will do all these things. Russell W. Porter briefly explains this modification thus:

"Let us start with the familiar right angle prism *A,* Figure 1, top, indicated with light lines. We grind away two sides of its hypothenuse face until only the line *BC* is left. This gives us two faces, *D* and *E,* which we shall call the roof. The sides of the roof must make an angle to each other of 90°.

"Now consider a beam of light entering the prism from *F* and emerging at *G,* at right angles to the immergent beam. If two arrows are used to represent the incoming object, it will be seen that, on emerging, the image has been reversed, as the arrows show.

"By tracing the arrow points and tails through the glass, shown by dotted lines, their rays are seen to cross each other by internal reflection from the roof faces. The image is also turned through an angle of 90°."



Drawing by Russell W. Porter

Figure 1: Roof prism principles

It may prove difficult to visualize this from a drawing, if the reader is not already familiar with roof prisms—it usually is confusing even to those who, for the first time, actually examine a roof prism. At first one looks very complicated. An added reason for this confusion is the fact that in such a prism there apparently are nine facets. Five of these are not, however, true optical facets. The two tips of the prism which lie outside the circle of rays that reach the entrant face, as well as the heel part of the right-angle portion which lies outside the telescope's aperture, are ground off to save space in the mounting, and are left fine-ground, as are the two sides.

Thus a manufactured roof prism has only four polished, flat, optical faces. These are: the entrant face; the two roof faces which were made over from the right angle prism's hypothenuse side and which are at exact right angles to each other; and the emergent face at right angles to the entrant face.

G. B. Amici (1786-1864), an Italian, invented this prism, which is sometimes called the Amici prism. Sometimes, too, it is called other names not fit to print, by those who wrestle with its difficulties. Ordnance Document 1065, prepared under the direction of the Chief of Ordnance by Dr. I. C. Gardner, Chief of the Optical Inspection Section of the National Bureau of Standards, states: "It is one of the most difficult to manufacture because the roof angle cannot differ from 90° by more than a few seconds. Angles having the requisite accuracy cannot be produced directly, but must be carefully approximated by usual manufacturing methods: after which the faces must be carefully polished by a skilled operator and individually tested until the angle is so nearly correct that the image is not doubled. An error of a few seconds is sufficient to make the prism worthless. This tedious method of production limits the output, as few men become sufficiently skilled to do this local retouching." Local retouching and "hand-correction," mentioned in the article for general readers elsewhere in this number, are the same thing.

Roof prisms are used in elbow telescopes, and elbow telescopes are used in all anti-aircraft sights, in order that the observer may look horizontally into the eyepiece. In the panoramic field-gun sight a horizontal element with a rotating objective prism of right angle type is added to the top of the elbow telescope, so that the cannoneer, without changing position, may sight, first on his "aiming point" (not the actual target but some convenient fixed reference point), then turn off his azimuth, corrections for windage, drift, and so on, and fire the gun. This is the method of indirect laying of guns. That method is predominant because today the gun usually remains concealed and the firing data are given to its crew by telephone from a distant observer who can see the target. This explains why a straight, direct, telescope, used as a sight, which would seem to be the answer that would do away very simply with the roof prism problem, could seldom be used.

Every amateur telescope maker will be curious to gain a rough idea of the high spots of the procedure of making roof prisms. To this end MacTavish has contributed the following, by invitation:

"In Figure 1, bottom, *A* is a side elevation of a roof prism, showing the 90° angle ('end angle') between the entrant (immergent) and emergent faces, also the 45° angle between the roof line and the entrant and emergent ('end') faces. In addition, the roof faces are 60° to the end faces.

"In producing the prisms, all angles except the roof angle are controlled in grinding and polishing to 2′ of arc. This is assured if there is a light-tight reading under a fine standard square and a 60° gage. The roof angle is then brought to 90° ± 2″ by hand correction on a flat lap of pitch.

"The four optical facets must be flat within standard precision tolerances. Pits, scratches, grey surfaces, striae, ream, bubbles, nicks, and small fractures are not tolerated.

"Mechanical dimensions are held to close tolerances.

"The following roughly outlines the main processes, omitting the finer points, also the troubles—the former would add

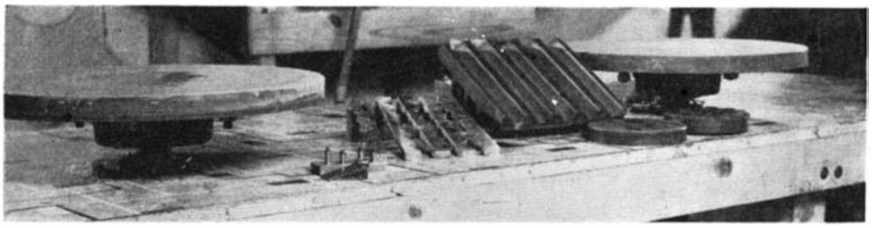
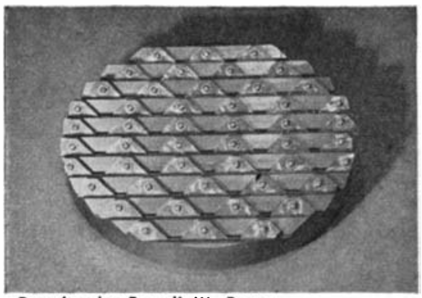


Figure 2: Fogarty's grinding spindles (splash-plates removed)



Drawing by Russell W. Porter

Figure 3: Widdicomb's home-made V-block, angles accurate to 30"

perhaps 25,000 words to the account, the latter from 50,000 up to, say, 1,000,000.

"The work starts with thick slab glass, though pressed forms are also used.

"The glass is sawed into rectangles, each large enough to make two prisms when later sawed diagonally.

"Groups of these are cemented to flat iron plates and held against wet abrasive grains on round, rotating, flat, iron plates, (Figure 2) first on one side, then the

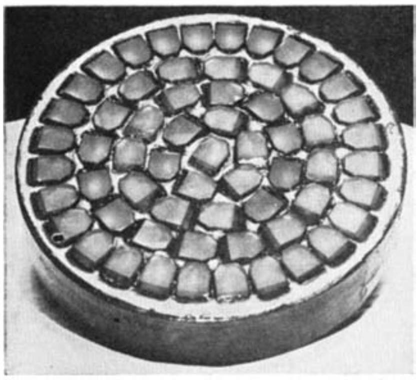


Figure 4: Block of end faces ready for polishing on machine. Widdicomb

other, till they mike correct to the prism thickness dimension specified.

"Several of these squares are cemented together in stacked-up form, and one side and one end of this block are ground square to the sides and to each other.

"The same cemented group is cemented to an optically flat iron plate with hot wax and the other side and end are ground parallel to the first side and end, respectively, in several operations.

"The pieces are removed, uncemented, and each square is cut diagonally with a diamond saw.

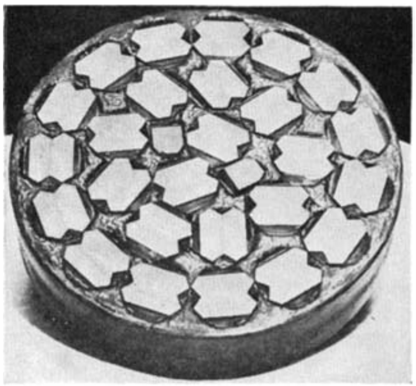
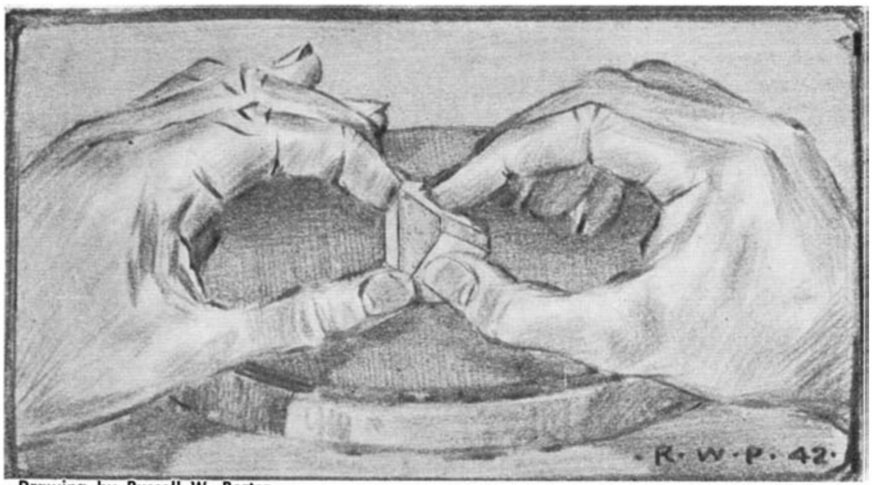


Figure 5: Block of roof faces paired to prevent edge nicks, and recessed



Drawing by Russell W. Porter

Figure 6: Hand-correcting a roof prism is simply freehand genius

"The sharp tips are then ground off and left fine ground permanently.

"The 90° angles are corrected by hand with fine emery; otherwise the roof-face-to-end-face angle will depart grossly from 60°, and the roof-line-to-end-face angle will depart grossly from 45°. Other sources of error at this point must be skipped.

"Next, the two roof faces are ground on. The prisms are inserted in accurate metal V-blocks (Figure 3), with V's to hold them laterally, also notched metal inserts to hold them longitudinally (these are shown disassembled in Figure 2), and the roof faces are ground on, first one face of all, then the other face of all.

"The roof faces are miked uniform all around through the V-block, so that the roof ridges will be in the exact center of the prisms.

"After the roof faces are ground on, the 60° angles are corrected by hand retouching against an iron plate with fine abrasive—a very ticklish, fatiguing task.

"Next, the sharp edges of the prism are beveled.

"The prisms are again cemented, bottoms up, into another V-block without inserts and the small (non-optical) bottom faces are ground off.

"Preparation for polishing is begun. Face by face the prisms, somewhat separated, are cemented to an optically flat iron plate with melted paraffine, or cold oil. A ring of sheet metal is placed around this plate and special plaster is poured around the prisms. This forms a matrix, or round block. The ring is removed, the bottom iron plate is warmed (if paraffine is used), and the block slid off. The plaster is cut back 1/16", so that the prism faces stand slightly in relief, and is waterproofed with shellac.

"This prepared matrix (Figure 4)—two of these also are visible in an illustration on page 203—is now like a big round blank with which you would make a flat. It is so regarded and dealt with in polishing, figuring, and testing. Another flat, good to a tenth of a fringe, is used for testing it. Here there is, however, a complication—for plaster expands on setting, also changing with temperature changes, so that it is not a perfect matrix. This often causes much trouble. One must also learn to seat the prism so that errors will not be introduced to spoil the already corrected angles.

"Polishing is done face up on a modified Draper machine. The polish must be free of all defects—clear and grainless.

"The two end faces are polished first, successively, then one roof face.

"Before the second roof face is blocked, the roof angle must be corrected by hand grinding as closely as possible to 90°, so that when the prisms come out of the block, the angle error will be 2′ or less, in order to save time later in hand correction.

"Great care and correct abrasives must be used in grinding the final roof side. No tiny chips, nicks, or fractures are permitted along the roof line. Even No. 1000 Carbo will cause fractures here, and superfine emeries are used.

"The second roof face now is polished (Figure 5).

"Thus all four optical faces have now been polished, and next comes one of the most thrilling operations known to me in optics—correction of the roof angle by freehand polishing on a small flat lap of pitch. Correction of the roof angle is not in itself so difficult, but the lap must be held flat at the same time—flat within precision tolerances — without astigmatic fringes or turns. The crux of the operation is the preparation of the lap and the use of strokes which will produce the desired results—and, of course, a skilful man doing it. Such a man, one of the most skilled hand-correctors in the country, is Pavel Uvaroff (see photograph on page 205), who has corrected as many as 55 roof prisms in a single day. Here is work where money and fancy equipment cannot substitute for the man. Figure 6 is Porter's sketch of one of numerous differing finger positions favored by prism correctors.

"As the angle is being corrected, frequent testing is necessary. A target of crossed thin lines is placed about 30′ distant and its image is viewed through the prism by means of a 20X telescope. The vertical lines do not double unless astigmatism is present in the prism. The horizontal lines double to a greater or less degree, depending on the angle error. The aim is to correct the prism till they coincide and are as sharp and clear as the vertical lines. With greater magnification we have proved that an error of 1″ of arc can be discerned.

"Readers who are already familiar with roof prism making will have found many omissions in the above hop-skip-and-jump outline. This is due to space limitations. I was invited to touch only the high spots, with the aim of giving the average amateur telescope-making reader a generalized picture.

"One noticeable difference between mirror making and roof prism making—noticeable because, if the maker doesn't notice it, the purchaser's inspector certainly will—is the fact that the maker is no longer his own judge and jury. Any tendency to be optimistic about one's own work is cancelled out by the same cruel and heartless inspector. The prisms must equal specifications or else."

BECAUSE it is anticipated that some readers will wish to go in for roof prism making, it probably will be a kindness—nothing less—to state here with entire candidness that it almost certainly is now too late to begin. Tooling up, alone, requires weeks or months, while learning the difficult art usually adds from three to six months more. It is not now believed that this would result in much, if anything, more than a bad headache, irretrievable expense, and disappointment. In any case, the Scientific American Roof Prism Making Program is no longer open to new entrants—it has done its work.

If this seems to be bad news, you may be tempted to ask why you were not invited to participate at the beginning, 18 months ago. Every effort was made to locate the ablest men, short of undesirable publicity, simply because every such man was actually wanted. Yet, despite a variety of under-cover fishing expeditions, many good men were no doubt missed.

Requirements for admission were: several mirrors previously made, also flats. This led to some heartaches—the less the applicant had done, apparently the greater the heartache; in fact, several who applied without having made any mirrors at all nearly died of heartache. This seeming (and actual) exclusiveness arose from only one motive: the leaders found it impossible to service more than approximately 80 candidates. As a war was on, it was found necessary to be arbitrary—for which apology and the above explanation are now offered.

Even as it proved, however, the leaders who tried hard to co-ordinate the work will probably never be the same again. Your scribe, after 18 months of preoccupation with the job, has selected a secret hole, acquired an eight-volume "History of the Dark Ages" (in which wars were fought without roof prisms), crawled in, and is about to pull the hole in after him —Goodbye!

Emerging after a spell in the Dark Ages, he will, however, if the war situation or its end permits, endeavor to offer a second account in which details of the program's accomplishments can be discreetly revealed. This will include a statement of the true identities of the heroes of the preceding story, each at present protected from sabotage under a name that, by censor's request, is fictitious.

Printed in the U. S. A. Press of the Wilson H. Lee Company, Orange, Connecticut.

That's no Dove of Peace he's building...

Give the devil his due. The Japs didn't invent mechanized warfare, but they are pretty good at copying. They have even taught us something: *how to stretch to the utmost materials for making the weapons of war.*

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Group of 1943 Science Talent Search Winners leaving the Pan-American Union Building after discussing South American relations with Dr. L. S. Rowe, Director-General.

Prospecting for future scientists

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It is quite certain that early discovery of ability helps crystallize the interests of the students and stimulates them to further activity.

For these reasons, Science Service, Science Clubs of America and Westinghouse are cooperating in an annual Science Talent Search. Methods employed in the Science Talent Search, including the science aptitude tests, were devised by Dr. Harold A. Edgerton, Ohio State University, and Dr. Steuart Henderson Britt, Office of Psychological Personnel, National Research Council.

Each year, 40 boys and girls selected on the basis of the criteria set up by Dr. Edgerton and Dr. Britt, are taken to Washington as guests of Westinghouse. There, after further examinations and interviews, those who qualify receive Westinghouse Science Scholarships ranging from $100 to $2400.

Last year, 20 Westinghouse Science Scholarships were awarded, but every boy and girl selected for the trip received offers of scholarship help from leading colleges and universities.

Every one entered college.

Every one is making a scholastic record considerably above the average.

Since the Science Talent Search is only in its second year, there are yet no data on the correlation between aptitude as measured by the methods employed and actual achievement in science. Dr. Edgerton and Dr. Britt have, however, begun a projected ten-year study of these boys and girls, covering their work in college and the early part of their after-college careers.

Full information on the Science Talent Search, including reprint of an article by Dr. Edgerton and Dr. Britt describing the methods employed, will be sent on request. Write to Science Service, 1719 N Street, Washington, D. C., or to School Service, Westinghouse Electric & Manufacturing Co., 306 Fourth Ave., Pittsburgh, Pa.

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