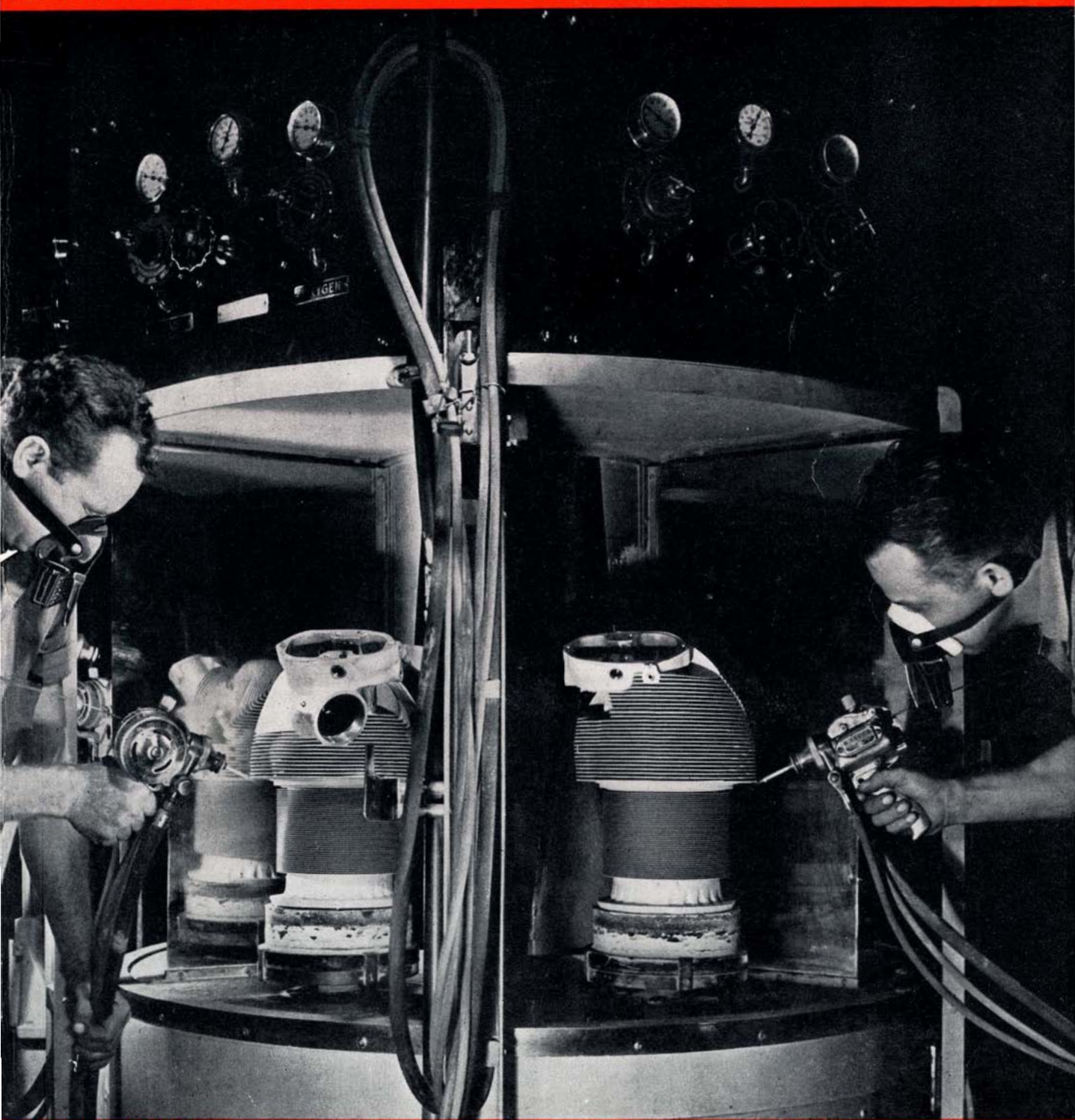
Scientific American

JANUARY
1944

★

35 CENTS
A COPY
50c IN CANADA

EPORTING THE PROGRESS OF SCIENCE AND INDUSTRY



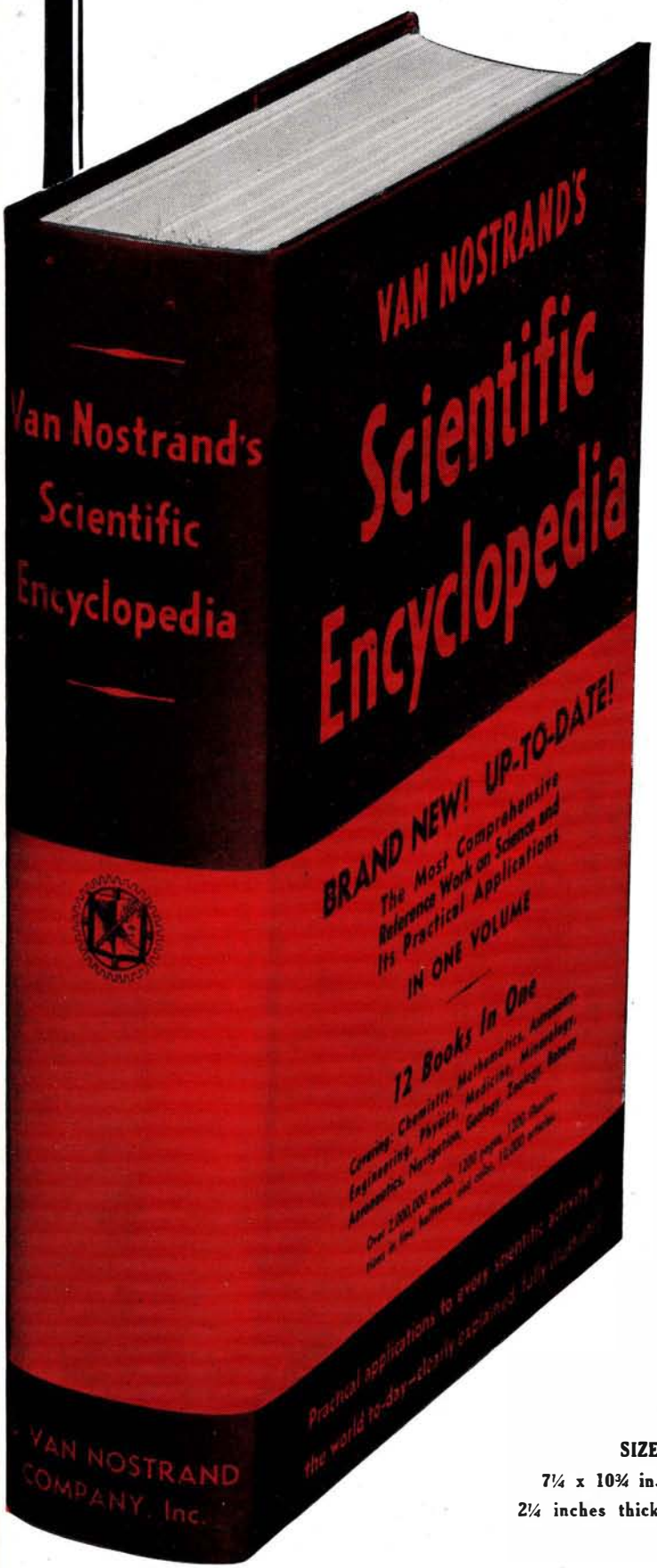
raphy by Robert Yarnall Richie

Air-Sprayed Aluminum Protects Cylinders . . . See page 2

All the Sciences

1500 Pages

1200 Illustrations



SIZE
7¼ x 10¾ in.
2¼ inches thick

THIS great new work presents—for the first time in one volume—a complete coverage of the terms of science and engineering. Principles are clearly explained—methods of calculation are fully described with the formulae and units—chemical structures and reactions, physical laws and instruments, engineering design, construction, and operation are merely suggestive of its tremendous scope — which extends throughout the entire range of technical knowledge up to the most recent advances and inventions. The great number of photographs, diagrams, and charts have been specially prepared and selected to show the salient facts most clearly. Innumerable tables and summaries make all this information easily available for instant reference.

This vast fund of information has been prepared and organized by a plan that insures its usefulness, completeness, and accuracy. Each entry is first explained in simple, broad terms that are easy to understand, and that serve as an illuminating introduction to the detailed and more advanced information which follows.

From Fundamentals to Latest Advanced Discoveries—

Principles, Methods, Formulas—Clear Charts, Diagrams

FOR the student, the hobbyist, the manual worker, this great volume supplies, for the first time, a single, convenient source of reference covering all the sciences. The ample cross-references make it easy to follow a complete course of study on any chosen subject. By this flexible plan of arrangement, the *professional* scientist, who wants specific information instantly, either in his own field or *any related field*, can find it in a few seconds in its alphabetical place—comprehensively treated in the language he works with—*the language of science.*

The Instant Question-Answerer for Laboratory and Shop Workers, Mechanics, Home Scientists, Students

Answers tens of thousands of questions such as: The value of radial, rotary gas engines—How the Diesel Engine operates—How air conditioning functions—What is the coming television system—How storage batteries work—How to find your position at sea—How to do dead reckoning—How your nervous system works—How to recognize every star, planet, constellation—How optical instruments are constructed—How to work arithmetic, algebra, geometry problems—How bridges are constructed—How an airplane beacon system works—How petroleum is cracked to make gasoline—How rayon is made—How to survey a piece of land—and thousands more.

in One Great Book

10,000 Separate Subjects

Twelve Big Volumes in One

The vast wealth of useful information in the Scientific Encyclopedia if published in the ordinary way, would fill more than 12 average-size volumes. Here is just a brief outline of some of the subjects covered:

CHEMISTRY: Chemical elements—symbols, atomic number, atomic weight, density, hardness, melting point, etc.—common reactions, occurrence in nature, method of production from ores, uses in industry. Compounds—full information, including manufacture and use. Organic compounds; industrial products. Agricultural chemistry, food chemistry.

PHYSICS: Mechanics, heat, light, sound, electricity, magnetism, X-rays, fully covered; principles and application profusely illustrated.

MATHEMATICS: From fundamentals of arithmetic to algebra, geometry, trigonometry, calculus, differential equations, etc.; with special emphasis on their application to science.

ASTRONOMY: Articles cover the entire subject. Each important constellation is shown on a star map so that it can be easily located in the sky. Complete information on planets, use of telescope, spectrometer, etc.

ZOOLOGY: The whole story of life from the tiniest single-celled organisms up to man himself, including vast numbers of common insects, mollusks, worms; birds, fish, reptiles, mammals.

MEDICINE: Thorough coverage of anatomy, circulatory system, nervous system, muscular system, skeletal system, excretory systems, etc. Vitamins, hormones. Bacteriology. Diseases—symptoms, diagnosis, treatment. Drugs. Latest researches and findings.

MECHANICAL ENGINEERING: Principles of mechanics, machine design, engineering parts and instruments. Types and functions of bolts, cams, gears, and other fundamentals up to automobiles, aeroplanes, locomotives, etc. Steam, gas, gasoline, diesel engines.

CIVIL ENGINEERING: Surveying. Bridges, highways, railways—every subject thoroughly explained.

ELECTRICAL ENGINEERING: Motors, generators, lighting, radio and television—every branch fully covered and clearly illustrated.

The foregoing is only a partial list of the countless special subjects covered. You will find hundreds of articles on GEOLOGY, BOTANY, NAVIGATION, CHEMICAL ENGINEERING, and, in fact, any special branch of science in which you want information.

EXAMINE A COPY FREE

It is difficult in this limited space to give you a complete adequate idea of the immense amount of material contained in the Scientific Encyclopedia. See this volume for yourself, without expense or obligation. We will send it to you for free examination. D. Van Nostrand Co., Inc., 250 Fourth Ave., New York 3, N. Y.

Prepared by Outstanding Authorities In Each Field of Science

The high technical standing of the editors is your assurance of the authoritativeness and accuracy of every statement. Although the responsibility for each subject was in the hands of a single noted scientist, the authors and publishers have had the co-operation and advice of a large group of well-known authorities.

CONTRIBUTING EDITORS

GEOLOGY
RICHARD M. FIELD, Ph.D. ..... *Princeton University*
ASTRONOMY AND NAVIGATION
WARREN K. GREEN, Ph.D. ..... *Amherst College*
ZOOLOGY
ARTHUR W. LINDSEY, Ph.D. ..... *Denison University*
ENGINEERING AND AERONAUTICS
FREDERICK T. MORSE, M.E., E.E., *University of Virginia*
MEDICINE
R. S. MUELLER, M.D. ..... *Columbia University*
MATHEMATICS
LL YD L. SMAIL, Ph. D. ..... *Lehigh University*
MINERALOGY
EDWARD S. C. SMITH, S.B., A.M. ..... *Union College*
CHEMISTRY
RALPH K. STRONG, Ph.D. .... *Rose Polytechnic Institute*
PHYSICS
LEROY D. WELD, Ph.D. ..... *Coe College*
BOTANY
R. M. WHELDEN, Ph. D.
Massachusetts Institute of Technology

Among the many CONSULTING EDITORS

ROBERT H. BAKER, Ph.D., D.Sc. .. *University of Illinois*
HEMPSTEAD CASTLE, Ph.D. ..... *Yale University*
C. W. CUNNINGHAM, B.S.
College of the City of New York
HERBERT O. ELFTMAN, Ph.D. .... *Columbia University*
ERICH HAUSMAN, E.E., Sc.D.
Polytechnic Inst. of Brooklyn.
ADOLPH KNOPF, Ph.D. ..... *Yale University*
JOHN C. RATHBUN, Ph.D.
College of the City of New York
EDGAR P. SLACK, S.B. *Polytechnic Institute of Brooklyn*
HUGH S. TAYLOR, D.Sc., F.R.S. .. *Princeton University*
JOHN TURKEVICH, Ph.D. ..... *Princeton University*
VOLNEY H. WELLS, Ph.D. ..... *Williams College*

MAIL THIS COUPON

Send No Money Now Unless You Wish To

D. VAN NOSTRAND CO., Inc.
250 Fourth Avenue, New York 3, N. Y.

Send me Van Nostrand's SCIENTIFIC ENCYCLOPEDIA, complete in one volume, 1500 pages, bound in Sturdy Fabrikoid. Within 10 days I will either return it or send you $2.00 as first payment, and $2.00 monthly for four months thereafter. (S. A. 1-44)

Name .....
(Please Print)

Address .....

City and State .....

Reference .....

Address .....

Scientific American

Founded 1845

CONTENTS • JANUARY 1944

Cover Design by LeRoy Barfuss

COVER: One of the multitudinous uses of compressed air (see also page 24) is in the metallizing process, coming into wide use, among others, as a means of corrosion prevention. Our front cover illustration, by Robert Yarnall Richie, shows one application of this process—spraying a coating of pure aluminum onto the cylinders of a Cyclone aircraft engine in a plant of the Wright Aeronautical Corporation. This aluminum coating is highly resistant to salt water corrosion, protects the underlying cylinder.

SCIENTIFIC AMERICAN, January, 1944. Vol. 170, No. 1. Owned and published by Munn & Co., Inc., Orson D. Munn, President; I. Sheldon Tilney, Vice-President; John P. Davis, Secretary-Treasurer; A. P. Peck, Assistant Secretary; all at 24 West 40th Street, New York 18, N. Y. Entered at the New York, New York, Post Office as second class matter June 28, 1879, under the act of March 3, 1879. Additional entry at Orange, Connecticut. Published monthly by Munn & Co., Inc., 24 West 40th Street, New York 18, N. Y.

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

Previews of the Industrial Horizon

By A. P. Peck

PAPER—NOW AND LATER

PAGE margins of this issue of Scientific American will be noted by all, commented upon, probably criticized by many. The underlying reason, of course, is obvious: Paper conservation. Trimming a quarter inch or so from the blank margins saves a tremendous amount of paper over the course of a year, a saving that must be made if publications are to continue operations under the stress of war-caused shortages.

All of which brings us to the condition of the paper industry now and in the future. Despite the wide-spread knowledge that forests cannot be indiscriminately logged indefinitely, many pulp-wood producers have been blithely continuing with little or no thought for the future. Result: There is little forestry reserve in the United States today and the vast timberlands of Canada are facing exhaustion.

Add to this the other uses for wood that have been developed in recent years—in plastics, explosives, construction work, for examples—and it is obvious that unless something is done, and done vigorously and thoroughly, the paper industry is going to face an even greater crisis after the war than it is facing today. Scientific forestry management in all its phases must be applied to all forest reserves instead of to a scattered few as in the past. Only through such means can future pulp supplies be assured, not alone for the production of paper but also for the multitude of uses which chemistry is developing and has developed in the recent past.

AUTOMOBILES TOMORROW

A GLIMPSE of possibilities in the automobile field of the future, afforded by speakers at a recent convention of the Society of Automotive Engineers, shows a desirable trend toward increased economy of operation. Not only is this desirable from the standpoint of running costs but, more important, from the angle of reduced drains on fuel reserves. Better fuels we now have, born of military demands. Such fuels point to possible 30-mile-per-gallon economy with cars of present weights; even better with lighter-weight vehicles. Also, there is going to be a continuation of the race between fuel chemists and engine designers, with the public as the ultimate beneficiary.

CARGO BY AIR

VIEWED from this vantage point, it appears that, while air-cargo mileage in the future will continue to mount with satisfactory rapidity, there is little or no danger that such operations will have serious effects on surface transportation. Rather, indeed, the cargo plane should shortly prove to be a valuable supplement to established means of delivering goods from one point to another. High-speed transportation will develop new business for all, resulting in increased activity not only in the air but on the ground and on the water as well.

Some of the present and future aspects of air cargo work are presented in the article on page 13.

ON THE RADIO WAVES

A REVOLUTION—minor, perhaps, but a revolution nonetheless—is in the making in the radio field. Well known is the fact that military communications methods will later redound to the benefit of all communications. Add to this the fact that the frequency-modulation method of broadcast transmission and reception is on the way up and it may safely be stated that radio entertainment in the future will reap the advantages of technological advance.

Today there are 900 amplitude-modulation transmitters in the United States, but only 53 of the frequency-modulation type. Every day hundreds of radio receivers are going out of service through lack of replacement parts. These represent a market that by the end of the war, will be tremendous. And here is where frequency-modulation will get its chance. It is estimated that by five years after peace arrives there will be only 750 AM stations on the air, but that FM will have climbed to at least 500. And in the interim there will be the revolution in receiver design and sales, based on the advantages and disadvantages of the two systems.

MANAGEMENT CAN LEARN

INDUSTRIAL executives who fail to develop and encourage the ingenuity of their workers are missing a good bet in more ways than one. The War Production Board's drive for stimulating suggestions from employes is bearing fruit in many industries, bringing forth time, material, and labor-saving methods, and building employe morale at the same time.

The man who does the actual work on a specific job often sees things about it which his boss would overlook. When the workman puts forth an acceptable suggestion, management and the war effort benefit; the worker himself likewise should gain through material award but, what is even more important, he receives the psychological lift of personal accomplishment. The management that does not build on the basis of employe co-operation is short-sighted indeed.

ELECTRONICS AND WALL STREET

BEARING out predictions regarding the future of electronics in industry are the facts that a series of lectures on the subject has been delivered in the Governing Room of the New York Stock Exchange and that various financial analyses of probabilities have been made and published by Wall Street houses. When the Street takes this much interest in science, it is sure that the interest is not engendered by any academic aspirations on the part of market men.

TELEVISION RECEIVERS

A BROAD survey of public interest in television, recently completed by RCA, indicates that, when radio-picture receivers are made available, a large portion of the public would be willing to spend as much as $200 for one. On this basis RCA estimates that, granting the construction of adequate transmission facilities, there will be a market five years after the resumption of commercial television, for receivers in this price class at a rate of approximately 2,500,000 units per year.

LET THERE BE LIGHT

RECENT developments in luminous paints of various types, now finding wide military applications, hold promise of extensive civilian use when they become available after the war. These paints, now far superior to any heretofore made, will become markers for stairways, light switches, and so on; even, some say, for modified room lighting.

And then there are methods of illuminating instrument panels in aircraft through the use of "black light." By this means there is no direct light in the cock-pit, hence no glare to render seeing difficult. Here is something for transplantation into the automobile of tomorrow.

50 Years Ago in . . .

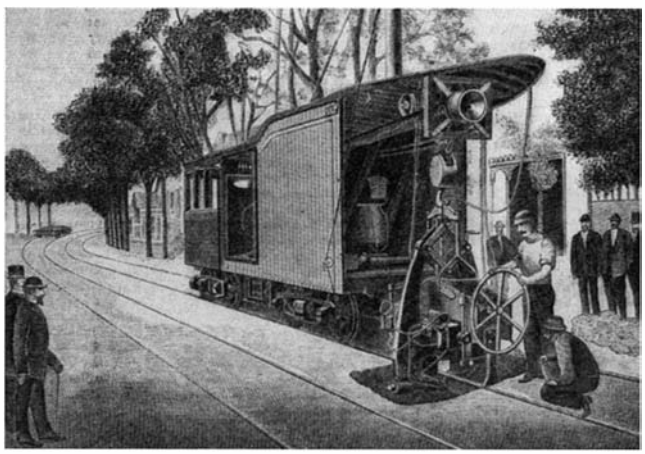
SCIENTIFIC AMERICAN

(Condensed from Issues of January, 1894)

CHEMISTRY — "The young giant, chemistry, has a future before it which involves that of the race of man more intimately and more completely than all the other sciences combined. . . . The great amount of more or less random research yet prevailing proves that chemistry is as yet but an infant, destined to a gigantic growth—a growth in fact illimitable."

DEEPEST MINE — "The United States has now, we believe, the deepest metal mine in the world. . . . The No. 3 shaft of the Tamarack Copper Mining Company, in Michigan, which on December 1st was 3,640 ft. deep, and is now more than 3,700 ft., the average rate of sinking being about 75 ft. a month."

WELDED RAILS — "After conclusive experiments on expansion effects in street-car rails made by the Johnson Company, it was decided to apply welding to a tramway line that had been laid for two years by the West End Street Railway between Boston and Cambridge. The materiel necessary for the operation was ordered from the Thomson Electric



Welding Company. The first experimental welding was done with this materiel upon a foot rail of the Johnson type. . . . The welding took an electric power of 150 kilowatts, furnished by the continuous current actuating the tramway from Lynn to Boston. It was this materiel that was utilized . . . at Cambridge, upon a length of nearly two miles. The illustration gives a general view of the special car devised for the welding of rails in situ. The box of the car contains the materiel necessary for the production of the alternating current and the regulation of it. The front is reserved for the welding apparatus."

IRON STRENGTH — "An official statement of tests made at the Massachusetts arsenal to ascertain the effect of temperature on the strength of iron has been published. . . . The results present the interesting fact that the specimens in question were all stronger in the neighborhood of zero than they were at ordinary temperatures—all of them, in fact, showing a minimum of strength at 210 deg. or thereabout, and a maximum of strength at about 550 deg."

TUNNEL ELEVATORS — "Between Finnieston and Govan, two tunnels have been laid under the Clyde, side by side, one for vehicular traffic going north and the other for that going south. Above these two, and over the point of junction, there is a third tunnel for foot passengers. At either end of these tunnels, and close to the riverside, vertical shafts have been constructed, each 80 feet in diameter. In each of these shafts there are to be six powerful lifts, designed to lower and lift the largest vans, lorries, etc., with their horses, just as they are. On being lowered to the bottom, they will go, as on a road, through the tunnels, and be raised at the opposite end."

PEANUTS — "Dr. P. Furbringer treats of the peanut as an article of food rich in albumen, of which it contains forty-seven per cent, together with nineteen per cent of fat and non-nitrogenous extractive matters. He recommends the use of roasted peanuts in the form of soup or mush."

ENGINES — "It was but a few years ago that the gas engine was but little better than a toy; noisy and expensive in its operation and with but little promise of ever becoming a rival of the steam engine. Now, however, their action (in the best makes) is smooth and regular and their economy compares favorably with that of the steam engine."

SCULPTURING — "We have recently had an opportunity of examining a new application of electricity that is worthy of being made known. It is a question of a sculpturing machine actuated electrically. This machine is evidently not designed to replace the hand of artists, but is valuable for making copies, and is capable, in a short time, of making rough-hewn statues, upon which the talent of the professional sculptor can afterward exercise itself usefully."

STREET CAR — "A tramway company near London is trying a new car on a portion of its route. The car is known as the Luhrig gas car, and is a German invention, propelled, as its name implies, by means of gas. It is self-contained and has a running capacity for about 15 miles. Refilling can take place in about 70 seconds through an ordinary India rubber delivery hose fastened on to a nozzle in the body of the car."

CORROSION-PROOFING — "Mr. W. Thomson recently read a paper before the Manchester Association of Engineers, on 'The Influence of Some Chemical Agents in Producing Injury to Iron and Steel,' in which reference was made to the effects of different paints and varnishes used for the preservation of structural iron and steel from rust. From experiments made by himself, Mr. Thomson has arrived at the conclusion that red lead paint is the best preservative."

ALLOYS — "The alchemists of the Middle Ages were incessantly occupied with the endeavors to transmute metals. Many alloys were known to them which are lost to us, and their recipes contain many useful hints, worthy of the attention of modern scientists."

PRE-MOVIES — "One of the uses of the optical lantern is to perpetuate beautiful forms and scenes, thus cultivating the taste and increasing the knowledge of multitudes who could never have seen the objects themselves."

TANKERS — "Almost all the molasses which comes from Cuba to the United States is brought in the same tanks in steamships that are used to carry petroleum as a return cargo. . . . It might be supposed that the petroleum would have a bad effect on the molasses, but it has been shown that the contrary is the case, and as nearly one-half the importation is made into rum and the balance refined into sugar, a little oil is not of much account."

WATER-PROOFING — "What was at first considered a doubtful experiment, viz., the use of coal tar as a means of rendering masonry impervious to water, especially in positions exposed to direct contact with the latter, has proved a practically valuable resort."

ICE — "The Massachusetts State Board of Health concludes, from investigations of artificial ice, that artificial processes of freezing concentrate the impurities of the water in the inner core or the portion last frozen, that the impurities are least if distilled water is used, that the number of bacteria in artificial ice is insignificant, under the prevailing methods of manufacture, and that the amount of zinc found in ice is insufficient to cause injury from its use."

THE SEARCH THAT NEVER ENDS

IN THE industrial life of America, research has been of constantly increasing importance. And today it is a national resource, for the research of industrial and college laboratories is proving its value in War.

To the Bell System, research is an old idea, for the telephone itself was born in a laboratory. Behind its invention, sixty-nine years ago, were researches in electricity and acoustics and in speech and hearing.

And, ever since, there has been a laboratory where scientists have searched to know more about these subjects; and with their associated engineers have applied the new knowledge, fitting it with all the old, to make the telephone better and better.

Their fields of inquiry have broadened and deepened through these years; they inquire into all the sciences and engineering arts which have any promise of improving the telephone. Much has been learned but still more will be, because their search goes on. That is why the telephone laboratory grew to be Bell Telephone Laboratories, Incorporated, the largest industrial laboratory in the world. And it exists to improve telephone service.

Improvements in industry can be left to chance in the hope that some one, sometime, will think of something useful; that some good invention will turn up.

The other way to make improvements is to organize so that new knowledge shall always be coming from researches in the fundamental sciences and engineering arts on which the business is based. From that steady stream will arise inventions and new methods, new materials and improved products.

This is the way of Bell Laboratories. Its search will never end. And as fast as it can the Laboratories will apply its new knowledge practically to the design of equipment and communication systems.

At present—and this started before Pearl Harbor—its trained scientists and engineers and all their skilled associates are concentrating on products of importance to our armed forces. But when this work is happily over they will be ready to continue their developments for the needs of peace.

BELL TELEPHONE SYSTEM

"Research is an effort of the mind to comprehend relationships no one has previously known; and it is practical as well as theoretical." . . . . . BELL TELEPHONE LABORATORIES

"Quotes . . ."

"YOUR FILE of post-war ideas can be alive . . . don't just file 'em and forget them . . . look at them regularly and think about them lots, until they begin to crystallize into definite possibilities." W. B. Spooner, Jr., Spooner and Kriegel.

" " "

"NOT ONLY must the business man have incentives to utilize what equipment he has, but in our type of society there must be a constant expansion in employment facilities if we are to have prosperity." *Dr. Emerson P. Schmidt.*

" " "

"THIS COUNTRY cannot tolerate any government philosophy which, under the guise of controlling prices to prevent inflation, seeks to intrench anti-business forces, set up a system of federally-imposed grade labeling, and impair or destroy the values of trade marks and brand names." Representative Charles A. Halleck.

" " "

"CALIFORNIA has more cork oaks than any other state. About 4000 cork trees have been located in California. Los Angeles County has more than 1000 trees. The cork oaks in California are growing in parks, along the highways, about public buildings, and on private estates. During the past four years more than 100,000 cork seedlings have been planted in the state." *Dr. Giles B. Cooke, Research Department, Crown Cork and Seal Company.*

" " "

"THE SHORTER distance travel market—the really mass travel market—has hardly been touched by air transport. It represents perhaps the largest chunk of travel business potentially available to our domestic airlines." Charles I. Stanton, Administrator of the Civil Aeronautics Administration.

" " "

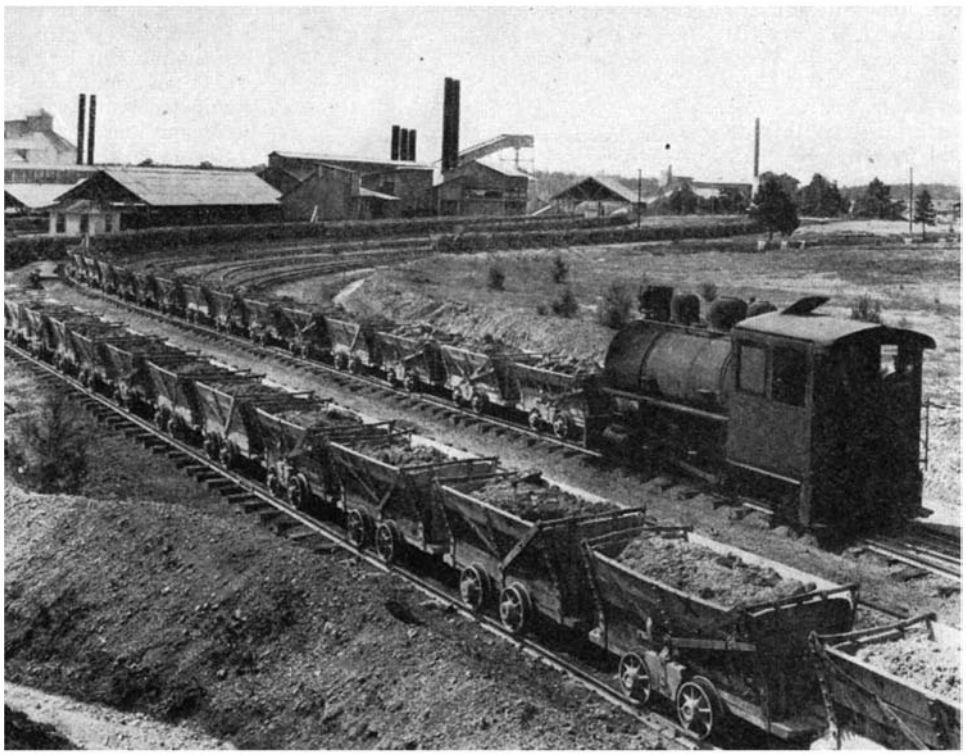
"FOLLOWING the war our agricultural research must be sufficiently broad and inclusive to insure our own security and comforts beyond anything we have yet known, and to provide the much needed co-operation in a world-wide program of research designed to establish a more universal security and, we hope, a more permanent peace." *Dr. W. H. Tisdale, Director, Du Pont Pest Control Research Laboratory.*

" " "

"THE ANNUAL need rate (for housing) has been at the high level of approximately 900,000 homes for the 1931-1941 period, while only an average of 350,000 housing units were built per year during the same period. A need backlog in excess of five million housing units has, therefore, accumulated. If spread over a 10-year post-war period, it would place the annual total housing need potential at 1,400,000 homes." Irving W. Clark, Westinghouse Electric and Manufacturing Company.

CHEMISTRY IN INDUSTRY

Conducted by D. H. KILLEFFER



Bauxite goes to one of the mills of the Aluminum Company of America

As Metal Resources Dwindle

The Point of Scraping the Bottom of Some of the Mineral Barrels is Rapidly Approaching. Rich Iron and Aluminum Ores are Nearing Exhaustion, but the Chemical Industry is Doing Things about the Development of Methods of Working Wide-Spread Low-Grade Ores

AMERICANS are faced with a new and strange emergency. Certain of the richest mineral resources of the nation are in alarming danger of exhaustion. Conservationists have from time to time urged care in using this or that raw material lest present-day extravagance impoverish future generations. Yet the enormous rate of depletion of natural deposits of economic minerals to meet the necessities of global war brings impoverishment of some of them so close that the present generation must do something about it for its own protection.

Post-war planners—and who is not one now?—find themselves face to face with a new problem of supplies which already is alarming in its implications. Capacity to produce has soared and so, of course, has the consumption of raw materials. Shortages developed in war production have been laid to bottlenecks of manpower, of processing plants, of transportation: the state of inventories of minerals could not be considered under pressure of war. However, planning for the future must be based on availability of supplies and it now becomes clear that the point of scraping the bottom of some of the mineral barrels is rapidly approaching. Furthermore, evidence accumulates that the problem of the future can be solved only through a broadening of our mineral base which involves amplification of available metallic ores through development of methods for economical working of those ore bodies now considered too poor.

The solution obviously lies in the field of chemistry and chemical industry, for the processes employed are fundamentally chemical. That ores of low concentration can be utilized is amply attested by past accomplishments of chemical industry in recovering traces of needed elements. Outstanding is the working of sea water for its 0.0064 percent of bromine and its 0.13 percent of magnesium. Both of these are produced now in competition with richer sources. While the methods employed on ores will differ radically from these, the basic chemical technology and ingenuity required for developing needed new techniques are amply available to meet the new emergencies now imminent.

Present-day magnified aluminum production threatens exhaustion of high-grade bauxite ores within three or four years. Heavy drains on our richest and most cheaply available iron ore deposits in the Mesabi Range in Minnesota are sapping its life. Present estimates place the life of our invaluable petroleum reserves at 12 years. Tin ores in the United States are negligible and lead and zinc have never been abundant. Our richest copper ores are dwindling in the face of our enormous use of this metal for war purposes.

It is obvious that our traditional careless attitude toward mineral resources

cannot continue. New direction must be given post-war planning, lest what is now alarming become grave in the extreme. Indeed, any valid plan for tomorrow must of necessity be based on the fundamental availability of minerals and not on any naive faith in the complete adequacy of our resources.

Frederick W. Willard has recently emphasized the essential, but universally neglected, fact that of the 92 known chemical elements only eight combine to form more than 98 percent of the composition of the earth. The remaining 84 constitute less than 2 percent of the total. Among the eight plentiful elements only three—aluminum, iron, and magnesium—are metals that lend themselves to structural uses by any technology which has so far been achieved. Moreover, these eight elements, including the three structural metals, are so plentifully distributed throughout the world that every considerable area possesses them in some semblance of abundance.

THINKING out the problem of the future on such a basis yields a plan of far-reaching consequences for the peaceful development of the world, yet one which requires the solution of vital problems of science and technology.

In the light of the basic fact of plentiful distribution of essential elements over the face of the earth, the statements with which this article started may appear to be ridiculous. Yet the growing scarcity of high-grade ores of both aluminum and iron cannot be gainsaid; only the significance of this scarcity changes against the factual background. Search for new deposits of high-grade ores is naturally the first necessity, but far more important is the development of a new technology to win both metals from ores now outside the economically workable range of present methods.

High-grade bauxite is definitely limited in geographical distribution within our own country and elsewhere and also in the fraction which it constitutes of the world's aluminum supply. Present technology is based on refining this important metal from such high-grade ore, a hydrated aluminum oxide. This procedure is satisfactory so long as rich ores can be had in sufficient abundance. However, bauxite occurs in pockets of limited extent and forms only a tiny fraction of the total potential aluminum in the world. Thus the end of commercially economical deposits of this ore is swiftly approaching. Yet aluminum is definitely the most plentiful metal in the world—at least half again as plentiful as the next one, iron—being found also in clays of which abundant supplies are universally distributed. The aluminum content of clays, which may be as high as 25 percent, is combined as a silicate, however, and is difficult to separate from impurities and to recover.

Technology is already grappling with the problem of winning the metal from these sources now largely neglected. Ultimate success in utilizing clays is still in the future, largely, be it noted, for economic reasons. Several methods have been devised for this purpose but none can yet compete with bauxite in cost, except as a war measure.

The situation of iron is similar to that of aluminum, with the important difference that abundant low-grade iron ores have a character similar to the best, distinguished only by diminished iron content. With aluminum, bauxite differs sharply from clay in chemical constitution; iron ores, on the other hand, are mixed oxides and hydrates whose cost of smelting merely rises as the iron content diminishes. Some relatively low grades are now being worked. The extremely low present cost of iron may thus be expected gradually to rise as lower and lower grade ores must be worked. Indeed, one of the principal advantages of the great Mesabi Range ore deposit lies in the low cost of open pit mining as contrasted to much higher costs that will be met when a larger share of our iron production must come from underground workings.

CHEMICAL ELEMENTS OF THE EARTH

Oxygen	46.46%
Silicon	27.61
Aluminum	8.07
Iron	5.06
Calcium	3.64
Sodium	2.75
Potassium	2.58
Magnesium	2.07
84 other elements	1.76
	100.00%

Magnesium is in quite a different category. Although originally produced from natural brines of more or less definitely limited extent, the metal is now being recovered from sea water (containing almost incalculably huge quantities of the metal but in great dilution) and from apparently inexhaustibly huge deposits of dolomite rock which is one of the major constituents of the Appalachian Mountains. Perfection of present methods of recovery and their wider application appear to be all that is necessary to insure a perpetual supply of magnesium beyond any present expectations for its use.

OBVIOUSLY, then, our post-war planning must include provision for the immediate improvement of our methods of producing iron and aluminum from more abundant sources; it must also include due consideration of the fact that only aluminum, iron, and magnesium are available for use in inexhaustible abundance for the long-time future.

The development of methods of recovering metals from low-grade ores is already well advanced. It is no new thing. Steel companies for decades have realized that top-grade ores would some day give out, and have continuously directed their research toward meeting this problem. Also, it is worth while to note, iron ores are often chosen for exploitation for so simple a reason as the location of the deposit with respect to transportation facilities or even with respect to the surface of the ground itself because of the low price at which iron and steel must be sold.

Among the less plentiful metals, copper ore of first grade is becoming rapidly scarce. It is even likely that our post-war use of this metal may have to be seriously restricted to prevent a prompt rise of the base price of the metal to offset both its increasing scarcity and the higher cost of its recovery from more refractory or less concentrated ores. Zinc and lead seem still to be reasonably plentiful but our use of them must necessarily shrink in the long-time future.

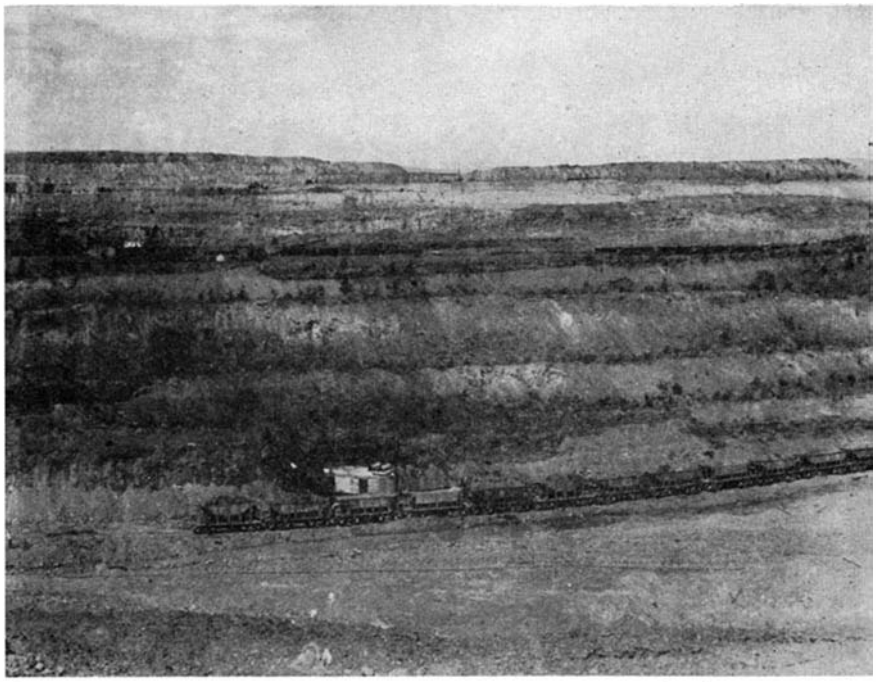
The case of tin has already advanced to a point where it shows something of what may be expected regarding other metals in the minor class. When supplies of this metal from the Far East were summarily stopped by the Japanese conquest of Malaya, restriction of its use followed immediately. Tin had been vital in several ways: tinplate, especially for cans; tin solders; tin for bearing metal and numerous other alloys including bronze, type metal, and others similarly useful; tin foils; and

Dow Chemical Company extracts magnesium from brine at this Michigan plant

collapsible tin tubes for paste products. Present developments include an electroplating method of applying tin continuously to steel strip at a saving of at least 50 percent of the tin required to afford protection; new solders containing much reduced quantities of tin or none at all, made with lead and silver; tin foils, even metal foils, seem definitely doomed by the efficiency of new synthetic and semi-synthetic sheeting materials; bearings plated with silver are proving extraordinarily efficient in high-speed applications and seem likely to prove permanently valuable. Meanwhile, a single smelter operating on Bolivian ore in Texas supplies the United States' requirements of tin, now only a small fraction of its previous amount.

The relationship of iron and steel to aluminum and magnesium in commercial application must be kept clearly in mind in this discussion. Present production of both light metals is less than 2 percent of current output of iron and steel. Obviously, then, many of the prospective uses for the light metals require development, probably over a long time, before their full potentialities are realized. Their complete future usefulness will not arrive suddenly with the coming of peace, as some appear to believe. Rather, in future decades they will occupy positions of constantly increasing importance in our economy.

Finally, the future role of plastics in relation to metals must be clearly understood. Despite their current high value in replacing metals for many purposes, plastics by their very nature are excluded from the great structural applications of metals. Even now emergency shortages push plastics only into minor items customarily made of metal. This, naturally, is in no wise intended to disparage these valuable synthetics, but rather to save them from their friends whose enthusiasm would apply them where they would surely fail.



In the Mesabi Range, dwindling source of richest iron ore

SPEEDING PENICILLIN

Accomplished by High-Vacuum Dehydrator

A NEW high-vacuum diffusion process adapted to the drying of penicillin is believed to solve an important problem in processing the active germ-killing principle extracted from mold.

The 20- to 24-hour cycle now considered necessary for the last stage in processing penicillin can be reduced through this high-vacuum diffusion method to six hours, and the cost of dehydration cut to one-sixth of that of conventional methods.

A single installation of this novel dehydrator can handle ten billion units of this life-saving drug a week, far surpassing the output by methods now in use. Such an installation would make available 1300 doses of penicillin a day.

Penicillin is unstable in solution and hence dehydration is necessary to preserve it. Heat would injure the product and consequently dehydration must be done at low temperature in a vacuum. Heretofore, steam ejectors, mechanical pumps, and a freezing method utilizing a cold trap have been used on a limited scale in vacuum dehydration.

Penicillin is in a frozen state when it is dehydrated, the moisture being removed in vapor form without melting. Because of the enormous expansion of gases under the high vacuum employed, a pumping system of tremendous capacity is required to handle the great volume of water vapor formed. Some idea of this volume can be gained from the fact that an ice cube weighing one ounce represents at ordinary atmospheric pressure a little over a cubic foot of water vapor. At the low pressure involved in the new process, this ice cube expands into more than 25,000 cubic feet of vapor.

Freezing methods of vacuum dehydration have heretofore been handicapped by the building up of heavy ice layers in compartments designed to collect the vapor as evolved. Difficulties have also been experienced in attaining extremely low pressures. In the vacuum diffusion process, developed by the National Research Corporation, residual air pressures are reduced to less than one ten-thousandth of an atmosphere by special high vacuum pumps of tremendous capacity. The water vapor is continuously removed from the pumping system by means of a rotary condenser at very low temperatures.

In drying penicillin, as well as blood plasma and certain drugs, it is imperative that all moisture be removed. Extracting the last 2 percent of water vapor ordinarily has taken as much time and is more difficult than driving off all the rest of the original content. Since even minute amounts of moisture are harmful, proper drying and packaging are highly important parts of the process and have proved both costly and troublesome. Packaging in permanent containers is also done under high vacuum, to insure that no harmful moisture will be picked up.

GLASS OVERCOATS

Insulate Storage Batteries for Winter Use

GLASS overcoats are keeping storage batteries in working order in Army motorized equipment operating on the Alaska Highway and in the Aleutians. To prevent battery solutions from freezing when the temperature falls as low as 40 degrees below zero, Mid-West Fiberglas Fabricators is insulating the steel-box battery holders with half-inch thick boards of bonded glass fibers.

The glass fiber board, manufactured by Owens-Corning Fiberglas Corporation, has high insulating qualities, while resiliency of the glass fibers provides shock absorption and offsets any tendency to fragmentation or settlement under vibration.

POST-WAR SYNTHETICS

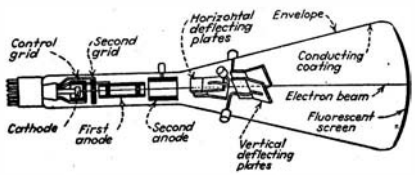
Will Invade Many New Fields

ONE OF the useful synthetic resins having rubber-like properties, Koroseal is expected to have important post-war applications in insect screens that can be rolled up like a curtain; water pipe that cannot be damaged by freezing since it is elastic; coated wall paper that can be washed when dirty; woven seats for garden furniture that resist weather indefinitely; and garden hose of lighter weight and longer life than customary rubber hose. These applications, announced by L. H. Chenowith of the B. F. Goodrich Company, suggest the extraordinary versatility characteristics of the synthetics now replacing rubber in many of its uses.

Seeing is Believing

The Cathode-Ray Tube Comes Out of the Laboratory and Goes Into the Factory. Electrons were First Discovered and Their Characteristics Measured in the Cathode-Ray Tube; Now This Member of the Electron-Tube Family Performs a Large Number of Useful Industrial Jobs

STOCK demonstration apparatus used in all physics laboratories of a generation ago consisted of certain elongated glass tubes with metal electrodes in the ends, across which a high voltage was placed. Beautiful patterns called "glow discharges" were to be seen in these tubes, known as Geissler or Hittorf tubes. Out of these devices came our first knowledge of the electron and its properties; then came the Braun tube which developed into the modern cathode-ray tube which is the heart of television and other related apparatus widely used in the war.

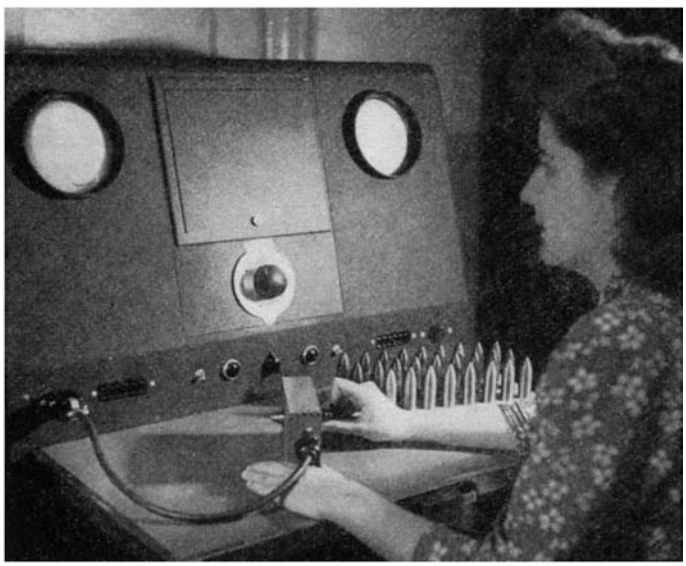


From "Engineering Electronics," by Fink, McGraw-Hill

Parts of a cathode-ray tube of the type in which the electron beam is controlled by deflecting plates

The cathode-ray tube, long used only as a laboratory measuring instrument, now finds wide application in the production line for sorting machine-gun bullets, aircraft bolts, roller bearings, forgings, and other metal parts. Other non-laboratory applications are increasing rapidly to add luster to the already bright picture of electronics at work in industry.

Just what, now, is a cathode-ray tube? How does it work? What makes it useful to industrial processes? Answers to these questions require a glance at fundamentals.



Testing hardness of steel in armor-piercing shells by inserting individual shells into a pick-up coil connected to the Cyclograph. Patterns appear on the cathode-ray tube screens

Consider a glass tube about a foot long and an inch in diameter. Metal disks are sealed into the ends and a vacuum pump is attached to an elongated glass stem. A comparatively high voltage is connected to the two electrodes. When the air is pumped from the tube, things begin to happen. As the internal pressure is reduced to about 500 to 1000 millionths of atmospheric pressure, current flows through the tube and each electrode is covered with a visible glow. At one half this pressure the glows extend out into the region between the electrodes but separated by a dark space. At still lower pressure the glows break up into striae or thin bands of light and the walls of the tube fluoresce. At 10 to 100 millionths atmosphere the glows disappear but the glass is bright and beautiful with fluorescence.

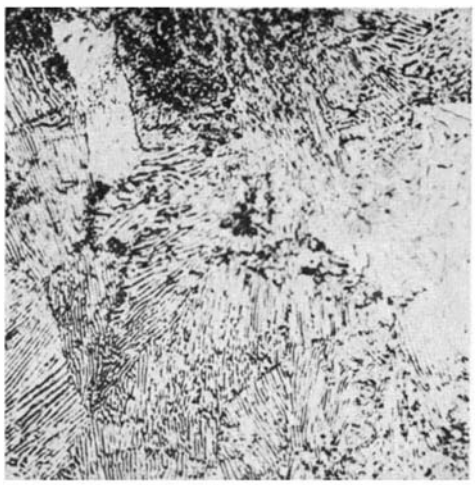
These phenomena naturally excited the interest and attention of many early scientists, who speculated among themselves as to what was going on inside the tube. Plücker is credited with the original discovery of the fluorescence of the glass walls in 1859. Hittorf observed that the "rays" traveled in straight lines from the negative electrode and at right angles to this electrode. By 1897, the date of J. J. Thomson's elegant research on the phenomena, it had been demonstrated that the rays could be deflected by electrostatic and magnetic fields; that an obstacle placed between the cathode and the glass wall casts a shadow on the wall.

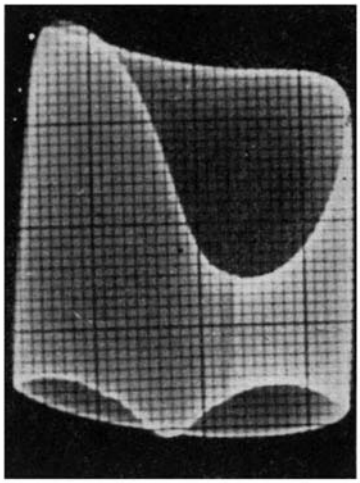
Some physicists thought the rays were ether vibrations, like light, but in 1885 Perrin showed that, whatever the rays were, they had a negative charge. Finally, in 1897, J. J. Thomson demonstrated that the rays were particles which had a definite mass 1/1840 as heavy as the hydrogen atom and that they carried an electric charge equal to that transported by the hydrogen ion in liquid electrolysis.

The particles, of course, were electrons, but the phenomenon still bears the name of cathode "rays" originally applied to it. The cathode part of the name arises from the fact that the electrons proceed from the electrode which is maintained at negative potential by the external current source; the negative terminal of electrical apparatus of that day and this is known as the cathode.

Thus the facts of life of the electron became known through the cathode-ray tube. Roentgen, experimenting with a tube of this type in 1895, discovered X-rays; soon Becquerel and the Curies discovered the natural phenomenon for which they are famous (radium) and the scientific world was off on another vast chase into totally new and exceedingly interesting facts. Up to that moment scientists were pretty well satisfied; 'most everything had been explained; and yet the ultimate nature of matter was one of the mysteries. Out of the Geissler and cathode-ray tube came our vast knowledge about the building blocks of the universe.

The present-day cathode-ray tube differs only in refinements from the tubes with which J. J. Thomson worked. A source of electrons, which is merely a heated cathode like that in ordinary radio tubes, is at one end of an elongated glass envelope. Along the narrow neck of the tube are placed electrodes in the form of small metallic plates. At the far end—which is flared out so it has a diameter as great as 20 inches—is a screen coated with fluorescent materials. When the electron leaves the cathode it is attracted toward the far end by a positive voltage; when it hits the screen its kinetic energy is given up to form a momentary flash of light.





At left is a photomicrograph of the base metal of a shell which proved brittle on fracture test. At right is an electronic analysis of the same metal. Upper and lower curved sections change to indicate hardness of metals

If voltages are placed upon the deflecting plates in the neck of the tube, the place where the electrons hit the screen can be changed and if variable voltages are placed upon these plates, a definite pattern of light flashes will be traced on the screen. For example, if the voltage on the plates varies from zero to some positive and negative values, the electrons hit the screen in a straight line and if similar voltages are placed on another set of deflecting plates at right angles to the first two, and if the proper phase relationships are maintained, a circle of light appears on the screen. Of course, the intensity of the spot on the screen can be adjusted by varying the accelerating voltage. The size of the spot can also be changed at the will of the user.

In television, the streams of electrons from the heated cathode are deflected back and forth in straight lines in synchronism with a similar scanning of the picture at the transmitting end of the system. After one line is produced, another similar line just below the first is formed. This goes on until the entire screen is filled with horizontal lines which can be exceedingly close together. If the intensity of the beam is changed at any point in the cycle through which the electrons pass in going from left to right, the fluorescence at the screen shows this variation in intensity. Thus a complete picture may be traced out on the fluorescent screen. Since the electron is so low in mass, it can be deflected with great ease and rapidity so that the entire picture may be set up in a fraction of a second. Due to the persistence of vision, the eye sees the effect as a continuously moving picture.

In the laboratory, the cathode-ray tube has many uses. The amount which the beam of electrons is deflected from its normal position in the center of the screen depends upon the voltages placed upon the deflecting electrodes. Thus the amount of deflection is a measure of voltage and can be so employed. Since the electrons may also be deflected by a magnetic field, it is not difficult to see that a varying current of electricity passing through a coil of wire adjacent to the neck of the tube will produce variations in the place where the electrons hit the screen and produce their fluorescence. In this way the tube can be used as a measuring device of current amplitude.

Again it is worth noting that the electrons can be deflected in a millionth of a second or less, so that the characteristics of currents of extremely high frequencies can be studied. By placing a photographic film at the screen end, or by focussing a camera on the screen, a visible record of electrical phenomena occurring but once in a fraction of a second may be made. If the occurence can be repeated so that a steady pattern is produced, happenings at a rate of millions of times per second can be seen and recorded.

Now how can such an instrument be used for production testing?

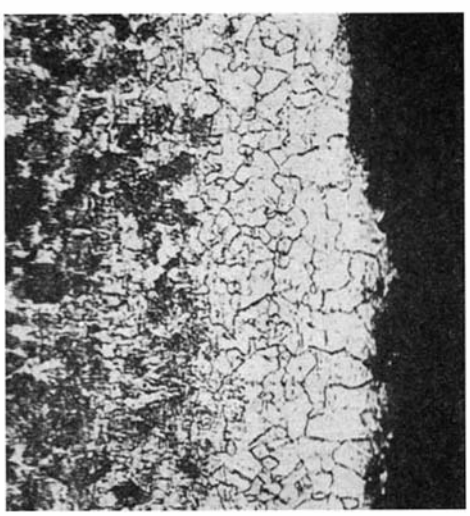
IF A PIECE of steel of certain desired characteristics is inserted in the deflecting coil of the tube, a pattern will be produced on the screen which may take, for the sake of simplified illustration, the form of a straight line exactly an inch long. Pencil marks may be made on the screen to serve as a guide. If now another piece of steel is substituted for the standard, and it has somewhat different characteristics, it will produce a straight line longer or shorter than one inch. If the pattern indicates that it is outside the predetermined limits, the piece under test is discarded.

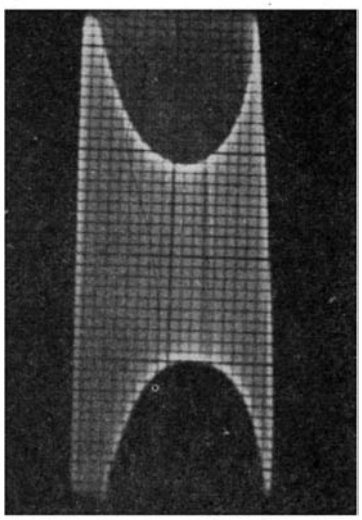
An operator can make such tests very rapidly; in fact, much more rapidly than in most other ways. Since steel has electrical characteristics which change with variations in permeability (nickel content), in hardness, in density, in temperature, size or weight, all of these characteristics may be used as test factors. Thus it may be desired to make bullets which are to have a certain weight so that they can be fired a certain distance up in the air. If they are too heavy, they will not go so high; if too light, they won't have the desired punch when they hit an enemy plane. Such variations in weight will produce variations in an electric current in the coil into which the bullets are inserted, and the operator sees the result as a change in the desired screen pattern.

A cathode-ray instrument of this sort will detect changes in weight as small as 1/200 of an ounce. Also, since the permeability of steel is a function of the alloys in it and the heat treatment through which it has gone, the alloy content and the hardness can be easily and visually tested in the same manner.

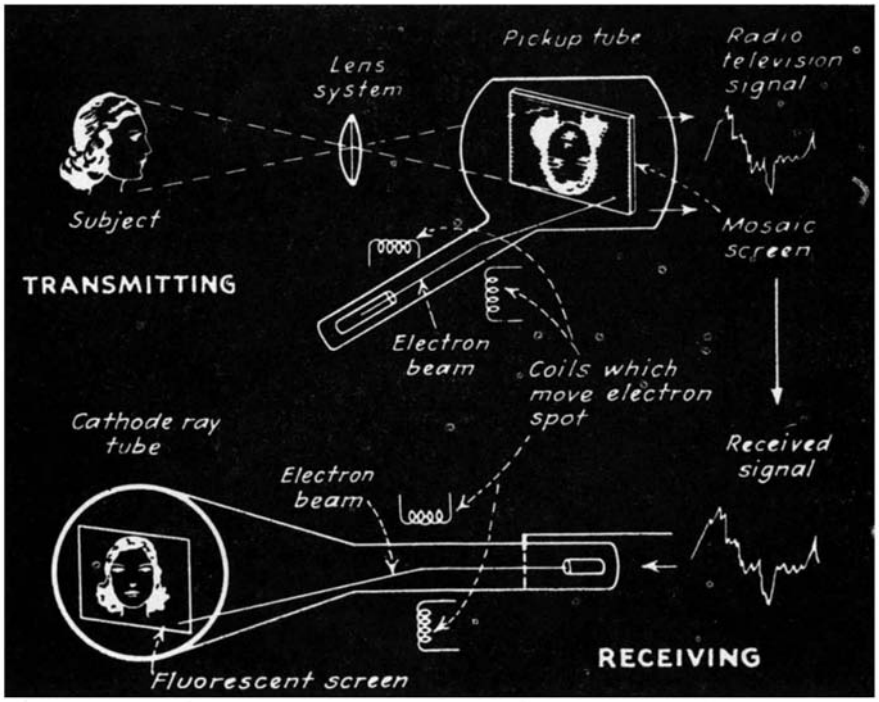
Working on this general principle, a testing instrument known as the Cyclograph has recently been developed by the Allen B. Dumont Laboratories.

The Cyclograph is a cathode-ray instrument designed to perform both qualitative and quantitative metallurgical tests on both ferrous and non-ferrous metals, and adapted to facilitate the checking, evaluating, and sorting of these materials according to their metallurgical properties. This instrument has been developed to provide a non-destructive means of determining differences or variations in the metallurgical properties of metal parts or stock. Some of these properties which have been investigated successfully include measurement of case depth, core hardness, plating thickness, carbon content, brittleness, and variations in the





At left is a photomicrograph of hardened steel, showing a case depth of about 0.020 of an inch. At right is a Cyclogram of the same metal. Each division on the screen is related to case depth and in this example the waist thickness (distance between curves of the ray pattern) indicates 0.020



Simplified set-up of a cathode-ray television transmitting and receiving system, using electron tubes in which the beams are deflected by magnetic means

results of various types of treatment.

The Cyclograph utilizes the principle that the metallurgical properties noted above cause variations in the core loss of a pick-up coil which surrounds the piece under test. These variations affect the shape of an easily interpreted visible pattern or oscillogram displayed on the cathode-ray tube indicator screen. By means of these pattern variations, a semi-skilled operator can easily determine differences in metallurgical properties of a number of ostensibly similar parts

In addition to checking and evaluating metallurgical samples, the Cyclograph can also be adapted to automatic sorting. This automatic sorting feature is invaluable where large quantities of samples are involved, as in actual production and production-test routine. Such automatic sorting is done accurately at relatively high speed—as high as five pieces per second.

Some representative practical examples, typical of the various kinds of sorting which have been done with the instrument, are:

1. Several million aircraft bolts were successfully separated into three groups with analyses of SAE 1020, SAE 4130, and SAE 1065.

2. Three hundred tons of 1 21/32-inch billets were sorted into the two analyses present, in eight hours. The Cyclograph was taken to the mixed billets. One end of each billet was lifted in a sling and the coils slipped over the end to test the billet

3. Eight thousand cylinder-head bolts were sorted in one day into the two analyses present. The analyses were SAE 1035 and SAE 1335.

4. Several thousand machine-gun bullets were successfully sorted. The only difference in analyses was that one group contained no nickel while the other contained 1.5 percent nickel.

5. Ten thousand small bolts were automatically sorted in a few hours. The bolts were of the same analysis, but some had been quenched and drawn, while the rest had only been quenched.

6. A large number of roller bearings were sorted according to case depth. Those which had too thin a case were separated from the others and rejected.

While the functions of weight checking and metallurgical testing have been dwelt upon here at length as being the latest achievements of the cathode-ray tube in industrial production applications, there are many other practical uses of this versatile instrument. These include testing electrical response of transformers, resistors, or other components, magnetic characteristics of laminated materials, insulation between turns in motor armatures, conductivity of chemical baths, and so on.

In fact, any variable, whether it is electrical, chemical, or physical, which can be translated into an electrical change, can be made to produce on the cathode-ray tube screen visible patterns which are easy to see, relatively untiring to look at, and which accurately portray the change being studied—all without damaging in any way the material under measurement.

⊕ ⊕ ⊕

X-RAYS IN NEW USES

Ability to "See Through" Opaque Objects Used by Food Packers

USES OF industrial X-rays are, by now, an old subject. Nearly everyone knows that X-ray technique enables an industrial engineer to look into a heavy casting and see whether there are flaws in it. But still the ability to see the inside structure of opaque objects by means of X-rays is finding many more uses.

For example, food is now automatically packed in all manner of containers. Manufacturers and packers are continually liable to heavy damage suits if in such a container there is a drop of solder or a piece of machinery which may have dropped off the packing or cutting apparatus. This is a constant worry and it is much greater at the present moment when so many thousands of cans of food are going to the armed services.

By a simple X-ray apparatus equipped with a fluoroscope, it is now possible to look into the inside of every can or jar or carton and to reject those which contain unwanted material—even if only pieces of bones.

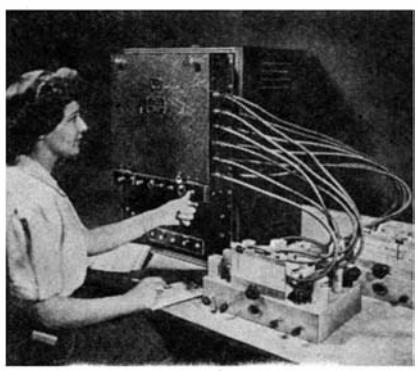
The post-war market for X-ray apparatus will be materially increased by just such simple, yet extremely effective uses as this.

HIGH-SPEED CIRCUIT TESTER

Checks 120 Circuits In 4 Minutes

A RECENTLY developed automatic mass-production tester employs electronic tubes in a measuring circuit served by an ingenious motor-driven selector switch to permit checking of circuits in electronic, communication, and electrical equipment at the rate of one circuit per second.

The instrument, made by Communication Measurements Laboratory, reveals errors in resistance and reactance



Using automatic circuit tester

as well as in circuit wiring. Once this almost robot-like instrument has been set up for checking a particular piece of equipment, its operation simply involves making connections between the tester and selected points in the equipment under test, then pressing a button and watching the indicator light. When an error is detected by the instrument, it stops so that the operator can record the number assigned to that particular test and thereby locate the fault. Pressing a button starts the machine again for completion of the sequence of tests.

A recent application involves checking of multi-wire cable harnesses for aircraft, tank, and switchboard wiring. Up to 120 circuits, including several hundred separate wires, may be tested at one time in about four minutes.

Air Transportation—A Review and Forecast

Views of Men Outstanding in the Aviation Industry Serve to Present a Picture of What is Being Done Today and of the Effects of these Efforts On the Post-War Transportation World. Air Cargo, Safety, Gliders, Local Air Service, Airports and Airways, All are a Part of the Whole

At a recent Air Transport meeting, held by The Institute of the Aeronautical Sciences and attended by officers of the Air Transport Command as well as representatives of the airlines and of airplane manufacturers, the papers delivered by outstanding men in the industry covered the whole field of American air transport. Aviation people are giving their strength to winning the war; yet, in the light of recent events, it is impossible not to give some thought to the future, and this meeting may well serve as a guidepost for post-war air transport.

The Air Transport Command has probably had more experience with air cargo than any other organization in the world. Hence the paper presented by Colonel Harold R. Harris, Assistant Chief of Staff, A.T.C., entitled "Some Problems Encountered by Air Transport Command in Handling and Movements of Air Cargo," was received with intense interest.

In December 1941, the Army Air Forces found itself saddled with an enormous air-transportation problem, world-wide in scope. Almost the only service-tested transport plane then available was the DC-3, widely used by the airlines and in which many of our readers have no doubt flown. Rapid conversion of these ships to cargo carrying was undertaken and accomplished by the simple expedient of stripping out passenger fixtures, installing cargo equipment and strengthening the cabin floors. To this day, the Douglas DC type aircraft is a most important part of the Air Transport Command fleet, with wide double doors added for more efficient handling of cargo.

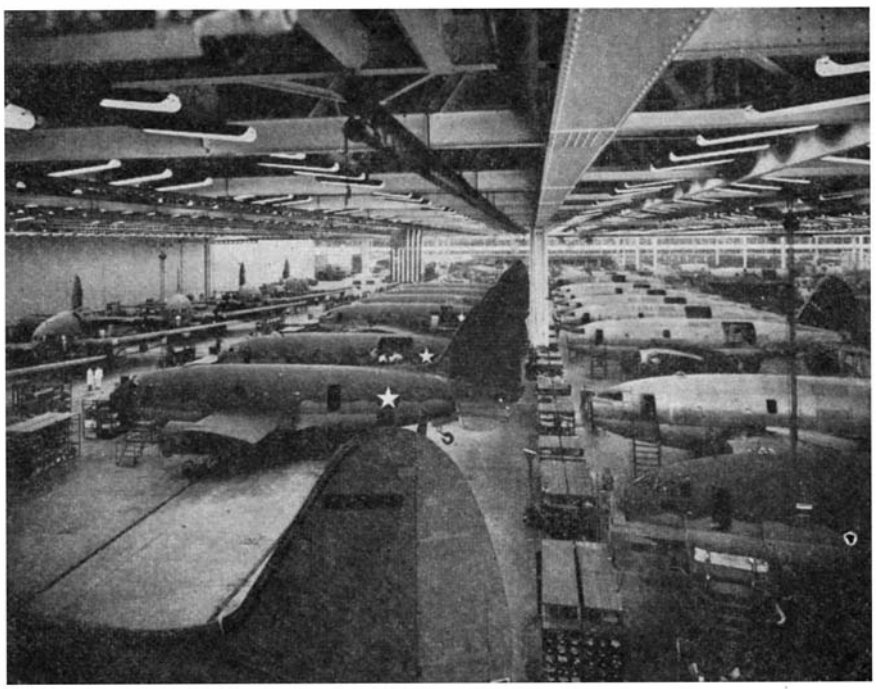
Several Boeing Clippers and Boeing Stratoliners were also put to work, and, soon after, a large four-engined plane, the Douglas C-54, was added. The Consolidated B-24 Liberator bomber was then converted to cargo use, and is giving fine service as the C-87. A new transport type coming into widespread use is the Curtiss Commando, or C-46, well adapted to cargo work with its wide doors, large cabin dimensions, tie-down rings, good flying characteristics. Just over the horizon is the Lockheed Constellation, largest transport yet designed. The Army has operated these craft, not always suited to its purposes, in every range of temperature, humidity, and weather.

Military cargo is now traveling by the northern route to Great Britain; by the southern route to Africa, the Middle East and the Far East. The Central American route brings the Panama Canal to within a few hours of flight.

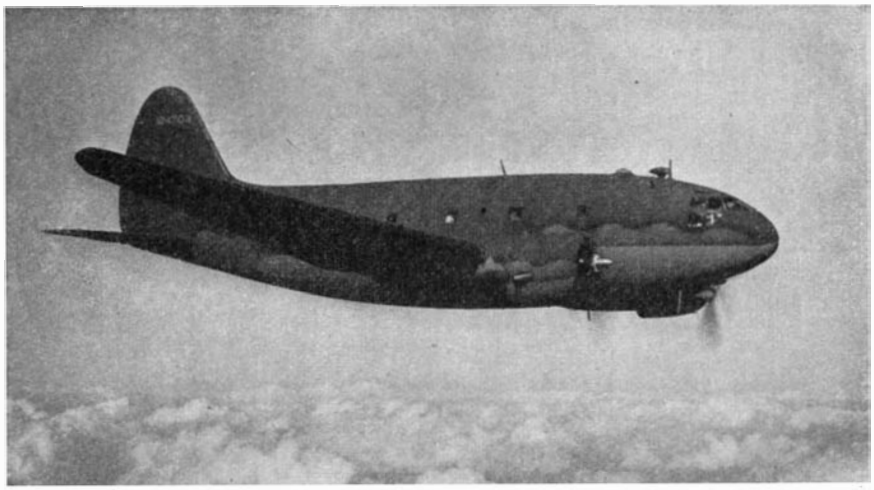
Aircraft engines, bulldozers, oil drums, barrels of cement, are carried as a matter of course. As distinct from heavy cargo, odd-shaped pieces are not so hard to move into the airplane, but steel pipes and bars, propeller blades, wing tips, aircraft cowling, and ailerons are difficult to stow and tie down. Some of the cargo can be packed in containers of conventional size and shape; other cargo requires special handling in stowing and tie-down, as in the case of explosives. Serums and some other types of medical supplies require icing.

Of the above problems, that which has occupied the Air Transport Command most is the tie-down. The objectives of a good tie-down are not simple. Ease of loading and unloading, positive securing of cargo within the cabin, and economy of material used must all be considered and these objectives are not easy to achieve. At first, the Army turned to rope, but rope stretches, knots slip, and sometimes knots are cut with a knife, wasting valuable material.

It was interesting to learn from Colonel Harris that the research facilities of commercial organizations had, after much experimentation, developed improved methods of cargo tie-down All A.T.C. cargo aircraft are now being equipped with a system utilizing vertical bars inside the cabin to which horizontal cross-beams are anchored over the top of the cargo. Locks are slipped over the bars and jacked down over the cross-beams. The jacks are simple but powerful and insure ample pressure on the cross-members so that the cargo is firmly held. The vertical bars are held in floor rings fastened to the structure of the airplane. The locks can be instantly released and an entire tie-down dismantled in a few minutes. Rope still plays an important part but only in securing light, unsymmetrical pieces, standard lengths being used with previously attached hooks so that knots are largely eliminated. Heavy wire tighteners in the form of levers take up slack and provide adequate security.



Curtiss Commandos on the assembly floor. Note wide doors



A Commando transport in flight. Now "coming into wide use"

The Air Transport Command has shown how air cargo can be handled under great difficulties; its lessons will not be lost on commercial operators.

One of the recognized authorities in the field of airline engineering operation, William Littlewood, Vice-President in charge of engineering of American Airlines, discussed "Realistic Air Transport Planning" at the meeting. Of late, ambitious and even fantastic projects have been announced on all sides, and Mr. Littlewood did the industry a service by bringing matters to a more prosaic level. Careful planning has to be undertaken, with consideration of reasonable schedules as well as adequate capital, revenues, and facilities for air navigation and the like.

THE SPEAKER pointed out that there was grave doubt whether some of the very ambitious undertakings described in the press could be realized. It is all very well to draw lines on a map to indicate flight lanes across the polar caps, but there were many problems in cold weather flying that have not yet been solved.

Then, too, the helicopter still had to demonstrate reliability in day-to-day service and in cargo carrying. Floating seadromes across the Atlantic are a magnificent conception but no one knows how safe they may be or how economically feasible.

Speaking of the airplane equipment which would be available at the end of the war, Mr. Littlewood again voiced a word of warning. On the whole, it may be a year after the termination of the war before airplanes now in service can be converted for transport operation, and it may be two or three years before entirely new airplanes are available. Instead, therefore, of counting on fundamentally improved equipment in the immediate future, it would be better to see what can be done first with equipment of the type now available.

For passenger carrying, it is absolutely essential to have two engines and to be able to fly on one engine only. This is a great measure of safety, but, on the other hand, it is also an economic penalty. It is just as possible that, for cargo carrying, the Civil Aeronautics Administration may permit the use of a ship with only one engine and pilot.

In general, it would appear that the larger the airplane, within limits, the better its payload capacity. A prognostication may be drawn, therefore, that for a given route, as large an airplane as possible will be used, provided its capacity does not exceed the traffic demands of that route. In the immediate future, however, a maximum passenger carrying capacity of some sixty passengers may be expected.

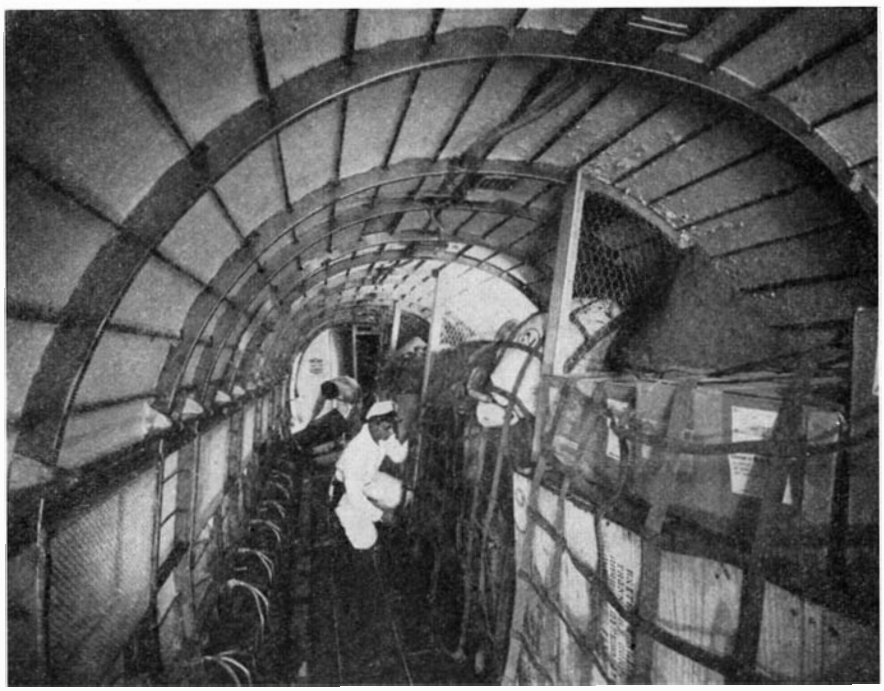
Railroads, generally speaking, run their fastest trains across the continent and their slower trains in suburban traffic. Mr. Littlewood stated that with the airplane the reverse would be logical. For short range, the very fastest planes are necessary to balance loss of time in loading at the airport.

The subject of gliders in military use and air transportation was discussed by Grover Loening, Consultant on Aircraft for the War Production Board. While hampered by the necessity of military secrecy, Mr. Loening gave a remarkable picture of progress in the efficiency and serviceability of the glider. The pick-up system for these gliders has been developed to an extraordinarily successful degree, particularly in the hands of the late Richard C. du Pont. Gliders can be taken up by an aerial tug in flight and released over a given field. The air train is a decided possibility and may become one of the most important fundamentals of air transportation in a few short years. It would permit an enormous amount of cargo to be carried at relatively slow speeds; it would give greater versatility to air transportation; it would allow some of the smaller cities to be more adequately serviced from the air.

THE DISTINGUISHED Vice-Chairman of the Civil Aeronautics Board, Edward P. Warner, stated that 64 percent of the people of the United States now live within about one hour's highway traveling distance of one or another of the points now certificated to receive air transportation. But, to take advantage of this situation, the number of stops on air-transport routes would have to be increased from the present 284 to 1600 so as to reach the bulk of such population.

Before the war the degree of public experience with air transportation was not great enough to support more than a few local services operating under the best possible conditions, but the present popularity of air transportation should make it possible to run a larger number of local services after the war. Mr. Warner said it would be reasonable to increase the number of airline stops to about 3400. The air route mileage within the United States would then grow to about 200,000 miles and the flying of about 750,000,000 airplane miles could be expected, which would be considerably more than the present annual passenger-train mileage of the railways of the United States.

The organization of the Civil Airways of the United States was described by William A. M. Burden, Special Aviation Assistant to the Secretary of Commerce, who has made a splendid repu-



Interior of a United Air Lines cargo plane

A surprise for the Japs: The new Hellcat resembles the Wildcat

tation for himself as one of the most far-sighted aviation men in Washington. The 35,000 direct route miles of the airways system is divided into 23 geographical units, the traffic in each of which is controlled from a central office. Passenger movement had increased from 150,000 in 1937 to over one million by 1939. During 1942, six and a quarter millions were handled and it was conservatively estimated that this might increase to twenty millions per year by 1950.

The Civil Aeronautics Administration is making plans to handle this extension of traffic, particularly as regards communication. A new ultra-high frequency radio range eliminates the effects of weather, static, fading signals, and other shortcomings of the present radio range. When the C.A.A. establishes the airways system using the new radio range, direct routes, approximating great-circle routes, will be provided between large terminals and the air space will be stratified. It is probable that shorter city-to-city traffic will continue to operate on the present type of airways system at lower levels. As routes are added, procedures will be devised to permit aircraft to enter or cross principal airways at specified points. Long-haul traffic will by-pass points of congestion. Long-distance traffic above 12,000 feet will be directed by automatic direction-finding equipment and ocean traffic may be similarly handled. Anti-collision devices already developed will provide greater safety.

It was predicted by Mr. Charles B. Donaldson, Director of Airports of the Civil Aeronautics Administration, that there will be 300,000 private aircraft in operation within a few years after the war. To meet this enormously increased traffic, plans for airport development are being revised on a tremendous scale. Nor will airports always remain the same. John C. Leslie, Manager of the Atlantic Division of Pan-American Airways, in his paper "Effect of Airport Operating Characteristics on Airport Runway Patterns," presented some novel ideas on the design of airports. To meet the ever-growing traffic, long runways might be parallel or multiple, they might diverge or converge, they might form a triangular pattern or be tangential to a circle at the field's center.

Discounting the fact that the papers thus briefly reviewed were read by aviation enthusiasts, there still emerged from the meeting a definite feeling that one may well expect after the war a tremendous extension of air transport, both passenger and cargo, that private flying would keep pace with it, and that, keeping pace with increased flying, there would come increased airway and airport facilities.

CARGO STOWING

As Developed by United Air Lines

IT IS not the Air Transport Command alone which is carrying cargo by air. United Air Lines has inaugurated a coast-to-coast all-cargo schedule for essential war-time mail and express. Planes leave San Francisco and New York daily at 12:30 A.M. The San Francisco-bound planes reach that city at 5:46 P.M. the same day and the New York-bound planes arrive at La Guardia Airport at 9:46 P.M. on the same day. The difference in speed is only apparent, and is explained by changes in time.

The ships employed are the well tried Douglas DC-3s, which will carry about 6000 pounds of express.

One of the illustrations in the preceding feature article shows the manner in which the luxurious passenger ships have been converted to cargo use. They have been stripped of furnishings and equipped with special cargo features such as plywood floors, plywood siding, steel screened windows, cargo bins, and means for holding cargo in place by the use of wire mesh compartments and flexible straps tied down to rings on the floor and sides.

THE HELLCAT

Has Great Combat Advantages Over the Wildcat

THE UNITED STATES NAVY now has the two finest shipboard fighters in the world; one is the Grumman Hellcat, the other is the Vought Corsair. The design of the Hellcat, which succeeds and surpasses the Wildcat, came from a happy combination of the practical knowledge of fighting pilots and the great engineering skill of Grumman engineers. In fact, that is the way all combat airplanes should be designed. No Government, however well informed, no group of engineers, however skilled, can build effectively without tapping the knowledge of pilots who have actually fought.

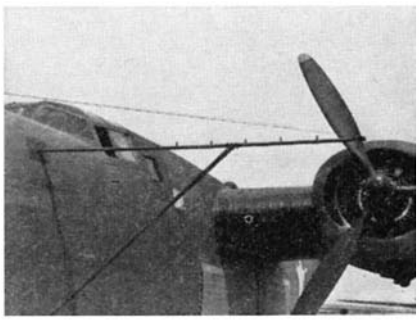
The Hellcat, as seen in the photograph, has many of the well-known Grumman features, such as the square wing tip; it also has more armor, more firepower, heavier guns, and all other necessary equipment and much more power than the Wildcat. As a result, it has the good qualities of the Wildcat plus more range, more speed, faster climb, and above all, more maneuverability. The Hellcat has a remarkably short turning radius and better visibility is obtained by pitching the engine cowling down so that the pilot can see over the nose of the fuselage when training his guns on the enemy.

It has been pointed out, with malicious pleasure, that the Hellcat can be easily mistaken for the Wildcat, and that the Japanese must have received some very unpleasant surprises when the new fighter first appeared.

ICE FORMATION

Now Studied Under Flight Conditions

THE MATERIEL COMMAND of the Army Air Forces reports an ingenious method of studying ice formation on the propeller in flight, by means of the system illustrated in these columns. On the B-24 Liberator Bomber an outrigger is installed leading from the fuselage to a point ahead of the inner propeller blades. Water stored in tanks located in the bomb-bay of the ship is sprayed into the propeller while the plane is in flight, and a camera installed inside



Water sprayer for icing study

the plane is pointed at the propeller through a specially built window. The shutter of the camera is synchronized with the propeller speed, so that the propeller appears to stand still and detailed photographs of ice formation can be taken. From such photographs the engineers learn of the character and rapidity of ice formation, and subsequently can study the remedies applied, such as slinging of anti-ice liquids, heating of the propeller, or whatever else may suggest itself.

Ultra-Low-Melting Alloys

Peculiarly Fascinating is the Group of Alloys that Melt at Hot-Water Temperatures. Such Alloys are Now Wholly Engaged in War Work, Doing Jobs that Will Surprise Many and which Forecast an Extended Post-War Utility

BISMUTH as a common ingredient of antiseptic or stomach-sweetening drugs is well-known to millions of Americans, but as the basic constituent of a group of industrially important alloys it is less renowned. This situation fails to reflect the large increase in the use of bismuth for metallurgical purposes that has occurred since the war production program started, also the changed proportion of metallurgical to other uses of this interesting metal.

Actually the non-pharmaceutical uses of bismuth, which once represented less than 20 percent of its tonnage consumption, will require more than half of all the two and a half to three million pounds of bismuth produced in this hemisphere this year. Most of these non-pharmaceutical uses are metallurgical, and the most important of the latter are those filled by a group of bismuth-base alloys especially developed for their very low melting temperatures, their expansion or virtual freedom from shrinkage on solidfying (permitting sharp reproduction of surfaces against which they are cast), and their usefully high strength and hardness when set.

These applications have been established within our currently most vital industries—aircraft, ordnance, machinery, and electrical parts particularly. In the aircraft manufacturing field the use of low-melting bismuth alloys for fixture work, forming dies, tube bending, and anchoring has become commonplace. These, when added to other uses developed in other fields and to new applications, some with brand-new alloys, still in the experimental stage, provide a foundation on which an important post-war structure is expected to be built.

The description "low-melting-temperature" most commonly used to designate the chief characteristic of these alloys is, of course, relative. Bismuth alloys are, however, *really* low-melting, many of them being liquid at temperatures below that of boiling water (212 degrees, Fahrenheit). Some are so low-melting that a startlingly accurate replica of the palm of a hand can be produced *without discomfort* by spraying it with a molten bismuth alloy.

In the accompanying table are presented recent and accurate data on the compositions and corresponding freezing ranges of the most important bismuth alloys in commercial use today. These data are supplied by the Cerro de Pasco Corporation who pioneered the technical development and commercial application of bismuth alloys especially compounded for specific jobs, and are in fact the only large company in this country manufacturing a series of standard trade-named bismuth alloys (Cerromatrix, Cerrobend, Cerrosafe, Cerrobase, and so on).

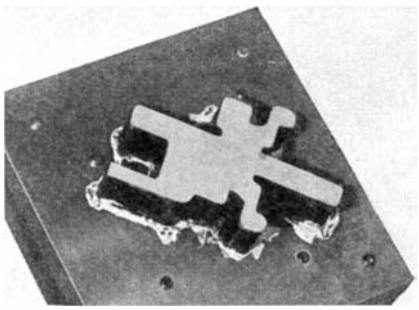


Figure 1: Blanking die made by locating and mounting the working section in a low-melting alloy

The low-melting temperatures of bismuth-base alloys has made them the traditional choice for such applications as electric safety devices, safety plugs in compressed gas cylinders, and fusible elements in sprinkler heads, fire-door releases, and so on. But a long list of new uses has been found within the last few years that depend not only on the low melting temperatures of the alloys, but on their "growth" behavior.

The growth behavior is interesting enough to merit some explanation. Most molten alloys, when allowed to solidify in a mold, undergo a certain amount of contraction or shrinkage in the process. This is responsible for the shrinkage cavity or pipe in a steel ingot, and also for the difficulty in reproducing fine mold details in a casting made of iron, brass, or aluminum, since the solidifying metal tends to shrink away from the mold surfaces as it freezes. Many of the bismuth alloys, however, actually *expand* on freezing—thus assuring the most accurate reproduction of the surface against which they are cast—and then continue to expand slowly in the solid state for many hours after reaching room temperature.

This tendency to expand for some time after solidifying—(one bismuth alloy, for example, grows 0.005 inch per inch during the first 13 days after casting)—improves the "anchoring" quality of these alloys; that is, their ability to grip notched, keyed, or bossed surfaces on which they are cast or to fill tightly annular spaces despite the absence of any fusion bond with steel, iron, brass, bronze, wood, and so on.

Typical of the advantages of these alloys are those found in making complicated dies and punches. To machine the punch or projecting die face out of solid tool steel is always extremely expensive, and in addition the subsequent hardening is certain to introduce distortion of the working surfaces that may be costly or impossible to correct. The modern practice is to produce the dies and punches in simple, easy-to-machine sections and then mount them in low-melting alloy. The wasteful machining of non-working surfaces is avoided; the simpler shapes can be hardened individually and any distortion easily corrected on each; and the die parts can finally be located in relation to each other with extreme accuracy during the mounting.

All this is clearly demonstrated in the case of the blanking die, shown in Figure 1. The parts of the die are secured to the base by Cerromatrix, a strong, hard alloy of bismuth, lead, tin, and antimony that begins to soften at 219 degrees, Fahrenheit, and is completely molten at 440 degrees, Fahrenheit. The temperatures used are too low either to distort the die sections or to draw their hardness.

Dies constructed in this way have given service and life on a par with those made by other methods and at only a fraction of the latter's cost. Sectional dies, lamination dies, perforating dies, and compound (piercing and blanking) dies also have been found especially amenable to this type of construction.

The use of the matrix alloy for anchoring stationary parts of machines has rapidly expanded in recent months. It has been found particularly useful for mounting bearings and bushings that must be located with the utmost accuracy in relation to their shafts. The problem is very simply solved by providing an oversized hole for the bushing, accurately alining the latter in it, and then securing it in place with the matrix alloy. Experience has revealed

a subsidiary advantage of this arrangement—overheating of the bearing through failure of the oil supply results in melting of the inexpensive matrix alloy before serious damage is done to the expensive bushing.

Allied to these applications is the use of the matrix alloy for making chuck jaws for holding irregularly shaped pieces during machining. The finned die casting in the center of Figure 2 is a good example of such a problem. To machine-out a suitable set of chuck jaws for this part in the usual way would be prohibitively expensive, so a low-melting bismuth alloy (Cerromatrix, again) was cast against it inside a two-part retaining shell of brass.

Another recent chuck application of bismuth alloy is for separating the pole piece on *magnetic* chucks. The bismuth alloys are electrically ideal for such use, since they are among the most diamagnetic materials available; the "expanding" property provides a water-tight fit; and the low pouring temperature permits previous case-hardening of the pole pieces, which thus have improved wear resistance.

SHORT-RUN sheet metal stamping and forming dies represent another field that these ultra low-melting alloys have invaded in recent years. The matrix alloy die may be used with a rubber punch, the matrix alloy may be employed for both the die and punch, or a matrix alloy die may be used in conjunction with a punch made of a lower-melting bismuth alloy.

In Figure 3 are shown a light-gage stainless steel airplane part and the bismuth alloy punch and die used to form it. The die is made of Cerromatrix and the punch of Cerrobase (the eutectic alloy of bismuth and lead, which melts sharply at 255 degrees, Fahrenheit). A replica of the punch was first made in a plaster composition and became the pattern against which the matrix alloy die was cast. This casting then served as the mold for casting the lower-melting Cerrobase punch.

The aircraft industry has been a heavy user of another bismuth-base alloy—a controlled version of Wood's metal, known as Cerrobend and designed especially as a filler for bending the tubing used so lavishly in that industry. This alloy contains bismuth, lead, tin, and cadmium in eutectic proportions and melts at the very low temperature of 158 degrees, Fahrenheit. Among its most useful properties are the family traits of expanding on solidifying and its ability, as one engineer put it, of passing through a hole "finer than a frog's hair."

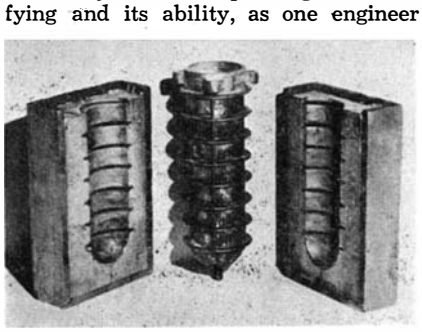


Figure 2: Cast bismuth alloy chuck jaws (left and right) hold the part (in the center) during machining

Obviously, if one attempts to bend a thin-walled metal tube around a small or medium radius, it will buckle or flatten. To overcome this such fillers as rosin, sand, pitch, lead, solid mandrels, and so on have been placed inside the tubes to make them behave in bending like a solid bar. None have been found so satisfactory from the standpoints of convenience, production-speed, accuracy, and safety as the bismuth alloy.

Its application is simple: The fully-annealed, internally-cleaned and oiled tubing is plugged at one end with a rubber or hardwood plug, and then filled with molten bismuth alloy. The tubing is quenched to solidify the filler alloy, rewarmed somewhat, and then bent with a slow uniform pressure over a forming block or in a bending machine. The bent tube is placed in a tank of boiling water to melt the filler alloy, which is then poured out and the tube quickly cleaned inside. The tendency of the alloy to run through pores or "heave" surface defects aids in revealing flaws in the tubing.

Bismuth alloy has been applied to the bending of aircraft tubing made of all the usual materials. Tubes of irregular section can be bent as readily as round tubes; one of the most interesting applications is the edgewise bending of rectangular molding by combining two pieces to make a single rectangular tube, filling with bismuth alloy, and bending.

Another development within the aircraft industry is a new kind of metal-clad manufacturing fixture that depends for its success on the use of bismuth alloy. The Castaloy Corporation has employed these low-melting materials (chiefly Cerrobend) to make metal model replicas, gages, assembly fixtures, spotting fixtures, and so on, that assure complete interchangeability of parts whether made by a prime contractor or by one of his numerous sub-contractors. Such perfect interchangeability not only speeds production but simplifies field service.

Composition and Melting Temperatures of Some Bismuth Alloys

Yield Temperature, Degrees Fahrenheit	Freezing Range, Degrees Fahrenheit A—B	Composition, Percent				
		Bismuth	Lead	Tin	Cadmium	Others
119	129-119	39.00	20.80	10.40	7.80	22.00 Indium
140	154-131	42.00	21.00	10.50	10.50	16.00 Mercury
153	223-131	35.60	49.10			15.30 Mercury
153	158-149	47.50	25.40	12.60	9.50	5.00 Mercury
158	158-158	50.00	26.70	13.30	10.00	
162	174-158	50.00	34.50	9.30	6.20	
163	194-158	42.50	37.50	11.30	8.50	
171	207-158	38.40	30.80	15.40	15.40	
197	197-197	51.60	40.20		8.20	
203	203-203	52.50	32.00	15.50		
203	239-203	50.00	25.00	25.00		
208	271-203	46.10	19.70	34.20		
214	244-208	40.00	40.00	20.00		
217	217-217	54.00		26.00	20.00	
223	441-217	48.00	28.50	14.50		9.00 Antimony
223	280-217	40.70		27.90	31.40	
226	271-207	36.50	36.50	27.00		
234	241-225	54.40	43.60	1.50	0.50	
241	246-232	54.40	43.60	2.00		
255	255-255	55.50	44.50			
275	275-275	57.40	1.00	41.60		
280	280-280	58.00		42.00		
291	291-291	60.00			40.00	

The "yield temperature" of a fusible metal is the temperature at which the fusible metal or alloy will yield, or melt, as determined under conditions specified in bulletin File 122 of the Compressed Gas Manufacturers' Association, Inc., New York.
Freezing range: (A) formation of crystals; (B) completely solidified.

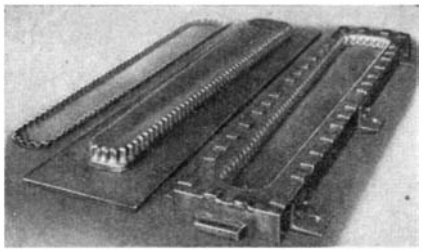


Figure 3: Two different bismuth alloys are used for this punch and die set for forming aircraft parts

In practice a master model—(perhaps the part itself or a plaster cast or mock-up)—is employed as a dummy, from which a bismuth alloy template, an alloy-clad wooden template, or a frame-type or skeleton fixture with the working points faced with bismuth alloy is prepared. Once the original model or fixture has been approved it is a simple matter to duplicate it in as many bismuth alloy—(solid or clad)—fixtures as are required.

The method saves many operations and much time. One plane plant, for example, reports that its use saved about half of the time normally required to obtain cowling tools, parts, and assembly fixtures, and in addition permitted design flexibility not otherwise possible.

Of considerable post-war interest is the variation of this principle illustrated in Figure 4—a bismuth-alloy-clad wooden template used in conjunction with a forming punch for making automotive roof panels. By this method several dies for different panels can be made simultaneously from the original fitted templates, with assurance of perfect fitting, instead of having to be made in succession and individually fitted, as before.

A very recently developed bismuth alloy (known as Cerrosafe) is being extensively used for accurate proof casting of molds, gun chambers, forging dies, and so on. The new alloy melts above 165 degrees, Fahrenheit, (its freezing range is actually 190 to 160 degrees, Fahrenheit) and contains bismuth, lead, tin, and cadmium. It shrinks ever so slightly during solidification and cooling to room temperature, returns to its original dimensions in the next 50 minutes and grows very slowly thereafter.

The new alloy is also being used as a sprayed-on coating for protecting wooden patterns and core boxes used in foundries. The protection not only extends the life of the pattern several-fold but also eliminates distortion resulting from moisture absorption.

In addition there are a host of developing applications for these ultra-

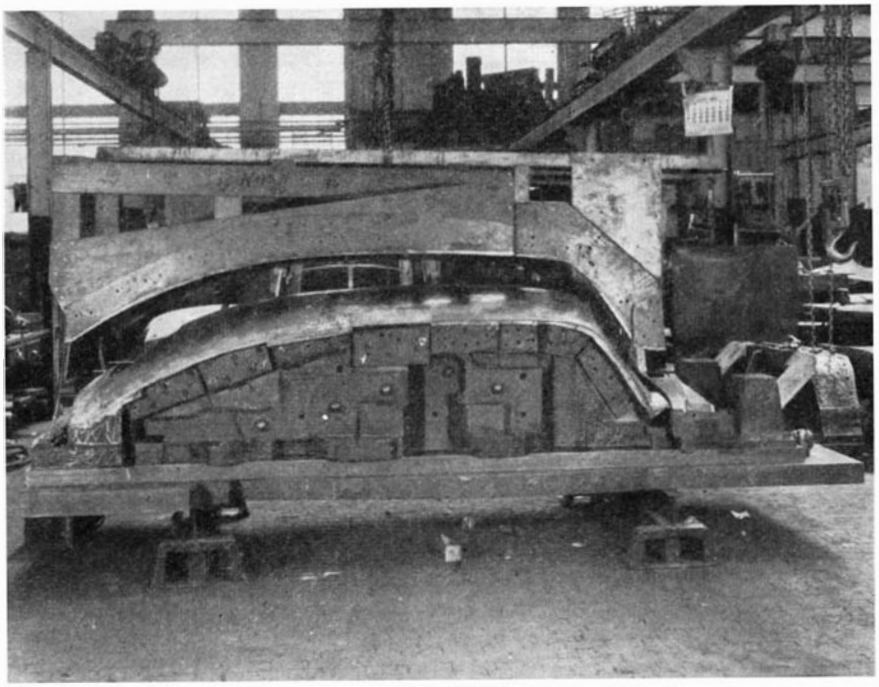


Figure 4: Forming an automobile roof panel on a bismuth alloy-clad punch

low-melting alloys that can only be mentioned but which may hold the spotlight when peace returns and the bismuth alloys can again be made available for civilian uses. One of them is as conducting, but subsequently easily removable, cores on which metals are electroformed for various purposes. One company is now electroforming a copper Pitot tube using a cast bismuth alloy cathode core, with internal baffles and protruding heater parts inserted in the original mold.

One of the newest developments is a bismuth alloy (called Cerrotru) that shows no *measurable change in volume* while passing from the molten state to the solid condition and on aging. This means complete absence of piping and perfect reproduction of mold detail.

The ultimate in low-melting temperatures has yet to be reached. At present, bismuth base alloys containing indium are being studied that melt 'way down at 119 degrees, Fahrenheit. These alloys are still experimental, still relatively expensive, and still without important application, but they do demonstrate that the search for new materials has not been forgotten in the effort to find new wartime uses and post-war business for bismuth and its alloys.

LOST-WAX PATENTS

Licensed to Production Pool

SINCE publication of the article on the "lost-wax" process in the December issue of Scientific American the editors have been advised that many of the operations and parts described in that article are covered by patents issued or pending to T. G. Jungersen of Summit, New Jersey, who had licensed members of the Jewelrycraft War Production Pool to use his processes where required.

CORROSION RESISTANCE

Increased by New Phosphate Coatings

PHOSPHORIC acid solution treatments of steel and zinc surfaces have been used for centuries to increase paint adhesion, and thus to improve corrosion resistance. The phosphating of steel has come into extensive use in the last few years with widespread applications of such processes as Parkerizing, Bonderizing, Coslettizing, and so on.

As a rule, the corrosion resistance of the base metal was never increased appreciably by the phosphate coating alone, the purpose of the latter being chiefly to increase the adhesion of a finish-coat of lacquer, oil, wax, or paint. With the recent development of a so-called "titanium predip" method, however, it is now possible to obtain decided corrosion resistance of zinc-plated steel without a supplementary organic coating. In addition, when an organic coating *is* applied over the new phosphate treatment, the corrosion resistance is considerably better than that obtained by straight phosphating.

For many years it has been known that mechanical wiping of the surface of zinc-plated steel just prior to phosphating refined the structure of the subsequent phosphate coating and increased the corrosion resistance of the finished article.

The new process, developed by Mr. George Jernstedt of Westinghouse's Meter Division, replaces the mechanical wiping with an immersion of the zinc-plated steel in a "titanium-activated" disodium phosphate solution. Titanium activation is achieved by adding a soluble titanium salt to the disodium phosphate at the time the bath is made up, so that the titanium is present during the evaporation-to-dryness operation which is part of the preparation of the bath.

The titanium disodium phosphate predip remains active for weeks at a time, and its relative cost is extremely minor. The finish obtained on steel or zinc is unusually smooth and fine-grained, and lacquer may be applied without any rub-down of the surface. Finally, the coating is so smooth and corrosion-resistant that in many cases a subsequent organic coating may be dispensed with.

MILITARY CONSERVATION

Shows What Can be Done When Necessity Demands

SOME of the over-all conservation achievements of American industry and of the armed forces were described by Howard Coonley, chairman of The Conservation Division of the War Production Board at the joint Toronto meeting of the American Society of Mechanical Engineers and the Engineering Institute of Canada.

The steel cartridge case program still stands out among ordnance savings. After many obstacles were overcome in the fabrication of a satisfactory steel case, the .45-caliber ammunition was completely converted from brass to steel, with production now running many millions per month. The .30- and .50-caliber sizes are also in production at a somewhat lower rate. In addition, the 10.5mm, 20mm, and 40mm cases and even the Navy's 3-inch cases have been certified for combat use and are now in full production. At the present rate, brass in excess of 200,000 tons a year will be saved by the continuance of this program.

In the use of die castings as a conservation measure hundreds of items have been changed from screw machine products, forgings, sand castings, and so on. Die castings give high-speed production and involve very low scrap loss, and their employment has provided high savings in materials, manpower, and machine time.

Many government specifications have been changed in the interests of conservation. For example, specifications for bronze valves were changed to cast iron, sometimes with bronze seats. Cast aluminum searchlights became sheet steel, and bronze wire screens were converted to galvanized steel. Fire-hose couplings were changed from high-tin bronze to malleable iron for shore use and low-grade bronze for shipboard. Many other conservation means have been described in recent issues of this magazine.

Simplification and standardization have also been helpful. For example, a new fluorescent lamp schedule that reduced types from 3500 to 1700, colors from 13 to 3 and voltages from 32 to 7 actually saved 35,000 pounds of solder and 2000 pounds of tungsten and released 1.2 million man-hours per year.

Winning The Battle With Snow

Modern Methods of Snow Removal and Disposal, as Practiced on Airports, City Streets, Highways, and Railroads Are Equally Applicable to Parking Lots and Long Driveways of Industrial Plants. No One Scheme of Attack Will Do a Big Job. Mechanical, Chemical, Heating Methods Outlined

By HAL W. HUNT
Editorial Staff, *Engineering News-Record*

Snow removal is one of the major battles of the home front this year. The strategy of the attack, which must be mapped out months in advance, involves the use of an army of men and the use of mechanized equipment, some of it only recently perfected. No one group of workers or scheme of attack is sufficient. All must work together in a well planned advance to prevent being overwhelmed by the forces of winter.

As the first illustration of modern snow fighting, consider what goes on at a big airport. Weather reports, available far in advance of those furnished to civilians, warn of an approaching snowstorm, usually with some information as to its probable duration although its intensity is difficult to predict. The airport maintenance engineer plans the strategy of battle, selects the crews to make the initial attack, and sees that all machines are given thorough servicing in preparation for the grueling hours ahead.

Clearing starts when the snow is about two inches deep. The best method of attack is small machines in front, followed by heavier and slower units, the latter perhaps supplemented by minor auxiliary machines. The attack leaders are one-way plows, pushed by medium-size trucks at 25 to 35 miles per hour, which throw the snow to one side. When snow piles up to a point where the speed is reduced so that the plows are merely pushing the snow rather than throwing it off the blades, larger plows, probably with adjustable side-mounted wings, and heavier truck units are indicated.

Next in the procession of machines on a well equipped field is a one-way plow delivering snow to a wing in which is mounted a rotating vane driven by a separate motor located on the truck behind the cab. This vane boosts the snow, already moving in the same direction, off the end of the wing and 40 to 50 feet off the runway. If heavy windrows build up, it is sometimes necessary to bring in heavy rotary snow throwers that break down hard banks of snow and throw it 50 to 100 feet.

The foregoing sounds simple enough but when the operation is performed at night in a driving storm, with planes expected to land at any time, and when runway lights along the field are obscured by falling snow, it takes on all of the aspects of real fighting.

But getting snow off the runway is only part of winter maintenance on an airport. There are miles of taxiway and acres of aprons from which the snow must be removed so that it will not impede movement of the planes.

Here the snow must be handled differently. The relatively narrow taxiways to be traversed by planes only at slow speed can be cleared by a few passes of the plows, but the aprons are another matter. The wide paved area, often with only small open spaces between taxiways or runways, offers little room for disposal of snow. The procedure here is to plow as much of the snow outward as is possible, allowing it to accumulate along the exterior edge, then plowing additional swaths out and piling it against the banked snow.

Near the buildings, however, there is no alternative but to load the snow and haul it away. The rotary plows, used for breaking up and dissipating windrows, generally are equipped with hoods that can be used for deflecting the snow into trucks. Thus these rotary units continue to be used after the runways themselves have been opened for traffic. The conveyor type loader can be used here if available. This machine is a self-powered outfit on crawler treads or wheels, that can work itself along a windrow, having paddles or some other device for breaking up packed snow and ice and feeding it to an endless conveyor belt that carries the snow to a point high enough for discharge into a truck.

Beyond the paved limits of the runway, it is desirable to slope the snow to an easy rise to prevent drifting on the runways and to assist in preventing damage to a plane in case it skids and veers off the paved area. Also important is rolling the snow on the rest of the field to compact it to prevent blowing and to give a reasonably smooth surface.

An ever-present hazard is ice or solidly packed snow that may not be removed by the original plowing. Blades mounted under the body of a heavy truck sometimes are useful in removing such ice but the best solution appears to be to spread abrasive material—sand or cinders, for example—over the ice and leave it until action of the sun melts it. But the sand or cinders will not stay on the ice under action of high wind or propeller blasts. Consequently, the abrasive materials have to be heated so that they will embed themselves in the ice, or treated with low-melting-point chemicals that will soften the snow sufficiently for the material to gain a foothold.

Big trucks with hopper-bottoms and a screw conveyor feeding to the rear

Rotary snow throwers dissipate snow piled up by plows

The rotating forks at the front end of this machine break down any kind of snow bank and feed it to blowers which throw it well off to one side

are used for this work, with actual distribution on the field by rotating spreader. Here again the forces of winter are difficult to overcome, since the abrasive materials freeze in stockpiles and require heating and drying. Then there is the continuing problem of applying the materials while hot. Reaching successful stages are experiments on heating the material in the truck with oil burners so that it falls almost white hot on the ice, thus winning a toehold that can be readily maintained.

The application of heated abrasives is quite expensive and can be avoided by use of calcium chloride or other chloride treatment of the sand or cinders. The objection to the use of chlorides is that they may cause an accelerated oxidation and rusting of metal parts, particularly the intricate mechanisms of the wheel-retracting devices on airplanes. This scheme is quite widely used, however, despite the objection, in which case the chloride splashings are carefully washed off the plane as soon as practicable.

Similar operations are used on city streets, employing similar machines but essentially different methods. When the news of an impending storm arrives, the snow-plow units, held in reserve, are put on the garbage collection and other heavy trucks owned by the city. Owners of suitable trucking units, contracted with far in advance, are notified to stand by to assist in disposing of snow. In the larger cities the snow-fighting equipment is distributed throughout the area in accordance with an organization chart made up during the summer months; supervisors of the various city departments are assigned with their personnel to specific work so that when snow starts to fall each can move quickly in a coördinated, all-out attack.

LIKE the airport clearing, first equipment of the attack is light one-way plows on moderate size trucks. Here, however, the plows are designed so that snow slides across the blade rather than being thrown. One or two passes with the plows ordinarily pushes the snow to the gutter where it is left to melt naturally if the snow is not expected to be of long duration or is loaded on trucks and disposed of off the streets. Crosswalk clearing is an important factor in street work and here small wheeled tractors with bulldozers are especially helpful.

Experiments have been made on machines to dispose of snow by melting it on the street or runway but to date have not proved entirely satisfactory. Most machines burn oil and direct a flame downward against the paving. Some difficulty has beeen experienced in getting all of the burners to function properly, and to continue operation. If a stop is made to adjust one of the burners while the rest continue to function, the pavement surface is likely to suffer some damage, so to date "frying-pans" have not been widely accepted.

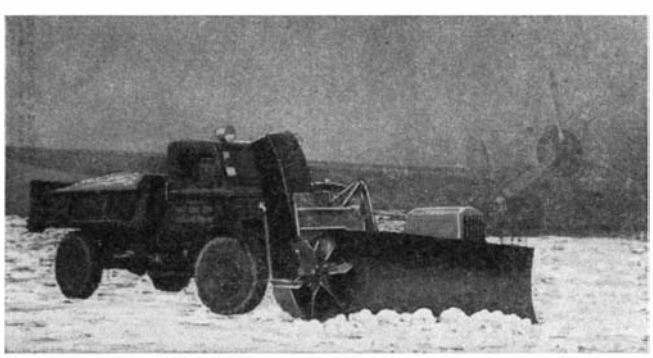
Other machines frequently are pressed into emergency service for moving snow. Large, lightweight buckets are used on power cranes and shovels, making these units efficient snow loaders. Tractors with bulldozer and angledozer blades and with regular snow plows are useful in heavy snow, while patrol blades, with or without snow plows and wings, find many applications. Tractors mounting high-lift scoops and overhead shovels also serve as auxiliary equipment.

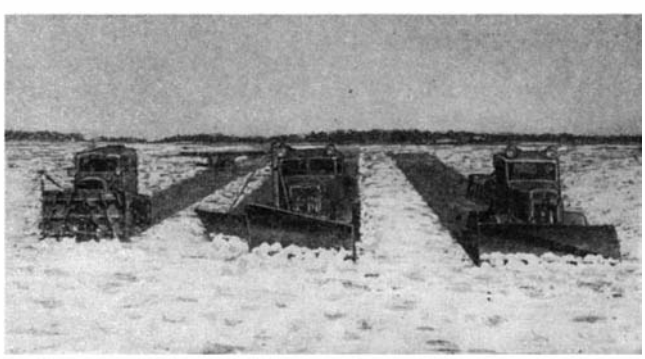
Final diposal of the snow is a major problem. In seaports, such as New York, much of the snow is disposed of by driving the trucks out on docks or wharves and dumping it overboard into the salt water. Movement of the tides and the low freezing point of the salt water prevent any building up of dumped snow even where a considerable amount may be disposed of at one point. Dumping into small fresh-water courses, where the water may already be near the freezing point, might restrict the flow of the stream and cause difficulties. Dumping on vacant land is often possible and a large amount of snow may be disposed of into sewers through existing manholes, a stream of water from a hydrant being used to flush it down and assist in melting.

Snow, slush, and ice can be effectively removed from the pavement by applying a stream of water under pressure to loosen the material and flush it to the drainage inlets. This method, limited to times when the temperature is above freezing and where water is available, is reasonably successful since little equipment is required, paved surfaces are swept clean, and parked cars do not seriously interfere with the operation.

Highway maintenance crews perhaps have the best general organization throughout the year for adaptation to snow handling and the greatest flexibility of forces for what they must do. They also have an advantage in clearing only a moderate width and generally just throwing the snow off the highway and leaving it. But they do have the enemy of drifts that occur less frequently on airports or in the cities. Highway cuts, through hill country, often fill with snow and offer serious obstacles to removal because of high banks on the sides.

Machines for moving snow on the





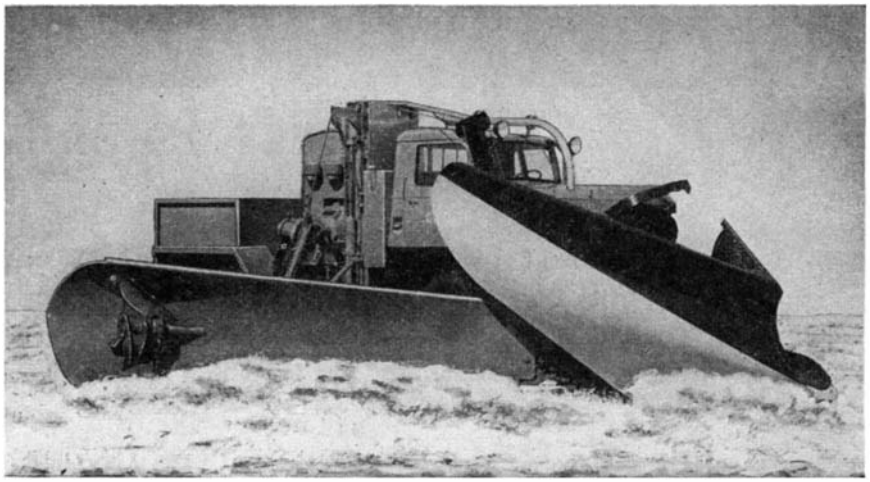
Above: A type of plow equipped with a rotary impeller that cuts an eight-foot swath, throwing the snow aside in a single pass over an airport runway. In the illustration at the right is shown an effective working force for use where large areas must be kept completely snow-free. At the right in the photograph is a one-way plow. Center is a one-way plow with a side wing. The third machine, at left in the illustration, is a rotary snow thrower provided with helical screws for breaking down banks

highways are similar to those for airport runway clearance—light one-way plows operated at high speeds, heavier plows with wings on four-wheel drive trucks, the blade plows with powered rotary vanes, and finally, the big rotary snow throwers for moving packed snow.

Abrasives to avoid skidding again are necessary but here there is less tendency for the material to blow off the road and less objection to the corrosive effect of chloride. Ordinarily, abrasive materials are treated with calcium chlorides as they are stored and then additional chloride added as they are prepared for actual placing on the road. In some cases common rock salt is spread over the highways, particularly at intersections, to prevent the snow from packing and becoming hard. When the rock salt is applied early it is possible to plow the highways or city streets clear at almost any time as the snow has a tendency to "mush-up" rather than compacting.

The railroads have their own battle against snow. In most of the areas of the United States, except the mountains, their problem is as much one of keeping switches and yards open and free of snow as it is of getting any considerable quantity of snow off the main line. Snow removal on single-track lines is done generally by V-plows on a work train heavily loaded to give it weight; on double tracks one-way plows are used, both types being operated at relatively high speed to throw the snow. Yards are cleaned with what is known as a Jordan spreader that has plows and bulldozer wing-blades at the side that push the snow laterally. Much loading of snow is necessary in restricted areas of platforms and yards. Clearing and freeing of switches is done quite generally by various types of heaters, including steam and oil and gas burning devices and a newly developed electric unit.

Because of the dependable army of home front workers, planes take off headed into a snow storm with no misgivings about others having a place ready for them to land. Motorists and trains are so infrequently stalled by snow that it is front page news if they are. And the so-called stay-at-home may drive his car from his home to his office before he has time to shovel his own front walk. Men and machines, under the guidance of the engineer, generally can win the battle with snow before it really gets a foothold, but snow is a formidable foe with an unlimited reserve, and is not to be treated lightly.



Offset V-plow and side wing with a power-driven vane that boosts the snow without changing its direction is fastest of the big snow plows recently designed

SLUDGE CAMOUFLAGE

Conceals Light Colored, Exposed Soil at Plant Site

DRIED, digested sewage sludge, the solid residue from municipal treatment plants, has been found useful as a camouflage material at one of our new war production plants. Because of its strategic location, it was decided to provide protective concealment measures for the plant, but one of the major problems was to obliterate reflection from the light-colored soil on the plant site, which was exposed during construction operations.

Tests revealed that dried sludge—available in large quantities from a nearby sewage treatment plant—was ideal for a ground cover. The material is dark brown in color, has the physical characteristics and appearance of humus, and is free of any odor.

Some 30,000 tons of sludge were hauled to the plant and spread to a depth of several inches. Not only did this provide a cheap and effective means for immediate obliteration of ground reflection, but the sludge is expected to serve as a soil conditioner to promote the growth of grass.

HORIZONTAL WATER WELLS

Now Being Successfully Used by War Industries

A NOVELTY when it was introduced to this country a few years ago, the horizontal well has now achieved considerable importance as a means of obtaining the large quantities of ground water required by industrial plants engaged in war production. Technically described as a radial well water collector, a single unit will produce as much as 10,000,000 gallons of water daily, and some plants employ as many as seven units to meet their needs.

A radial well consists essentially of a large shaft (about 16 feet in diameter) sunk to a depth where groundwater prevails, and from this shaft are driven horizontal, perforated pipes for distances up to 300 feet. Radiating from the shaft, like spokes from the hub of a wheel, each collector pipe conducts water to the shaft from which it can be lifted to the surface. The perforated screen pipes are eight inches in diameter and the number of pipes projected is determined on the basis of the amount of water desired and the specific geological conditions encountered.

The success of this method of abstracting water from the ground rests in large measure on the development of a suitable boring head by which projection of the collector pipes is facilitated. In Europe, radial wells have been built by simply forcing horizontal strainer pipes of small diameter into the ground, but this procedure results in compressing the ground around and ahead of the pipe so that permeability of the adjacent soil is greatly reduced, with resulting loss in water yield.

This problem was tackled by Leo Ranney, a petroleum engineer of California, who perfected and patented a boring head of special design. With this head attached to the outer end of a screen pipe, it is possible to remove fine sand and silt that are in the path of and around the pipe as it is projected outward. In effect this permits the formation of a subterranean gravel pack around the screen pipe, the permeability of which provides easy access of water from the surrounding ground into the perforated pipe.

The screen pipes are projected through port holes near the bottom of the concrete well casing by means of hydraulic jacks. As the pipe is jacked out into the ground, additional lengths are welded on. The jacks rest against the wall opposite the port holes through which the pipe is being extended.

CONCRETE SCALING

Minimized With Linseed Oil Emulsion

SPRAYING of newly laid concrete paving with an emulsion of linseed oil has practically eliminated surface scaling, according to engineers of the Ohio state highway department.

This cheap and effective procedure to minimize surface disintegration and maintain a smooth pavement costs only 2½ cents a square yard. To apply the linseed oil, water and kerosene are added in the proportions of one part oil to an equal volume of kerosene and eight parts of water; in addition, ¼ pound of soap powder is included for every gallon of linseed oil.

The resulting emulsion is applied with a standard highway pressure distributor at the rate of 0.1 gallon per square yard of pavement.

What Glass Is and Isn't

If You Can Define Plain Common Glass You Are Wiser Than Average. Has the Essence of it Something to Do with Transparency, Brittleness, Artificiality, Ceramics, Chemical Composition? Try to Define Glass Before Reading; but None of these Goes to the Root of it. You Can Start an Argument

By C. J. PHILLIPS
Corning Glass Works
Author of "Glass: The Miracle Maker"

THERE IS a substance, so common that we usually take it for granted, but so uncommon in many of its characteristics that scientists have had trouble finding a name that exactly suits it. At the end of many years they still are not completely satisfied with their choices. In their less abstruse moments, they call this substance "glass." At other times they speak of it as a solid, an amorphous solid, a liquid, an undercooled liquid, and so on.

This would not be a matter of much significance were it not that glass is a material well worthy of study, not only for reasons which are obvious but also for several which are not. Usually we consider glass important because of its optical, chemical, or electrical properties. We think at once of windows and lenses for military fire control; of fruit jars and drinking glasses; of tubes in the home radio and antenna insulators hitched to the tree in the back yard. Yet, as Dr. Frank Preston points out, ". . . . the largest single piece of glass ever made, and by far the most valuable, viz., the 200-inch mirror for Mount Palomar, is made of glass, not for any optical property, not for transparency, not for electrical resistivity, but for its mechanical properties. In this case we are concerned with permanence of shape, freedom from 'creep,' freedom from elastic hysteresis, freedom from warping and from thermal distortion. For in that mirror, the silver or aluminum is on the front face, not the back one, and the light never passes through the glass. The glass is a purely mechanical support for the almost infinitesimally thin mirror. We use glass in this case, not because it is transparent, but because its general rigidity and permanence of shape are better than steel or concrete."

This observation, which may be old stuff to some, is new stuff to most. It is not generally appreciated that in such respects glass is the ideal solid and that as such it is perhaps the best material we have in which to study the mechanical properties of matter. Moreover, this study can extend over a range of many hundreds of degrees Centigrade as the material changes continuously from a true (though perhaps unusual) liquid at high temperature to its common form at room temperature. Only for these and similar reasons has it seemed desirable to add another article to the already voluminous list concerned with "What Is Glass?" And even these reasons are not valid unless the present article can in some measure clarify the situation by reducing it to its simplest terms.

We shall have to start with something very simple indeed, setting aside our specific subject for quite a time in order to fill in scientific background preparatory to the return to glass.

Almost every substance can exist in three states: solid, liquid, and gaseous. The elementary physics texts distinguish them by the descriptions and examples given in the accompanying tabulation.

THE THREE STATES OF MATTER

State	Description	Examples
Solid	A solid has a definite shape and a definite volume, and offers resistance to any attempt to change these.	Wood, granite, coal, iron, gold.
Liquid	A liquid has a definite volume but no definite shape. The shape of a liquid is the same as that of the containing vessel.	Water, alcohol, kerosene, turpentine.
Gas	A gas has neither a definite shape nor a definite volume. Both are determined by the containing vessel.	Hydrogen, oxygen, chlorine, carbon dioxide.

The description of each state is so fundamental, so much a part of our everyday thinking, that normally we have no difficulty whatsover in deciding whether a diamond, for example, is liquid or solid.

Now, two very different things can happen to any substance, whether solid, liquid, or gas. It can change chemically: iron rusts, milk sours, gunpowder explodes. It can change physically: steel springs bend, glass springs bend, snow melts, water freezes.

We shall first consider one kind of physical change. In developing this concept it is instructive to consider the ordinary behavior of most of the solid substances with which we are likely to be familiar. If one of these—ice, for example—is heated to its melting point, it changes abruptly to a liquid: water. When melting of such a solid begins, the temperature remains constant until all the solid becomes liquid. Upon cooling, the reverse phase changes take place. The liquid changes to a solid when a certain temperature, specific for each substance, is reached. Solidification takes place at the same temperature as for melting and this temperature remains constant until all the liquid is solidified. If the temperature of the cooling liquid is plotted against the time, there is a break in the curve at the freezing point of the liquid. In this process of cooling and solidifying, such substances form solids which have a fixed, regularly repeated, geometric structure. These substances are called crystalline solids. Ice, the metals, and most laboratory chemicals are familiar examples.

The elementary parts of crystalline solids may be ions, atoms, or groups of atoms. Common salt, NaCl, is an

ionic crystal. The sodium ions alone form a face-centered cubical lattice; likewise the chlorine ions alone. Each positive sodium has six negative chlorine neighbors; each chlorine has six sodium neighbors. X-ray analysis has proved to be a very powerful tool for determining the structures of other crystals, most of them much more complicated than salt. But make note of an interesting viewpoint: If we wish to retain the very useful idea that "a molecule is the smallest particle of matter that possesses the characteristics of the mass," then the whole salt crystal is really a single gigantic molecule! For, we cannot tell *which* sodium is associated with *which* chlorine. The molecule, Na^+Cl^-, has lost its identity. We can say only that a great number of sodium and chlorine ions are joined together, in a certain distinctive way, by chemical or physical forces. As a matter of fact, there may be several distinctive arrangements, each involving the same atoms. We have monoclinic sulfur and rhombic sulfur, gray tin and white tin. There are six known crystalline forms of ice, but we call them all "ice."

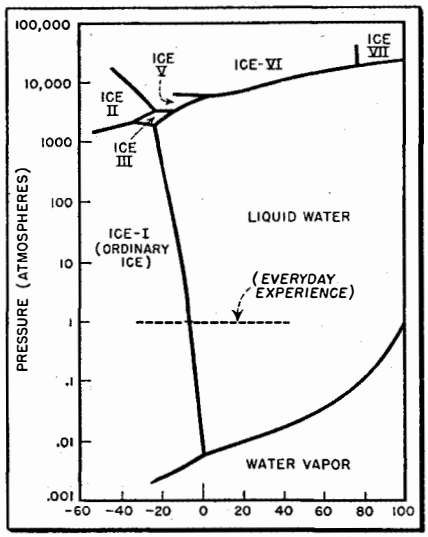
We may, with equal propriety, argue that a liquid, like a crystal, should be considered a single molecule: a "molecule" which can flow, because the constituent parts can change their linkages, but which in any case always retains a certain limited regularity of structure. The regularity or orderliness is less than for crystals, but it is there, and can be shown by X-rays.

IT IS becoming increasingly obvious that solids and liquids have much more in common than was originally supposed. In elementary mechanics, we like to think of solids as rigid, retaining their shape perfectly, and of liquids as incompressible, retaining their bulk perfectly, no matter what forces act upon them. Actually we know that such substances do not exist. Even the best-behaved solids, if acted upon in one direction by great forces, exhibit an elastic limit. Beyond it, they retain a deformation or "set," whose extent and permanence depend upon the duration of the excessive stress. The solid has begun to show the plasticity of a very viscous liquid. In this sense, ductility and malleability are both quasi-liquid in character. There is a large, vaguely classified group of materials, called amorphous solids, which no one can quite force himself to call either liquids or crystalline solids. Pitch, tar, wax, lard, gutta percha are in this category.

In this way, example can be piled upon example to show that no solid, and no liquid, is as "perfect" as we would like it to be for mental ease in definition. We cannot lock each concept in its own air-tight compartment. In many borderline cases it is difficult or impossible, and probably futile, to distinguish one from the other.

Now, when we come upon a substance which is fabricated at very high temperatures, which in fact can be fabricated only because it is then a very viscous liquid, but which it always used at lower temperatures as a hard, rigid solid—then we can confidently expect difficulties in definition. Such a substance is glass.

At room temperature a glass is obviously a hard, rigid solid, in the ordinary, rather loose meaning of those terms, and it apparently remains a solid as its temperature is increased several hundred degrees Centigrade. As the temperature is still further increased, it gradually softens, almost imperceptibly at first, and finally becomes a viscous liquid, without exhibiting any sharp melting point.



In everyday experience water has three states, or phases—the solid (ice), the liquid, and gaseous (water vapor). Within recent years several more icy states have been discovered when water was put under extremely high pressures. Ices II and III melt at lower temperatures than the familiar Ice I but Ice VII doesn't even freeze until the temperature has been raised to 179 degrees, Fahrenheit; and if the pressure is raised still higher its freezing point will be higher than the boiling point of water at atmospheric pressure. Therefore "hot ice" isn't just a case of hot air. These different states of ice result from changes in crystal structure due to the high pressures and temperatures involved

At high temperatures glasses are ordinary liquids which, like all liquids, assume the shape of the container and flow under the action of any small force. When this liquid is cooled it does not devitrify; that is, it does not undergo a discontinuous change into a stable crystal or aggregate of crystals. At the temperatures at which glasses might be expected to crystallize they are still liquids, liquids of such great viscosity that they can be cooled through their freezing points without devitrification. They thus become "undercooled liquids." The increase in viscosity is a continuous process from the very hot liquid to the rigid glass at ordinary temperatures. Glasses have smooth cooling curves without the sharp break which indicates the freezing point of a liquid which crystallizes as it cools. Morey summarizes this behavior and defines a glass as follows: "A glass is an inorganic substance in a condition which is continuous with, and analogous to, the liquid state of that substance, but which, as the result of having been cooled from a fused condition, has attained so high a degree of viscosity as to be for all practical purposes rigid." This kind of material is a glass, regardless of its chemical composition.

It is possible to argue almost endlessly about some of the expressions used in the last paragraph. There have been violent objections to the term "undercooled liquid." It is pointed out that glass at room temperature is much less capable of flowing under stress than such characteristic solids as iron and steel. If various estimates are correct, strain-free glass formed at the dawn of creation and subjected ever since, at room temperature, to as high a stress as it would stand, would not have flowed at all within the limits of observation. This is probably true and from that point of view, but that point of view only—in the cold, one might say—the term "undercooled liquid," used in any popular sense, probably strains one's credibility. But glass would not be glass, at room temperature or any other temperature, were there not a strong but highly flexible system of atomic bonding carried down continuously, and reversibly, from the high temperature condition. It is therefore vital to retain this concept, and this the expression "undercooled liquid" does do.

THE TERM "amorphous solid," also applied to glass by scientists, is both useful and misleading. The word "amorphous" is variously defined as meaning formless, irregularly shaped, uncrystallized, or unorganized. Several of these terms give the wrong implications and this classification is too broad and general. The expression is useful if we agree that there is one distinctive branch of the group of amorphous solids—that branch produced by undercooling a melt and giving substances which, at ordinary temperatures, exhibit brittle, conchoidal fractures— and that we shall call such substances glassy or vitreous.

Commercial glasses are not the only representatives of the vitreous state, as it is sometimes called. Certain elements and compounds can be obtained in this condition—selenium, arsenic trioxide, and boric oxide, for example. Pure silica can be fused, without fluxes, and becomes vitreous silica. Stick candy is a vitreous substance. The vitreous state is well represented in nature. In Yellowstone Park there is a great mass of volcanic glass, nine miles long and five miles wide, in which there are only occasional traces of crystalline forms. On the island of Lipari in the Mediterranean there are two mountains of pure white glass better known to us under the name pumice. This useful material is really a glass foam created by trapping countless gas bubbles as the molten mixture solidifies.

If we define ceramic products as being the result of the action of fire on earthy materials, we can see why such apparently different products as brick, terra cotta, chinaware, refractories, enamels, glazes, and glass have much in common. All are certainly created

(*Please turn to page* 39)

Compressed Air In Industry

Air is Used in Almost Limitless Volumes in a Seemingly Unlimited Variety of Work. When these Applications Are Rounded Up into a Synthesis They Constitute an Impressive Array. Many of the War-Time Operations Accomplished Through the Use of Air have Definite Implications for Peace

By ED C. POWERS

AIR, PROVERBIALLY free, has become a vast and limitless resource for America's war production. It is being blown and pumped in great tornadoes to speed planes, guns, ships, food, chemicals, and other necessary war materials from the mines, mills, and factories of the United States to the armed forces around the world.

In such great demand is the force that can be stored up and released in air and other gases, that millions of horsepower in compressors, blowers, and fans have been put to work on a scale gigantic in scope. The Compressed Air Institute, which keeps its fingers on the air arteries of the nation, estimates that distinct and definite uses of compressed air in industry number between 450 and 500.

Blast furnaces and steel mills, metal and coal mines, shipbuilding yards, ordnance factories, and the aviation industry require vast quantities of air and gas that stagger the imagination.

Air is not usually thought of as having great weight because it ordinarily offers such slight resistance to our movements, but industry has come to make its compressed-air weight calculations in millions of tons. For example, the mass of air and gases set in motion by compressors and blowers in the iron and steel industry alone during 1942 totaled about 240,000,000 tons, or about three times the estimated weight of steel coming out of the same mills.

In the shipbuilding and aviation industries, vast amounts of compressed air are used all along the production line, from the point where the castings for the engines are first formed to the final spraying of paint on the finished jobs.

In the ordnance industry, compressed air has made possible rapid forming of huge shells and bombs, and high-speed casting and machining of guns and other weapons.

In the explosives industry, compressed air and other gases are being used to synthesize nitric acid and ammonia—two of the warring nations' most vital chemicals. (See page 270, December 1943 Scientific American, for details of this process. *Editor.*)

Oil refineries are using hundreds of thousands of horsepower for the movement and compression of gases, and in the manufacture of synthetic rubber the demands for compressors to transport air and gas are placing a heavy load upon compressor manufacturers.

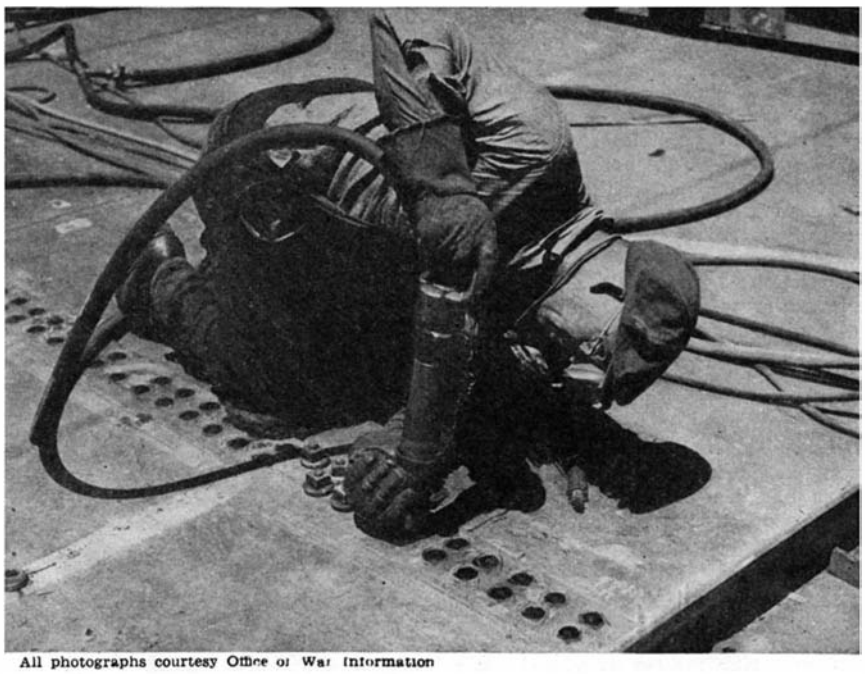
There are compressors on cargo vessels and fighting ships, for the operation of controls, elevators and hoists, and many other appliances. There are compressors for the release of torpedoes, compressors impelling air to blow gases out of guns, and compressors for general ship services.

To provide warmth and fuel for the public and industry, the gas industry runs compressors by the hundreds of thousands of horsepower. One natural gas company alone has 100,000 horsepower in compressors. They use compressors to pump the gas through miles of pipelines and store it away. During the summer months one company, whose compressors total 36,000 horsepower, pumps billions of cubic feet of gas into storage. The largest part of this goes into two large underground reservoirs, and the company is planning to store over 300,000,000 cubic feet by liquifying it and pumping the liquid into huge cork-lined containers. In the winter when demands for the gas are heaviest, it is released from these storage reservoirs.

Some of the largest volumes of air are handled in war plants and government buildings for heating and ventilating. As an example, one plant of 5,000,000 cubic-feet capacity moves 1,000,000 cubic feet of air a minute through the plant. At five pounds pressure and 70 degrees, this much air, if perfectly dry, would weigh 500 tons. In other words, just one war plant of moderate size moves 1,220,000 tons of air every 24 hours.

To speed up war production, many industrial plants have installed pneumatic conveyors which send messages and blueprints from one end to the other of a 1000-foot factory in less than 40 seconds. One of the largest pneumatic conveyor systems in the world has been installed in the War Department's Pentagon Building in Washington to speed up communications.

Compressed air is used to control many automatic and semi-automatic industrial processes. At the new synthetic rubber plants valves and other



All photographs courtesy Office of War Information

Air powers this rivet hammer, at work on deck plates of a ship

WARTIME ANNOUNCEMENT!

Revolutionary RADIONICS Product of Great Importance

For All Hard of Hearing – their Friends and Families

$40.00

READY TO WEAR
COMPLETE
—WITH RADIONIC TUBES
—CRYSTAL MICROPHONE
AND BATTERIES
. . . Liberal Guarantee

★

TO PHYSICIANS: A detailed scientific description will be sent upon request. Further technical details will appear in medical journals.

★

There are cases in which deficient hearing is caused by a progressive disease and any hearing aid may do harm by giving a false sense of security. Therefore, we recommend that you consult your otologist or ear doctor to make sure that your hearing deficiency is the type that can be benefited by the use of a hearing aid.

★

The Zenith Hearing Aid can be supplied only by your Zenith franchised Optician or Optometrist (no home calls or solicitations).

Zenith Radio Corporation
CHICAGO

OFFICE OF
E. F. McDONALD, JR.
PRESIDENT

To: Manpower Authorities, Employers, Physicians,
Parents, Teachers and Hard of Hearing.

Our country's manpower crisis calls for everyone's maximum efficiency. Since I lost the hearing of one ear in an accident twenty years ago, I have been acutely conscious of the handicaps of the hard of hearing. While pioneering in radio I have for some years directed Zenith's research toward development of the best wearable hearing aid that science could produce.

My own company has spent millions, the radio industry tens of millions for research. This research has been paid for by scores of millions of purchasers of radio sets.

We, with this technical knowledge and engineering skill, now bring to the hard of hearing a new precision aid — the ZENITH RADIONIC; an instrument of the highest quality.

A hearing aid is essentially a part of a radio receiver. It wires the human body for sound. It is composed of a crystal microphone and parts of a radio receiver set reduced to miniature size and manufactured with watch-like precision. For many years it has seemed to me incredible that the public could buy a complete radio receiver for $29 or less with which they could hear the words whispered in Europe, Asia, or South America, but people with deficient hearing have paid $100 to $200 for a comparably good hearing aid to hear the human voice across the room.

Zenith's facilities and methods for precision mass production of radio sets, Radionic devices, etc., enable it to bring this superb hearing aid within the reach of all.

Eye-glasses, like hearing aids today, were once the luxury of the few. What the optical companies have done to make the finest spectacles available to everybody at low cost, Zenith is now prepared to do for the hard of hearing — to bring with the aid of modern radionic science a highly perfected hearing aid within the reach of the masses.

ZENITH RADIONIC — low cost battery upkeep wearable hearing aid — complete with miniature radio tubes, crystal microphone and batteries — will sell for $40 — about one-quarter of the price of the better vacuum tube instruments of today. Hereafter no one, child or adult, need be without a hearing aid because it is too high-priced. There are ten million people, of whom over three million are children in our schools who are hard of hearing.

Even if Zenith never makes a dollar at this low price, it is willing to take its pay in the good will of the hard of hearing, their families and their friends. Thus begins a revolution in hearing aids — a revolution to "lower the cost of hearing" within the reach of all.

E. F. McDonald Jr.

President,
Zenith Radio Corporation

Write for Free Descriptive Booklet

ADDRESS DEPT. SA-1, HEARING AID DIVISION

ZENITH RADIO CORPORATION ★ CHICAGO 39, ILLINOIS

ZENITH
•LONG DISTANCE• RADIO
RADIONIC PRODUCTS EXCLUSIVELY—
WORLD'S LEADING MANUFACTURER

Air-driven reamers truing holes in ship construction

controls are operated by thoroughly dried air. Dry air is necessary to insure performance of controls in the lowest sub-zero temperatures.

Compressed air is also used to operate many safety appliances in machine shops.

In shipbuilding, aircraft construction, ordnance, and other industries doing war work, the contribution of compressed air in saving of production time has been most spectacular. The foundry molding machine revolutionized the production line in the automobile industry. In the early days of the industry completion of three or four engine blocks by hand was a day's work for a molder and his helper. Today a pair of molding machines operated by two men can turn out large automotive engine blocks at a rate of one a minute. These machines are operated by compressed air, which jolts, rams, and squeezes the molding sand, not only many times more quickly than hand labor can possibly do it, but also more uniformly and more precisely.

The aircraft and shipbuilding industries use immense volumes of compressed air to operate hand air drills, grinders, riveters, impact wrenches, vises, automatic chucks, and expanding arbors. Modern pneumatic tools are light and compact, and they pack a lot of power for their weight and volume. Highly flexible, they can be used for long hours without fatiguing the worker. Portable compressed air hammers are designed to drive rivets from the very tiniest to giants 1½ inches in diameter. Pneumatic hammers can deliver as many as 10,000 blows a minute.

In these and related industries, air pressure is necessary in die forming and molding operations for the ejection of metal parts from the dies. Compressed air is used to obtain and control the proper pressures between electrodes in welding machines. Compressors make a large contribution in the storage of oxygen, acetylene, and other gases for welding and many other vital operations.

One of the more recent applications of gases under pressure is in "metallizing" worn machine parts, a process which is also used for adding metal to surfaces to prevent corrosion. The molten metal is sprayed onto the part under treatment, as shown on our cover.

As the potential supply of high-grade iron ore on or near the surface of the ground in the United States diminishes, more and more underground mines open up. On the surface the iron ore is scooped by steam shovels, but when it comes from underground, the ore bodies must be drilled and blasted. This requires compressed air for drilling on a large scale.

Just as compressed air must accompany men underground for the recovery of valuable ores, so it also must accompany men under the water for the recovery of sunken ships. Salvaging of ships requires compressed air for diving suits and other appliances to aid in bringing engines, cargoes, and sunken hulks to the surface. Salvage crews of the United Nations are recovering engines, reconditioning them, and giving them new jobs in ocean transportation.

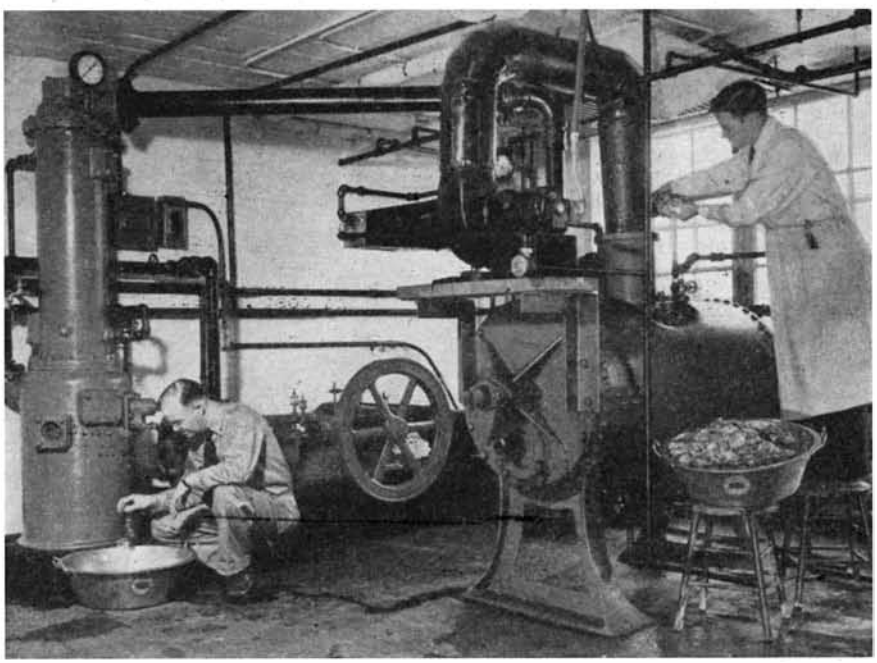
Compressed air hammers are used in breaking rock and tamping concrete. Large volumes of cement are transported to construction jobs by means of air that forces the material through pipelines. Air compressors are transformed into vacuum pumps to draw excess water out of poured concrete to speed the work and improve the quality.

The huge chemical industry upon which the world depends for synthetics, for basic materials for plastics, for explosives, and for many other valuable products, uses air and gas in many degrees of pressure, from the highest pressure to the greatest vacuum. Vacuum pumps make possible the production of some vitamins, valuable for the maintenance of nutrition. Distillations are carried on in many degrees of pressure. The industry uses air pressure in filtration and agitation of liquids, in flotation processes, and in numerous other applications.

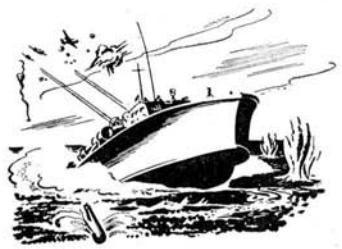
Before the war ends, this country will have sent hundreds of millions of pounds of dehydrated food to our soldiers, sailors, and marines and to people needing relief in many lands. Blowers and fans are used to drive the air which removes the water from the food.

The electrical industry is constantly using compressed air and trying out new and often important applications. In their research they have developed circuit breakers using compressed air, to protect high potential lines from dangerous shorts. Six-hundred-mile-an-hour wind gusts are being applied in 22 circuit breakers to protect the electrical equipment at a large new steel mill in the West.

The nation's railroads probably have the highest number of different applications of compressed air of any industry. It is used for starting fires in coal-burning locomotives, as well as in the superchargers of the new oil-burning Diesels. It operates pneumatic hammers and drills, cleans flues, calks boilers and tanks, operates air hoists, lifts, and jacks; operates turntable motors, drills holes for bond wires, places and removes track nuts, operates third-rail ice scrapers, delivers sand and fuel to locomotives, lays new tracks, cleans switches, operates crossing gates as well as switch and signal systems, operates sand blasts for removing paint, cleans castings and so on, operates pneumatic sand rammers, sprays paint and white-



Vacuum pumps are used in some processes of food dehydration, a rapidly growing industry. Shown is an experimental pork-dehydrating set-up, with vacuum pumps



Fresh food on the high seas during long, heavy-action periods away from port is the result of compact, efficient refrigeration.

Self-Contained
¼ h.p. Refrigerating Unit

Cool, clean air protects the life of the wounded in Army hospitals. Special aircraft refrigerators safeguard serums and plasma.

Aluminum
Aircraft Refrigerator

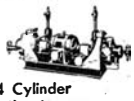
Peak welding efficiency is made possible by cooling of welding tips with water or brine held at the right temperature.

Spot Welder
Tip Cooling Unit

Tool life is increased and rejections are fewer when cutting oils used in high-speed machining are properly cooled.

Refrigerating Unit

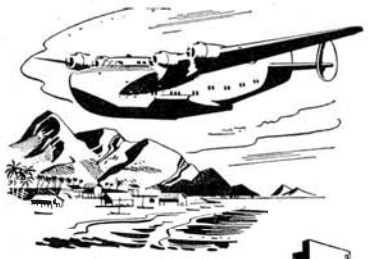
The health of our armed forces is protected by dependable refrigeration in cantonments, huts, barracks, and on ships.



14 Cylinder
Refrigerating Compressor

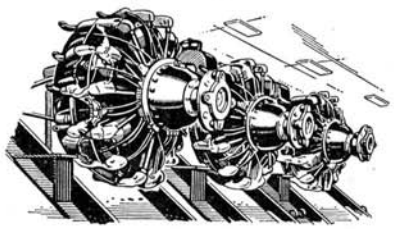
Super accuracy in gauge rooms is possible when the air is clean, dehumidified, and maintained at a constant temperature.

3 h.p. "Packaged"
Air Conditioner

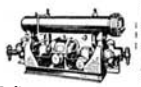


Protection in the tropics against the ravages of humid atmosphere and vermin is necessary to preserve food and equipment.

Portable Panel
Refrigeration Unit



Identical performance of aircraft engines is assured by operation tests with carburetor air kept at the same temperature.



14 Cylinder
Air Conditioning Compressor

Clean, dry atmosphere is vital for machining sensitive metal surfaces where a spot of rust would ruin high-precision products.

5 h.p. "Packaged"
Air Conditioner

★ CHRYSLER AIRTEMP AT WAR ★

From tiny, fractional horsepower to big 75 horsepower units, Chrysler Airtemp Radial Compressors are performing a major war job on both the production and battle fronts.

The science of air control is built around the compressor. Chrysler Airtemp's *exclusive* Variable Capacity Radial Compressor provides a new efficiency and accuracy in indoor climate regulation. The radial cylinders cut in or out automatically, one at a time, to meet varying load requirements. This flexibility eliminates the peaks and valleys resulting from abrupt starting and stopping of ordinary compressors . . . holds temperature and humidity at a constant level.

Years spent in building delicate mechanisms, have developed high-precision, versatile skills at Airtemp, now devoted to war production. Backed by Chrysler Corporation research and engineering, when peace comes, these skills will again create heating, cooling and refrigeration units for homes and commercial use that will set new, high standards of efficiency and performance.

The lessons learned during peace in free competitive enterprise—freedom of the individual to produce and compete—today bring strength to a nation at war.

War Products of Chrysler Corporation

Tanks • Tank Engines • Navy Anti-Aircraft Guns • Army Anti-Aircraft Guns • Bomber Fuselage Sections • Bomber Wings • Bomb Racks • Bomb Shackles • Fighter Landing Gears • Aluminum Alloy Forgings • Aluminum Alloy Castings • High-Powered Aircraft Engines • Cycleweld Cement • Wide Variety of Ammunition • Anti-Tank Vehicles • Command Reconnaissance Cars • Troop and Cargo Motor Transports • Ambulances • Weapons Carriers • Gyro-Compasses • Navy Pontoons • Marine Tractors • Harbor Tugs • Marine and Industrial Engines • Smoke Screen Generators • Air Raid Sirens and Fire Fighting Equipment • Powdered Metal Parts • Cantonment Furnaces • Tent Heaters • Refrigeration Compressors • Field Kitchens • and Other Important War Equipment

Tune in Major Bowes every Thursday, C B S, 9 P. M., E. W. T.

Chrysler Corporation

PLYMOUTH • DODGE • DE SOTO • CHRYSLER • AIRTEMP • AMPLEX

BACK THE ATTACK—BUY WAR BONDS

Air-driven grinding wheels speed up the nation's industrial war effort

wash, cleans cars and car furnishings, transfers oil, pumps water, sets valves, screws up flash plates, drives nails and spikes, bores wood, tamps ties, pulls spikes, operates pneumatic saws for trimming car roofs and for other construction, straightens rails, and forms and cuts grease wafers.

In many places where danger from sparks makes electricity or steam impractical as motive power, compressed air is used to operate locomotives and ammunition hoists, as in ammunition depots. In gas plants, such as those where highly explosive acetylene is generated, compressed air is used in hoists and motors. It also operates doors on heat-treating furnaces where the temperature runs high enough to burn up electric motors.

As additional examples of its versatility, compressed air is used for agitating pickles in canneries; building tunnels under rivers; regrooving tires; spraying colors and enamels on porcelain before firing; moistening tobacco in cigar and cigarette factories; pumping milk in dairies; carving wood in furniture factories; molding, pressing, blowing, and etching glass in glass factories; unloading logs in lumber plants; starting and maneuvering motorships; lifting oil and gas in wells; fabricating news print in paper mills; mixing drugs in pharmaceutical manufacturing; stopping fires in gas mains; pumping brine in salt wells; handling scenery in theaters; and bending wood in woodworking plants.

All in all, the free air of nature has been harnessed by man to do a wide variety of jobs, many of which have been fostered by the impetus of war production, yet will remain as industrial time and labor savers in days of peace.

⊕ ⊕ ⊕

SOUND CONDITIONING

Reduces Interference With Efficiency

TWENTY machine operators and their machines, hard at work in a busy war plant, have to produce a good deal of noise, but 20 typists and clerks, working in the adjoining room, don't need to have their concentration interrupted by the unavoidable racket next door.

This has been demonstrated in many factories where sound conditioning, long used in auditoriums, schools, office buildings and other structures, has been installed.

Statistics gathered by The Celotex Corporation show that well-planned use of sound conditioning not only lessens the general uproar of a busy plant but creates islands of quiet in thoroughly sound conditioned rooms where workers, whose job does not require noise, may work without disturbance.

Bell Telephone Laboratories estimate that noise which cuts into an average worker's efficiency by 5 percent will lower an executive's output by 30 percent.

SECTION-BUILT

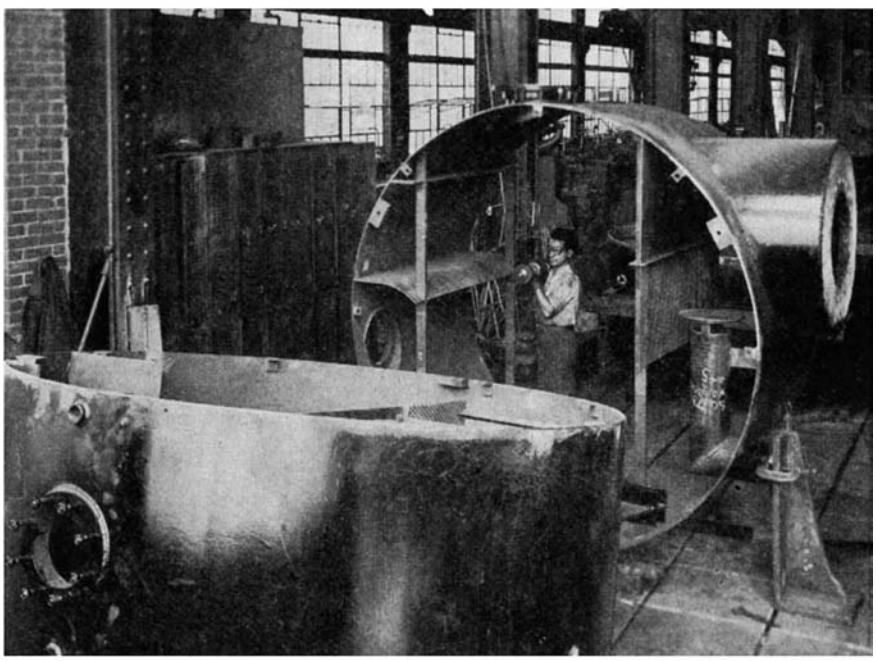
Deaerating Heater Unit Welded on the Job

IT IS seldom that the interior of a deaerating feedwater heater is visible to the purchaser who installs it in his plant. But because of unusual installation problems, the accompanying photograph could be taken, showing the middle section of a 350,000 pound-per-hour horizontal unit, and revealing the bracing, baffles, overflow pipe, and steam inlet connection.

Ordinarily the shell of a feedwater heater is made in one piece. In this case, however, the completed unit was too big for available openings in the existing power plant of a large automobile factory where it was to be installed as part of the expansion necessitated by a conversion to war work.

Faced with the problem of elevating the heater over outside coal bunkers and carrying it in through a steel window frame only 6 feet high and 18 feet wide, Elliott Company designed the unit in three sections for welding together on the job.

The heater was installed in the customer's boiler room at considerable elevation above the pump, where ample room was available for a unit that could be handled sectionally.



The workman is grinding a weld on the center section of a deaerating heater

BIOLOGICAL MINING

Offers Interesting Possibilities for Future Metal Supplies

AS CONCENTRATED minerals are made into manufactured articles and spread over the face of the earth we may wonder how future generations are going to obtain iron, aluminum, and the other elements of which economical production depends on the availability of concentrates. Part of the answer already exists in the commercial success of extraction of magnesium and bromine from that ultimate of dissipation, the sea. The reconcentration of other elements may not be feasible by chemical methods, and biological methods may perhaps be the answer to the problem. [Another angle of this "reconcentration" problem is dealt with in the article on page 7 of this issue.—*Editor.*]

Manganese, an important element in high-grade steel, is obtained from large deposits of pyrolusite, which some day will be exhausted. There remain large deposits on ocean floors, the exact origin of which is unknown. One hypothesis suggests that these deposits may have been formed by the remains of animal organisms which had manganese instead of iron in their tissues. Even land deposits of pyrolusite may have had their origin in the life cycle of marine animals in prehistoric seas.

The skeletons of many species of diatoms are finely divided pure silica. Oyster shells form an immense reserve of pure calcium carbonate. Some radio-

larians (*Acanthometron*) have shells of strontium carbonate instead of the usual calcium carbonate. The amount of strontium in the ocean has not been determined, yet these animals have power to obtain it in high purity. Vanadium is another element concentrated by an ascidian, and by a holothurian (sea slug) found off the Cornish coast. Iodine, although present in very minute traces in the ocean, is concentrated in certain seaweeds and has been extracted commercially from the ash. Seaweed is used in Ireland as a fertilizer because of its high concentration of potassium, a necessary fertilizer ingredient.

The blue blood of lobsters and king crabs is due to the presence of copper instead of iron, and organic copper salts in marine organisms are of great use in treating pernicious anemia. Arsenic, too, is found in several of the ocean crustaceans.

Another well-known example of biological mining is the plant *Astragalus pectinatus*, which takes up selenium from the soil. Selenium has little economic value, and this phenomenon remains merely a scourge on animal raising on selenium-containing soil. There is also geochemical interest in the concentration of radioactive mesothorium by a pond plant.

Plants which extract gold have been used in prospecting in Colorado to locate veins. Millions may be awaiting the biologist who develops a seaweed which likewise uses gold in its tissues. A sea organism which concentrates tin would be of more intrinsic value today, and is not entirely out of the question because there is a certain species of yellow violet which grows only where it can get tin.—*Industrial Bulletin* of Arthur D. Little, Inc.

RADIO HEAT

Proving its Usefulness In Many Ways

Some war production operations have been speeded up by as much as 2500 percent by the use of electronic devices for industrial heating, according to Henderson C. Gillespie of the RCA Victor Division, Radio Corporation of America. Addressing the 587th meeting of the New York Electrical Society, Mr. Gillespie cited the experience of several firms in the aircraft and plastics industries.

One electronic device stepped up the soldering of bases of radio condenser cans from 100 cans an hour to 2500. In addition to soldering, and the pre-heating of wood and plastics for molding, radio-frequency heating has proved its advantages in terms of improved products and savings of time, space, and labor for case-hardening, annealing, and welding of metals, baking paint, tacking plywood, seaming thermoplastic fabrics, drying textiles, and other industrial operations.

By comparison with flames and other usual sources of heat for industrial processes, radio-frequency heating is not only quicker but also permits closer control as to the area to be heated, provides more uniform heating, and for many processes is more efficient and more easily adapted to mass production methods.

The degree of control is illustrated by the fact that one end of a set screw can be brought to a white heat while the other end remains cool. This is an advantage in the manufacture of many machine parts which function best if one portion is case-hardened while adjacent areas remain unhardened.

AMPLIDYNE

Puts Electrical Short-Circuits To Useful Work

The short circuit—often blamed for knocking out lights in homes and huge apparatus in power stations—is now increasing the maneuverability of guns on planes and ships and speeding the output of armor plate and other products of war industry.

The short circuit and a coil arrangement known as a compensating field winding are features of a General Electric development, the amplidyne—a simple rotating unit which resembles a motor or generator. The device can pick up small whispers of electric signals and magnify them instantly into powerful commands to large machines

The amplidyne was developed by Dr. E. F. W. Alexanderson and other G-E engineers just before war broke out in Europe. Now, a typical amplidyne assignment is controlling guns in aircraft turrets. Although one man could not, by himself, maneuver guns

Alexanderson and amplidyne

against the terrific wind resistance encountered by a plane flying 400 miles an hour, with the amplidyne he controls fire power as deadly in the air as a machine gun battery on land, and with the same ease as he would sight a rifle on a target range.

Already the amplidyne is in successful operation on fire-control equipment aboard ships, on anti-aircraft guns, and on searchlights both ashore and at sea.

Here are some of the industrial applications of the amplidyne:

Mining: Installed on the world's largest power shovel, the amplidyne is simplifying control and maintenance. On hoists which bring coal from depths of several hundred feet, the amplidyne is also adding to the output of vertical coal mines.

Steel mills: One of the first operations in steel production requires the loading of iron ore and other materials into blast furnaces. The amplidyne enabled one blast furnace skip hoist to produce 49,705 tons of pig iron in a month—a world's record.

Hundreds of other applications of amplidynes have been made in the armed forces and throughout industry, all of which can be expected to play equally important roles after the war.

GUN-DIRECTOR

Practically Eliminates Human Errors for Anti-Aircraft

AN OUTSTANDING development in Army ordnance was shown recently when the Army and Bell Telephone Laboratories jointly demonstrated the Electrical Gun-Director. As an Army plane overhead simulated a bombing run, observers noted that four guns of an anti-aircraft battery were following the plane, without manual operation by their gunners, and that they were trained not at the plane but at a point ahead of and above it. Seated at a sizable metal box mounted on a pedestal, observers with eyes glued to telescopes kept the cross-hairs trained on the plane. Both telescopes turned vertically; and also, along with the box and the observers, they turned horizontally. By another instrument, the plane's distance was measured. After the plane had been "tracked" for a few seconds, the fire-control officer gave the command "Fire!"; the shells for each gun were pulled out of their individual fuze-setters, where their burst had been timed under the control of the Director; immediately and automatically rammed home, and the breeches closed. The guns were not fired but if they had been the shells would have travelled on a path converging with that of the plane, and would have exploded within lethal range of it. Officers who had seen the set-up used against a target said that instead of an occasional hit, the target sleeve was invariably torn to ribbons by a salvo of four guns.

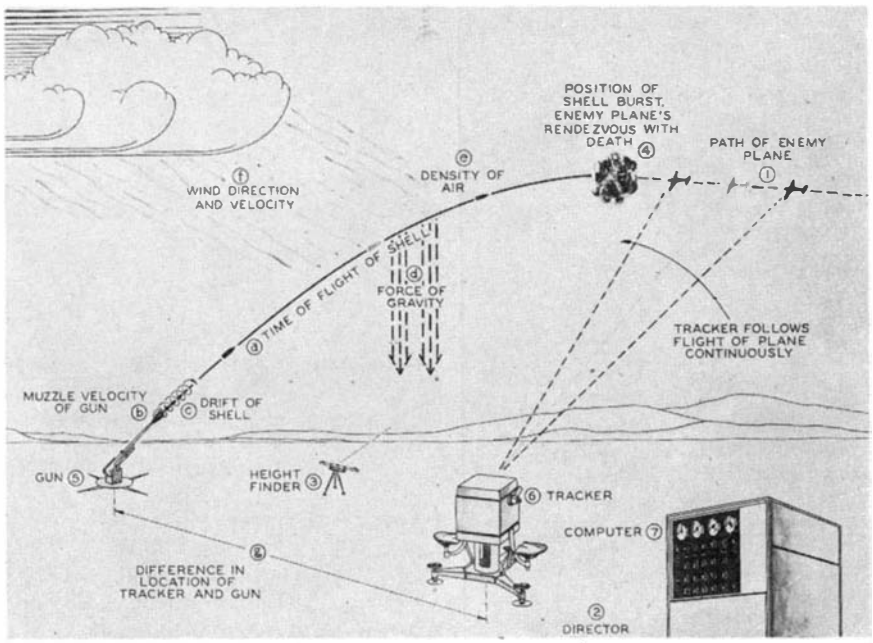
For such fire control consideration must be given to the distance and course which the plane will travel during the several seconds while the shell itself is in flight, as well as to direction, shell velocity, direction and speed of wind, and air density. As the telescopes follow the plane, the Electrical Director gathers information from which it predicts just where its target will be when the projectile reaches it, assuming that the plane flies a straight course as precision bombers must. The Director then selects, with the aid of its built-in ballistic tables, a direction and angle of fire, and a fuze setting, which bring the shell to its rendezvous with the plane and explode it there.

In the art of ranging on a moving object, the Electrical Director has solved the difficult problem of compensating for the errors introduced by the human element. There is a natural tendency for the observers to permit the target to stray from the cross-hairs in the telescopes. Realizing that this has occurred, the observer attempts a quick recovery which may be interpreted as a change in the speed of the target. If this information were used, the gun would quickly change its lead to fit the false rate of speed. Engineers of the Bell Telephone Laboratories have invented a brand new method by which the momentary fluctuations are averaged out, and the Electrical Director considers only the smooth rate reported over a period of several seconds.

COAL-IN-OIL

May Have Effect on Fuel Shortages

SAVING of many lives of men on torpedoed ships, as well as a large impact on problems of fuel shortage, will result from the use of coal-in-oil fuels, one of the newest combustion developments growing up since the war, John V.



How the Electrical Gun-Director works. When an enemy plane (1) looms in sight, the crews of the tracker (6) and of the height finder (3) spot the target and follow it. The computer (7) of the Electrical Director (2) instantly measures the position of the target and then predicts where the anti-aircraft gun (5) is to be aimed and how the fuze of the shell is to be set so that the shell will burst at the predicted plane position (4). Not only does the computer make its calculations continuously while the target is being tracked but it makes constant and continuous corrections for a number of factors. The time of the flight of the shell (a) to the predicted position of the plane is dependent upon the muzzle velocity (b) which, in turn, is governed by the temperature of the powder and the number of times the gun has been fired. The shell's path is also influenced by the drift (c), caused by the spin of the shell. At the same time the pull of gravity (d) deflects the shell downward and the varying density of the air (e) slows down the projectile more or less. The direction and velocity of wind also have their effects (f), retarding or speeding the shell or forcing it to one side. To add to all these variables which the Director must take into consideration, the distance between the gun and the tracker (g) must enter into the final solution of each anti-aircraft directing problem

Pyle recently told members of the American Society of Mechanical Engineers.

Mr. Pyle, manager of the steam division of the Kennedy-Van Saun Manufacturing and Engineering Corporation, described how his company began experiments with "colloidal fuels"—pulverized coal mixed with oil—in 1928, dropped them because fuel was plentiful, but renewed its experiments when the war brought on the fuel crisis.

The saving of lives of men on torpedoed ships will result from the fact that, mixed with carbon, the oil does not remain on the water's surface. Hundreds of lives, lost because men plunged from sinking ships into seas of burning oil, might have been saved through use of this fuel, Mr. Pyle said.

In mixing the pulverized coal with the oil, it is ground "finer than ladies' face powder." It is estimated that 100 million tons of coal waste are discarded annually in the anthracite coal regions of Pennsylvania alone, because this coal has been regarded as too fine for use. The ultimate goal is to reclaim all this wastage.

LUBRICATION IMPORTANCE

Stressed as a Means of Speeding Production

LUBRICATION engineers, who once devoted their efforts to selling industrial lubricants, are now engaged in a battle against friction, heat, cold, speed, dust, dirt, moisture, and water in the nation's war production factories, the Standard Oil Company of New Jersey revealed recently in outlining some of the unusual ways in which these specialists have speeded up war production through eliminating costly shutdowns, preventing undue wear of manufacturing equipment, and cutting down waste and inefficiency.

These specialists study the nation's war machines in actual production, test them to determine if they are operating efficiently, check speed and power output, analyze oils and greases used in their operation, determine gear-operating temperatures, take plaster impressions of gear teeth to determine the extent of gear-tooth wear over given periods and, through engineering analysis, trace causes of shutdowns and breakdowns which, if permitted to continue, might well seriously slow America's output of war materials.

One lubrication engineer not long ago found reduced production in a plant making shells. The delay was caused by the breaking of a die in the shell-nosing department. The trouble was traced to the use of an incorrect die lubricant. When a new compound was employed the shutdowns ceased and production rose substantially.

In a chemical plant making phosphorous for flame throwers and incendiary bombs, production was delayed by faulty lubrication of bearings of the conveyor which carried raw materials to the furnace. The lubrication engineer found that the bearings, subjected to high temperatures, burned out because of an unsatisfactory lubricant. He suggested a high melting point grease. This ended the shutdowns and brought about increased production.

A Pennsylvania machine shop's contribution to the war was the manufacture of small parts for gliders. Production lagged because in one turning operation the workers could obtain only one piece per tool grind. A lubrication specialist found that the plant was using a cutting oil which was too heavy and lacked sufficient compounding. A transparent cutting oil was substituted and the same machine not only produced 20 pieces per tool grind, but the transparency of the product also enabled the operators to see their work at all times.

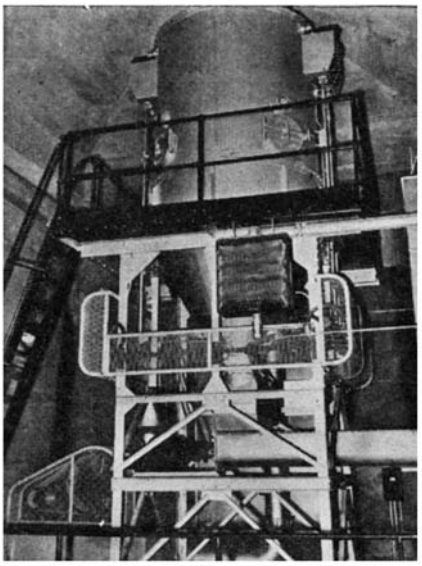
These specialists never know just where they will find trouble nor can they forecast the results of their inspection and study of production problems. The problems they encounter and solve frequently have baffled production experts and their work takes them into a wide variety of fields.

PNEUMATIC UNLOADING

Conveys Chemicals from Cars to Storage Bins

TYPICAL of what may be accomplished by the use of compressed-air materials handling equipment, operating either above or below atmosphere, is a pneumatic system for unloading and conveying chemicals at the Municipal Water Plant, Lansing, Michigan.

The system makes use of a positive



Filter and exhauster at water plant

pressure blower used as an exhauster to produce a partial vacuum that picks up various chemicals from cars and delivers them into a receiver and filter.

The conveying duct is carried underground some 180 feet with a vertical lift of 70 feet to the receiver located above and adjacent to the storage bins.

According to the Compressed Air Institute, this system unloads and conveys to storage bins lime, soda ash, and alum at the rate of 10 tons per hour, with a minimum of labor used to handle the hose in the car, and with complete control and retention of dust. The conveying duct is carried up within the building, taking a minimum of space at the various floors. Similar systems using compressed air equipment, because of their flexibility, may be utilized for the handling of any dry, finely divided, granular or lumpy material.

WELDING TOMORROW

Will Touch Every Human Endeavor

THE GROWTH in arc welding has been so phenomenal in the past three years that it has become "one of the great hopes for rebuilding our war-shattered world," and may revolutionize many aspects of modern living, says J. R. Morrill, Assistant to the Vice President of the Lincoln Electric Company.

"In the world of tomorrow it is not difficult to conceive of new petroleum fuels for power or even atomic power made available and harnessed by arc-welded pressure vessels. The present arc-welded magnesium flying wing indicates possibilities for new methods of transportation. Welding may change the entire world of agriculture by making possible food processing equipment at the site of growing and harvesting. Our clothing is inevitably related to the world of synthetic chemistry to which arc welding is making contributions. Welded skyscrapers and buildings, and prefabricated welded bathrooms and kitchens for the dream shelter of tomorrow are already on the drawing boards.

"Arc welding has grown from a simple repair tool to where few products or structures made of metal are without welds in one form or another—from all-welded ships weighing thousands of tons to clusters of aircraft tubing made of material 25/1000 of an inch in thickness."—*American Society of Mechanical Engineers.*

FLUX-GATE COMPASS

Works Near Earth's Poles, Opens New Navigational Possibilities

TWO BLIND spots on the earth's surface totalling nearly 10,000,000 square miles have been opened up to air travel by one of the most dramatic scientific achievements to come out of the war. Anywhere within 1200 miles of either of Mother Earth's magnetic poles, magnetic compasses begin to jive and planes enter a shadowy no-man's-land of lost ships. Around the North magnetic pole this no-man's-land takes in half of Greenland, the northeast corner of Alaska, and most of Canada down to within 250 miles of the United States-Canadian border at one point.

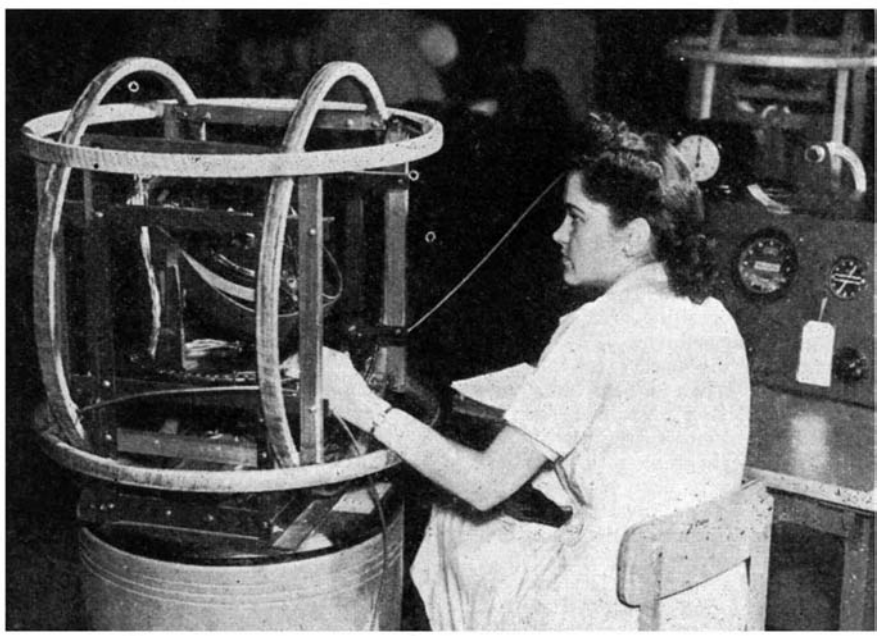
Now, with the gyro flux gate compass, developed by engineers of the Bendix Aviation Corporation, this area has been opened for the fast shipment of war materiel to our Allies and for trans-polar transportation after victory is won. Thus the air freight and passenger routes between continents is shortened by thousands of miles, cutting many travel hours off future weekends in Vladivostok or Christiana.

Three years ago the War Department asked Bendix — manufacturers of Pioneer instruments — to develop a compass that would work in the polar regions. Scientists of the corporation's Eclipse-Pioneer Division gave them what they asked for — and a lot more. The new compass permits accurate navigation near the poles and, as an added feature, will not lose its "heading" when the plane goes into a steep dive, climb, or bank. In place of a compass card that "hunts," oscillating with every movement of the ship, the needle of the new instrument points the plane's direction steadily on a dial. In a bomber, as many dials as are needed are provided — for pilot, co-pilot, and bombardier — each of them synchronized with the master dial or "mechanical brain" on the navigator's work table. With this equipment a navigator can plot a course to almost any spot on the earth's surface with unprecedented accuracy.

The gyro flux gate compass is a far cry from what was for thousands of years the principle of all compasses — the simple magnetized needle that, answering the pull of the earth's magnetism, seeks North. It dates back vaguely to the "earth induction" compass that Pioneer developed in 1927, but it has grown into a complicated partnership of mechanical units, the result of intensive research.

Heart of the new compass is the "flux gate" itself which consists, essentially, of three double-wound electromagnets, forming the sides of an equilateral triangle. One of the coils

Demonstration model that shows the operation of the flux gate compass



Making final accuracy tests on a unit of the flux gate compass

on each magnet is for the purpose of excitation and is connected to a power source. In the other is generated a fluctuating current as the compass cuts the lines of force of the earth. By the use of the three magnets, properly placed, different voltages are generated in each, according to the angles at which the lines of force are cut. Thus the basis of the indication on the compass dial is the combination of the angles and hence of the voltages generated. The resulting current, amplified by vacuum tubes, is stepped up to sufficient power to turn a motor, the shaft of which moves the needle of the dial. A gyroscope spinning at 10,500 revolutions per minute holds the little flux gate level with the earth. The gyro flux gate unit, however, is not related to the gyroscopic compass used on ships. It is entirely different in principle.

Joint authors of the new compass are engineers Alfred Stuart, Paul Noxson, John Emerson, and Don Smith, who worked under supervision of W. A. Reichel, Pioneer's director of engineering.

The War Department has decided that the secret of the new compass can now be told, for though the Germans know about it and have tried to copy it, they simply cannot do the job.

RESEARCH

Defined, With a Glance Into the Future

THE PHILOSOPHY of a dynamic economy, perhaps, finds its best expression in the field of research In its broadest sense, research means seeking for better ways of doing things by the most effective use of resources, facilities, and manpower. The spirit of research dispels smugness and constantly searches the unknown in the quest for new and broader opportunities for all. That great practical achievements have been attained is evidenced by the fact that one third of the persons employed prior to the war were in industries that had been created by research in the course of the preceding quarter of a century. The new techniques and tools developed in wartime will have widespread peacetime application. By using the available facilities we can magnify our productiveness, open up new frontiers, and pilot into constructive channels the dynamic and irresistible forces now in motion.

There is no end to progress, for human wants are insatiable and can be fulfilled at an encouraging rate if we but use intelligently the instruments of creation and the vast storehouse of accumulated scientific knowledge at our command.

The shape of things to come will depend in large measure upon how wisely we plot our course. No nation has become great by clutching at security or by clinging tenaciously to the past, but rather by boldly venturing into new fields of experimentation and exploration, and by providing rewards commensurate with the risks involved. We should revitalize our enterprise system all along the line so that we may most effectively muster our strength to meet the challenge before us.—*New England Letter* of The First National Bank of Boston.

FIRE PREVENTION

More Important than Fire Fighting

THE MODERN trend in the use of chemicals for the control of fire emphasizes prevention rather than fire fighting, says H. L. Miner, manager of the Du Pont Company's Safety and Fire Protection Division and past president of the National Fire Protection Association.

Mr. Miner points to recent accomplishments of research in flameproofing everyday materials, noting that paper, cloth, and wood now can be chemically treated to make them incapable of spreading flames. Lumber is being fabricated in large quantities, chemically made so fire retardant that it is classified on a combustibility scale closer to asbestos than to ordinary wood. A recent Underwriters' Laboratories report on this new type of building material states that fire resistance is achieved in proportion to the amount of the chemical—chromated zinc chloride—deposited in the wood.

"Practically all kinds of paper and cloth, including the sheerest fabrics, may now be chemically flameproofed," Mr. Miner says. "Treatment is so effec-

tive that it is impossible to set such textiles or paper on fire. In fact, no afterglow occurs following the use of a new fire retardant based on ammonium sulfamate. Today production is almost entirely devoted to protective garments for the armed forces and for war workers. It will render great service in safeguarding life and property in peacetime.

"Research work is in progress in our laboratories to produce fire retardants of a permanent nature," he states. "It is no longer necessary to re-treat frequently except after laundering, nor need retardants alter the appearance or stiffen fabrics. But retardants that are sufficiently economical and available today to warrant wide usage still are soluble in water. We hope to have better ways of transforming the inherently flammable nature of those many common things that supply the kindling for destructive fires in industry, in public places, and at home."

BOMB FUZE TESTS

Conducted in Miniature High-Speed Wind Tunnel

A THREE-FOOT-LONG wind tunnel which creates 300 to 800 mile an hour gales to simulate the wind currents encountered by falling bombs has been developed by Westinghouse engineers to test fuzes for 20-pound fragmentation bombs, according to A. L. Atherton, Manager of Quality Control, who first applied the wind-tunnel tests to these fuzes.

"To protect our aircraft which drop them," continued Mr. Atherton, "these bombs are equipped with safety fuzes —small cylindrical devices installed on the bombs' noses. By timing release of a firing pin during descent of the bomb, the fuze prevents premature explosion.

"Only when the vane of the tip of the fuze has revolved a pre-determined number of times will the bomb be ready to explode on impact. Revolving of the vane loosens a safety device which in turn releases the firing pin to strike explosive portions of the bomb when it hits the ground. Unless the fuze releases the firing pin, the bomb will be a dud."

To maintain a constant check on the

Man-made gales test bomb fuzes

quality of fuzes produced, a certain number are taken each day from the final assembly line and tested in the wind tunnel. Their performance is measured by the speed in "arming," or releasing the safety devices. To pass the wind tunnel test, a fuze synthetically "dropped" at 250 miles an hour, 500 miles per hour, and 800 miles per hour must arm within a pre-determined length of time.

To test a fuze, a laboratory technician places the fuze inside the narrow three-foot-long tunnel. Then the technician presses a button which starts an automatic timer and opens a magnetic valve. As the valve opens, a burst of air rushes from the tank through a reducing nozzle to the fuze, whirls its vane, and releases the safety device. As the safety device flies off, it permits a beam of light to strike a photoelectric cell. This causes the cell to electronically close the valve and stop the timer.

Speed of the wind created for each test is determined by measuring the change in the tank's pressure and the time that the valve is open. "Arming" time of each fuze is measured by the automatic timer in intervals as small as one hundred-and-twentieth of a second.

MOSQUITO BOMB

Uses Material from Household Refrigerator

USE OF a "mosquito bomb" in mechanized warfare against diseases means certain death to malaria and other fever-carrying mosquitoes. It contains a mixture of pyrethrum extract and sesame oil which is vaporized and ejected under pressure by Freon, a refrigerant used prior to the war in many household mechanical refrigerators.

Used in the "mosquito bomb," Freon produces a high-pressure spray which saturates the tent or dugout of a soldier, tracking down and killing every last mosquito in the area. The soldier can then enter, secure in the knowledge that no malaria mosquitoes are alive. The insecticide, moreover, while bringing sudden death to insects, is harmless to human beings.

Freon was invented by Dr. Thomas Midgley, Jr., vice president of Ethyl Corporation, and is used in refrigerating and air-conditioning equipment. It was not until comparatively recently that its strange new war role was discovered.—*Ethyl News.*

MILDEW PREVENTION

Inexpensive Treatment in Manufacturing Mildew-Proofs Many Products

A NEW technique called the Puratized process, employing a revolutionary chemical formula for the prevention of mildew in paper, paints, plastics, leather, textiles, and rubber, has been developed which effectively renders manufactured products antiseptic and prevents growth of micro-organisms that are causitive agents of mildew. The process can be easily modified to meet specific requirements in many industries. Introduced in early manufacturing stages, no additional plant equipment or extra processing are necessary for its application.

The spores of the fungi which cause mildew are air-borne, either floating freely or attached to particles of dust, and it is difficult to combat them successfully in this state. When they alight on wallpaper, upholstery, carpets, draperies, freshly painted surfaces, leather, fabrics, and other substances on which they can put out roots, the surface becomes contaminated in short order. Treating the material with an ordinary antiseptic is largely ineffective; the antiseptic will kill only existing micro-organisms but will not act as a permanent repellent. The phenols, such as carbolic and cresylic acids, while effective, may not be used on fabrics that are intended to be worn next the skin as they are both irritating and toxic; not being water-resistant their potency is short-lived and is lost when the goods are washed or dry cleaned. By incorporating the new process during the manufacture of susceptible materials, however, not only are micro-organisms killed which may be present at the time of treatment but the material is rendered lastingly immunized,even after washing or cleaning.

Dr. Frank J. Sowa, research chemist for Gallowhur and Company, Inc., manufacturers of the Puratized process, after surveying the problems involved in rendering fabric antiseptic as well as imparting lastingly bacteriostatic and fungistatic qualities, determined that the chemical formula required should be such that lasting mildew-resistant properties would be imparted to military fabrics under conditions of field use and, in the case of civilian goods in the post-war era, the treated material would be able to meet all climatic and storage conditions and yet be free from toxic or irritating properties.

Dr. Sowa's formulations—there are six variations—have been exhaustively tested.

Not at present generally available

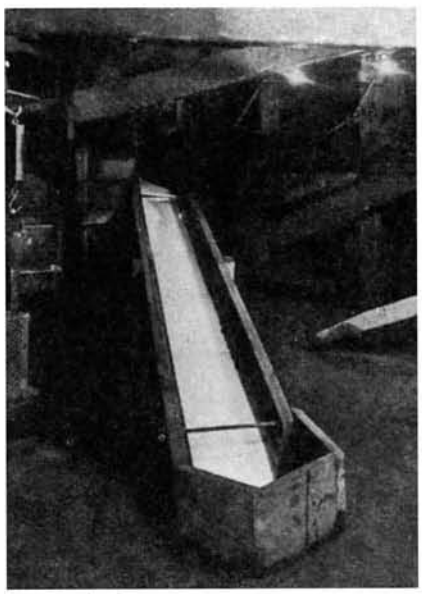
for application to goods intended for civilian use, the Puratized process has been used for treating millions of yards of canvas, mosquito netting, and other military fabrics. Even under the ideal conditions for mildew which are found in the humid jungles in which many of our troops are fighting, material processed by Dr. Sowa's formulations has been found to be definitely fungistatic and bacteriostatic and to have longer serviceability. One formulation has been used in treating over 20 million pairs of shoe linings, not only to eliminate loss from mildew but to act as a safeguard against the shoe lining being destroyed by *Trychophyton interdigtale*, the causative organism of Athlete's Foot.

GLASS CHUTES

Outwear Steel in

Ceal Handling

FIVE GLASS coal chutes are now in use in the breaker of the Locust Coal Company. Alternate sections of Carrara glass and steel were used for the experiment, making possible an ideal



Glass wears well in coal chutes

comparison between the two materials. It was found that the steel plates had to be replaced about every three months due to the wearing through caused by sulfur water and the abrasive action of the coal. After a year and a half, the glass installation is still in use. Although carrying an average daily load of 100 tons, there has been no breakage and very little sign of wear or abrasion. Indications are that the glass will last almost indefinitely.

AIR-CARGO DEVELOPMENT

Planes Should Be Free of

Domination by Other Lines

PUBLIC interest demands development of an air-cargo business free from domination by surface transportation companies and independent of monopolistic combines, Dr. John H. Frederick, of Austin, Texas, declared recently before an Air Cargo Meeting of the Society of Automotive Engineers. He warned that air cargo should not jeopardize its future by making expedient arrangements with those who may supply coördinating services, whether in airport operation, cargo handling at terminals, or local pick-up and delivery services.

"The public should be told in no uncertain terms," asserted Dr. Frederick, "that while there will have to be certain coördinating agencies between it and the actual transportation of air cargo in the air, air cargo is, and will be, airline business.

Dr. Frederick explained that air cargo will take some traffic from rail and motor carriers, and that many marketing and merchandising methods will be changed. He said that local and short-haul tonnage will remain the motor carriers' business, long-haul tonnage of raw and heavy commodities the business of the railroads, both in large volume.

"If the ground carriers handle this traffic properly," according to Dr. Frederick, "they will have all they can attend to. It would, moreover, not be in the best interests of the public for American transportation to become too much integrated, to merge the competing agencies into huge, monopolistic combines in which the surface interests would inevitably play a dominating part, particularly the railroads with their greater capitalization."

AUTOMATIC PILOTS

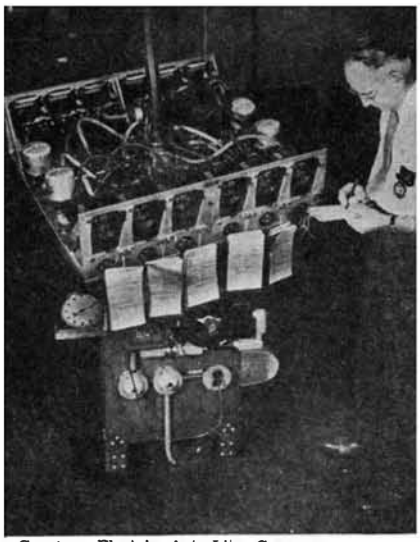
Require Utmost Care

In Manufacture

FOR MANY years the flying of a plane, even for relatively short distances, required perfect muscular coordination, natural aptitude, and an especially high grade of instinctive intelligence on the part of the pilot. Improvements in the planes, and intensive research on the part of the aircraft instrument industry, have resulted in the development of automatic plane controls, which, at times, are better able than a human pilot to hold a plane to true course.

The full import of this innovation, and its effect upon post-war world commerce and transportation, is the subject of much thought and speculation in the aeronautical industry. Following our entrance into the war, however, the immediate task has been the further development and production of these automatic controls for use in military planes. Their importance to the war effort is a story which cannot be told until victory has been achieved, except to say that automatic pilots are required by our armed forces in tremendous quantities.

Known affectionately as "Elmer," by the men whose lives often depend on it, the automatic pilot is truly a "mechanical brain." It is faster and more nearly infallible than the human brain in "thinking" and in introducing corrective forces when a plane starts to deviate from its true course. As might be expected, the manufacture of a device of this kind calls for the utmost precision and extraordinary precautions. Minute particles of dust, if lodged in a critical part of the control, will



Courtesy Electric Auto-Lite Company

Testing the directional gyro under all motions possible in an airplane

prevent proper functioning. Rust and other chemical actions of a degree which is ordinarily of no consequence introduce major problems in the manufacture of this type of product.

Freedom of movement and perfect balance are two requirements which involve highly specialized skill on the part of the instrument assemblers. Stickiness in any degree makes an assembly unacceptable. The cause may be misalinements, poor bearings, or poor finishes on vital parts, rust or dirt on pivots or bearings.

Because of the vital part played by the ball bearings and pivots in automatic pilots, these ultra-precision parts are processed and inspected in a white tile lined air-conditioned room where the utmost precautions are taken to prevent rust, dust, and mishandling from causing bearing troubles on the assembly floor. Special lint-free uniforms are worn and dust counts are regularly taken to insure that bearings washed microscopically clean remain so until removed from sealed cellophane bags and assembled safely in place as part of the instrument. High precision measurements made on 100 percent of the pivots and bearings serve to eliminate fitting operations, with attendant dirt-gathering possibilities, in the assembly department.

RESEARCH MANAGEMENT

Requires Increased Expenditures Te Insure Keeping Pace

RAPIDLY changing conditions require that more money be spent for research and development by the medium-sized chemical company, according to C. L. Gabriel, vice president of Publicker Commercial Alcohol Company, in a paper presented before a Symposium on Research Management sponsored by the Division of Industrial and Engineering Chemistry of the American Chemical Society.

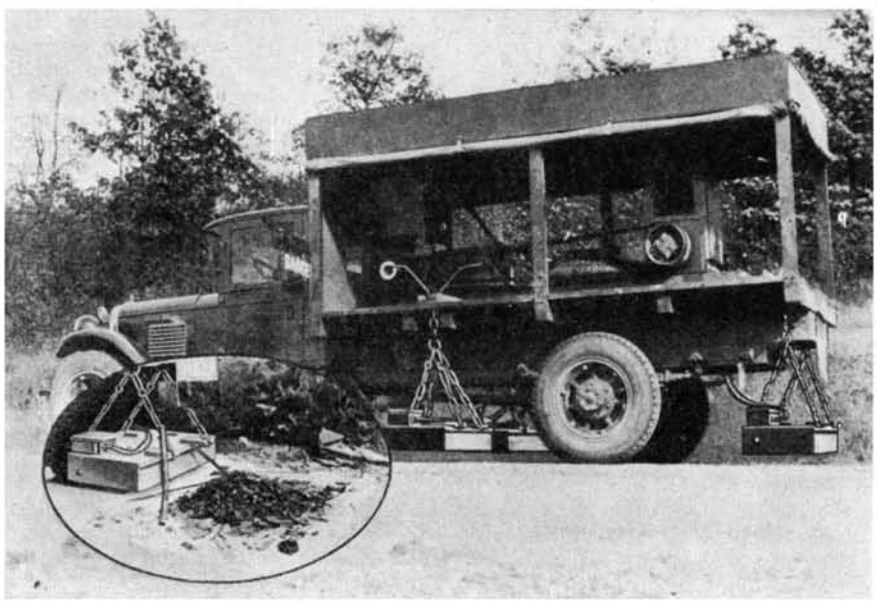
Between 5 and 10 percent of the annual profit of a company making a profit of from $3,000,000 to $15,000,000, before Federal income and excess profit taxes, should be devoted to research and development, in the light of swift technological advance and high taxes, Mr. Gabriel said.

Improvement in processes, utilization of by-products, new uses for products already manufactured, new chemicals to round out lines of products sold to various industries, and new developments which may possibly have nothing at all to do with the company's immediate business should be included in the subjects of research, according to Mr. Gabriel.

ROAD CLEANING MAGNET

Helps in Conservation of Automobile Tires

A ROAD cleaning magnet recently developed by Cutler-Hammer is mounted on a truck; three magnets can cover a road span of eight to nine feet, drawing any metal in the path. The magnets are best operated when suspended to within two to three inches of the ground, since then they can draw subsurface material from loose ground. An



Three magnets on a truck. Inset: "Sweepings" from a roadway

ordinary farm generator plant is sufficient to supply the necessary power.

These magnets are being widely used to conserve automobile and airplane tires by removing metallic debris from war plant driveways and parking lots as well as from airport runways and aprons.

SOLE MATERIAL

Produced by Processing Unused Leather

SUCCESSFUL development of a new process of manufacturing shoe sole material, which may help solve the nation's shoe leather shortage, was announced recently by the Russell Manufacturing Company. This new material

Crude material and finished sole

is produced by processing parts of fine leather hides, not generally used, with trolene, a secret chemical compound developed at the company laboratories. The resultant product is reported to be comparable in many respects to high grade leather.

Tests made by the United States Testing Company, Inc., showed the new product, known as "Trolene-ized" leather, to compare favorably with high quality sole leather in flexibility, abrasion resistance, resiliency, moisture absorption, and certain other characteristics. These tests also disclosed some factors of superiority, such as the fact that this material is water-proof in high degree without being air-tight; and also that it has a high coefficient of friction which reduces the danger of slipping.

PACKAGED POWER

Opens New Possibilities In the Transportation Field

A COMPLETE, self-contained "packaged power" unit, combining a six-cylinder, horizontally opposed aircraft engine with all accessories, plus a clutch and flywheel, into a single, self-cooled package, has been developed by Lycoming Division of The Aviation Corporation.

The fact that this unit is completely self-contained and that it weighs less than one-third as much as existing power plants of comparable output used in busses and other motor driven vehicles currently operating on American highways indicates important post-war as well as current uses.

A salient feature in this respect is the fact that, being air-cooled, it is immune to temperature extremes, such as those encountered during winter highway operation in Northern Canada and in the high heat of southwestern deserts. The new unit has been operated successfully under test conditions at 120 degrees, Fahrenheit, and at 20 below zero over protracted periods.

The engine has a dry weight of 755 pounds and develops 162 net horsepower at 2800 rpm on 73 octane fuel at sea-level atmosphere. It was designed for enclosed, or submerged, installation. The principal element of the cooling system is a cast aluminum fan, or blower, mounted integrally with the flywheel and having an outside diameter of 28¼ inches. The 16 blades of this fan have airfoil shape. About one-half the volume of air propelled by the blower is used for cooling purposes and the balance to maintain ample air supply to the carburetor at a pressure above atmosphere on the intake side of the heavy-duty air cleaner.

According to Lycoming engineers, later developments in this "packaged power" field already have forecast further considerable reduction in both weight and cooling system power consumption. Weighing one-third the weight of current motor bus engines of comparable horsepower, this complete power plant also has the advantage of the usual aircraft engine characteristic of being designed to operate constantly at 75 to 85 percent of full power.

PLASTICS APPLICATIONS

Critical Factors Numerous, But Wide Use Probable in Future

PLASTIC materials are only temporarily limited in their engineering applications and already possess characteristics which make them increasingly attractive to designers and engineers, according to speakers at the Materials Meeting—War and Post-War—of the Society of Automotive Engineers.

Characteristics of plastics as engineering materials were discussed by W. F. Bartoe and Dr. D. S. Frederic, of Rohm and Haas, who said that such qualities as low weight per unit volume, ease of fabrication, low thermal conductivity, available transparency, and low unit cost for mass production entitle plastics to consideration for every application. Ease of fabricating complex structures, they added, already has led to the manufacture of one-piece plastic bomber noses, one-piece plastic gun turrets, intricate manifold forms, and complex forming dies.

Development of more comprehensive engineering data on plastics was reported to be helpful in extending uses, but the speakers warned that factors other than safety margins and more critical than those affecting metals must be considered. These factors include stress, dimensional changes with time, required service temperature ranges, and effects of temperature on physical properties.

Service temperature ranges were characterized as extremely critical, differences of as little as five to ten degrees demanding choice between thermosetting and thermoplastic materials, and determining the eventual success of the application.

What Glass Is And Isn't

(*Continued from page* 23)

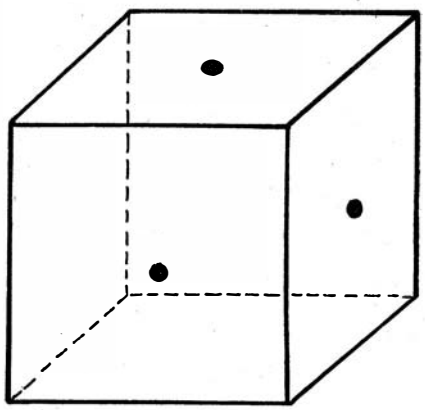
by the action of fire on earthy materials of one kind or another. These earthy materials, which may be rocks or minerals, are composed largely of silica and the silicates. The result of exposure to high temperatures may be glass as one extreme, an aggregate of crystals as the other, but very often it will be a mixture of the two. When certain ceramic bodies are fired, some of the more fusible minerals melt and form glasses which act as a bond between the unmelted grains of the less fusible minerals. There are indications that many clay products have properties almost wholly dependent upon this vitreous matrix. The reasons underlying these changes in the earthy materials are found in the complicated physical chemistry of the silicates. For our purpose we need only point out that Morey's definition of glass, quoted above, can be supplemented by saying that commercial glasses are ceramic products, chemically related to the silicate minerals, and physically related to all other vitreous substances.

WHAT'S A LATTICE?

Some Considerations Involving A Corner of Physical Chemistry

IN THE preceding article the author refers to the face-centered cubical lattice of sodium and of chlorine ions in sodium chloride. The first of the accompanying drawings shows diagrammatically a face-centered cubical lattice. Its three atoms are respectively at the center of the top, side, and front faces of the cube.

The second drawing represents the

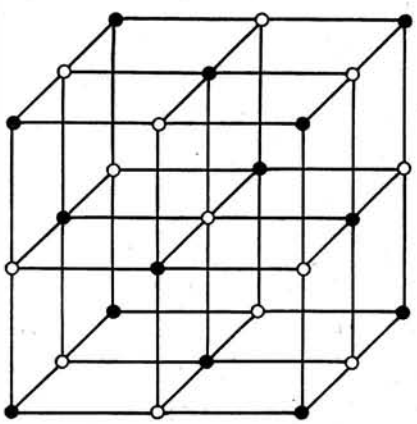


A face-centered cubical lattice

arrangement of atoms within a space lattice of the cubically crystalline mineral halite—sodium chloride, or common salt, Na Cl.

The solid dots represent sodium ions and the circles chlorine ions. It is, of course, unlikely that atoms or ions actually have these shapes. Science does not yet know what atoms would look like if they could be made clearly visible. X-ray diffraction experiments made on large numbers of atoms give results which can be best interpreted as indicating that, in crystalline matter, these atoms are "concentrated" in fixed, regularly repeated positions, much like a wallpaper pattern but in three dimensions rather than two. Most matter has been found to be crystalline, built from immense numbers of these small three-dimensional units.

In his article the author points out that if we wish to retain the idea of the molecule, we are still unable, in the example he cites, to isolate individual sodium chloride molecules, and that therefore the whole salt crystal is really a single gigantic molecule. Now, in the



Atoms within a lattice of salt

mental concept of a sodium chloride molecule one sodium atom is linked to one chloride atom, the two constituting one molecule. So let us examine the drawing (second sketch) and see whether this will work. We select one sodium atom (black dot) and then locate for it one chlorine mate (circle). This proves to be easy but at once five other chlorine neighbors at exactly the same distance protest, "Why pick that one? Why not some of us?" (If the drawing were extended by adding additional lattices in all directions, as in crystals of matter, it would be clearer that there are no exceptions to this situation, except at the very edges.)

We could, of course, arbitrarily assign one particular chlorine to one particular sodium, like men and women in dinner couples around a table, but Nature makes no such convenient assignation. There is, therefore, no such actual entity as the sodium chloride molecule. Nor is this a mere quibble over words. Each sodium has six chlorine neighbors, not merely one, each chlorine atom six sodium neighbors. It smacks of communism, polygamy, polyandry.

What the drawing therefore shows is the interpenetrating space lattices of chlorine and of sodium, together forming the compound sodium chloride.

Sodium chloride is commonly selected for diagrammatically demonstrating these elementary facts of physical chemistry because its system of crystallization is so simple—neat, symmetrical, cubic. Some other compounds that might be employed would not be quite so accommodating in the matter of simplicity. In other words, not all matter, or even a majority of it, is cubically crystalline.—*A.G.I.*

Current Bulletin Briefs

Conducted by
K. M. CANAVAN

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

THE MODERN WORLD AT WORK is a series of six non-technical pamphlets dealing with the progress in science and industry which has been made in the United States through the concerted efforts of all concerned. Each pamphlet consists of approximately 50 pages, profusely illustrated, covering electricity, standards, agriculture, roads, automobiles, and weather. *Superintendent of Documents, Government Printing Office, Washington 25, D.C.—15 cents for individual pamphlets, 90 cents for the set.*

HOW TO SHIP BY AIR EXPRESS DURING WARTIME is a 12-page illustrated pamphlet, file size and with file tab, which lists the data needed when applying for a shipping priority, gives weight and size specifications, and delineates the advantages of air express shipments. *Railway Express Agency Inc., Department of Public Relations, 230 Park Avenue, New York, New York. —Gratis.*

CYCLOGRAPH is an eight-page illustrated folder describing in considerable detail the operation and the uses of the electronic instrument mentioned in the article on page 10 of this issue. *Allen B. DuMont Laboratories, Incorporated, Passaic, New Jersey.—Gratis.*

AUTOMOBILE FACTS AND FIGURES is a yearly publication, the 1943 edition consisting of 64 pages of important tabulations, presented in both graph and tabular form. This year's report, of course, deals largely with the industry's war effort. *Automobile Manufacturers Association, New Center Building, Detroit 2, Michigan.—Gratis.*

METAL CUTTING SAW BLADES is a 20-page pocket size booklet describing hand and power hack-saw blades and giving diagrams and hints on the correct and incorrect ways of using such blades. *The Capewell Manufacturing Company, Hartford, Connecticut.—Gratis.*

THE MULTI VAL LUBRICATING SYSTEM is an eight-page illustrated bulletin describing an improved method of providing positive lubrication to a group of bearings from a central distributing block. Photographs and drawings show how the system can be installed on a wide variety of machines. *The Farval Corporation, 3249 East 80th Street, Cleveland, Ohio.—Gratis.*

MAKING DEMOCRACY AND THE WORLD MUTUALLY SAFE, by Arthur Graham Glasgow, is a 44-page pamphlet based upon a half century of worldwide engineering experience. The greater part of the text is devoted to a discussion of the abuses discrediting democracy and of proposed remedies. *The Secretary, 1900 Monticello Avenue, Norfolk, Virginia.—Gratis.*

TELEVISO AIRCRAFT AND INDUSTRIAL MEASURING INSTRUMENTS is a 48-page illustrated catalog, divided into five sections covering aircraft gyro test instruments, aircraft vibration test instruments, aircraft industrial production testers, industrial vibration measuring instruments, and electro-mechanical laboratory and production test equipment. *Televiso Products, Incorporated, 6533 North Olmstead Avenue, Chicago 31, Illinois.—Gratis.*

A HISTORY OF PREFABRICATION, by Alfred Bruce and Harold Sandbank, is an 80-page lavishly illustrated booklet covering the whole general field of prefabrication of buildings and the manner in which human requirements are met by developments in structural technique. A glimpse is given of future possibilities. *John B. Pierce Foundation, 40 West 40th Street, New York 18, New York.—75 cents.*

THE METAL CLEANING HANDBOOK is a 72-page technical manual on materials, methods, and machines for wartime metal cleaning. The text provides an organized means of selecting the material and method best adapted to various kinds and shapes of metal articles. *Magnus Chemical Company Inc., Garwood, New Jersey.—Request this bulletin on your business letter head.—Gratis.*

DUST—THE SILENT SABOTEUR OF PRODUCTION is an eight-page bulletin describing the hazards of dust to specific industries, with recommendations for control at the source. *American Foundry Equipment Company, Mishawaka, Indiana.—Gratis.*

PRODUCTION MANAGEMENT is a 32-page booklet describing in simple and non-technical language the application of one system of production management which has been applied in a large number of manufacturing plants. The objective of such work is the increased utilization of manpower resources and of plant facilities. *The Bedaux Company, Incorporated, Chrysler Building, New York, New York.—Gratis.*

FLAME HARDENING MACHINERY is a folded bulletin describing and illustrating equipment for this type of work, as well as special machinery for bending, broaching, and drilling. Request Bulletin SM 843. *Hydraulic Machinery Incorporated, 12825 Ford Road, Detroit, Michigan.—Gratis.*

ASHES MAKE POOR GUN POWDER is an illustrated pamphlet which tells something of the little-known things that fire insurance companies do to aid a nation at war. These things concern specialized phases of engineering, research directed toward reduction of fire hazards and damage by fire, and so on. *National Board of Fire Underwriters, 85 John Street, New York 7, New York.—Gratis.*

New Products

"DEHYDRATED" HOUSEHOLD PRODUCTS

A MANUFACTURER of household repair products has developed a line of "dehydrated" products for household use, based on the same principle as the dehydrated soups, drinks, and other food products as used by the United States Armed Forces. The manufacturer claims savings in packaging materials, including metals; ease of use and conservation of vitally needed household items which cannot now be replaced.

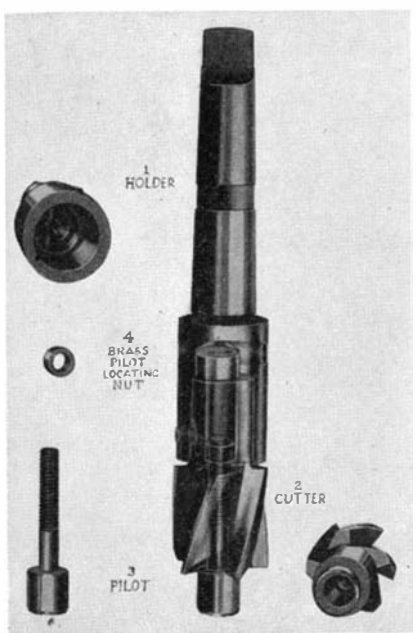
The manufacturing company, So-Lo Works, Inc., states that there are 20 household repair and maintenance products now on the market in the new form and that others are being planned. A few of the "dehydrated" products are cements for mending furniture, glass, stoves, rubber articles. Also there are paint removers, silver polishes, rust preventers, wood plaster, and so on.

CONVEYOR BELT

GENERALLY comparable in all respects with pre-war high quality conveyor belts, a new super-quality synthetic-rubber conveyor belt by Goodyear has the additional advantages of resisting oil and high temperatures. Designated "Style SS" type, Goodyear's new conveyor belt is adapted particularly to all mining operations, including coal, metals, and similar materials, and to the transportation of gravel and aggregate of all kinds.

SHEARPROOF DRIVE

UTILIZING the eccentric principle in its design to equalize the torque load on the holder and the mating driving member of the cutter, Moreland Tool Company announces production in a range of sizes of a shearproof counterbore drive. The driving member of the cutter fits into a spherical off-center hole in the holder, both shank of cutter and corresponding hole in holder being round in shape and eccentric in location only. Without any sharp edges, pins, or wedges, this method of coupling cutter and holder eliminates any tendency to shearing action—it is practically as strong as a piece of solid bar stock of the same diameter and analysis.



Phantom view of holder and cutter

PASTE SPREADER

A NEW linoleum paste spreader, known as the Victory Spreader, is made of tempered board with 35 deep-recessed teeth. It is claimed by the manufacturer, Allmetal Weatherstrip Company, that the material used in this product is water and acid resistant and that the spreader is definitely stronger and more durable than other substitutes for metal spreaders.

Teeth assure uniform spreading

SPONGE

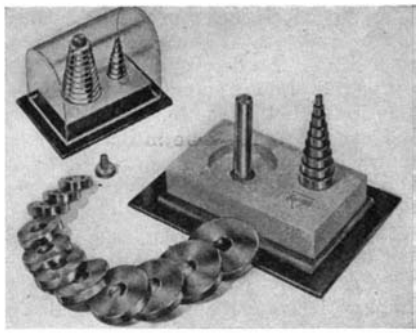
A NEW general-purpose synthetic rubber sponge, made in three densities, has good oil resisting properties, and can be made in slabs, cord, tubing, or in almost any other molded shape. The grades correspond pretty well with pre-war crude rubber sponges.

CHECKING ROLLS

SETS OF new master setting and checking rolls for the checking of micrometers and other precision inspection and gaging instruments consist of 20 individual rolls ranging from .100 to 2.000 inches in diameter. The rolls are hardened, ground, and lapped to gage makers' X tolerance. They are deep frozen before finish grinding to eliminate internal strains and provide accelerated ageing.

When micrometer anvils have become unevenly worn by long use on one type of work, checking with flat gage blocks is not adequate, as only the high points of the anvils come in contact with the block. This method of checking will obviously result in an inaccurate reading when the micrometer is subsequently used on round work.

Improper checks may also occur when a micrometer has had long use through one particular part of its range so that one section of the barrel is worn more than other sections. In this case, checking the micrometer through any one part of its range



Master setting and checking rolls

might show it accurate, while actually the instrument might be out considerably at the point of greatest wear. Sav-Way setting and checking rolls provide a convenient means of making 20 quick, accurate checks throughout the entire range of the instrument at one time.

In addition to checking, these rolls are extremely useful in setting up jobs where dial indicators and amplifiers are to be used.

ANGLE COMPARATOR

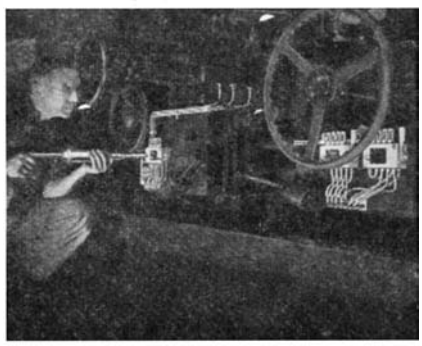
THE CHIEF purpose of a new Angle Comparator is to afford a rapid method for comparing dihedral angles, which at the same time possesses a high degree of sensitivity. This method was developed particularly for use in the processing of prisms for mass production work, but may also be used for comparison work of other glass or metal parts.

The instrument is so constructed that it may be used with parts of various sizes, and may also be used when prisms are cemented together in the form of a stick. A simple adjustment of a few screws is all that is necessary in changing from one size to another. The range of the present instrument is for parts whose faces are approximately 1 inch square to 4 inches square; but the instrument may be easily altered to accommodate parts of smaller or larger dimensions. The instrument, made by the Optical Engineering Laboratories, may be set to compare angles from 45 degrees to 135 degrees.

MACHINE LUBRICATION

POSITIVE lubrication of all bearings on machine tools and similar equipment, regardless of location or condition of bearings, can be had through the improved "Multival" system made by the Farval Corporation. Oil or grease under pressure is delivered to the distributing blocks by means of a manual or power-operated portable gun which serves as a central pump.

Complete Multival equipment consists of multiple valve blocks, each serving two to ten bearings, lubricant lines leading to individual points, and suitable fittings to accommodate practically any type of bearing connection. The systems can be readily installed by shop maintenance crews. Each measuring valve can be individually adjusted to deliver the exact amount of lubricant required by the bearings it serves.

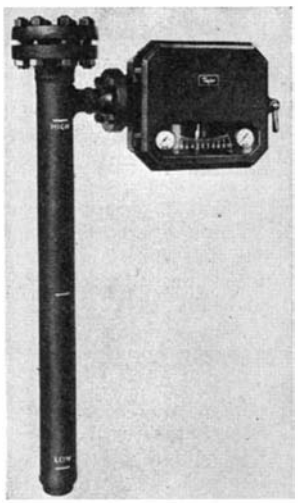


"One-shot" machine lubrication

LEVEL-BUOY

WITH THE announcement of its new Level-Buoy the Taylor Instrument Companies adds to its line a buoyancy-type instrument which both controls and indicates liquid level. The new instrument employs the Taylor Fulscope Control Mechanism with either completely adjustable sensitivity for smooth throttling level control, or automatic reset for averaging of liquid level with a minimum disturbance to the process.

A torque tube transmits the level changes to the instrument mechanism.



For controlling and indicating liquid level during industrial processing

This eliminates a stuffing box with its need for lubrication or packing and gives a closed system which eliminates leakage. The torque tube in interchangeable with the ones used in the Taylor aneriod manometer. There are no internal parts to cause friction or wear.

SPATTER-PROOFING

WHILE there are various methods of protecting work surfaces from weld spatter, many of them are either satisfactory makeshifts or require special washing for removal. Now there has been developed, by G. W. Smith and Sons, a compound for spatter-proofing which not only protects work surfaces but also is reported to have fluxing qualities which improve the operation of any electrode and provide stronger welds.

This spatter-proofing material, known as Protect-O-Metal, is brushed or spread into the seam and onto surrounding surfaces. During the welding

operation the compound in the seam fuses with the molten metal, reputedly removing oxides and impurities from the weld. After welding, all spatter, surface oxide, and residual compound are removed quickly with a damp cloth.

FLEXIBLE FASTENER

THERE HAS been added to the long list of vibration absorbers a new device, known as the Packless Flexible Fastener, which has the combined functions of a supporting strap and a vibration absorber for stationary or movable tubing. It was developed at the request of aircraft builders who desired a simplified and improved hose strap that would eliminate the whip of hose in airplane engines.

The fastener consists of a sensitive spring, cone-spiraled and terminating in a clip which snaps on to the tube or similar unit to be fastened. It is affixed to a supporting surface by means of a standard or wood screw fitted through the cone. Inasmuch as it flexes in all directions, the fastener can be installed in either lateral or vertical position. Its small hose area both facilitates placement and gives a large working area to the cone.

On corners, the fasteners can be systematically set so many inches apart in order to prevent tubing bends from making abrading contact. Upon any impact, the fastener compresses into its cone, thus cushioning the hose against injury.

While designed originally for aircraft use, the fastener is as well adapted to application in the railway, refrigeration, and scores of other industries.

FOR METAL PLATERS

Two new products for covering plating racks were recently announced by Goodrich. One is known as Koroseal Tape RX, while the second is Koralac RX, a solution of Koroseal. In some applications the two are used together, with the tape being applied after the rack has been coated with the solution; in other cases they may be used separately.

Koroseal Tape RX possesses good resistance to wear and abrasion, has excellent insulating properties, and can be used for practically all kinds of plating service, since it has resistance to all plating solutions, including chromic, alkali, and acid dips.

No special equipment is needed when Koroseal Tape RX is used in conjunction with Korolac RX solution, the rack being first treated with two or three coats of the solution and the tape then wrapped under firm tension, after which one or two more coats of the solution are again applied. If the tape is used alone, the rack must be placed in an air oven with a minimum temperature of 300 degrees, Fahrenheit, for two hours after the tape has been applied. This fuses the tape together.

The plating rack solution Korolac RX provides a corrosion resistant, tough, inert coating with good insulating properties, satisfactory for nearly all kinds of plating rack service. Liquid at room temperature, it holds its position on the racks after application because of shrinkage as the solvent evaporates.

POCKET PROTECTION

SHIRT, coat, and vest pockets may be protected from the wear-and-tear of pen and pencil clips through the use

Protects pocket, holds badge

of a new and inconspicuous transparent plastic pocket protector developed by Hurley Smith. The protector, as shown in the illustration, also provides a place for attaching a war-plant badge, thus eliminating pin holes in garments.

WAX ALTERNATE

TO MEET the growing shortage of micro-crystalline wax, Wishnick-Tumpeer, Inc., announces the development of Witco Hamp Wax, a new group of waxes for use in the manufacture of Ordnance wraps and other military and essential civilian products.

This new product is a hard amorphous petroleum wax of the greaseproof type, which possesses an exceptionally high resistance to moisture vapor transmission. Its general uses are for waterproofing ends of bags for export shipments and for manufacture of Ordnance papers and similar applications where melting point, hardness, and other properties of this range are desired. It should fill a genuine need for an alternate to micro-crystalline wax.

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"

IN REFLECTING telescopes, seeing is often hampered by "temperature effects" within the tube. In the valuable contribution that follows, one amateur telescope maker, F. N. Hibbard, of the U. S. Weather Bureau Office at Richmond, Va., describes experiments on various types of tubes, made with J. C. Vaughan of Petersburg, Va.

"Bell's book, 'The Telescope,' 'A.T.M.,' and many other books tell what a stellar image may look like and what it should look like. A good image of a star, under a power of 40 or 50 times the telescope aperture in inches, and under good seeing conditions, will be a perfectly round disk, of a size varying inversely as the diameter of the objective according to the Dawes formula, with the disk surrounded by a series of concentric rings of graded intensity. On rare occasions of exceptional seeing, the rings will be needle fine like the web of a spider.

"Deviations from this perfect image, assuming the mirror to be well figured and supported by ample leverage, can

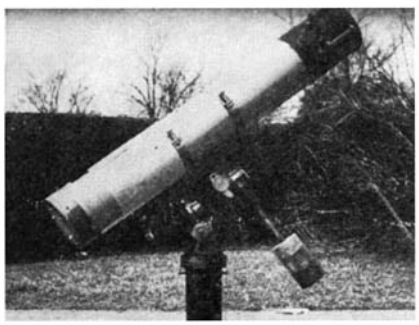


Figure 1: The common set-up

usually be traced to a pinched or imperfect prism, improper alinement of the optical train, a poor eyepiece, a possible warping of the mirror by changing temperatures, unsteady air, imperfect eyesight, or temperature differentials in the telescope tube.

"These defects, their images and their remedies, have been well covered by writers—with the exception of temperature differentials. The latter, otherwise known as 'tube effects,' have been cussed and discussed for years, without any final agreement as to remedy, and, curiously, without exactly spotting the underlying cause. One writer says he likes a metal tube; another says a better image is possible with a lined tube; a third suggests the use of a fan on the tube to mix the tube air into uniformity of temperature; another mentions the superior performance of a wooden tube, particularly after the panels had been removed.

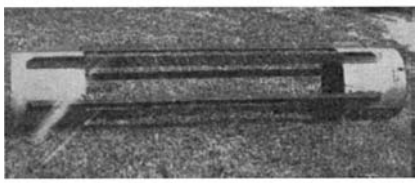


Figure 2: Wrapped skeleton tube

"It is not generally known, outside the Weather Service, that various substances or materials exposed in the open air under a clear night *attain temperatures different from that of the surrounding atmosphere.* Repeated experiments prolonged for months show that thermometers so exposed consistently register lower-than-air temperatures, differences amounting generally to several degrees and occasionally as much as 8°. They further show that the differences persist for hours at a time. In other words, objects exposed to the clear night sky seldom attain the temperature of the air, but differ from it and from one another.

"To conceive the process by which two contiguous substances, such as air and metal, can attain and maintain such an anomalous thermal condition for hours together is difficult. It depends, however, principally upon the individual absorption and radiation properties of the substance.

"With this background, we are ready to see what happens in a telescope tube.

"My first experiment was to use an 8" mirror in a solid metal tube open at the upper end. (Figure 1). The air next to the metal of the tube chilled and drained down the tube, producing differential refraction of light and a poor image.

"The second experiment consisted of lining the tube with cork, asbestos, and paper. This left the air in the tube warmer than the outside air. As the chill of evening advanced, a mixing of this warm air with the cooler outside air at the mouth of the tube again produced images distorted to some extent.

"The third experiment consisted of boring holes in the cork and metal of the upper part of the tube to afford drainage of the tube air to the outside before it reached the mouth of the tube. This experiment showed that cool air from the outside drifted through the holes, and each wisp of cool air caused a streak across the stellar image.

"The fourth experiment was made with the same mirror placed in a skeleton tube built of six angle irons. Theoretically, this tube should have given a splendid image, as the air inside and outside should have had the same temperature. But, alas for science, the more sense I used the less she worked. Air drifting through the tube between the metal work became chilled by the metal, produced a different refractive index, and again left streaks across the image.

"The fifth trial was carried out by wrapping the same metal with thick paper (Figure 2) and painting the paper a dead black. This improved the image to some extent but bad images still resulted. In fact, the images some nights with this skeleton tube were quite intolerable, and well-known features of the lunar topography at times were obliterated. The effect of the chill of the metal was proved by placing a heavy cardboard lining within the tube, shutting off the wisps of air chilled by the iron. The moment the cardboard was in place, the images entirely cleared themselves of streaks and became passibly good. This experiment was tried over and over until the evidence of differential temperature was proved beyond question. The conclusion was inescapable that the ironwork had an entirely different temperature from that of the air, and that the difference persisted hour after hour.

"The final experiment was to use a solid metal tube, line it throughout with a quarter-inch thickness of cork, and cut a large hole of about 20 square inches in the tube just above the mirror to ventilate and cool the mirror. This gave excellent results, particularly when the hole was covered before observation to steady the inside air. The mirror was a wonderful piece of work and it cut doubles down to the Dawes limit time after time.

"By this time my friend, James C. Vaughan (Figure 3) of nearby Petersburg, Va., and I had decided that a larger mirror would be a fine thing to have, particularly for nebulae and clusters. So we prevailed on J. W. Fecker to fix us up with a mirror 12⅜" in diameter, which proved to have a magnificent figure. We decided to continue the temperature control experiments with this larger mirror, and built for it a skeleton tube (Figure 4) of duralumin, designed so that it could be converted easily into a closed tube when so desired. Observational results were identical, except that the larger tube, which was 15" or 16" in diameter and had relatively less metal, showed relatively smaller chilling effects. Differential chilling and differential re-

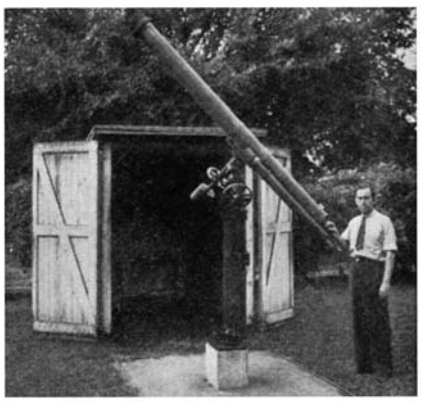


Figure 3: Vaughan, collaborator

fraction were slightly less, but were not eliminated until this larger tube was lined completely.

"In constructing this large lining, it was found that even a small crack or hole would produce a tiny ribbon of light across the image, the ribbon shifting erratically as the wisp of air drifted about within the tube. Spaces between the ends of the wooden lining and the metal work had to be calked with cotton or wool. Ample ventilation for the tube was provided underneath the mirror, but the mirror itself was protected from the direct draft. When we finally cut the vents through the cork lining of the cell, cold air from the cell felt like the discharge from an opened refrigerator.

"These experiments show us rather clearly what the 'tube problem' is; why the tube walls should be well separated from the cylinder of light entering the tube; why a skeleton tube does frequently produce unsatisfactory streaky images; why a tube must be ventilated; why a lined tube gives better results than a bare metal tube; and why a wooden tube, particularly if well ventilated and held solidly in alinement, does and should give excellent images. These deductions probably do not apply to telescopes housed in a dome but may apply to some extent to the dome itself and its surroundings.

"Several kinds of wood may be used to advantage in making tube linings, but my preference is Douglas fir or balsa, which are light in weight and have low thermal capacity and high insulating properties."

Cogitating on these matters, as a question in physics, independent of telescoptics, your scribe wondered if, then, a given object would not take on the temperature of the surrounding air if given *plenty of time,* and asked Hibbard, whether (to choose an extreme case) Tutenkhamon's toes after 3000 years in his tomb wouldn't assume the exact temperature of the air in the coffin. His reply:

"In a practical way, I should expect enclosed objects to have about the same temperature, such as Toot's toes. But I could arrange Toot *in the open air* so that each foot would have a separate temperature and neither foot exactly that of the air. Apparently, radiation of heat to a clear cloudless sky at night by suitable materials gives the maximum favorable conditions for temperature differentials. There is a rich field for quantitative determinations of variation, which has not yet been explored.

"Experiments in this field should bring out rather interesting relations between color, material, condition of surface, whether matte or polished, and changes that occur when night finally becomes day. I should expect most objects, particularly with a black matte surface, to become warmer than the air under daylight sunshine. The extreme heat of railroad rails on a hot day seems to point to an actually high temperature and not entirely to rapid transmission of heat from rail to finger when the rail is touched by finger.

"The lower temperature of metal at night under a clear sky would not be expected to obtain during the day.

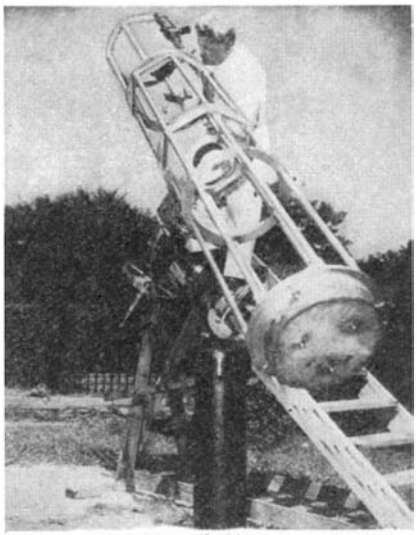


Photo Richmond News-Leader

Figure 4: Hibbard. Larger tube

The situation would be reversed. And this brings us back to the original statement that the temperature of a body depends on the *relative* rates of its absorption of heat from surroundings and its radiation of heat to its surroundings, principally the sky. There necessarily would be moments, if not longer periods, when metal and air were at the same temperature."

A noted meteorologist to whom the above discussion was shown added the following: "A material object will not necessarily reach the temperature of the surrounding medium, no matter how much time is allowed. It would, provided molecular conduction were the only influence acting to transfer heat; but in nature this is never the case. Among other influences, one that is always operating is radiation.

"Any object is always continually gaining heat by at least two processes, radiation and conduction, and also continually losing heat by both of these processes. An equilibrium temperature is reached when the rate of gain from the combined action of both radiation and conduction equals the rate of loss. In general, this equilibrium temperature will not be the temperature of the surrounding medium.

"*Within an enclosure,* however, with uniformly heated walls, the temperature would become uniform."

Tutenkhamon was "within an enclosure," hence not an ideal illustration since a telescope mirror is partly enclosed, partly open.

IN HIS letter Hibbard makes other comments. He votes for a gear drive with a 359-tooth gear on the polar axis, which makes possible a simple gear combination for sidereal time; a rotating tube, or eyepiece end rotating about the tube axis, which is easy to make and greatly adds to convenience in observing; four small holes in either end of the tube for the occasional use of cross-hairs, or threads, in checking alinement; and solid eyepieces, which give brilliant images and no ghosts despite their small field. He has a ½" triplet aplanat eyepiece that gives absolutely colorless images of such difficult objects as Venus.

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. Add 25 cents per book for mailing outside U. S.

TO MAKE CERTAIN that books ordered by or for men in the Army, located in the United States, or men in the Navy, located anywhere, will be delivered, insurance fees should be sent with orders, as follows: To $5 in value, 5¢ additional; from $5 to $25, 10¢; from $25 to $50, 15¢.

AIRBORNE INVASION

By John Hetherington

So TERRIFIC was the defense of the Island of Crete that at one phase the Germans almost gave up the attempt. This story is one of the great sagas of the war. The author, first war correspondent to arrive in the Middle East, was an eye-witness to part of the struggle. His years of reporting, his post-Crete research, and his interviews with other survivors enabled him to produce a factual and thrilling account of one of the most important delaying actions in the early part of the struggle. (178 pages, 5½ by 8 inches, detailed map.)—$2.60 postpaid.—*A.D.R., IV.*

OPTICS

By Arthur Cox, B.A., B.Sc.

NOT A treatise on optics but on some aspects of photographic optics and lens design. The author has sought to build a non-mathematical ladder by which the non-mathematical amateur can crawl upward toward the lofty heights of camera lens design, the most abstruse of all types of such design. Will this book then enable the lowly amateur to reach the summit and accomplish things there—design photographic lenses? No. But it will give him some hint of what the scenery is like. Mainly, however, the book is for the photographer. Chapters: Light and Lenses; The Ideal Lens (never realized); Defects of Every Lens (you wonder how any lens ever works at all!); Basic Lens Types (named, described, but curve and other specifications not stated); Testing Optical Equipment (tough examination of your camera lens); Aids to Better Performance; Accessories. Published in England last January. First edition vanished in three months. Second edition, revised. (333 pages, 4¾ by 7¼ inches, well illustrated.)—$4.10 postpaid.—*A.G.I.*

ELECTRONIC PHYSICS

By Hector, Lein, and Scouton

AN EXCELLENT text for beginners or for those who desire to acquire a sound basis upon which to follow the rapidly advancing applied science of practical electronics. The treatment is simplified but not too much so, and each chapter is introduced with a preview of what follows, thus shaping up the reader's thoughts as he goes along. Many of the illustrations are reproduced in two colors, adding greatly to legibility and understanding. (355 pages, 6 by 9 inches, 289 illustrations.)—$3.85 postpaid.—*A.P.P.*

MATHEMATICS FOR MACHINISTS

By R. W. Burnham

FOR machinists in overalls. Chapters on fractions, percentage, blueprint reading, measurements, square root, lathe work calculations, thread problems, planer problems, simple physics, work, power, ratio, pulleys, belting, gear calculations, milling machine problems, shop trigonometry, formulas—all being mathematics as applied in shop work and none that isn't; for this is a wholly practical, workaday book. It has many problems, with answers. (253 pages, 5 by 7 inches, 186 illustrations.)—$2.10 postpaid.—*A.G.I.*

AIR CONDITIONING ANALYSIS

By William Goodman

NOT "air conditioning" in the sense that the phrase is usually applied, but a comprehensive and unified treatment of the fundamentals of the science of changing the condition of the air. Specifically a text book for engineers and technicians. (455 pages, 6½ by 9½ inches, a large number of charts and tabulations.)—$6.10 postpaid.—*J.P.C.*

CHEMISTRY MADE EASY

By Cornelia T. Snell and Foster D. Snell

A FOUR-VOLUME set of well presented books which, as far as possible, bears out promise of the title. The authors warn, however, that study is necessary in order to assimilate the knowledge presented, regardless of efforts made to present it in pre-digested form. Volume One covers the theory of inorganic chemistry; Volume Two, elements and compounds in organic chemistry; Volume Three, the aliphatic

and aromatic compounds of organic chemistry; and Volume Four, chemicals of commerce. The last is essentially a reference book containing a list of industrial chemical and commercial war materials. (Uniformly bound, 184, 256, 232, and 542 pages respectively, 6 by 8½ inches, illustrated with drawings.) —$2.35 per volume postpaid.—*A.P.P.*

PHYSICS TELLS WHY

By Overton Luhr

A SUCCESSFUL attempt to make physics, not easy—since it isn't easy—but easier; accomplished by abandoning the chill, frosty diction of the typical textbook and writing like a human being talking to a friendly audience. Suitable for readers having high-school education or equivalent, though those with less would seldom be tripped by the very slight touch of elementary algebra in it. It is mainly devoted to classical physics—motion, solids, gases, heat, light, sound—rather than the physics of the atom. (318 pages, 6¾ by 9¾ inches, illustrated.)—$3.60 postpaid.—*A.G.I.*

A COURSE IN POWDER METALLURGY

By Walter J. Baëza

A SOUND view of the overall subject of powder metallurgy as it has been developed and is being applied today, with emphasis on those phases which must be stressed in training courses designed to produce our future powder metallurgists. Regardless of the "course" features of the text, this book will serve adequately as a guide and reference for anyone concerned with the subject. (212 pages, 6 by 9½ inches, a few graphs and illustrations.)—$3.60 postpaid.—*A.P.P.*

SO YOU WANT TO BE A CHEMIST

By Herbert Coith

ESSENTIALLY the text of this compact little book covers the various kinds of work which chemists and chemical engineers actually do. It is designed to guide the thinking toward the future of students of high-school grade. (128 pages, 5½ by 8 inches, unillustrated.)—$1.60 postpaid.—*J.P.C.*

KAISER WAKES THE DOCTORS

By Paul de Kruif

ABOUT engineer and shipbuilder Henry Kaiser's co-operative plan for prepaid group medical care, intended to forestall socialized medicine. Written as a narrative of explanation, in de Kruif's high-tension style. (158 pages, 5 by 8 inches, unillustrated.)—$2.10 postpaid.—*A.G.I.*

THE SCIENCE OF EXPLOSIVES

By Martin Meyer

INTRODUCTION to the chemistry, production, and analysis of modern explosives, presented in relatively simple and readable style, for both casual and serious students. The text covers the natufe of explosives, elementary theory of explosive action, practical explosive

The Editors Recommend

Best Sellers in Science

PLASTICS — *By J. H. Bubois.* Revised and enlarged edition of an important work on the whole general subject of plastics, plus much new material on synthetic rubber, manufacturing processes, and plastic molding. **$3.85**

EXPERIMENTAL ELECTRONICS — *By Ralph H. Muller, R. L. Garman, and M. E. Droz.* A solid book of eminently practical information on the characteristics and non-communication applications of electron tubes. The text describes experiments and presents results. For students, radio engineers, communications experts, and the serious general reader. **$4.75**

ATOMS, STARS, AND NEBULAE — *By Goldberg and Aller.* One of the "Harvard Books on Astronomy." An elementary treatise on astrophysics, neither light nor too formidable for readers familiar with elementary astronomy. **$2.60**

GET TOUGH! — *By Capt. W. E. Fairbairn.* How-to-win-in-hand-to-hand-fighting directions, by a man who really knows rough-and-tumble methods that are *not* "clean" fighting but *are* designed to win. **$1.10**

FUNDAMENTALS OF PERSPECTIVE — *By Theodore DePostels, A.I.A.* A method of showing the order, or sequence, in which lines of a perspective are drawn. Use of colors, numbers, and arrows eliminates much text found in other books on this subject. 20 loose sheets in binder. ~~$2.50~~

LEARNING TO NAVIGATE — *By Weemes and Eberle.* For those totally inexperienced or only casually familiar with the fundamentals of navigation, this text will provide a practical handbook leading to an understanding of navigation at sea or in the air. A number of illustrations and tabulations. **$2.10**

FUNDAMENTALS OF RADIO — *By Jordan, Osterbrock, Pumphery, and Smeby.* With this one volume alone, and with some diligence of application, it is possible to obtain a thorough grounding in radio principles. In thoroughness of treatment, with due respect for the needs of the reader, this book is outstanding. **$5.10**

FUNDAMENTALS OF ELECTRICITY — *By a Staff of Electrical Experts.* Although designed to supply men about to enter military service with a foundation for further training, this text will serve a similar purpose for anyone desirous of acquiring such knowledge. **$2.10**

ELEMENTS OF ORDNANCE — A textbook prepared for cadets of the United States Military Academy. Covers manufacture, the chemistry of explosives, types of weapons, mathematics of ballistics, etc. **$6.60**

AIRCRAFT INSTRUMENTS — *By George Ellis Irvin.* All types of instruments for aircraft use described for students, pilots, inspectors. Fundamentals, instructions. **$5.10**

MARINE DIESEL HANDBOOK — *By Louis R. Ford, M.A.* A compendium of data on design, construction, and operation of the marine Diesel engine with chapters covering applications, principles, types, fuel injection systems, lubrication, supercharging, and so on. **$7.25**

MACHINERY'S HANDBOOK—*Eleventh Edition.* "Bible of the mechanical industry," enlarged to 1815 pages of latest standards, data, and information required daily in the shop and drafting room. **$6.10**

PROCEDURES IN EXPERIMENTAL PHYSICS — *By John Strong, Ph.D.* A wealth of useful data of a practical kind for the constructor, experimenter, and skilled craftsman. **$6.80**

STEEL SQUARE POCKET BOOK — *by Dwight L. Stoddard.* Practical methods for using the carpenter's steel square for layout work of all kinds. Time-tried methods used by two generations of carpenters and found both rapid and accurate. **$1.00**

A MANUAL OF MECHANICAL MOVEMENTS — *By W. M. Clark.* Presents fundamentals on which all machines are built. 400 illustrations and 160 photographs of models demonstrating mechanical principles supplement the text. **$2.10**

WORKING WITH THE MICROSCOPE — *By Julian D. Corrington.* For the serious beginner. Explicit, practical. **$3.60**

TOOL MAKING — *By C. B. Cole.* Instructions for making and using all kinds, from personal tools to arbor presses, lathes, planers, etc., in different metals. **$3.60**

THE ELECTRON MICROSCOPE — *By Burton and Kohl.* A well-written account of this newest tool of science, with all technicalities explained for complete understanding by average persons. **$3.95**

ENCYCLOPEDIA OF KNOTS AND FANCY ROPE WORK — *By Cranmont and Hensel.* More knots are described in this remarkable book than in any book on seamanship ever published or dreamed of. 3257 knots are illustrated in half-tone reproduction and are described in the text. **$5.10**

A MATHEMATICS REFRESHER — *By A. Hooper.* Prepared mainly to refresh aviation trainees whose high school mathematics is rusty. Scope — arithmetic through calculus. **$2.60**

PLASTICS, PROBLEMS AND PROCESSES — *By Mansperger and Pepper.* The whole story of plastics, including a resume of manufacturing processes and a number of thorough-going chapters deveted to plastic uses. **$3.10**

AUTOMATIC ARMS — *By Melvin M. Johnson and Charles T. Haven.* Comprehensively covers machine guns, machine rifles, sub-machine guns, pocket pistols, shotguns, sporting, military rifles in automatic classification. ***$5.10***

MANUAL OF LABORATORY GLASS-BLOWING — *By R. H. Wright.* Practical book of glass-blowing operations, elementary and more advanced. **$2.60**

HANDBOOK OF CHEMISTRY AND PHYSICS — A classic reference book recently revised and brought up-to-date to keep pace with recent research. Includes material on all branches of chemistry, physics and allied sciences. Used in laboratories and by engineers throughout the country. Flexible binding. 2503 pages. **$4.10 Foreign $4.50, postpaid**

ATOMIC ARTILLERY — *By John Kellock Robertson.* Electrons, protons, positrons, photons, neutrons, and cosmic rays, all described for the layman in plain language. Also transmutation of the elements and the manufacture of artificial radio activity. **$2.35**

● **The above prices are postpaid in the United States, Add, on foreign orders, 25¢ for postage on each book, except as noted.** ●

For Sale by: **January, 1944**

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

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

.....

.....

Name .....

Address .....

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

devices, safety problems, and so on. Specific explosives are dealt with in considerable detail. (452 pages, 6 by 9 inches, a number of drawings and tabulations.)—$4.60 postpaid.—*A.P.P.*

A TREASURY OF SCIENCE

Edited by Shapley, Rapport, and Wright

FAT VOLUME of choice reprints carefully combed from outstanding scientific writings of a non-technical type and together forming a reasonably unified panorama of all science, physical, biological, and human. Selections from Copernicius, Galileo, Newton, Franklin, Darwin, and Huxley are combined with others from Pavlov, Einstein, Eddington, Jeans, Hogben, Keith, also Moulton, Furnas, Harrison, Kaempffert, de Kruif, Gray, Dietz, Mather, and numerous others. Introduction by Harlow Shapley the astronomer. A chance to get at hundreds of originals otherwise difficult of access. (716 pages, 6 by 8½ inches, unillustrated.)—$4.10 postpaid.—*A.G.I.*

THE AMERICAN ANNUAL OF PHOTOGRAPHY

THE OLD standby of amateur photographers, presenting outstanding photographs of the year and the latest in dark room technique. (206 text pages plus advertising, 7½ by 10 inches, paper cover.)—$1.50 postpaid.—*J.P.C.*

THE SHARPS RIFLE

By Winston O. Smith

HISTORY, development, and operation of the first successful breech-loading rifle. Possibly no other firearm played so important a part in American history as did the famous and reliable "old Sharps." It was a prominent weapon in the Civil War; the favorite of the early hunters on the Great Plains; and an invaluable ally in the winning of the West. This is an indispensable volume for all who like guns. Note: Scientific American first presented the story of the then revolutionary mechanism devised by Christian Sharps, inventor of the rifle in its issue of March 9, 1850. (138 pages, 6 by 9 inches, 35 illustrations.)—$3.10 postpaid.—*A.D.R., IV.*

INTRODUCTORY PSYCHOLOGY

By Lawrence A. Averill, Ph.D.

TITLE IS misleading, perhaps purposely so to beguile the adolescent reader, at which the book obviously is aimed, into believing he is studying a great science, when the book instead is essentially about how to study, pay attention, think, learn, remember, meet obstacles, and develop a healthy mind, character, personality. All this comes under psychology but this is not an introductory psychology. However, to read it under any auspices would be good medicine for a wobbling youth who hadn't found himself and was adrift. Most adults would find it too "pedagogical"—too preachy in tone—for their own reading; it talks down. (564 pages, 5½ by 8 inches, 73 illustrations.)—$2.30 postpaid.—*A.G.I.*

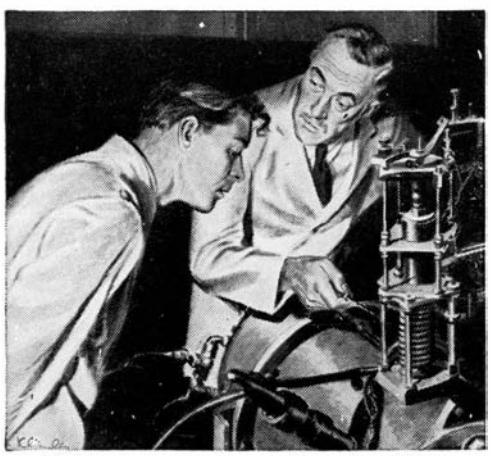
Helping the tire maker: Pictured here is a laboratory model of the new Westinghouse-developed "mass spectrometer," an adaptation of which analyzes gases with incredible swiftness and accuracy. Right now, one of the most important of its many uses is speeding up tremendously a step in the making of synthetic rubber.

Westinghouse research accepts every wartime challenge . . .

Under the spur of war, Westinghouse research is delving into numberless mysteries, not only in the vast field of electricity and electronics, but also in chemistry, physics, metallurgy, plastics. And as a result, out of the great Westinghouse laboratories has come a steady stream of new war products, and new and better ways of making old ones.

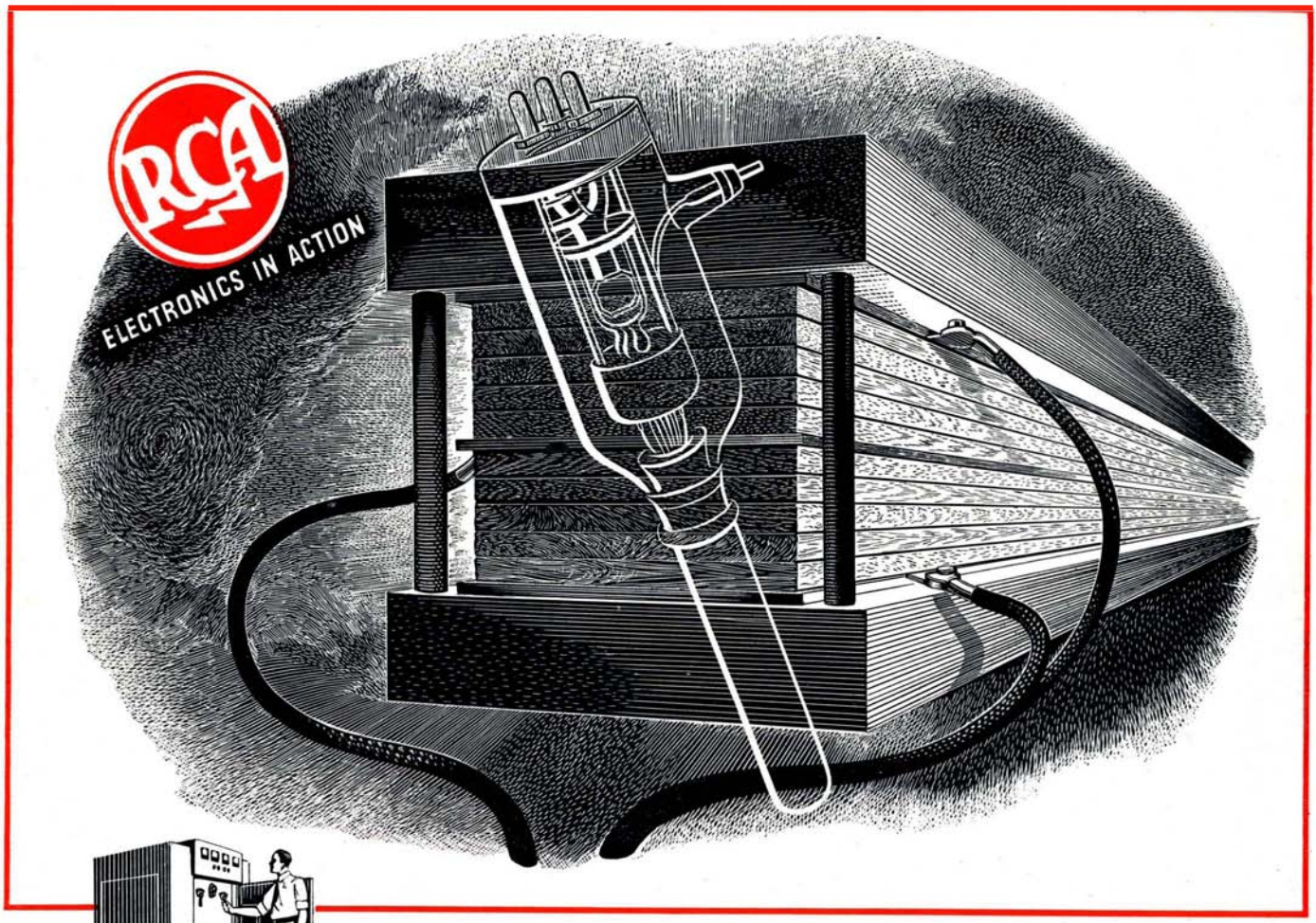
Westinghouse research develops new talent for America . . .

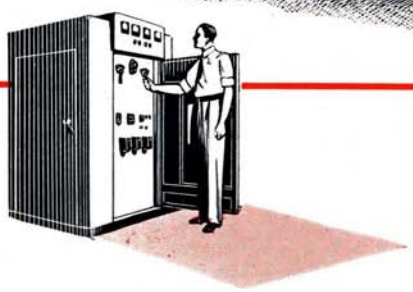
To Westinghouse, each year, come several hundred budding scientists and engineers—to work, to learn, to blaze new trails in electrical research. And each year, through more than 100 Westinghouse scholarships, young men enter America's engineering colleges to develop the native skill and talent that have made America great and will make it greater.



Westinghouse research promises new wonders for peace . . .

You have heard much talk of the marvels science will offer you after the War. Well, there *will* be marvels—plenty of them—and Westinghouse research is working to contribute its full share. But we will never lose sight of what we consider our first duty: seeing that, beyond all question, each Westinghouse product, old *or* new, is the very finest of its kind. Westinghouse Electric & Manufacturing Co., Pittsburgh, Pennsylvania. Plants in 25 cities, offices everywhere.





Gluing Wood with Radio Waves

GLUING wood with synthetic resin glues used to be a slow process because it took so long for the glue to "set." Aircraft and other wartime needs greatly accelerated the use of these glues—thereby sharpening demand for shortening the setting time.

Speedier gluing means faster heating of the glue lines to drive out the moisture and hasten chemical reactions. Wood, being an excellent insulator, prevents the inward flow of heat from hot platens at anything but a maddeningly slow rate. Really rapid heating therefore demands a method whereby heat is "born" right *inside* the wood.

That is exactly what electronics makes possible. Radio frequency power unleashed right inside the wood is instantaneously converted into heat and causes an almost phenomenal speeding up of the glue-setting process.

The manufacture of "compreg" — a highly compressed plastic-impregnated wood product now used extensively for airplane propellers — too, has been speeded up remarkably by such electronically generated heat. Production time has been cut as much as *60 per cent* over old methods—making it possible for expensive equipment to turn out proportionately more of badly needed products.

Radio frequency power for setting wood glues offers many attractive possibilities. Yet it is only *one* of many manufacturing processes involving a heat cycle for which RCA electronic heating offers important advantages. Moreover, all such applications collectively are but *one* phase of electronics—the art of harnessing electrons to the service of man. Bear in mind, too, that *every* electronic device of *every* kind depends basically on electron tubes. And that RCA is the fountain-head of modern electron tube development.

TUNE IN "WHAT'S NEW?"

Radio Corporation of America's great new show, Saturday nights, 7 to 8, Eastern War Time, Blue Network.

A new booklet—"RCA Electronics In Industry"—shows some of the ways RCA is prepared to help put electronics to work. It may suggest applications important to your business. Free on request. Please use business letterhead when writing. Address—Dept. 68-4N. RCA, Industrial Division, Radio Corporation of America, Camden, New Jersey.

RADIO CORPORATION OF AMERICA