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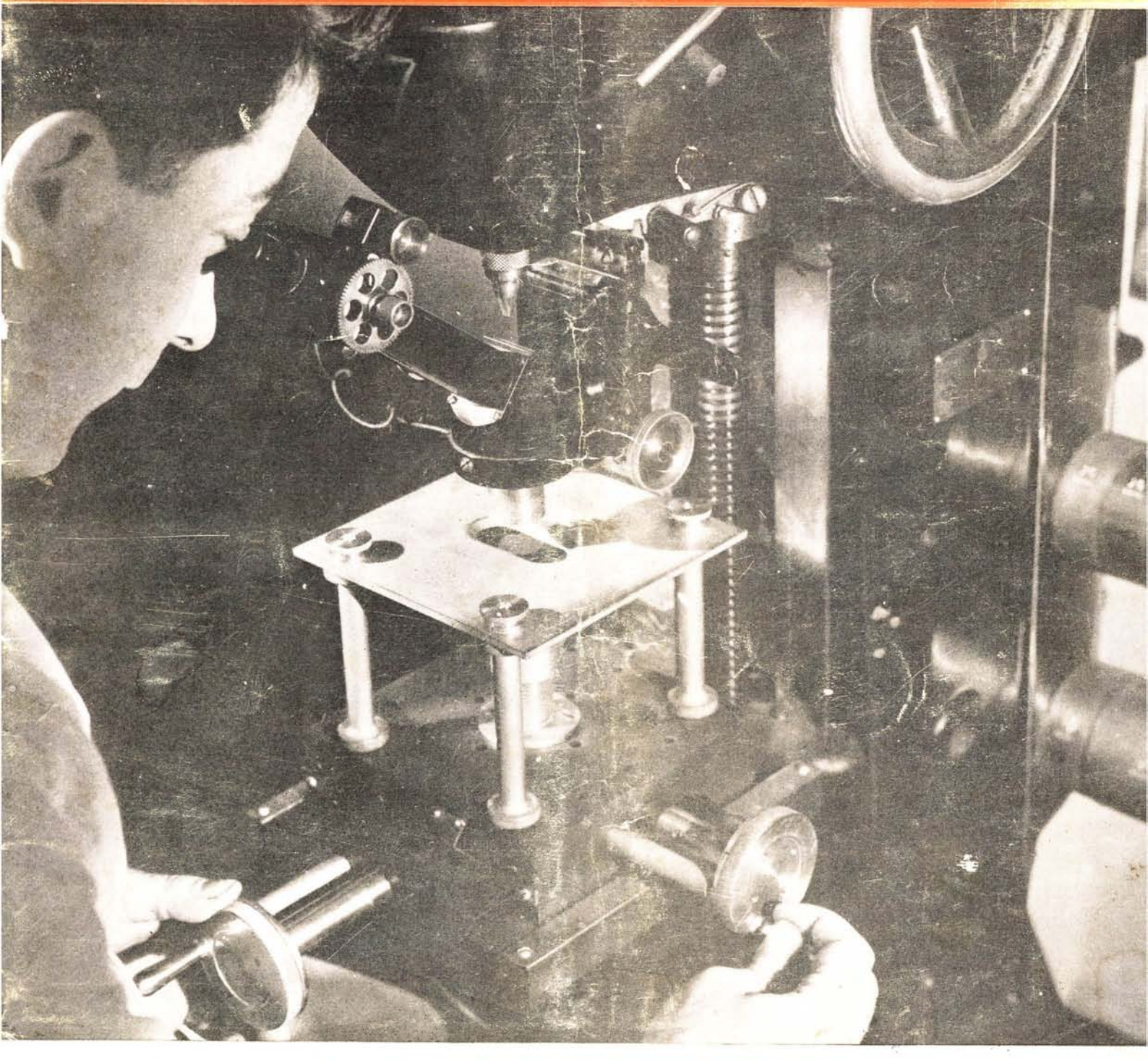
PROGRESS IN INDUSTRY



MEASURING THE HARDNESS OF HEAT-TREATED STEEL

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GERARD PIEL joined the editorial staff of the new *Life* Magazine in 1937. He resigned as its Science Editor in 1945 to launch the development of a new magazine of the sciences.

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LEON SVIRSKY was variously Education, Science and Medicine Editor of *Time* from 1938 to 1947. He is Editor of "Your Newspaper (Blueprint for a Better Press)", written by nine Nieman Fellows and published by Macmillan.

K. CHESTER was staff photographer on *Life*. During the war he was Photographic Officer attached to SHAEF and afterward to the International Tribunal at Nuremberg.

ALBERT G. INGALLS is the author of "Amateur Telescope Making" and "Amateur Telescope Making—Advanced." His column on optics will be continued as a regular feature of the new SCIENTIFIC AMERICAN.

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You are holding in your hand the final issue of SCIENTIFIC AMERICAN in its present form. Next month — May — will bring you an entirely new magazine.

The SCIENTIFIC AMERICAN was purchased in October 1947 by a new publishing company organized in 1946 by Gerard Piel, Editor and Publisher, Dennis Flanagan, Managing Editor, and Donald H. Miller, Jr., General Manager, to create a new magazine of the sciences. The new company has acquired the SCIENTIFIC AMERICAN as its publishing vehicle. The new SCIENTIFIC AMERICAN will resemble the old in name only.

The new SCIENTIFIC AMERICAN will fill the wide gap between the two kinds of science magazine that are published today. One is the technical journal; the other is the popular magazine of the sciences. In the gap between these extremes is the growing community of U. S. citizens who share a responsible interest in the advance and application of science. Their magazine is the new SCIENTIFIC AMERICAN.

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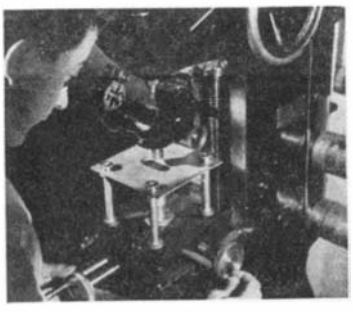

ON THE COVER: The Vickers Hardness Tester determines the hardness of an austempered steel stub in a study of isothermal transformation. For the importance of such studies to modern steel technology see story beginning on page 149.

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Founded 1845

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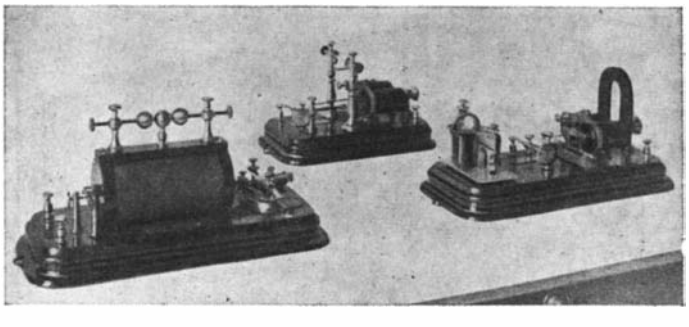
50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of April, 1898)

AMERICAN SUPREMACY IN THE IRON TRADE — During the past decade there has been a gradual increase in the exports of iron and steel from the United States; but the increase for the past year is very remarkable. From 1866 to 1896, the exports of pig iron rose from 6,659 tons to 29,862 tons. During the same period our exports of iron and steel railroad bars rose from 3,969 tons to 27,645 tons. During the year ending June 30, 1897, however, the export of pig iron was 168,890 tons and the export of iron and steel railroad bars was 112,172 tons. The aggregate value of all our exports of iron and steel to Europe during nine months of the year 1897 was $45,693,000, as against $34,549,000 during the corresponding period of 1896—an increase of 33 per cent. During the same months there was a decrease in the imports from $16,361,000 to $10,032,000.

THE SUBMARINE TORPEDO BOAT — Rightly or wrongly, the naval world believes that the production of a successful submarine torpedo boat will mark the greatest revolution that has ever occurred in naval warfare. The change from sails to steam, the introduction of armor plate, the breech-loading gun, the advent of the torpedo and the torpedo boat, have all in their turn produced radical changes in the construction and the tactics of war vessels, but not any one of them has ever produced the upheaval of long-established customs or the distrust of accepted theories which will occur on the day that a thoroughly practical submarine boat makes its appearance. There is a general belief that an effective under-water warship would have the above-water ship at its mercy, and we think the belief is well founded.



WIRELESS TELEGRAPHY — At the present moment, when such strained relations exist between Spain and the country, nothing could be more welcome than the announcement of a practical method of carrying on electrical communication between distant points on land, and between ships at sea. During last year Guglielmo Marconi, an Italian student, devoted considerable time to the development of a system of wireless telegraphy, and although he has made use of well known principles, he has so arranged and designed his instruments that he has found it possible to transmit intelligible Morse signals to a distance of over ten miles. It has been left, however, for the American inventor to design apparatus suitable to the requirements of wireless telegraphy in this country. After months of experimenting Mr. W. J. Clarke, of the United States Electrical Supply Company, of this city, has designed, and his company is placing upon the market, such a complete set of wireless telegraphy apparatus that it will in all probability come rapidly into use.

FIRST RAILROAD TO THE ARCTIC SEA — The first railroad running to a port on the Arctic Sea is the continuation of the Vologda Railway, in Russia, which is now finished to the port of Archangel, on the southeastern corner of the White Sea and at the mouth of the river Dvina. This new line, which was opened some weeks ago, says The Engineering and Mining Journal, is nearly 400 miles in length. The Vologda-Archangel Railway passes for the most part through deserted or sparsely populated regions, or across "tundras" and marshes, which are sometimes 50 feet in depth.

100 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of April, 1848)

FACTORY LABOR — The Senate and House of Representatives of Pennsylvania have passed the following law:—"Be it enacted that labor performed during a period of ten hours in any secular day, in all cotton, woolen, silk, paper, bagging, and flax factories, shall be considered a legal day's work, and that thereafter no minor or adult engaged in any such factories shall be holden or required to work more than ten hours in any secular day, or sixty hours in any secular week, and that after the fourth of July, of the present year, no minor shall be admitted as a worker, under the age of twelve years in any cotton, woolen, silk or flax factory, within this Commonwealth; that if any owner or employer in any such factories aforesaid, shall employ any such minor, he shall be adjudged to pay a penalty of fifty dollars, one-half to the party so employed, and the other half to the Commonwealth, to be recovered in like manner as debts of like amount are now recovered by law.

CONCRETE — This is the name of a mass of sand and small stones cemented together by lime, or some other cement. It would be well if the foundations of all buildings, when there is not solid rock, rested upon a strata of cement concrete. Seventy parts of fine stones, twenty parts of sharp river sand and ten parts of good lime mixed with water and grouted in. A good plan is to mix the lime dry with the other material and then throw water over them to make a perfect mixture by turning over. There is about one-fifth contraction of the concrete, in reference to the bulk of its ingredients before misture. This would be a fine substrata for plank roads as well as block pavement.

CONSUMPTION AND VENTILATION — Sir Jacob Starks, physician to the Queen of England, enumerates as the exciting cause of consumption, "long confinement in close ill-ventilated rooms, whether nurseries, or school-rooms, or manufactories;" he also says, "if an infant, born in perfect health, and of the healthiest parents, be kept in close rooms, in which free ventilation and cleanliness are neglected, a few months will often suffice to induce tubercelous chachexia"—the beginning of consumption.—Persons engaged in confined close rooms, or workshops are the chief sufferers from consumption.

NEW BALLOON SHIP — Mr. M. Von Ruyter, a Dutch engineer, has invented a new Aeronautic Ship which rises into the air from the impetus of its own working, with a weight of 200,000 pounds, with immense rapidity, and can be steered at will. Mr. Von Ruyter resides in Rotterdam, and exhibited a short time ago a working model 1 ell 27 inches in breadth and 83 ells 14 inches in length.

AN ANNOUNCEMENT TO OUR READERS

This page in the last four issues of this magazine has been devoted to the description of a new magazine of the sciences which is to be published under the century-old name of the SCIENTIFIC AMERICAN. Next month, May, will see the publication of the first issue of this new SCIENTIFIC AMERICAN.

●

In August 1845, when the first issue of the SCIENTIFIC AMERICAN was published, the meaning of science was the application of horse sense and mechanical ingenuity to improve the convenience of man's daily life. Nearly all of science was common knowledge. Under its great Editor, Orson Desaix Munn, the SCIENTIFIC AMERICAN became a fixture on the parlor table.

Now, a century later, our entire existence depends upon a science which is no longer common knowledge. The total of scientific information today exceeds the knowledge of any one man. It is the multiplied knowledge of science specialists in hundreds of separate fields.

During the past 50 years science has moved forward at a continually accelerating rate of progress; each new discovery has opened the way for many more. Whole new industries have now arisen at frontiers which were yesterday occupied by the advance forces of research science. Science has become a prime mover of modern history.

Demand For Scientific Information

This new role of science in human affairs has been recognized by a growing community of U. S. citizens. The members of this community have expressed an increasing demand for a source of authoritative and understandable information about science. Though they include experts in each field of science, they recognize that they are all, experts included, laymen before the sum total of scientific knowledge. They want to see science as a whole. They want to follow the major month-by-month advances of science no matter what field they occur in. They want to understand the new advances in the context of the history, the philosophy and the method of science which gives each discovery its meaning.

Their demand for scientific information is overlooked by the two kinds of magazine published today in the name of science. One is the technical journal in which the specialist reports his work to other specialists in the same field. The other is the "popular" magazine of science, published for mass audiences. To fill the gap between these extremes is the assignment of the new SCIENTIFIC AMERICAN.

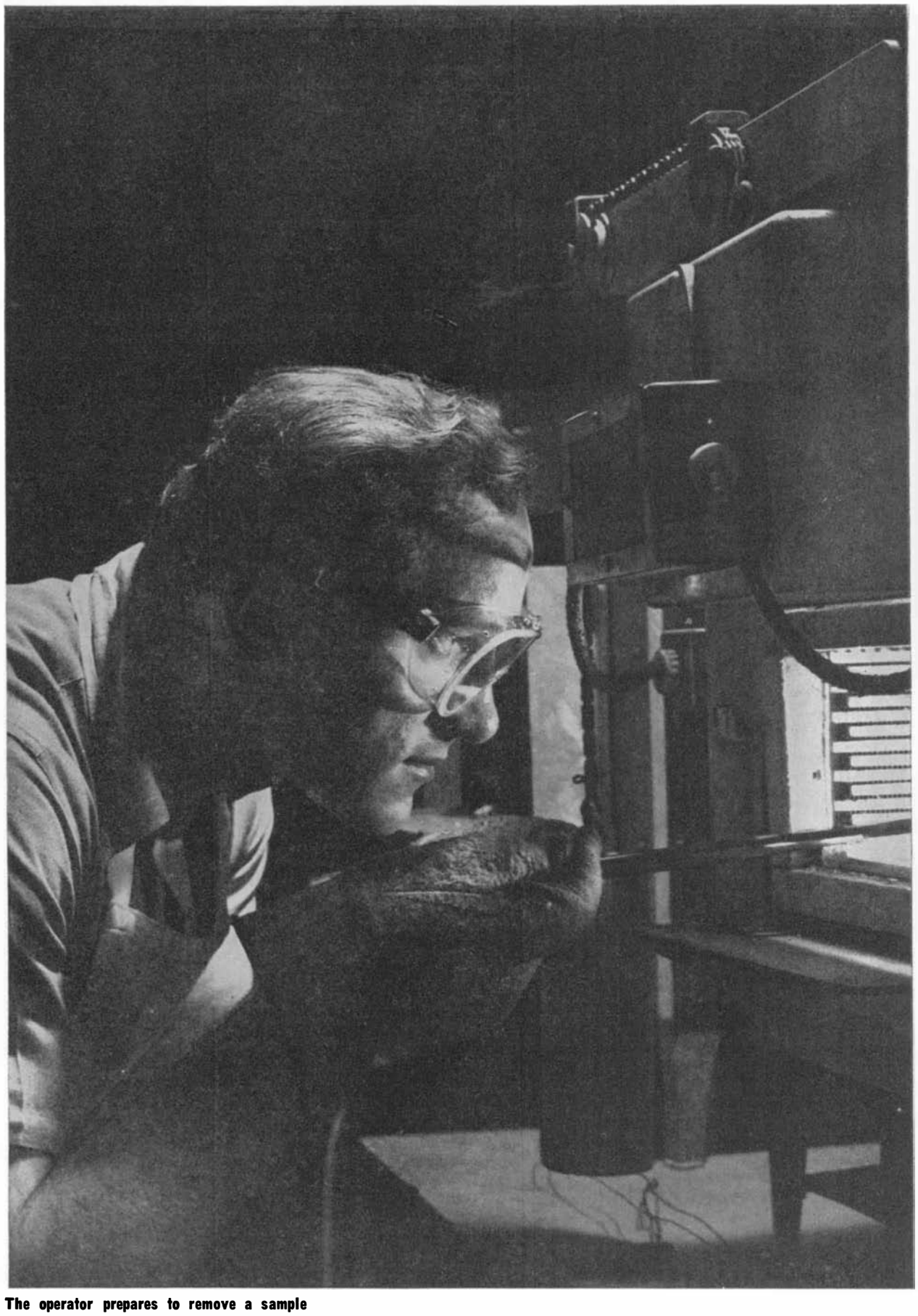
The SCIENTIFIC AMERICAN, its name, goodwill and circulation have been purchased by a new publishing company. Under a new Board of Editors the SCIENTIFIC AMERICAN has become the vehicle for the creation of an entirely new magazine of the sciences.

Scientist and Journalist

The Board of Editors will collaborate directly with the men whose work they report in the production of every article that appears in the new SCIENTIFIC AMERICAN. Many articles will be written by scientists themselves. Others will be written by the Editors and the small fraternity of journalists who are qualified to write about science. In either case, all articles will represent the joint effort of the best talents of scientist and journalist working in close collaboration.

The articles in the new SCIENTIFIC AMERICAN will be written in plain English. Where words are inadequate, the new SCIENTIFIC AMERICAN will make use of the full range of the graphic arts for their power to convey the nature of the tools, the matter and the method of science.

The new SCIENTIFIC AMERICAN will find a unique place among U. S. magazines. It will serve as a universal medium for communication among men in the sciences, and between them and the public that is best equipped to understand their work and purpose. It will provide a much-needed "digest" of the technical press. More than a digest, it will organize and relate the basic documents on each subject, which are scattered among the many journals that make up the archives of science. Providing it achieves in performance the high editorial standards on which it has been designed, the new SCIENTIFIC AMERICAN will establish itself as indispensable to the community of U.S. citizens whose demand for scientific information has inspired its creation.



The operator prepares to remove a sample of steel from the heat-treating furnace in a study of isothermal transformations

Scientific American
APRIL • 1948

PROGRESS IN THE HEAT TREATMENT OF STEEL

"Isothermal Transformation" Studies in the Laboratory Have Supplied the Metallurgist With a New Range of Useful Properties

By E. S. Davenport
United States Steel Corporation

SINCE the days of Tubal Cain, or whoever it was who first fashioned metals for use by man, blacksmiths, armorers and sword makers traditionally practiced the art of hardening iron products on the basis of "handed-down" experience and rule-of-thumb methods, with little or no real understanding of what took place within the metal during the hardening process. In fact, it is only within the last 40 or 50 years, particularly since the development and application of such modern research tools and techniques as the metallurgical microscope, X-ray diffraction apparatus, precise mechanical testing equipment and, more recently, the electron microscope, that metal technologists have begun to get a real insight into the nature of our metallic materials of construction and an understanding of the processes which we employ to control and enhance the useful properties of these materials.

Over the centuries, the hardening of iron and iron-carbon alloys (steel) consisted essentially of heating the metal to a high temperature and then quenching it in some liquid medium such as water, brine, oil or one of the numerous weird mixtures concocted by the early practitioners of the heat treating art. One ancient prescription for hardening sword blades called for plunging the red hot blade into the body of a slave. Quenching was effected *by passing the blade through the thigh of the slave.* The method indicated was too wasteful of slaves, and the ancients—like ourselves—would have hesitated to use it.

What took place within the steel during the quenching operation—that is, what made the steel harden and the actual mechanism of the hardening action—excited relatively little curiosity until about the beginning of the present century when certain French, English and American scientists began to apply the microscope to the study of the internal structure of metals. Professor Henry M. Howe of Columbia University and the Belgian-American Professor, Albert Sauveur of Harvard University, were notable among the pioneer metallurgists in America who devoted much of their effort to the scientific study of steel and other ferrous materials and who helped to train the first generation of metallurgists in this country.

The science and technology of the making, processing and heat treating of steel developed rapidly over the early years of the present century and, as has frequently happened in other fields, the experimenters began to move beyond the limits of the university laboratories and into the industrial research laboratories then just beginning to assume the important role they now play in the economic life of the nation. In the late 1920's the scientists at the newly organized Research Laboratory of the United States Steel Corporation at Kearny, New Jersey, began studies on the fundamental nature of the hardening of steel, using laboratory methods relatively new to metallurgical science. It should be said, however, that these methods had been applied to problems in other fields of physical chemistry long before.

As an example, physical chemists had long been familiar with the abnormal behavior of liquid solutions when cooled under certain conditions. The solubility of a given substance (for example, common salt) in a liquid such as water, is a fixed value at any definite temperature. That is, a definite quantity of water will dissolve only a certain amount of salt at any definite temperature. At a higher temperature, more salt can be dissolved; at a lower temperature,

The photomicrographs show Bainite magnified 2,500 diameters (left) after 50 per cent transformation and (center) after 100 per cent transformation. The structure of Austenite magnified 500 diameters is shown at right

less. When the solution contains all of the salt it is possible to contain, it is said to be saturated. By carefully controlling conditions, it is possible to cool a saturated solution in such a manner that it will contain the same amount of salt that it did at some higher temperature. Such an "undercooled" solution is said to be "supersaturated" since it contains more salt than it could under normal conditions. Methods had been worked out for studying the break-down of these so-called "supersaturated" or "undercooled" solutions by measuring changes in chemical, electrical and other properties as the break-down proceeded.

APPLIED TO STEEL — It was a logical step to apply these scientific principles to the study of similar changes or transformations in a solid metallic substance such as steel. However, the experiments with solid, hot steel had to be carried out with the aid of furnaces, microscopes and other metallurgical testing equipment instead of in beakers and test tubes, and many of the experimental steps and observations had to be made at high temperatures in contrast to the room temperature methods and techniques of traditional laboratory chemistry. Although it is not generally realized, modern physical metallurgy is really a special field in the broader science of physical chemistry. While many of the metallurgist's problems involve transformations and reactions in solid as well as liquid metal, the established laws of physics and chemistry apply to his problems with equal force. This holds true even though his experimental technique and equipment may be quite different from the physicist's or chemist's.

This fundamental work on the hardening of steel has been carried on continuously at the United States Steel Research Laboratory for almost 19 years and it has also been taken up and extended by countless other metallurgical investigators all over the world. It is now generally conceded that this new approach to the ancient art of hardening steel has resulted in an entirely new concept of the subject and has cleared the way for many outstanding developments in the treatment and use of modern steels. For example, thousands of tons of special ordnance parts with superior properties were produced in World War II by heat-treating methods based on these fundamental metallurgical studies. Production schedules were speeded up by shortened heat-treating methods made possible by the improved understanding of transformations in steel. In fact, a sizeable industry has grown up around the equipment and industrial techniques which have developed from this research.

The new laboratory technique which the United States Steel scientists applied to the study of hardening permitted the investigators, in effect, to watch the structural changes that took place in the steel while it was undergoing the internal, atomic re-arrangements which occur during the hardening process. This is accomplished by making certain observations and measurements on series of small steel specimens cooled rapidly from a high temperature to some lower temperature. These specimens are then held at this lower, constant temperature while the transformation or change in internal structure goes on. More specifically, a series of small steel samples is heated in a furnace to a high temperature, say 1,650 degrees, F., and then rapidly transferred to another furnace filled with molten lead or molten salt at a selected constant lower temperature, such as 800 degrees, F. Each individual steel specimen is held in this 800-degree bath for a different length of time; thus a series of specimens might be held in a series of holding times such as two, four, eight, 16, 32, 64, 128 seconds at 800 degrees.

At the end of each holding time one specimen is withdrawn from the 800-degree bath and cooled rapidly to room temperature in cold water. The treated specimens are then prepared for examination by the metallurgical microscope. If the experimenter has been skillful in choosing the time intervals in the series he will be able to detect in the microstructure, as revealed by the microscope, the beginning, the progress and the end of the hardening transformation as it occurred at 800 degrees, F. Hardness measurements on the same series of specimens give an added check on the microscopic observations. An alternative method of following the progress of the transformation is to measure the changes in length (or volume) which take place in the specimen as the transformation proceeds. This is accomplished by means of an apparatus called a dilatometer which registers, on an indicating dial graduated in ten-thousandths of an inch, the increase in length of a specimen as it undergoes transformation.

A motion picture camera can be arranged to take pictures of the indicating dial at periodic intervals

so the investigator can later project these pictures and read the information he needs to plot the course of the transformation. Still other methods based on changes in density, or in magnetic properties, which take place in the steel during the transformation can be used in such studies. Each method has its advantages and disadvantages and the researcher selects which ever method is best adapted to obtaining the information he needs.

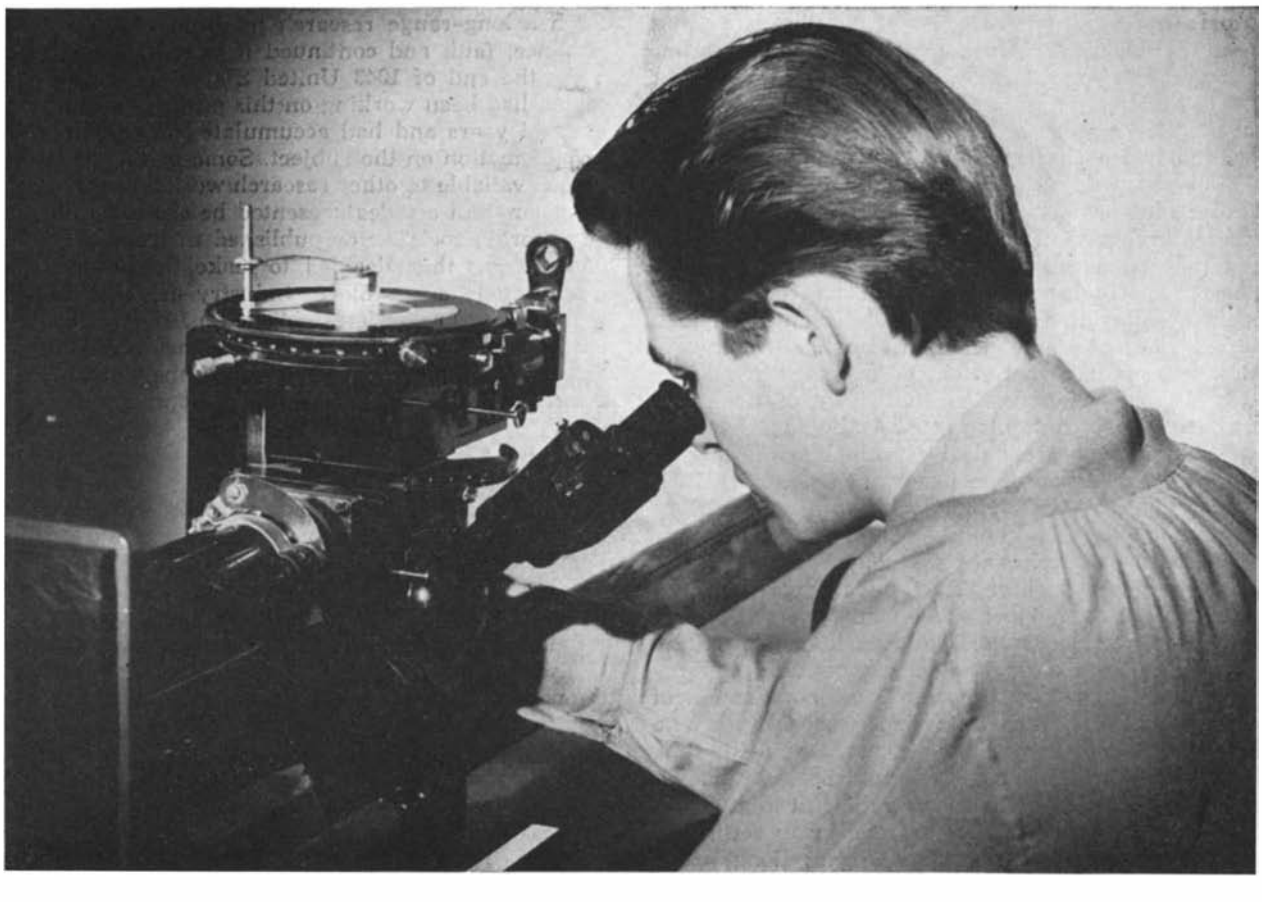
ISOTHERMAL TRANSFORMATION — In this general method of study, known as "isothermal transformation," specimens of many different temperatures below about 1,325 degrees, F., are made to undergo transformation at the same temperature. The results are then assembled in the form of a chart known as the "isothermal transformation diagram" of the steel. Such a diagram shows the elapsed time required for the beginning and end of the change in internal structure, or transformation, at any temperature level, together with other pertinent information of value to the metallurgist and heat treater.

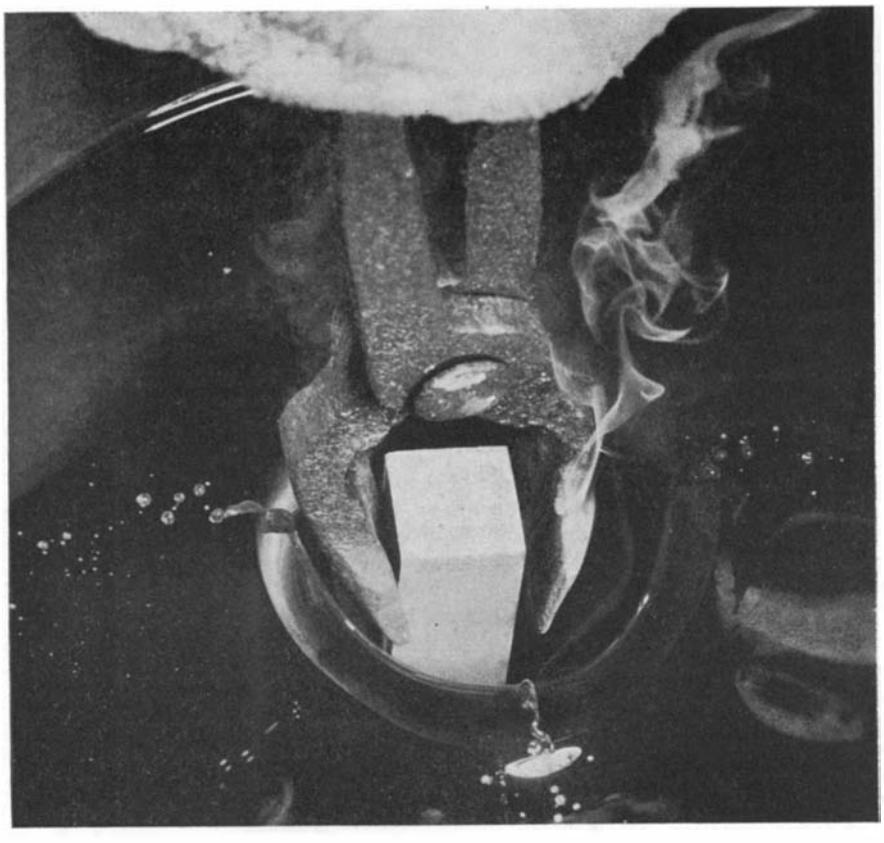
As an illustration, let us assume that the investigator has carried out his isothermal studies at 100 degrees, F., intervals from 1,300 down to 400 degrees, F. He has ten sets of observations, one at each of ten temperature levels. He then prepares a chart showing where transformation begins and ends at each level. He may also plot points for intermediate amounts of transformation. Now if he connects the points representing the beginning of transformation at all ten temperature levels he will have a curve which shows how the time for beginning of transformation varies with temperature. Likewise, if he connects all the points for the ending of transformation he gets a curve showing how the ending time varies with temperature. This type of information has proved to be of great value to heat treaters by showing them how fast they must cool the steel through certain regions of temperature in order to successfully harden the material in a quenching operation.

In addition to the above-mentioned curves, the investigator may indicate on the chart the type of microstructure that formed at each temperature level and the hardness of each structure, together with such other special information as may be of interest to the heat treater or ultimate user of the treated steel. The information on such a chart may also be used as a guide in developing greatly shortened heat treatments to *soften* steel, in contrast to *hardening* it. Such softening or so-called "annealing" treatments are often required to put the material in proper condition for machining or forming operations. These annealing treatments may often by long, drawn out affairs requiring many hours or even days to complete by older methods. Information summarized in the isothermal transformation diagram thus shows metallurgists how to save many valuable hours of furnace time.

Isothermal transformation studies reveal many startling facts about the hardening of steel—facts which were entirely unknown or only vaguely suspected until this work was undertaken. It was discovered, for example, that at certain temperature levels

Structures of the transformed metals are examined under a metallographic microscope





The high-speed photograph shows a sample bar of red hot steel being plunged into a bath of still oil as part of the quenching operation in the study of isothermal transformations

the transformation may complete itself in a matter of a few seconds or even fractions of seconds, while at other temperature levels the time required may run into hours, days, weeks or even months depending upon the chemical composition of the steel and other factors under the control of the steel maker and heat treater. Moreover, it soon became evident as the investigations progressed that each type of steel composition had a characteristic isothermal transformation diagram of its own and that many of the virtues of the alloy steels were traceable to their fundamental transformation behavior. Gradually, as more and more diagrams were worked out for different steel compositions, the specific effect of each of the common alloying elements (e.g., chromium, nickel, molybdenum) became clear. This enabled the metallurgist to predict what might be expected of new or proposed compositions. As the study of the more complex steels, containing several alloying elements, was taken up, a great deal of valuable information was accumulated on these important materials. Much of this was immediately applicable to a wide variety of products.

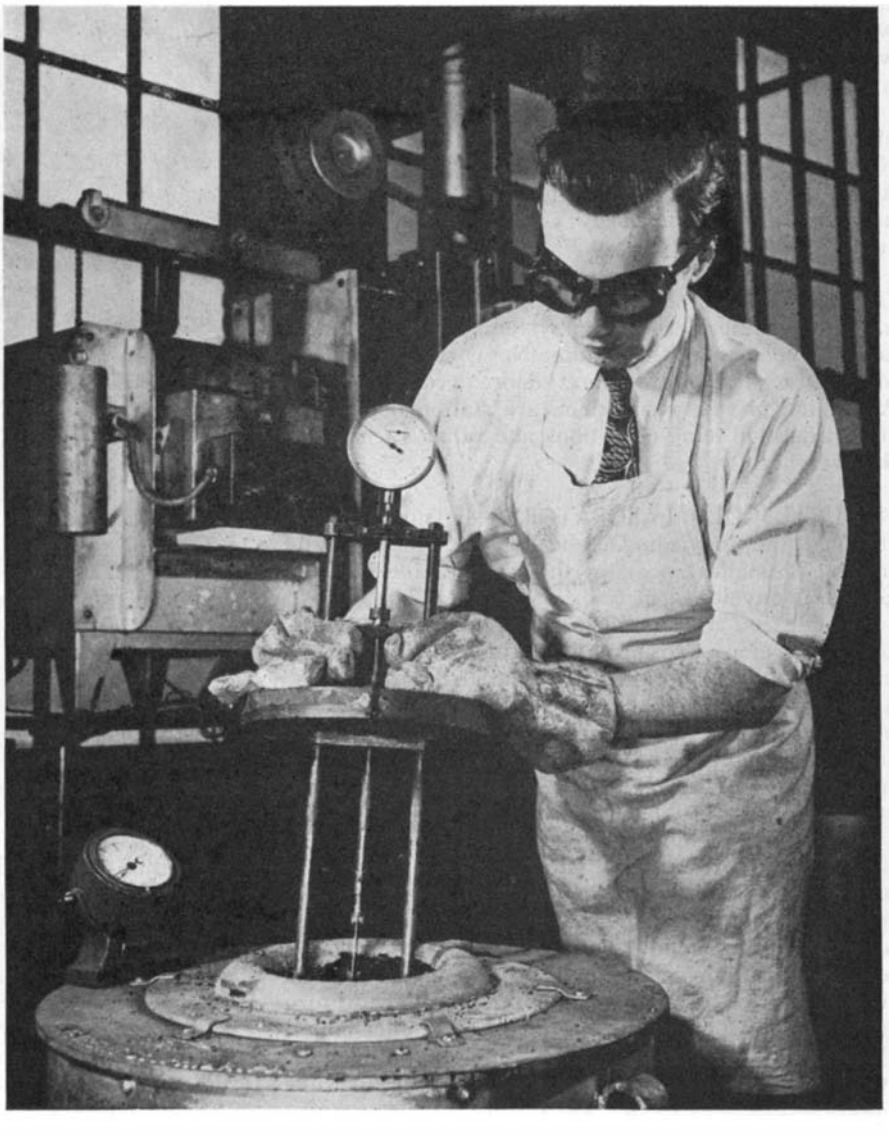
It should be emphasized that all of this work involved a great deal of effort by a large group of investigators over a period of many years. For example, to work out the isothermal transformation diagram of even a single steel composition may require the preparation, treatment and examination of well over a hundred laboratory specimens. In the case of alloy steels of more complex composition the time involved in the transformation often becomes longer, the microstructure becomes more difficult to interpret and the investigator is forced to feel his way, setting up new standards of comparison as he goes along, backtracking, discarding, revising his ideas and interpretations and making new hypotheses about matters that fall outside the realm of previous experience. Such a long-range research program requires time, patience, faith and continued financial support.

By the end of 1943 United States Steel's investigators had been working on this problem steadily for over 14 years and had accumulated a sizeable body of information on the subject. Some of this had been made available to other research workers in the form of papers and articles presented before scientific and engineering societies or published in technical journals. It was then decided to make this information more widely accessible to industry in general. Late in 1943 the Corporation published a 104-page booklet entitled "An Atlas of Isothermal Transformation Diagrams" containing 56 of these diagrams and covering a total of 47 different steel compositions.

NEW HEAT TREAT METHOD — One of the unpredictable by-products of these researches on the fundamentals of heat treatment was the discovery and development of an essentially new method of heat-treating steel, which came about as follows. In the early days of the work at the United States Steel Research Laboratory it was observed that a hitherto unknown microscopic structure formed in the steel if it was caused to undergo transformation at constant temperature within a certain temperature range, usually between about 450 and 950 degrees, F. Since this structure, now called "Bainite" after one of the original observers, was entirely new to the investigators, it was decided to look into the mechanical properties of steel having this particular microscopic structure. It was revealed that many types of steel treated in

this way exhibited a remarkable degree of toughness or ductility at relatively high hardness. The same steels treated by the older, customary methods were always lacking in toughness at high hardness. This led to further investigations culminating in the commercial development of an entirely new method of isothermal heat treatment which came to be known as "Austempering." This method was successfully used in many wartime products and is undergoing further commercial development. Variations of this isothermal treatment were explored by many other investigators and metallurgists, with the result that today several well-recognized methods exist for heat treating steel by isothermal means, all having their roots in the information presented in isothermal transformation diagrams.

In its broader aspects, this work of United States Steel's scientists, which began as a scientific investigation of the transformation process in the interest of a better understanding of metallurgical changes, has grown to have widespread industrial implications in the field of practical heat treatment. It has had a pronounced influence on the thinking and practices of metallurgists throughout the world. The following few examples of peacetime steel products, the quality and utility of which have been enhanced as a result of isothermal transformation researches, will give some idea of the scope of this metallurgical development: a wide variety of simple tools such as garden and farming implements, hammers, chisels, axes, screw-drivers, in fact, any tool that should embody a high degree of hardness without sacrifice of toughness; numerous machinery parts such as needle bearing pins, springs, bobbin rings, snap rings, lockwashers, linotype and typewriter parts, kicker and knockout pins, clutch parts, various wire forms requiring high hardness, similar applications of thin steel parts requiring a combination of hardness and toughness; miscellaneous articles such as shoe shanks, safety toe caps, knife blades and knife back springs, miscellaneous hardware, firearm parts, link chains, rolls, sidebars, fishing rods, golf shafts, and many others too numerous to mention. In fact, the whole broad range of steel products which undergo heat treatment, either during processing or as a final operation, have been benefitted by the increased metallurgical knowledge accruing from isothermal transformation studies.



The dilatometer. With this device the operator can measure the progress of the isothermal transformation by measuring the changes in length which take place in the specimen as it is held at a constant temperature

THE WORST WEATHER IN THE WORLD

The Freezing Winds and Perpetual Moisture At the Summit of Mount Washington, Tallest Peak in the Northeastern U. S., Make It an Admirable Proving Ground to Test Equipment Which Must Withstand Less Severe Conditions

By Martin Sheridan

TWENTY five hundred miles south of the Arctic, within sight of the Atlantic Ocean rears a wind-swept mountain blanketed by Arctic tundra, cold-stunted trees and Arctic flowers. It has Arctic weather in abundance—sub-zero temperatures, winds of greater-than-hurricane force, blowing snow, ice and freezing clouds.

The peak is Mount Washington, towering 6,288 feet above sea level in the rugged White Mountains of New Hampshire. It used to be as devoid of human life in the winter as the ice cap in Greenland. Today, however, a score of hardy young men inhabit the summit.

Three men run the Mount Washington Weather Observatory, one of the most important links in the nation's weather forecasting system; three engineers and two cooks man the Yankee Network's Frequency Modulation transmitter next door; a dozen Navy, Army and private researchers are stationed there to collect data on icing conditions and other vagaries of the weather.

NATURAL COLD LABORATORY — During more than half the time from October to June Mount Washington, the tallest peak in the Northeastern United States, is enveloped in freezing clouds which deposit tons of ice on its summit. From the research standpoint, therefore, Mount Washington is of enormous value as a "cold laboratory" to aviation and to de-icer and Arctic clothing manufacturers. In addition, power companies, railroads, communication and transportation companies, and resort areas are aided immeasurably by the reports from the tiny weather station.

Late last September the Navy hauled a jet fighter plane up the tortuous eight-mile mountain road to be anchored for the winter in an open-ended wooden hangar so engineers might try to correlate engine and wing icing conditions. Two huge tank trailers loaded with high-octane gasoline also made the difficult climb to the summit and were left there to furnish fuel for power runs. The plane, a McDonnell Phantom (FD-1), is faced into the prevailing west wind and anchored into the mountain with steel eye bolts which extend 18 inches into the solid rock. Should the plane be blown away during a storm, a good part of the mountain would be carried away with it.

At the end of the long flight of stairs are the quarters of the Navy engineers stationed atop Mount Washington

One of the pertinent questions that the scientists hope to be able to answer as a result of this research is: will the jet engine or the plane's wings ice up first under Arctic conditions? Constructed like a small wind tunnel, the hangar has a canvas drop at either end to protect the research personnel during non-test periods. The building has a steel frame skeleton covered with two layers of rough boards. The interior is lined with cement asbestos board. According to the Volpe Construction Company, builders of the

hangar, the steel frames were anchored on wooden sills which in turn were anchored to the rock with steel dowels.

Unlike a cold wind tunnel Mount Washington's natural testing laboratory furnishes *true* cloud icing conditions which cannot be simulated at any cost. The correct size of the water droplets and their proper distribution in the clouds cannot be reproduced artificially—not even at Eglin Field, Florida, the Army's $10,000,000 cold laboratory.

In charge of the project atop Mount Washington is the Air Co-ordinating Committee of top-ranking Army and Navy officers. This agency has contracted with Smith, Hinchman and Grylls, Inc., an engineering and architectural firm of Detroit, to provide housing and food for the engineers and researchers living on the mountain.

Both the Army's Air Materiel Command and the Navy's Aeronautical Engineering Laboratory direct the engineering research, while Harvard University is under contract to the Army's Atmospheric Laboratory to conduct studies on the basic physics of icing. Wallace Howell, research fellow at Blue Hill Observatory, is field director of the Harvard program.

The late Salvatore Pagliuca, former director of the Yankee Network's Weather Service and one of the original three modern weather observers to spend the first winter at the summit in 1932, conducted the first observations of icing conditions in 1934. He used wing models at that time to investigate the size of cloud droplets for the Massachusetts Institute of Technology. Since 1941 a device called a multi-cylinder which is composed of several small cylinders of varying diameters on a long metal rod has been used to measure the liquid water content of clouds and the distribution of the size of the droplets. During the war, weathermen measured ice formations every three hours. They were assisted for a time by the Army's 8th Weather Squadron.

This model of a DC-6's nose mounted on the cog railway trestle aids in the study of ice formation on aircraft

WARTIME RESEARCH — Other wartime research on Mount Washington covered:

Studies for the B. F. Goodrich Rubber Company of an aircraft wing de-icer. This rubber de-icer was installed on the forward section of a plane wing which was mounted on the water storage tank. Extensive observations of the tensile strength and adhesiveness of the ice, were made.

Development by the General Electric Company of the multi-cylinder and other instruments for measuring the atmosphere.

Work on a cloud meter to measure the water content of clouds.

Installation of an Army automatic weather station for tests by a weather squadron that pitched tents and lived below the summit for several weeks.

Testing of wearing qualities of phosphorescent paint for the U. S. Navy.

Testing of Goodyear synthetic rubber tires mounted on an automobile that was driven up and drown the mountain early in the cold season. An unexpected crippling snow storm in October trapped the vehicle on the mountain for the next eight months.

During the winter of 1946-47, Northwest Airlines, then under contract to the Army Air Forces, mounted a 2,200-horsepower Pratt and Whitney aircraft engine on a tank-like vehicle in the same location where the jet plane is now anchored. Engine controls, switches and gages were located inside an enclosed cab, thereby enabling parka-clad hermits to run the engine and conduct their experiments. The results have not yet been announced.

Mount Washington has always been the most lonely, windy, foggy, storm-racked and generally God-forsaken spot in America in which to spend the winter. But the introduction of a few innovations has made the lot of the weather observatory crew, the FM radio station operators and the government-sponsored researchers a bit less arduous. An electric window has been installed in the main observatory room to enable the men to make observations without going outdoors. Constructed of NESA glass with a special metallic coating, the window is heated with four amperes at 115 volts to prevent the formation of fog and ice. Instead of the old electrically-heated anemometer, pitot tubes (similar to those used in planes to record air speed) automatically record the wind velocity. An efficient oil-burner, replacing the old coal furnace, has been installed for heating the observatory building. The weather observers have electric foot warmers and electric blankets. Also, there is a sun lamp to supply vital health elements.

TWENTY-DAY SHIFT — All the inhabitants of the mountain work on a 20-day shift, with 10 days off. They must be rugged enough to brave frigid blasts encountered during their trek down the mountain for a respite in the valley or a visit to Boston—170 miles distant. The recent war has made even that task easier with the introduction of an Army weasel (tractor vehicle) at the Glen House in the valley for transporting the men part of the way up the mountain road. Compare these comforts and conveniences with the hardships suffered by the Hitch-

cock-Huntington Expedition of six men who occupied Mount Washington for six months during the winter of 1870-71 as the peak's first weather observers. Of that first winter, J. H. Huntington wrote in his log:

"The wind roared terribly, as if inspired with the power and spite of all the furies, and the wild rage was so deafening that we were obliged to shout to our utmost to make ourselves heard. . . In the room at no time has the temperature been higher than 35 degrees. And to accomplish this we have the stoves at red heat. The thermometer hangs precisely five feet from the stove. Ten feet from the stove at the floor the temperature is 12 degrees."

One of the pioneers froze to death.

Two members of the United States Signal Service, forerunner of the present Weather Bureau, were assigned to the summit from 1871 to 1887 and for the following five summers. No one dared to brave the winters on Mount Washington again until 1932, when Alexander McKenzie, Robert S. Monahan and Salvatore Pagliuca volunteered to serve without pay and report by radio to Albert Sise, an enthusiastic radio ham in Boston.

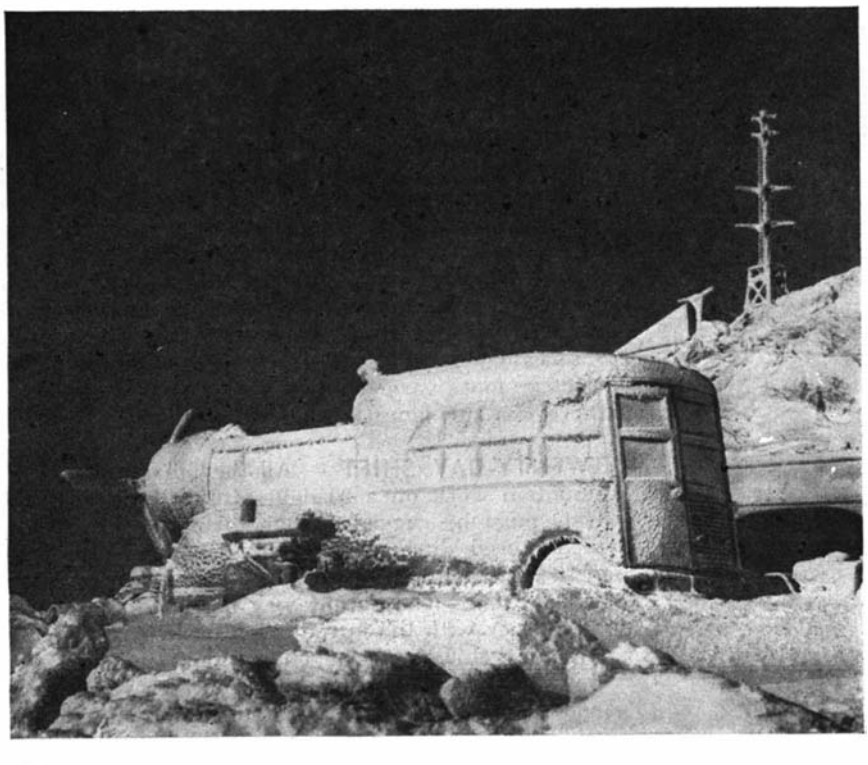
That winter found the slopes of the White Mountain region dotted with ever-increasing numbers of men and women on skis. A few summer hotels remained open all year 'round for winter sports enthusiasts and prospered. Mount Washington weather reports became the focal point for ski information. On the tiny observatory's promise of snow, the Boston and Maine Railroad advertised its first ski train leaving Boston on February 12, 1933. That Saturday afternoon four inches of snow fell, assuring the 1,000 persons, who arrived at Crawford Notch in 34 passenger coaches hauled by five locomotives, of excellent skiing conditions.

The present observatory was completed in 1937 with funds contributed by the Mount Washington Cog Railway, the Mount Washington Observatory and the Yankee Network. The building is constructed on 9 by 10-inch railroad ties securely mortised, the foundation fastened to 10 four-foot long bolts extending into solid rocks or blocks of concrete. The roof of the two-story building is trussed, braced and chained beyond description. No other building—wood or brick—has withstood the total annual wind velocities of more than 320,000 miles recorded at Misery Hill!

Imagine a place blanketed in heavy fog 53 per cent of the year; where more than 25 clear days out of 365 would be a record; where a temperature of 46 below zero has been recorded. Flurries not included, snow has fallen on the summit during every month since September 1939. Summer temperatures have dropped to 22 degrees, F., and the all-time maximum is 73 degrees. In 1934 a special anemometer registered a gust of wind with a velocity of 231 miles an hour—the highest ever officially recorded anywhere. The average rainfall is 80 inches, the average snowfall 208 inches.

Scientists describe the weather atop Mount Washington as the worst in the world. It is certanly the worst weather in which man is living. The continuous sub-freezing temperatures, super-hurricane winds, blowing snow and absence of sunshine support this belief. Though temperatures do not average as low as those in the Arctic, high winds and low temperatures nearly always attack together on Mount Washington and thus the chilling effect is tremendous. The severity of the cold is increased beyond conditions in the Arctic where low temperatures seldom are accompanied by high winds.

Mount Washington in winter is a mountain of misery. But the hardy young men who brave it risk madness from sheer monotony and the world's worst climatic conditions in the interest of science.



The 2,000-horsepower Pratt and Whitney aircraft engine was mounted on this vehicle with all controls and instruments located in the enclosed cab so that the engine could be thoroughly tested under the most severe weather conditions

PHOSPHORUS: BEARER OF LIGHT AND LIFE

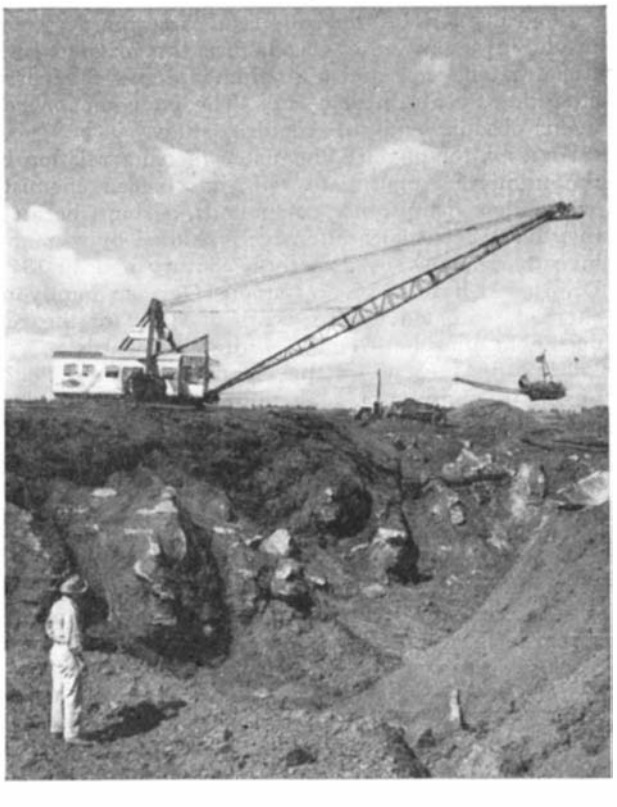
The World Shortage of Food Is Partly the Result of a Shortage of Phosphate Fertilizer. The Second of Two Articles

By William Mann

"THE BEST soil manure of all is human blood," says the author of *Kitab al-Falahah*, a medieval treatise on agriculture. One wonders how this Tenth-Century Arabic author discovered such a gruesome fact, if it is a fact. Human blood is a nitrogenous material, but nowadays it is not applied to the soil for nutrient purposes, although this may well have been done in the more ruthless youth of mankind. In our own time there are more efficient ways to bring in a crop, but even now maintenance of the food supply is one of the greatest causes of concern and cruelty. There are few things more apt to whip simple men into a desire for war than exaggerated fear of danger to the food supply. War guarantees that the food supply will get badly out of joint in the lands where the fighting takes place.

It is significant that all of the five official reports on which the European Recovery Program is based emphasize the prime need of that continent for fertilizers before hunger can be abated and recovery can begin. The need of hard-worked soils for nitrogen, phosphorus and potassium is acute. Despite the great loss of life during the war, the population of every nation in Europe except France has increased since 1939. These additional hungry mouths make it essential that soil nutrients be replenished. Many of the farms of Europe have undergone accumulated starvation for fertilizers ever since the fall of France.

Mining matrix—phosphorus-bearing rock



PHOSPHATE AND FOOD — An intelligent visitor from Mars, suddenly presented with a copy of the Harriman Report on the basis of the Marshall Plan, would probably consider the present difficulties of Europe incomprehensible, especially the superphosphate deficiency. Lying in North Africa are some of the largest and best phosphate deposits in the world. One would suppose that such an excellent source of soil nutrients would be gratefully accepted and intensively used by a crowded region constantly suffering from population pressure. But, as the Martian will learn from the Report, in 1940 the inhabitants of Europe abruptly stopped applying phosphorus compounds to the soil. Instead, phosphorus was suddenly diverted to fill mortar and howitzer shells for smoke screens and compounded into flamethrowers, all for death-dealing purposes. Our visitor from Mars might cynically conclude from this that Europe was bent on thinning its population to relieve the pressure. Not at all! Even after a large American army was transported to Europe with phosphorus in new and exceptionally malignant forms, we find that the total population of Europe has risen and the need for fertilizers is now greater than ever.

America was fortunate enough to wage a successful commuters war, and therefore the phosphate situation is rather better at home. Since 1940, when the European fertilizer industry began its enforced vacation, 125 new fertilizer plants have been built or are now in course of construction in the United

Matrix brought in from the mine is dumped on a large pile and sprayed with high-pressure streams of water. The resulting slush drains off and is carried away by conduits to be processed

States. Not all of these are superphosphate plants of course. It is estimated that in the twelve-month period ending on June 30, 1948, our phosphate industry will produce the equivalent of 10,000,000 tons of normal superphosphate. This represents about 1,850,000 tons of phosphoric acid and includes plant nutrient phosphate in all its various forms. Our needs will therefore be adequately met.

But let us leave the social problems of phosphate and return to chemistry, which is a good deal simpler. The use of phosphate compounds as fertilizers is the oldest use of phosphates by man, and it still demands a larger tonnage than any other application. This fact also has an important indirect effect on the chemical industry in general. For instance, when one reads of the enormous basic importance of sulfuric acid to industry, it is well to remember that its greatest use in war or peace comes from the manufacture of superphosphate fertilizers.

COMPLICATED CHEMISTRY OF PHOSPHATES — One of the things that has often worried soil chemists is the fact that most phosphate is wasted, even when the highest concentrations are applied. Only 10 to 30 per cent of the quantity added to a given soil immediately before planting is recovered through the crop. The rest of it is "fixed" in the soil; that is, something happens which renders it permanently unusable by the plants.

What becomes of the unusable 70 to 90 per cent of this rather expensive material? This problem is considered so important at present that the Tennessee Valley Authority recently (in 1947) assembled the nation's leading agricultural chemists at Muscle Shoals for a week-long conference. As a result of these discussions an extensive program of research was recommended, including study of "fixed" phosphate and of the properties of elemental phosphorus, using radioactive tracer techniques. For many years it was assumed without convincing proof that the bulk of the lost phosphate was consumed by micro-organisms in the soil. It is now known that soil organisms, like the useful ones that manufacture the antibiotics, are nearly innocent of making off with any significant amount of phosphate. Apparently, the loss is due mainly to precipitation and adsorption in the soil, rendering the fertilizer insoluble again, as it was before the original rock was treated. Iron and aluminum are the chief precipitating agents in acid soils. The phenomenon remains obscure and still requires study.

As a matter of pure chemistry the interrelation of the numerous phosphate salts has baffled chemists longer than many other compounds, perhaps because they have been more intensively studied by so many investigators. Almost exactly a century ago, in 1849, Dr. Heinrich Rose of the famous German family of chemists summed up his years of study of the remarkable phosphate family with these words:

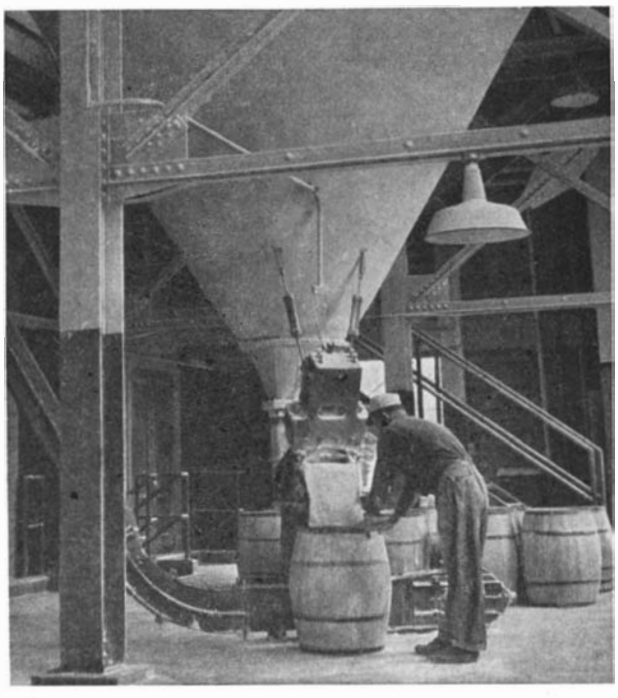
"No substance offers the chemist greater difficulties than phosphoric acid, and the longer the behavior of the acid is studied the more the difficulties increase. Each new investigation presents the chemist with new anomalies; fresh and puzzling phenomena constantly make their appearance while the older well-known difficulties still remain."

Although the learned Dr. Rose did not really know what difficulties remained, and although much progress has been made since 1849, his dictum is still true to a remarkable degree. In recent decades, since phosphate compounds have proved themselves useful in so many new ways, the situation is seen to be even more complex than Rose imagined. An astonishing array of complicated and dubious formulas for phosphate salts of commercial value can be

found in the scientific literature. Conflicting data are described in many instances, and it is clear that not a few people have published material that cannot be confirmed.

It was Dr. Rose who first prepared and analyzed the now famous salt, $Ag_5NaP_6O_{18}$. This compound is important as a type of metaphosphate salt with an alkali metal, sodium, *inside* its molecule. This is something that does not often happen and it leads to very interesting related phenomena. Metaphosphates are of great and increasing importance in the whole range of industry, in the huge fields of water-treating, detergency and food and fibre processing. The mother of them all is metaphosphoric acid, HPO_3 a deceptively simple looking compound which possesses, with its numerous salt offspring, the most complicated properties of all the complicated phosphorus acids. The reason for this is the strong tendency that these molecules have to polymerize, that is, to manifest a certain chemical clannishness which causes them to hang together and form varied products of high molecular weight called polymers. Moreover, on what seems like rather slight provocation, the metaphosphates will also isomerize, which is a species of chemical inter-breeding whereby the same atoms arrange themselves differently within the new molecule; the isomers thus formed are able to present different properties while retaining the same molecular weight. The metaphosphates are inorganic compounds, of course, but in polymerization and isomerization they exhibit the kind of behavior that makes organic chemistry so exasperatingly fascinating. In fact, the behavior of the larger metaphosphates is still so baffling that for the present most chemists do not try to work out definite formulas for them all.

AN EXPANDING INDUSTRY — Yet they are of constantly increasing importance, as we have said. Sodium metaphosphate is widely used under a number of trade names in treating boiler water, in laundry operations, and in the textile industry. The calcium and potassium metaphosphates have also received considerable attention because of their value as fertilizers, their chief advantage being an unusually high plant nutrient content.



A phosphate product being packaged for shipment

It may be well to mention here, since there seems to be a lingering doubt in many people's minds, that the Esch Bill passed by the United States Congress some 35 years ago, effectively did away with phosphorus necrosis in the American match industry. At one time white phosphorus was a serious menace to the health of match workers, but no longer. In fact, a major match manufacturing company sacrificed its patent rights in order to make the Esch Bill work. By this act of commendable altruism, a large corporation made commercially valuable information on the important substitute, phosphorus sesquisulfide, freely available to all of its competitors. The research and development work for this had cost the stockholders a good deal of money. Without the earlier efforts of such bold reformers, match workers might

Here martix is sized and concentrated. In the large circular tanks, called classifiers, impurities are settled out and the material moves over conveyor belts to the sintering plant

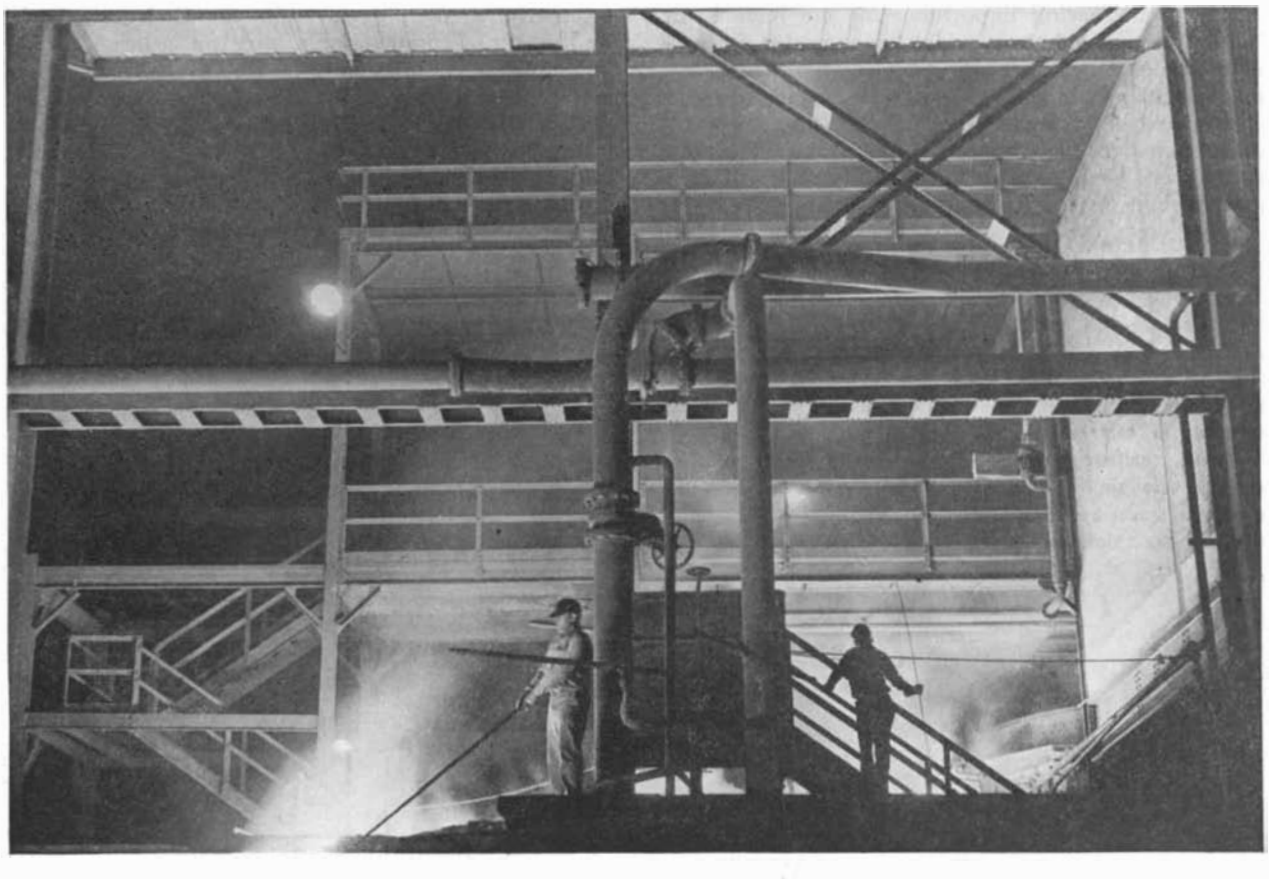
still be going about with their teeth falling out and their jawbones dropping off from the horrible effects of "phossy jaw."

The baking powder industry is reported to be the second largest consumer of phosphate rock. It is estimated that over 160,000,000 pounds of baking powder are consumed in the United States per annum. The function of this powder is, of course, to leaven dough. Nowadays, baking powders generally consist of a dry mixture of sodium bicarbonate with one or more acidic compounds capable of completely decomposing the bicarbonate into carbon dioxide gas. This prevents the precipitation of sodium carbonate or washing soda in the bread. The use of acid phosphates for this purpose is constantly increasing. They have an advantage over the older alum and tartrate powders in that the phosphates left behind by the new products are believed to be good for the growth of bone and muscle. The chief phosphates used for baking are the monocalcium and monosodium phosphate salts. Straight phosphate baking powder is a mixture of these two with sodium bicarbonate and diluents and fillers such as cornstarch or flour.

SOME NEW COMPOUNDS — Millions of dollars have been spent by firms on research of the new organic phosphorus compounds. Much of this work is still in course of development, but there can be little doubt that some of it, especially in the fields of plasticizers for the plastic and lacquer industries, inhibitors for rancidity of oils, and specific corrosion inhibitors will prove valuable in the future. The newer food uses include the important medicinal compounds, the glycerophosphates and the hypophosphites as well as phosphates containing sodium and calcium. The latter are considered a good source of two important constituents of men and animals. Sodium ferric pyrophosphate is reputed to be a good means of getting valuable iron into the body.

Water treatment is an important industry in which great quantities of phosphate compounds are used to soften water, decrease its corrosive properties, and help loosen dirt. Trisodium phosphate has long been standard for these purposes, but research has lately introduced many of the fancier hexa-,pyro-, and poly-phosphates, which are reputed to be better. We have already mentioned the organic esters of phosphoric acid. Phosphorus is also important in metallurgy as an alloying agent. It is still absolutely necessary in the match trade, both as an element and in compounds. It is an important catalyst in petroleum refining. The soft drink industry alone buys pure phosphoric acid by the ton for use in its beverages. Altogether, it is no exaggeration to say that all large industries use the phosphorus atom in one form or another. It is essential to many trades—paper making, brewing, cellulose, dye, soap, printing, leather and rubber, to name a few. In fact, the phosphate industry is one of the most progressive in the United States. Although it is no longer young, it seems to be one of the few really capable of challenging developments in the great new organic chemical industries and of giving them a real run for the consumer's dollar.

Workers direct the flow of molten slag and ferrophosphorus from the electric furnace to the cooling ponds



MANUFACTURING ADVANCES IN WARTIME GERMANY

Machines and Processes Which Were Developed in Competition With Allied Engineering Brains Are Now Available to U. S. Industry

By John L. Kent

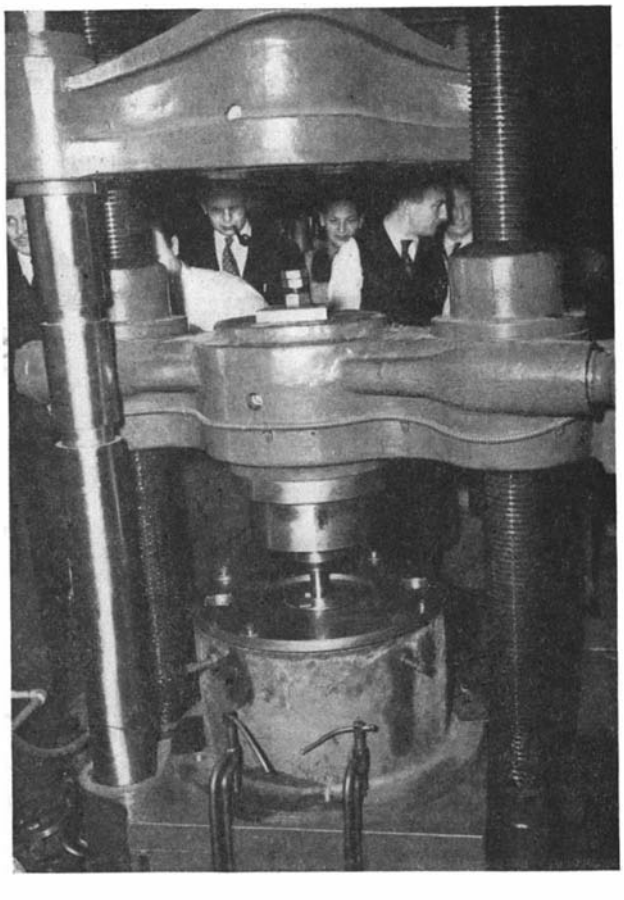
MANY ALERT American manufacturers can improve their products, add profitable lines, and even start new businesses by making use of technical information on German processes and equipment which can be obtained from the Department of Commerce. The Department's Office of Technical Services is releasing thousands of reports on German science and industry based on investigation by OTS industrial intelligence "detectives."

During the past two years these investigators have surveyed all German advances which could be of value to American industry and their reports can be obtained merely for the cost of reproduction.

Many of these reports, containing descriptions of processes and equipment, formulas, plant layout and other technical data, sell for less than a dollar! American firms and individuals are buying them at a rate of $1,000 worth a day.

COLD STEEL EXTRUSION — Job stamping shops and manufacturing shops which do sheet metal stamping will be interested in a report on a process developed in Germany to extrude cold steel just as we extrude tin, zinc, copper and other non-ferrous metals. German success in making cold steel "flow" under pressure opens up wide possibilities for American manufacturers. OTS investigator, W. W. Galbreath, says the process, which uses special dies and the application of a phosphate bonderizing treatment, can result in remarkably reduced costs for the production of many common steel objects.

The cold extrusion process promotes greatly increased production. For example, in shell fuses, where we produced a unit every two or three minutes, the Germans by the use of the cold extrusion press made approximately 20 or 30 per minute. The extrusion process also enables the manufacturer to make thousands of intricately shaped parts which cannot be made by the stamping procedures now



An experimental cold extrusion press. During the war the Germans succeeded in extruding cold steel with such a machine. The press is said to make possible greatly reduced costs in the production of many common steel objects

employed. Only a small amount of new equipment will have to be obtained because the work is closely associated with that normally done in job stamping shops and the cold extrusion dies are of the same general type as the dies used for stamping.

The process offers an unusual opportunity to American manufacturers for making parts now produced from malleable iron castings, drop forgings, or machined from bar stock. The German process requires little machining, and in some cases no machining at all. It is now being tested by the Heintz Manufacturing Company, Philadelphia, under a contract with the U. S. Army's Ordnance Department.

The bonderizing treatment used in the cold extrusion process is also expected to solve one of the difficulties encountered by small firms engaged in sheet metal drawing. Often poor design of molds and equipment causes tearing or results in unsightly ridges or corrugations in the finished product. The problem is friction. The remedy is a low-friction surface on both sides of the metal sheet so that the metal will flow freely when it is pressed into shape.

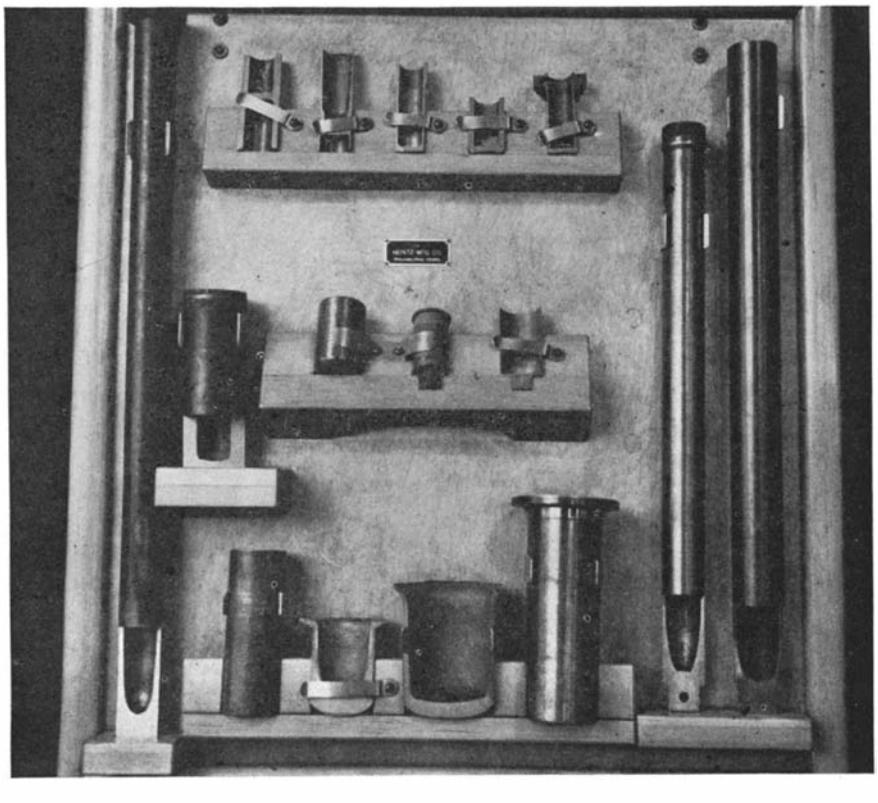
Investigations in Germany reveal that successful use has been made of zinc coatings (or bonderizing) that are applied on both surfaces of sheet steel to reduce the friction and to permit particularly extensive draw.

The procedure has markedly increased production and diminished the need for the establishment of large press facilities in the plant and extensive research upon lubricant media. The zinc coating process does not seem to be too difficult for the small manufacturer to employ. Equipment is not too expensive and the final product is of high quality. The coating processes will also be of interest to other manufacturers who produce cold reduced steel solids such as cold drawn wire and cold drawn rolled thread screws, because it reduces the number of intervening heat treatments and subsequent scale removal processes.

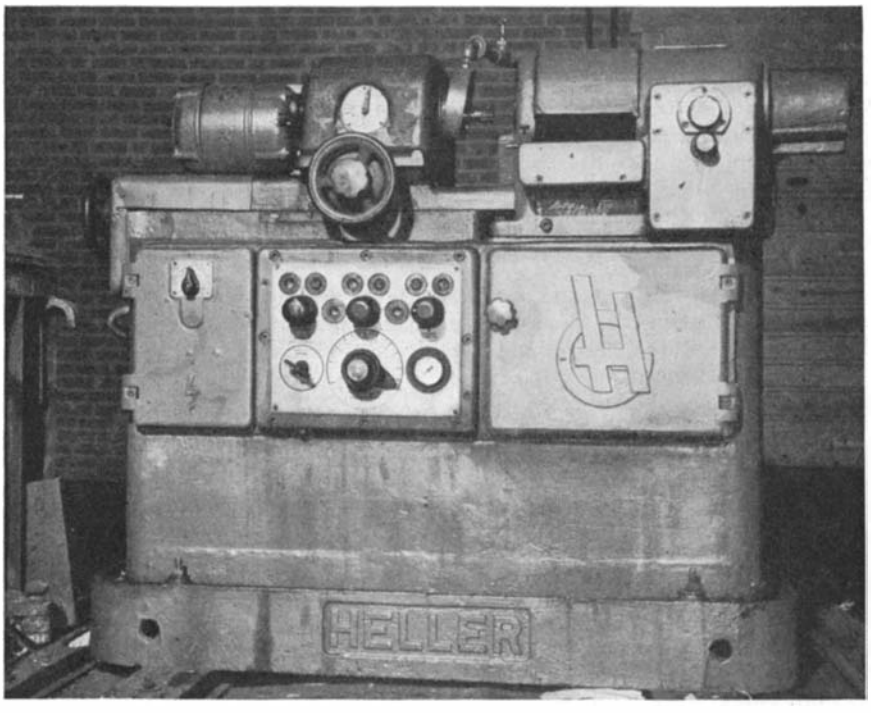
SALT BATH HEAT TREATMENT — Commercial heat treating firms will be interested in German salt bath heat treatment methods by which close control of temperature was obtained without undue attention to instrumentation. The Germans have used salt baths for many years as their chief means of heat treating and during the war extended their knowledge of salt baths for case hardening, decarbonizing, neutral surface treatments and for quenching as a substitute for oils which were in short supply. Information on their practices and research was obtained from several large metallurgical plants.

German practices indicate an emphasis upon the development of salt baths based on combinations of simple and relatively inexpensive salts. As an example, one combination for quenching consists of equal parts of potassium nitrate and sodium nitrate salts, with a melting point of about 180 degrees, C. Information on German developments in the use of cyanide salts for quenching baths may furnish small metal manufacturers and heat treating firms with specific procedures for unique treatments.

HIGH-SPEED TRIP MAGNET — Small welding shops and manufacturers using resistance welding frequently find that one of the most difficult operations in resistance welding is to make the proper electrical contact with the part to be welded. One method of processing work that was found to be successfully used in quantity production in Germany was a high-speed trip magnet that not only afforded



Samples of work produced by the German cold extrusion process. With this technique the manufacturer can fabricate many intricately shaped steel parts which could not be formed by conventional stamping procedures



This automatic thread milling machine was manufactured by Heller Brothers of Nurtingen. It weighs approximately 7,000 pounds and was valued at about 8,000 Reichsmarks

the proper electrical contact but also was of suitable strength to move the work to the vicinity of the welding machine. Magnets of this kind have been successfully used at the German firm of Semens-Schuckert on many types of work.

Another finding which has created unusual interest among American manufacturers is the remarkable die-casting machine from the Mahle works of Stuttgart. This machine, which weighs approximately 12 tons, makes magnesium castings of considerable complexity and intricacy at the rate of 80 per hour. Thousands of such castings were used during the war for radio and radar chassis. One of the 25 machines found in the plant was shipped to this country and set up for demonstration. The American Die Casting Institute and its member companies have shown great interest in it. The machine produces castings which have been thought impossible of manufacture.

Several novel machines used for continuous casting of light metals and non-ferrous alloys are described and illustrated in one OTS report on this industry. The Scovill Manufacturing Company of Waterbury, Connecticut, is using one of these machines for casting metal employed in their extrusion rod department and tube mill. The German Junghans machine used by them employs a bottomless ingot mold 12 inches deep of which the upper two inches are surrounded by a water jacket for cooling. The rate of downward travel of the ingot is controlled by rolls which engage the solid ingot as it emerges from the mold. Scovill has reported savings of several types as a result of their use of the machine.

POWDER METALLURGY — Manufacturers in the electrical components field may be interested in developing economical and efficient brushes and commutators from powdered copper and iron. The powdered copper and iron parts were only a few of the many items made from powdered metals in Germany. Their advances in powder metallurgy are described in a dozen reports.

Because of the shortage of copper, Germany was unable to produce any important amounts of copper powder, but iron powder production rose from 200 tons in 1938 to 32,000 tons in 1944. Although electrolytic deposition, atomization and reduction processes were used, the bulk of German iron powder manufacture was by the "Hematag" mechanical process. The most important German development in powder metallurgy was the "hot press" method. This is described in a report by Dr. Gregory J. Comstock, director of the powder metallurgy laboratory of Stevens Institute of Technology. Dr. Comstock made two trips to Germany under OTS sponsorship.

A series of machines used in Germany to produce hand sewing needles may result in the development of a new industry in the United States. The specialized equipment required for making needles has never been developed in this country. Our needles have always been imported from Europe.

OTS investigators surveyed the major facilities in Germany for the production of hand sewing needles and reports containing description of processes used in the conversion of steel wire to packaged sewing needles may be obtained from the Department of Commerce office. With information on German equipment and methods American manufacturers may seriously consider the establishment of a domestic industry.

Although their production machines were often ingenious and performed economically, the Germans' machine tools were not as advanced as our own. A projection form grinding machine, a combination boring and milling machine, and swivel head vertical milling machines were three of the very few machine tools developed by the Germans.

One machine, developed by Ultra-Prazisionwerk,

has a unique optical system whereby the operator can compare a magnified image of his work directly with the design drawing as the work proceeds. The work piece is mounted in front of a lens and illuminated by an adjustable spotlight. Through a system of lenses and mirrors, the silhouette of the work is magnified 40 times and projected onto a glass screen plate. A master drawing of the work to be done, etched with acid, on cellophane or glass, is superimposed on this image.

The operation can gage the progress of his grinding work by comparing the lines of the silhouette with those of the master drawing and produce round and flat forms to a standard of accuracy equal to that achieved with limit gages.

One of the "Ultra" grinding machines was shipped to the United States and aroused considerable interest among machine tool manufacturers and producers of optical equipment. Various features of the "Ultra" grinder are described in two OTS reports.

BORING-MILLING MACHINES — The combination boring and milling machines were made to increase precision and save resetting of the work. Work was moved from one set of cutters to another. The cycle was not simultaneous but successive.

In the grinding field, OTS investigators noted a tendency to build machines with low power for a designated work swing. Ten-inch grinders, for example, would have range for full 10 inches, but power, weight and grinding wheel capacity would be more nearly comparable to our 6-inch grinders.

Profile milling seemed to have been neglected in Germany until the war started. Most of the milling machines were made by Rhorschach in Switzerland.

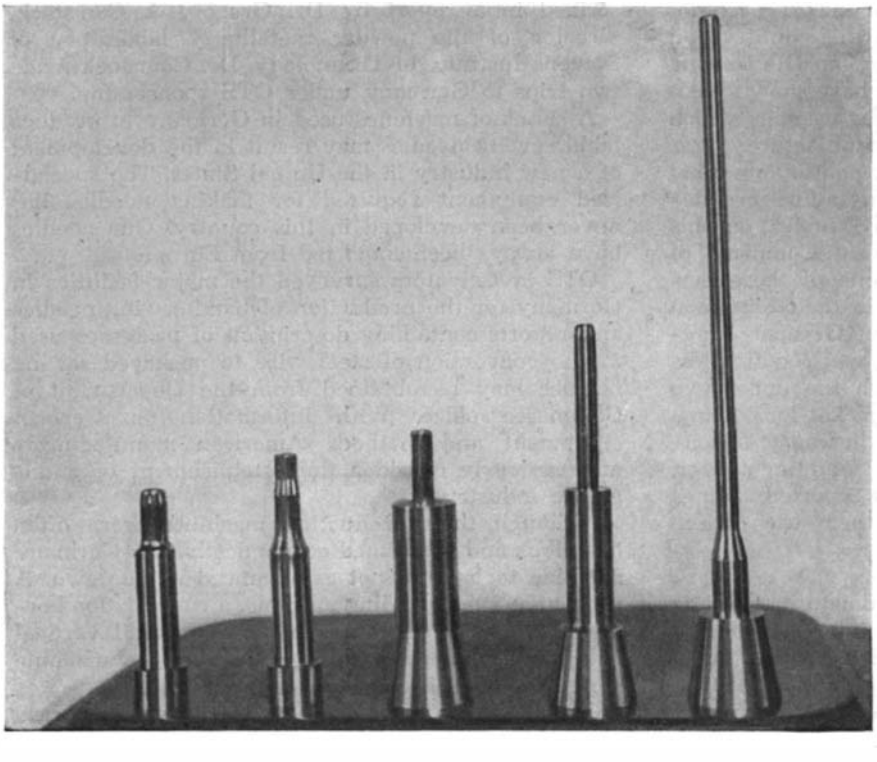
OTS investigators discovered an automatic bar chucking machine which they believe to be much more flexible than any automatic screw machine previously designed. They state that the machine, built by Alfred H. Schutte at Koln Deutz, is "very cleverly and cleanly designed" and that "in small job shops, where changes in tool setups are very frequent, a machine of this type has excellent possibilities."

The machine is equipped with four spindles and has six independently operated cross slides of the gunning type. Each spindle is provided with an individual longitudinal tool slide. The six cross slides and the four longitudinal slides are operated by individual cams through feed mechanisms which provide substantial variation in feeds without changing cams.

At the Gerb Heller Machinefabrik in Nurtingen a group of investigators found a giant machine for turn milling the crank pins and adjacent web faces of Diesel motor crankshafts. Since the crankshafts were large, it was necessary to use a 40-inch diameter cutter. Plant personnel claimed that the machine, estimated to weigh from 150,000 to 200,000 pounds, could finish a crankshaft in 24 minutes compared with two and a half hours by previous turning methods.

Abstracts of the several thousand reports on German advances released by OTS every week appear in the weekly "Bibliography of Scientific and Industrial Reports" which is published by the Superintendent of Documents and available by subscription at $10 a year.

Due to the innumerable technical discoveries which have been gleaned from a nation long prepared for war, it is difficult to immediately evaluate them in the true magnitude of their worth. Some of the smallest details may prove a great advantage to an American company. Only by a full study by our own engineers in our own plants can the true worth to American industry be determined. The reports present an unparalleled opportunity to cash in on research and discovery paid for by our enemies.



Examples of the punches used in punching extrusion and drawing operations. The Germans made considerable progress in these fields during the War

WHAT TO LOOK FOR IN FM

By David T. Armstrong

Frequency Modulation Radio Is Rapidly Becoming a Big Business. The Second of Two Articles Reviewing the Advantages of FM, and Some of the Disadvantages, for the Benefit of Prospective Buyers

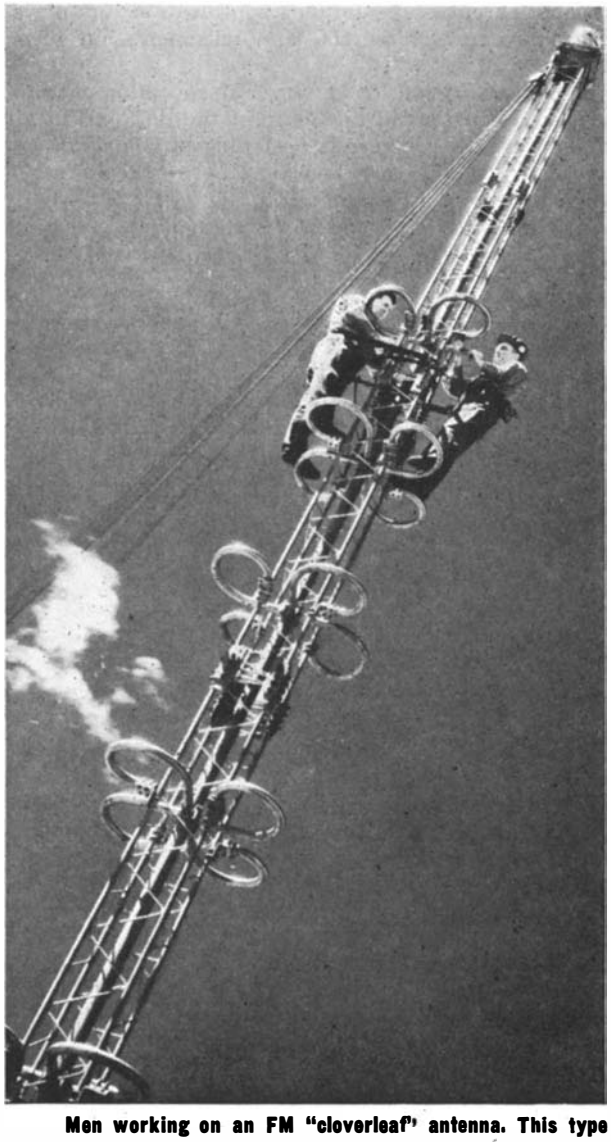
FREQUENCY modulation radio, FM in common usage, is at the dawn of a new era. The demand for its unique qualities is reflected in the soaring production figures for FM receivers last year. The high quality of FM reception is in itself a compelling reason for the average listener to add an FM receiver to his household radio equipment. But what are the outstanding advantages of FM reception? The following points briefly review them:

1. *Fidelity.* FM transmitters are capable of broadcasting the entire range of audio frequencies (those that can be heard by the human ear) and FM receivers are capable of receiving this range of frequencies and reproducing them with a high degree of fidelity and with the absence of concomitant noises, hum, static and so on. A concert that is broadcast from Carnegie Hall and received in your home would sound much the same as it would if you were in the audience at Carnegie Hall.

However, not every FM receiver will give high-quality reception just because it has an FM circuit. The amplifier and loud speaker system must be of sufficiently high quality to reproduce faithfully the natural sounds transmitted. But with a quality system all along the line FM will produce the golden overtones seldom heard in regular Amplitude Modulation broadcasting, where, with the tone control set to the limit, there is too much distortion.

2. *Dynamic Range.* In ordinary radio broadcasting it is common practice to "monitor" a program before it goes out on the air. This monitoring consists in regulating the loud sounds by toning them down and bringing up the soft sounds. In AM broadcasting this pianissimo for the low sounds and fortissimo for the high sounds is necessary to bring the low sounds above the static hum and to prevent distortion of the high sounds. On the AM band the range of sounds that can be heard is relatively narrow. On the FM band there is no monitoring of the program because there is no static and the sounds sent out can cover the entire dynamic range that can be heard by the human ear. This is one of the important qualities of FM that gives the listener the presence-of-the-speaker sensation, not obtainable with AM.

3. *Static.* There is another considerable advantage to the FM receiver. While it will not eliminate static under all conditions it will reduce static



Men working on an FM "cloverleaf" antenna. This type of antenna assures maximum coverage of a given area

and radio interference, as well as the background noise produced by the radio itself, to about 5 per cent of that heard on ordinary broadcast receivers. The higher the quality of the FM circuit, the greater the reduction of hum, sizzle, crackle and static.

4. *Station Interference.* The Federal Communications Commission regards an FM station as serving an area within a radius of 60 miles. Where two stations are 200 miles apart it is then possible for them to broadcast on the same wave length without interfering with each other. With two stations broadcasting close together on the same wave length, only the stronger of the two will be heard because the FM receiver has the characteristic of selecting the stronger and suppressing the weaker of competing signals.

5. *Programs.* On February 1, the musicians' union lifted the ban prohibiting musicians from broadcasting on AM and FM simultaneously. On this date most of the major stations began broadcasting their regular AM programs on FM as well.

In addition, there are a number of stations transmitting only in the FM band which broadcast programs of recorded classical and semi-classical music. These programs are uninterrupted except for an occasional break for station identification or news. There are no commercial announcements on these stations.

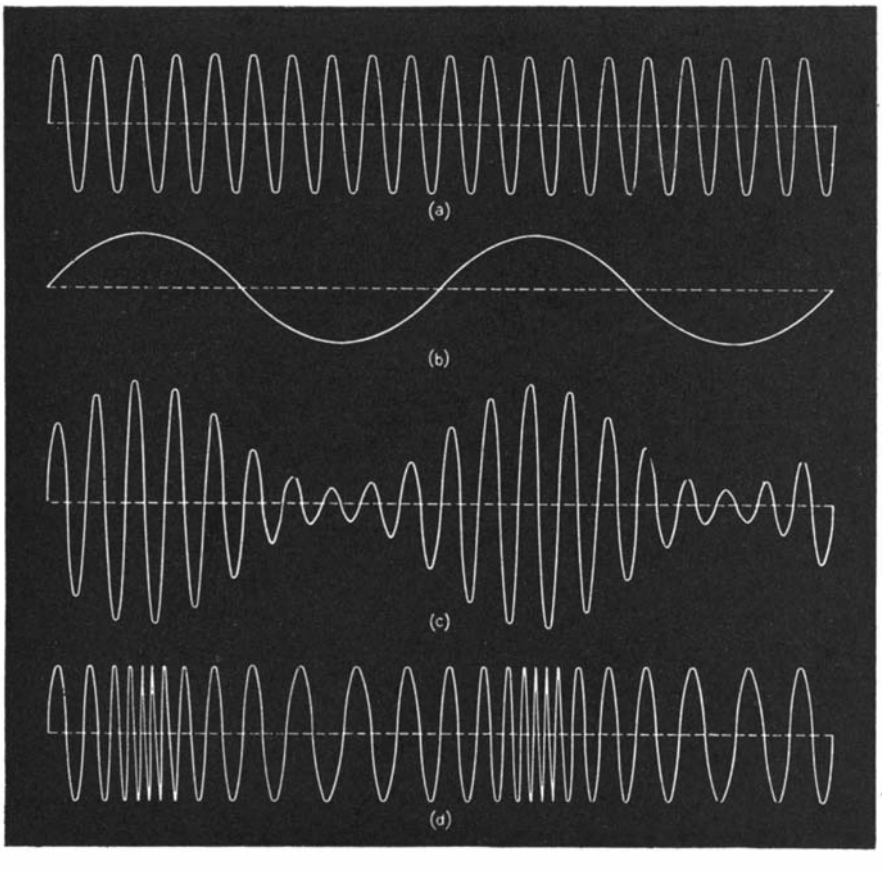
6. *Uniformity of Reception.* FM reception is uniform and constant at all hours of the day and in all kinds of weather. There is no fading of signals or increase in signal response when there is a storm or when the sun goes down.

7. *Number of Stations.* As stated above, most of the major AM stations now have FM outlets and there are quite a few stations broadcasting exclusively in the FM band. There is every indication that the number of FM stations will increase. FM stations are cheaper to set up, maintain and operate than AM stations. The band assigned for FM also makes possible a large number of stations. The nature of the FM wave is such as to make it feasible to dot the entire country with FM stations only 200 miles apart. Some school systems are already using FM radio. Witness WNYE, "the FM Voice of the Schools", in New York City. Unions are interested in FM because they have had difficulty in getting into the AM field. The International Ladies Garment Workers Union has made applications for FM stations in New York, Boston, Philadelphia, Chattanooga, St. Louis, and Los Angeles, and at least three of these applications have been granted. Moreover, this union is going after its own audience. The union's radio consultant has contracted with outstanding manufacturers for 25,000 FM receivers which are to be sold at cost to members of the union.

8. *Music in Factories.* FM radios are ideal for manufacturing plants which use radio to bring music to their employees because there is no distortion of the programs from the static produced by moving machinery, neon or fluorescent lights, electric motors and so forth.

DISADVANTAGES OF FM — FM is not all peaches and cream. There are some disadvantages, too, which we should consider in all fairness.

1. *Nature of the Wave.* The high-frequency wave assigned to FM moves in a straight line. It does not



Wave form (a) represents a carrier of constant amplitude and frequency. Wave (b) represents the audio signal. The strength of the amplitude-modulated wave (c) varies directly with the audio signal, while it is the frequency of the FM wave (d) that varies with the audio voltage

A console model equipped with an FM circuit. Owners of such luxury receivers form a body of listeners of unusually great purchasing power, a fact of considerable interest to advertisers

have the ability to bend according to the curvature of the earth like the waves assigned to AM. Thus, if there is a mountain or a bridge or a tall steel building between the transmitter and the receiver, reception may be difficult or impossible. Because the FM wave is a straight-line wave, it is limited principally to the horizon within sight of the transmitting antenna.

2. *Quality of the Receiver.* Not every FM receiver automatically brings the listener all the advantages of FM. There are good, medium and poor sets on the market. The built-in antennas are usually not satisfactory for any but the most ideal locations. It is generally necessary and always advisable that a separate FM antenna be installed and connected to the receiver by a high-efficiency and low-loss lead-in.

Apartment houses present a special problem because landlords object to having their roofs dotted with crosses that make them look like so many Flanders Fields. However, the Metropolitan Life housing projects in New York City will include FM antennas for approximately 13,000 families. Each apartment will be provided with aerial facilities for FM, AM and short-wave reception.

3. *Tuning Difficulty.* Tuning, an FM receiver presents a particular difficulty. A phenomenon known as "tuning drift" necessitates retuning the station shortly after the set has been properly tuned. At the present stage of FM development in tuning the push button technique is neither feasible nor desirable. An FM station comes in at three points on the dial; the middle position is the correct one.

4. *Audio Frequency Cut-Off.* Several manufacturers have been considering the possibility of making FM receivers which do not reproduce the entire range of audible frequencies. An audio-frequency cut-off at 6,000 cycles per second (as has been proposed) would mean an FM set with a tone range only slightly better than that of a good AM receiver, which can reproduce notes as high as 4,000 cycles per second. To take such a step would be to throw away one of the basic advantages of the frequency modulation circuit.

WHAT TO LOOK FOR IN YOUR FM RECEIVER— The purchaser of an FM receiver should make certain of the following important items:

1. Make certain the receiver is a genuine FM receiver, capable of delivering all the advantages of FM cited above. The basic FM circuit is the Armstrong circuit. Most manufacturers have made some slight changes in design in order to use recent developments and to facilitate manufacturing processes.

2. Regardless of the location, reception will be better with an outdoor FM antenna. Insist upon an installation that includes a suitable aerial. The built-in loops are not usually satisfactory.

3. The purchaser should make sure that he knows how to tune the FM receiver. It is not so easy as tuning an AM set. A receiver with a "magic eye" tuning device is preferable because this gives a visual indication of whether or not the receiver is properly tuned.

If the purchaser assures himself on these points he will be buying a receiver that will have good sensitivity, be free from static, and reproduce tone quality over the full dynamic range of speech and instrumental sounds audible to the human ear.

In addition to the FM outlets of the major AM networks, a live-talent network broadcasting exclusively in the FM band is now in the planning stage. The Continental Network, organized by Everett Dillard of Washington, D. C., and Major Edwin H. Armstrong, the guiding genius of FM, ties up Washington, Alpine, N. J., Rochester and Buffalo on a telephone hook-up. This same network also includes nine other FM stations in New York, Connecticut, Massachusetts and New Hampshire which merely rebroadcast FM programs from FM receivers. One of the decided economic advantages of FM over AM in the network problem is that in AM a wire connection between two stations is mandatory because AM signals picked

up by air and rebroadcast amplify and transmit all the static, fading and distortion.

It is quite possible that FM network operation will be generally less expensive than comparable AM network operation. FM transmitters, as stated previously, are cheaper to install, operate and maintain than AM transmitters. Dollar for dollar the broadcaster gets more out of his FM transmitter than from his AM. The concept that FM will not and cannot compete with AM in the network field is not so glibly accepted as it used to be.

For some time now radio sponsors have been thinking seriously about the large sums of money they spend for their AM network programs. They know that much of the AM network appeals to the mass audience that does not have too great a purchasing power. They know the FM market is a quality market. A man who spends several hundred dollars for a quality set is a potential customer for other quality goods. Furthermore, the man who purchases an FM receiver will be listening to it.

MORE AND MORE FM TIME — More and more time is being sold on FM. It is highly probable that in 1948 FM networks will be right in there fighting the AM networks for business in a field where there has not been much competition. Milton Sleeper, editor of *FM and Television,* makes the interesting suggestion that the FM networks might buy up live-talent shows and sell the time. Thus a $20,000, half-hour show could be bought up by 200 FM stations. Each would put $100 into a kitty or pay a pro-rated figure on the basis of area coverage! This would be one way of appealing to the high-quality local advertisers.

All the channels in the AM band are now in use and there is no possibility of assigning any new frequency to a newcomer. There are about 1,200 stations in the entire AM broadcast band and "that's all there is, there ain't no more." This is obviously discouraging to the would-be broadcasters who came late. It is also hard on buyers of time because the wealtheir customers have been able to monopolize select spots in the AM band and to dominate the most desirable periods of AM time.

But all is not lost. FM is throwing open this closed door to individuals, organizations, schools; to anyone who cannot find room in the AM band. There is room for about 4,000 stations in the FM band. Compare this with the 1,200 stations in the AM band and their concomitant overlap causing dissonance and static.

The entire radio industry is involved in the growth of FM. Whatever the system, obviously, the radio industry wants to sell radios. Whether these should be FM or AM radios may be resolved from the sage remark made by one observer: "My answer is that if you want to hear Toscanini, buy an FM set. If you want to hear Bob Hope, get an AM set." An FM enthusiast recently came up with the rebuttal: "If you want to hear Bob Hope at his best, ask your local station to put him on FM!" But the over-all advantages of FM have been better summed up by another FM admirer: "The thing that I like best about FM is not what I hear, but what I don't hear. I appreciate most its freedom from static, freedom from cross-talk, freedom from interference and freedom from distortion. With these bad features of ordinary radio erased by FM, the service is wonderful."

An FM receiving antenna. Regardless of the location of the receiver, a proper FM antenna and a low-loss transmission line are necessary for the most satisfactory reception

THE SETTLEMENT OF CANADA'S NORTHLAND

Using Modern Methods of Living in an Inhospitable Environment, Its Population Grows with the Demand for Its Resources

By Harry Chapin Plummer

THE NORTHWEST Territories and the Yukon together comprise approximately one-third of the total area of Canada. Lying in the Northwestern corner of the Dominion, this great expanse was long a virtual no-man's-land peopled by a few nomadic Eskimos and Indians with a sprinkling of traders, trappers, prospectors, missionaries and Royal Canadian Mounted Police.

Now, however, this region is taking shape as an important industrial area. Even the Arctic Sea is beginning to figure in terms of maritime trade. In 1944, 97 vessels—an aggregate of 58,179 tons—entered ports in the Yukon and Northwest Territories. Seven of these were in foreign service. The remaining 90 were operating in the coastal service. In the following year the Royal Canadian Mounted Police boat, "St. Roch," succeeded in navigating the Northwest Passage, both from east to west and west to east, thus setting to rest the time-honored legend that marine traffic on the Arctic Sea would never be possible. In 1946, some 120 port entries—an aggregate of 75,863 tons—were recorded.

The steadily increasing industrialization and settlement of the Canadian Northland is due, to a considerable extent, to the recent improvements in transportation facilities (the "snowmobiles," the "tractortrains" and air transport) and to the use of modern telephone and radio equipment.

Another reason for the rapid development of this region is the fact that its waterways afford easy access to the sea from May through to October. The Mackenzie River is navigable for 1,300 miles through Canadian territory to the Arctic Sea. The Yukon River, 1,979 miles long, is navigable for 1,400 miles through the Yukon and Alaska to the Behring Sea.

CLIMATE — The scene of this increasing settlement and infant industrialization is located in the West-

A maintenance camp on the Alaskan Highway. Transportation facilities in the Northland are constantly improving

Cutting a new road in the Northwest Territories

erly portion of the Northwest Territories and the entire Yukon. The climate of this area benefits from the same influences—although in lessening degree as one moves northward and farther inland—that are found along the entire Pacific Coastal region from California to Alaska. Warm air currents from the Japan Stream follow the river courses and canyons across the Alaskan mountains into neighboring Canadian lands and there meet the masses of cold air flowing down from the Polar regions. This results in a milder winter climate and in summer temperatures which are comparable to those of the Maritime Provinces to the south.

Beyond the eastern limits of the Mackenzie Valley in the Northwest Territories this dispensation of nature ceases. The climate of the intervening country to Hudson Bay and on through New Quebec (the former Ungava) and Labrador to the Atlantic Ocean is far more harsh and the terrain shows the resistance to timber growth that is characteristic of the more northerly latitudes. The southern coasts of Hudson Bay (55 degrees, North) and James Bay (51 degrees, North) are subjected to far lower temperatures than are Aklavik and other settlements around the Mackenzie Delta (from 68 to 70 degrees, North).

ELDORADO MINES — Near the Arctic Sea on the 65th parallel are the Eldorado Mines, second of the world's major supplies of pitchblende—source of radium and uranium. The mine's present personnel numbers 300. And when the mines reach full production a working force of 500 is anticipated. Future developments, whether of peace or of war, may render these mines a vital center of production for the Dominion.

More than 20 per cent of the total mineral production of the Northwest Territories between 1943 and 1946, valued at over $23,714,048, was credited to the pitchblende deposits mined by the Crown-controlled Eldorado Mining and Refining (1944) Limited, Bear Exploration and Radium, Limited, and other subsidiary units of the state corporation. The balance was divided: gold, $15,068,991; silver, $842,000; petroleum, $1,932,104; natural gas, $3,260; scheelite, $37,674; copper, $24,102.

The gold yield came almost entirely from the mines in the vicinity of Yellowknife, which is approximately 270 miles south of Eldorado. Yellowknife is a "boom town" transformed into a permanent, substantial community with a remarkable variety of secondary industries and concomitant crafts and trades. Among the major improvements now in progress is the Snare River hydroelectric power project, at the outlet on Big Spruce Lake, some 90 miles northwest of the settlement. When it is completed late this year, the plant will have a capacity of 8,000 horsepower in two power stations. Total expenditures in the development of the planned town are authoritatively estimated at $1,000,000. Construction of many large buildings is already well advanced, and it is expected that the majority of these will be completed by late spring.

The potential water power resources of the Northwest Territories and the Yukon are conservatively estimated at 430,000 horsepower under conditions of normal flow, and at 840,000 horsepower for the open half year when the ice and snow melt.

LUMBER — As at many other settlements in this "Western Arctic," Yellowknife is the scene of a steadily growing lumber industry. Timber cut in the region includes white and black spruce, white birch, tamarack, aspen and balsam poplar.

Another Yellowknife industry is fish canning. Lake trout and other varieties of fish are canned at a plant on the shores of the Great Slave Lake. Some 1,500,000 pounds of fish are shipped each year from this cannery to Canadian and United States markets.

Mining has displaced fur trapping as the top industry at Yellowknife, as it has at most other centers in this region. Nevertheless, pelts to the value of $14,000,000 were taken between 1940 and 1946 over the Northwest Territories alone.

NORMAN WELLS — The community of Norman Wells has a population of 375. It is another fast-growing industrial center. Located close to the 65th parallel, it is the site not only of a veritable lake of oil, but also of the most northerly petroleum refinery on this continent. The production of this refinery increased from 20,191 barrels in 1939 to 181,408 barrels in 1946. Distribution from the Norman Wells plant is maintained by bulk agencies at Fort Smith, Fort Simpson, Yellowknife and Aklavik. From Aklavik deliveries are made by steamers and schooners to Arctic shore points as far east as Coppermine, Holman and Reid Islands.

Problems posed by the climate of the Canadian North—even by the relatively mild climate of the Western Arctic—have activated intensive research and experimentation on the part of the Army and other government agencies in close coöperation with industrial and commercial interests. Many valuable innovations and devices have resulted from the combined efforts of these forces, particularly in the fields

of clothing, housing, insulation of water and sewer pipes and central heating.

Exhaustive studies of clothing most satisfactory for wear in the extreme cold have produced, among other items, a primary undergarment known as the "string vest." Developed by the Army, it is designed to be worn next to the skin, covering the torso. This string vest's wide mesh holds regular underwear clear of a perspiring body and permits a circulation of air next to the body to evaporate the perspiration. The weave of the vest is as coarse as that of a herring net. In fact, the idea was adopted from the Norwegians who have long used actual fish net next to the skin to guard against perspiration-soaked clothing in low temperatures.

Careful observation of the materials and methods employed by the Eskimos in building their igloos and other dwellings led the Army to the development of a "hutment" which provides housing for 20 soldiers. This prefabricated, demountable building is light enough to be transported by air. It is made of plywood panels with rock wool insulation and an aluminum foil moisture bar. Blank panels are interchangeable on walls and roof. Door and window panels are also provided. By the use of additional panels, a hutment can be expanded to a mess hall, administration building, store or hospital. The side walls of the hutment are made stable by notched recesses in the truss ends, with the end walls tied together by the roof frame. The individual wall, door and window panels are held firmly together by a bolted top plate. Panel joints are waterproofed by rubber mastic which does not hinder dismantling the hut, even if it has been painted.

A condition which greatly hinders the construction of permanent buildings in the Canadian Sub-Arctic Zone is the permafrost—a layer, or layers, of soil which remain permanently frozen. The surface of the ground thaws in summer to depths depending upon the length and warmth of the season. The depth of the "active layer" ranges from one foot to six or eight feet and the depth of the permafrost varies widely, even within a small area. Three methods of building have been analyzed thoroughly, and the results follow:

1. Conventional foundations last only a short time, as the heat from the building upsets the permafrost balance and subsidence follows. Buildings put up at various posts, such as Whitehorse and Norman Wells, during the war, have now taken on a "snake-like" appearance.

2. Some success has been attained by "floating" buildings on top of the muskeg, which provides a natural insulation without disturbing the permafrost. Insulating the floor to prevent building heat going into the ground has proved unsatisfactory for heavy buildings.

3. The method most satisfactory for permanent building appears to be the erection on piles—wood, pipe or concrete—permanently frozen into the ground about one and one half times the depth of the active layer. The upper portions of the pile are lubricated so that the active layer can expand and contract without disturbing the piles.

Frame buildings, well insulated by any one of various methods are the normal type of construction. Materials for this sort of building are easier to transport and to fabricate. In addition, until entirely satisfactory foundations are found, to use more rigid materials is to invite risk of cracking due to uneven settlement.

WATER AND SEWAGE PROBLEMS — Normal problems of water supply and sewage disposal are greatly complicated by the extreme cold, by permafrost and by the fact that many lakes freeze to the bottom during the winter. At Chirchill, scene of the Army experimentation, a large heated tank is used for water supply and the water is circulated continuously as an additional safeguard against freezing.

Above ground, pipes are carefully insulated, and steam is introduced at intervals. Heated corridors connect many of the buildings. These corridors house the utilities which are grouped together so that heating mains keep water and sewer systems from freezing. Due to the permanently frozen sub-

Removing the roof from one of the Canadian Army's demountable, prefabricated "hutments." The demounted hut is light and small enough to be transported by air

soil, conduits and pipes cannot be laid below ground.

In the Western Arctic a tremendous range of ground conditions—from great rock outcroppings to swampy muskeg and permafrost—are encountered. Gradually, however, the Army engineers have succeeded in overcoming many of the natural difficulties presented for vehicular movement. During the war special tracked vehicles known as "snowmobiles" were developed for operating over snow. The northward trek of "Exercise Musk-Ox" in 1946 brought these conveyances into first real service test. From that demonstration was evolved "Penguin Mk. 1," the good performance of which was followed by "Penguin Mk. 2," also utilizing the basic "snowmobile" chassis. This vehicle is now being produced by a Canadian manufacturer.

A simultaneous civilian development is the "tractor-train", upon which the government, mining and other private commercial interests now depend for low-cost hauling of supplies for a midwinter period of about one hundred days, beginning around January 15th when the lake ice is sufficiently thick to support heavy freights. A standard tractor-train consists of a $10,000 tractor pulling twenty-eight 15-ton sleds and a caboose. Difficulties occasioned by breakdowns usually call for a new tractor each season. The "train" is manned by two drivers, two brakemen and a cook. Running for the full 24 hours, the trains haul from 100 to 125 tons of freight and average about fifty miles per day. They operate from Waterways and Whitehorse—railheads for traffic destined respectively to the Mackenzie Valley in the Northwest territories and the Yukon. The tractor-train can climb only the slightest grades and rough ice on the frozen lakes is an ever-present problem. Because of the varying thicknesses of ice, rivers are avoided as much as possible.

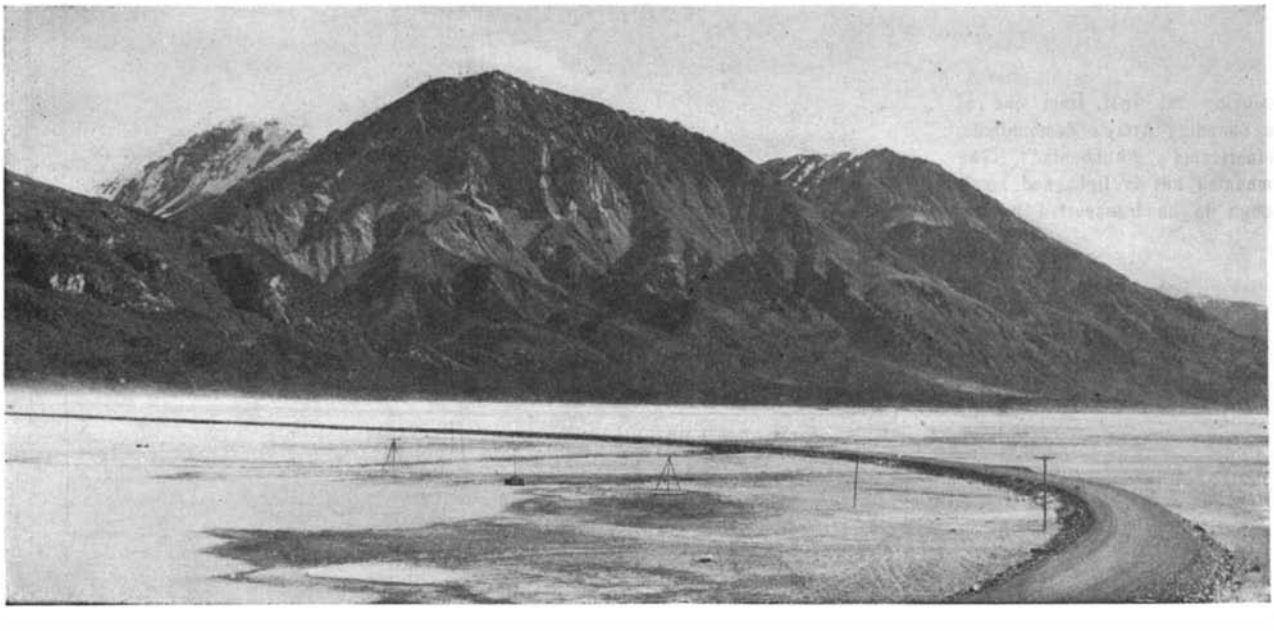
The Army is now doing considerable work on the winterizing of vehicles—both wheeled and tracked to adapt them for operation at low temperatures. Since much of the research is being pursued by the same manufacturers who produce civilian equipment, the work eventually must benefit civilian vehicle users. Such items as fuel, lubricants, batteries, heaters, anti-freeze, rubber components and structural material failures resulting from low temperatures and high stresses developed, by driving through deep snow over frozen ground and rutted roads, are receiving close scrutiny.

RECLAIMED ANTI-FREEZE — Recent emergency calls from the Alaska Highway of the Northwest Highway System (the Canadian portion of the former "Alcan Highway") for supplies of anti-freeze disclosed the fact that 7,000 gallons of water-glycol mixture had been drained from Army vehicles throughout the Dominion earlier in the year and that 3,000 gallons of glycol had been recovered by re-distillation at the Defense Research Council Laboratories in Ottawa. Two years ago approximately 10,000 gallons of glycol were recovered and re-inhibited by the laboratories for the Royal Canadian Air Force by this same economical process.

Many civilian agencies would be benefitted greatly if suitable vehicles were available for year-around land transportation in the Western Arctic. No single agency could afford to do the developmental work. However, when that work has been done by the Army, and adequate sources of manufacture have been established in Canada, many types of vehicles for such purposes can be produced for civilian interests. This equipment will be extremely valuable for rural mail delivery and for rural doctors, for police patrol vehicles, prospectors, surveyors, for timberlimit vehicles, and for rescue work, to name only a few of the possible applications.

The steady influx of families from the Canadian Provinces and the increase of those already located in the Northland constitute a powerful incentive for the armed services, various government departments, many civilian agencies and private interests to improve conditions, mitigate the hardships and eliminate the dangers of the Western Arctic. Through their efforts this once-inhospitable wasteland is rapidly gaining commercial and industrial importance.

Good highways and telephone and telegraph lines lace together Canada's Northland



VACUUM METALLURGY

Melting Metals in the Absence of Gases Produces Materials Which Are Purer, Denser, Tougher and More Ductile

By Harold A. Knight

ARISTOTLE is reputed to have said that "nature abhors a vacuum." But the scientist and engineer have often found the vacuum a useful friend. The ordinary citizen has found it serviceable in such articles as the vacuum bottle for a picnic and for the radio tubes in a portable set which is turned on after the scrap papers have been picked up and the checkered tablecloth folded.

By vacuum metallurgy, metals are made gas-free, porosity-free, denser, tougher and more ductile. What has been largely a laboratory or pilot plant process is now evolving into a full-scale commercial process. One of the most recent applications of vacuum metallurgy involves production of a new group of super-alloys such as those which must withstand high temperatures in the engines of jet aircraft.

A typical alloy of this type contains 60 per cent chromium, 20 per cent molybdenum, the balance being iron. This alloy must be melted and cast in a vacuum. In preliminary tests it seems better than the cobalt-base alloys, used so widely during the war, giving promise of safe use at higher stresses.

In speaking of this new chromium-base group of super-alloys, refined by vacuum metallurgy, Dr. Clyde E. Williams, director of the Battelle Memorial Institute, says that they will withstand higher temperatures and pressures than materials now available and so will offer potentialities for power generation that are "simply staggering."

Vacuum metallurgy was employed to produce nickel-chromium alloys in Germany as early as 1938. The Germans made batches of alloys up to 10,000 pounds, finding that alloys made by this process have properties which cannot be duplicated by any other means. During the war lithium metal was reduced from its ore, spodumene, in a single operation and at a cost less than half its then-current market price. It was a useful process in producing metallic magnesium from dolomite, supplementing production from Michigan brines or sea water from the Gulf of Mexico. In the ferrosilicon process, where dolomite is mixed with iron, a high vacuum is necessary to lower the temperature of distillation. One of these wartime ferrosilicon plants has been partially converted to production of metallic calcium, again in high vacuum.

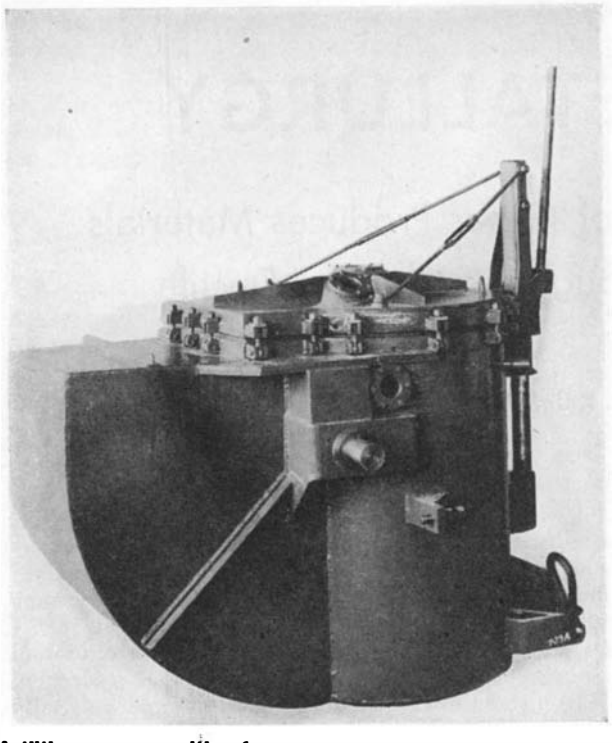
EARLIER EXPERIENCES — In Germany Dr. Rohn has applied vacuum melting to many alloys used largely in the electrical industry, with furnaces up to six-ton capacity. In this country, Sweden and England vacuum melting on a smaller scale has become quite common in connection with high-cost materials requiring high purity and freedom from small amounts of carbon, oxygen, nitrogen and hydrogen. When a vacuum furnace was operated experimentally at the University of Illinois from 1912 to 1916, it was demonstrated that the magnetic properties of iron and iron-silicon alloys could be greatly improved by vacuum melting, the carbon and oxygen being eliminated. Work was continued at Westinghouse research laboratories from 1916, the results laying the foundation for the Hipersil alloy used in Westinghouse transformers since 1940. The company is now applying vacuum melting to some new magnetic alloys which look very promising. Here it appears that the process may soon be applied commercially.

Most laboratory furnaces will handle only about 10 grams of metal at a time, but installations have recently been set up that will handle charges of 300 pounds and more. A Westinghouse expert stated recently: "I believe that before long we shall see 1,000-pound vacuum furnaces in operation in this country, to be followed by even larger ones."

The theory of vacuum work is fairly simple. Almost everyone is familiar with the fact that eggs will boil on a mountain top, where atmospheric pressure is considerably lower than at sea level, at considerably under 212 degrees, F., water's normal boiling point. In a high vacuum, metals may therefore be made to volatilize at temperatures as much as 1,850 degrees, F., below their normal boiling point.

The normal atmosphere of the earth at sea level supports a mercury column 760 mm high, with pressures read in millimeters and microns, the latter being a thousandth of a millimeter. In present-day vacuum furnaces pressures as low as one micron (1/760,000 atmospheric pressure) are obtained.

Not only are the metals melted in a vacuum, but they are cast within the furnace. The removal of the molten metal from the vacuum into the atmosphere would expose the metals to the various gases which should be eliminated. Ingenious devices provide for pouring the highly heated metal (perhaps as hot as 3,600 degrees, F.) into the molds. In some cases the furnace tilts and pours into a mold that is pivoted and remains upright. In other instances a plug made



A tilting vacuum melting furnace

of the metal being melted is placed in the melting chamber. At the proper time this plug is melted out by an induction coil and the metal allowed to flow through the hole into the mold.

High vacuum is maintained by two types of pumps: (1) a "roughing" pump which exhausts the main body of air and (2) a finishing or diffusion pump, the latter containing oil or mercury. The flowing oil brings out any "tramp" air and effectively seals the chamber against any back movement of air. Heat for the melt is applied by an high-frequency electrical induction unit. Furnaces are sealed at key points with rubber gaskets augmented by rubbery or plastic compounds where necessary. Often there are windows in the melting chamber so the operation may be observed.

As no slagging can be carried out in a vacuum furnace, the process is primarily one of melting, with elimination of gaseous and volatile impurities. Solid impurities are often reduced by special heat treatment before metals are introduced into the vacuum furnace. In the case of copper, it is sometimes desirable to take out such impurities as sulfur, selenium, tellurium and arsenic.

The principal metals which have thus far been studied by vacuum treatment are iron, copper, nickel, aluminum, chromium, manganese, calcium, barium and cesium. Copper treated by vacuum metallurgy is gas-free and purer than the best commercial copper. There is better density and soundness, a better electrical and thermal conductivity and a marked increase in ductility.

The National Research Corporation of Boston made some comparisons between the best commercial copper and vacuum-cast metal. The former contained hydrogen to the extent of 0.00012 per cent. The vacuum cast contained only 0.00001 per cent. As to oxygen, commercial copper contained 0.00045 per cent as against 0.00039 per cent for vacuum-cast. For other gases, comparisons ran to 0.0004 and 0.00002 per cent. Sulfur compared 0.0023 to 0.00006 per cent. As to the physical properties of the two types of copper, the vacuum-cast proved superior to the commercial, except in tensile strength. Here the two tied at 54,500 pounds per square inch. In density, commercial measured 8.922 grams per cubic centimeter against 8.930 for the vacuum-cast. The elongation was 17.3 compared with 20.3 per cent. Reduction of area ran 76 and 88 per cent. Electrical conductivity was 99.4 IACS for the commercial against 100.3 for the vacuum-treated.

Engineers have made good progress in development of vacuum-cast nickel. This has a much lower hardness value than the purest nickel now available. It can be supplied in 100-pound ingots that are very pure, soft and ductile, a metal which should be ideal for vacuum tubes in radios and other electronic devices. Such nickel is comparable with the highest quality nickels reported in metallurgical literature, exhibiting neither hot nor cold shortness in forging or rolling.

Aluminum has not been treated as successfully as other metals because of the perpetual oxide coatings on the metal. However, research has gone far with pure iron, 100-pound ingots having oxygen under 0.05 per cent, nitrogen as low as 0.0005 per cent and carbon under 0.005 per cent. It is an extremely homogeneous iron which is suitable for magnetic applications and for samples of perfect iron for spectrographic work, where the unknown is compared with a known sample.

Work on de-gassing chromium for high-temperature applications, as previously mentioned, seems very promising. Decreasing the oxide and gas content of chromium by vacuum sublimation results in purity of 99.95 per cent. Such chromium can be shaped by ordinary lathe methods and can also be somewhat deformed without fracture by hammer blows.

As already indicated, metals in vacuum furnaces may be made to volatilize at temperatures hundreds of degrees below their normal boiling points. When a volatile metal is contaminated with a metal of lower volatility, a separation may frequently be accomplished by vacuum distillation. Calcium is purified commercially in this manner. Manganese and chromium have been purified at 3,650 degrees, F., and at pressures as low as 10^{-3} mm. In short, the impurity is distilled off. Selenium, tellurium and sulfur can thus be distilled off copper. Zinc can be distilled off from brass scrap, leaving only copper. Sodium, potassium and lithium could be separated by a fractionating column, if necessary.

VACUUM CASTING — The experiments and commercial techniques in vacuum casting so far involve casting permanent molds and molds of the precision investment casting type. Forming of metal by forging, rolling or drawing in a vacuum is untried, apparently, and the possibilities are unknown. Ordinary sand casting is impractical in a vacuum. In older casting techniques the mold was lined with carbon or some similar mold wash, but this introduced carbon and other foreign elements which interfered with the purity of the product. Engineers of National Research Corporation chill the castings with water or

argon gas circulating around the molds, thus preventing solidified metal from adhering to the molds.

The applications of vacuum metallurgy besides those already mentioned are in the manufacture of radio tubes, magnetrons and various glass-to-metal seals. In such uses experiments have already been made. Other proposed uses are in the manufacture of thermocouple wire, precision resistor wire, aluminum collapsible tubes and many other applications where the ductility needed for deep drawing is essential.

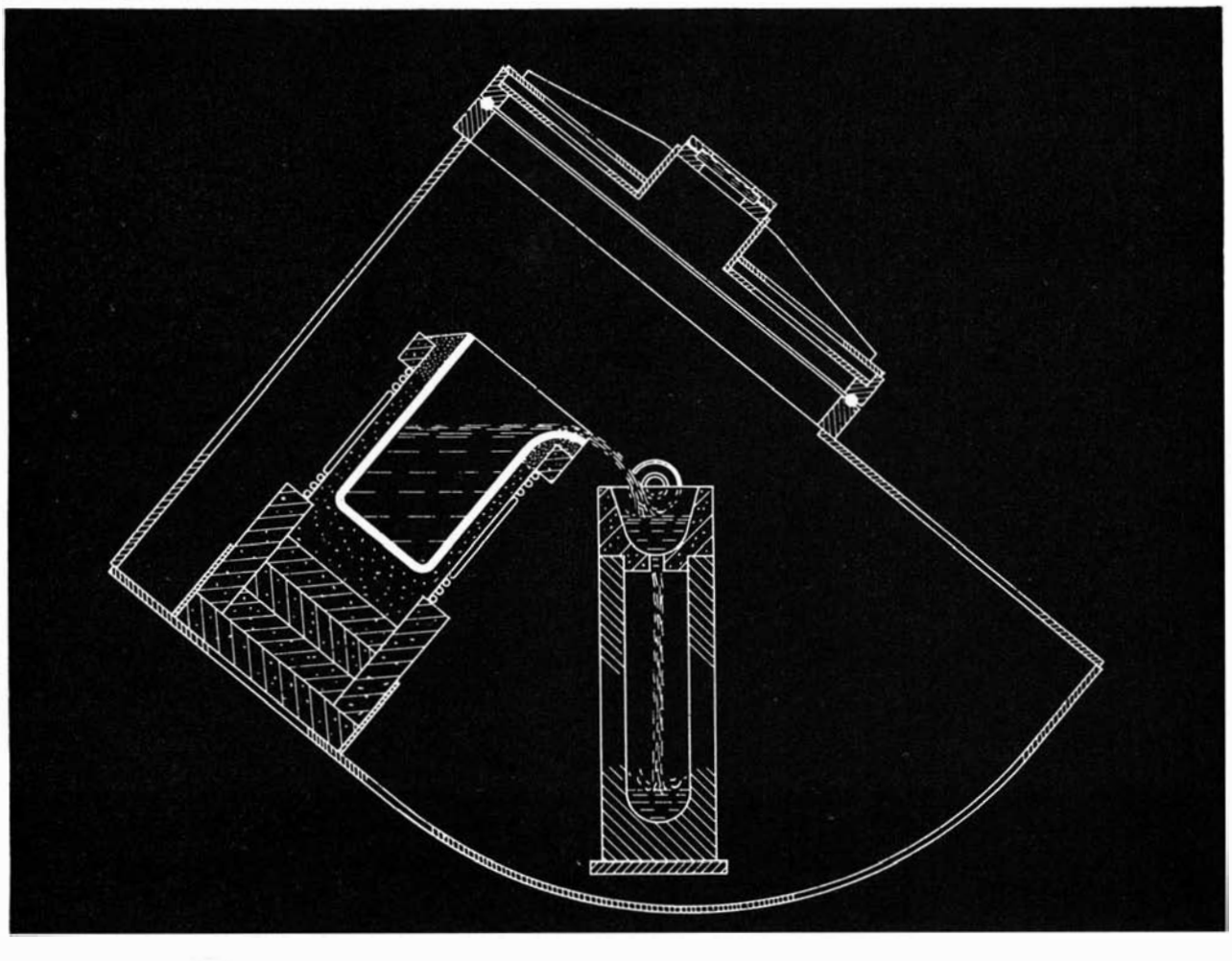
According to one authority, vacuum metallurgy is particularly well suited to the preparation of iron-nickel and iron-cobalt alloys because of the inherently high cost of these products. In other words, a material that is already high in cost to start with, can absorb a little more expense for perfection. An expert who has worked with this technique for several years estimates costs as follows: For a 1,000-pound charge which is melted down and poured once every hour, using five men and equipment costing $100,000, the cost would be between two and four cents per ingot on a continuous production basis. This is not at all prohibitive for alloys costing over 10 cents per pound for raw materials, particularly taking into account the fact that vacuum metallurgy can produce ingots practically without a "pipe" (a hollow caused by shrinkage in cooling).

Another expert has estimated that the cost of vacuum treatment adds from one to 10 cents per pound to the selling price of metals. Ordinary copper sheet now sells at around 33 cents per pound. The five cents added to the cost by vacuum treatment represents no significant increase in price for improved qualities. There are in fact six basic fields in which vacuum metallurgy is now, or can be, applied: Preparation of metals from ores and compounds, purification and degassing of ingot metals, casting, forming of solid metals, heat treatment of solid metals and finishing of surfaces. It is proposed to explore vacuum furnaces for certain forms of heat treatment such as bright annealing. The surface degassing of electronic tube parts has already been accomplished.

Hand in hand with developments in vacuum metallurgy goes progress in other fields using the vacuum treatment. One of the latest applications is a dehydration process for conversion of orange juice to a powder, in which the water content is reduced from 90 per cent to under 1 per cent. Water is removed from penicillin by the same technique. High vacuum is also used to bring about dehydration of blood plasma. It can also concentrate and isolate vitamins in pure form. Plastic sheets are being metallized by aluminum and other metals to form effective reflectors.

Vacuum metallurgy, then, is another versatile addition to the tools of modern technology.

Diagram of the tilting vacuum furnace. The mold remains vertical as the furnace tilts and the charge is poured



SCIENTIFIC AMERICAN'S Industrial Digest

X-RAY THICKNESS GAGE

Steel Strip Measured Continuously As It Comes From Rolling Mill

THE X-RAY thickness gage is an instrument which can measure the thickness of red hot steel without physically contacting it in any way. The device shoots one X-ray beam through the hot steel strip as it moves off the finishing stands in a rolling mill. Simultaneously a second X-ray beam from the same source penetrates a standard reference sample of steel which is known to be of the desired thickness. The instrument then measures and compares intensities of the two beams. If the two intensities are equal the steel strip is of the desired thickness. A difference in intensities indicates that the strip is either more or less than the desired thickness, and the amount of deviation is automatically noted by the instrument. The thickness gage takes measurements continuously while the steel strip is moving.

Traditional methods of measuring strip steel necessitated waiting until the steel had cooled from a temperature of 1,400 degrees, F., and higher to a temperature at which a micrometer might be held manually against the steel. Since the steel strip moves at speeds as high as 2,000 feet per minute, six tons or more of off-measure steel might be rolled under conventional measuring techniques before the error was determined and corrected.

Developed by Charles W. Clapp and Raymond V. Pohl in the General Electric Company's General Engineering and Consulting Laboratory, the X-ray thickness gage already is in use at the Irvin Works of the Carnegie Illinois Steel Company.

Although specifically designed for measuring the thickness of hot-rolled steel strip, the instrument should be adaptable to other industrial applications in which a non-contacting gage is desired.

DIAMOND-CHIP AMPLIFIER

Electron Bombardment of Crystal Yields High Current

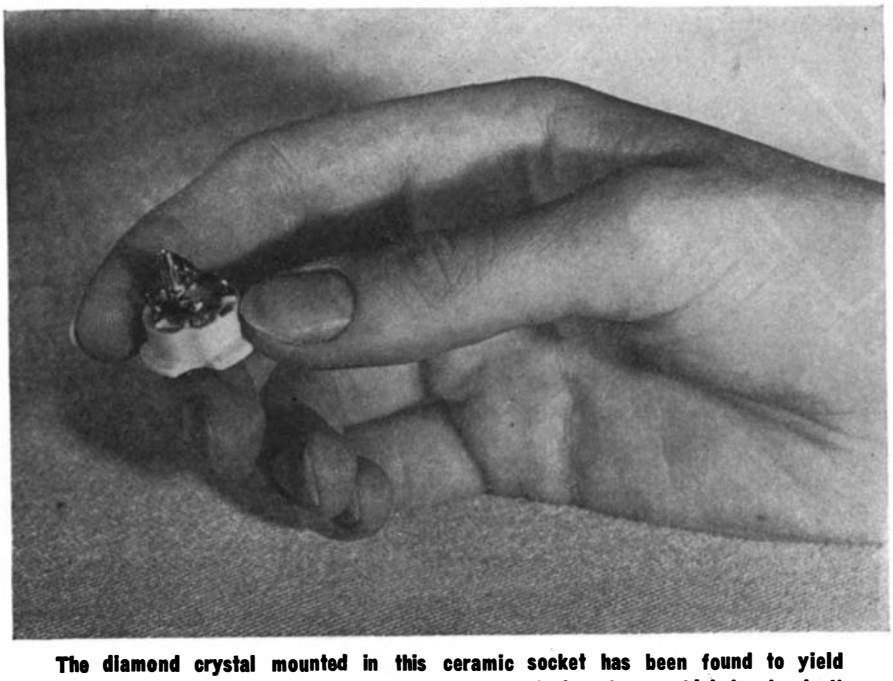
SMALL diamond chips, bombarded with a beam of electrons, have been found to yield electric currents as much as several hundred times as great as the original beam. This radically new method of amplifying an electric current may have a far-reaching influence on the future of electronics. It holds promise of opening up an entirely new approach to the design and use of certain types of electron tubes. Also, it is expected to be of considerable theoretical value, since it provides a new and powerful tool with which scientists may learn more about the fundamental structure of solid matter and how it behaves under the impact of electrons.

This technique, developed by Dr. K. C. McKay of Bell Telephone Laboratories, grew out of earlier work by Doctors D. E. Wooldridge, A. J. Ahearn and J. A. Burton, a so of Bell Telephone Laboratories. Essentially, their work consisted of causing an insulating material—which by definition will not conduct electricity—to carry considerable amounts of it by means of electron bombardment.

Dr. McKay, using a diamond chip as the insulating material, has reported that electric currents shot at the chips have been amplified as much as 500 times.

Inducing electric currents in diamonds by electron bombardment proved to be a difficult matter. One of the major obstacles was encountered when it was learned that as the current started to flow in the diamond chip, electrons became trapped in the tiny imperfections which are present in all crystals. Thus, after the first fraction of a second, the induced current tended to waste away under the opposition of the trapped electrons. To overcome this, an alternating voltage (60 cycles per second) was applied to the diamond chip. Alternately negative and positive charges thus were drawn through the crystal and some of each were trapped. The trapped positive charges canceled out the effect of the trapped electrons and the current induced by the electron beam was allowed to flow freely.

The diamond crystals used in these experiments are small chips or even so-called "saw-cuts" obtained from a natural diamond in shaping it for a gem stone. The chips average



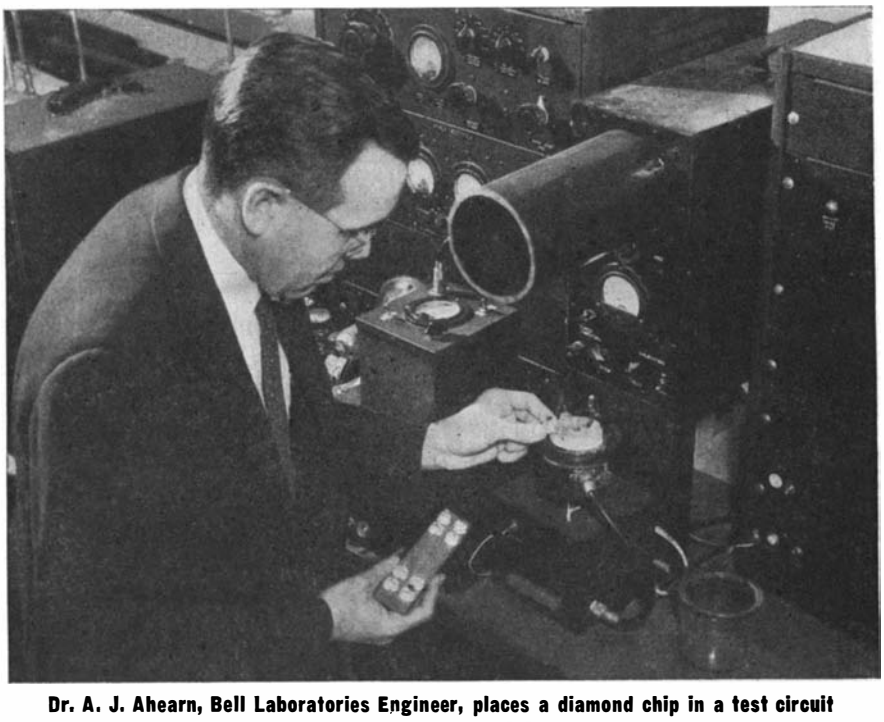
The diamond crystal mounted in this ceramic socket has been found to yield currents as much as 500 times greater than the electron beam which bombards it

a quarter of an inch square and approximately 20-thousandths of an inch thick. Most of the chips give satisfactory results, although some of them do not respond at all.

Before a crystal is ready for use, gold is evaporated onto its flat surfaces in films less than a hundred-thousandth of an inch thick to afford good electrical connections.

In bombarding the diamond chips, successive pulses of electrons lasting approximately a microsecond are used, rather than a steady current. Energies of 15,000 electron volts are employed.

One of the most important features of this new technique is that the induced currents are produced within exceedingly short times. In fact, the time required is so brief that thus far it has not been possible to measure it. However, it is estimated to be less than one ten-millionth of a second.



Dr. A. J. Ahearn, Bell Laboratories Engineer, places a diamond chip in a test circuit

MOISTURE DETECTOR

Conductance of Electrolytic Film Measures Water Vapor Content

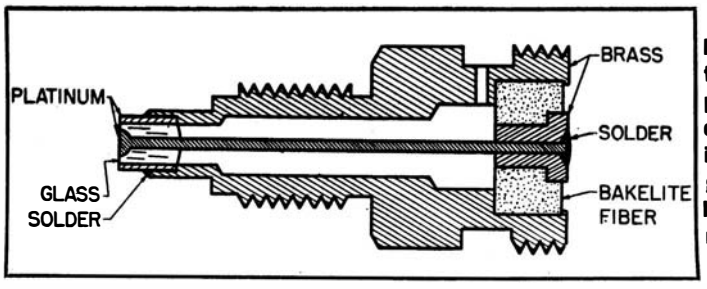
A METHOD for measuring small amounts of water vapor in gases by means of an electrolytic film has been announced by the National Bureau of Standards. This procedure, which may also be extended to the determination of the moisture content of certain liquids and solids, depends essentially on the change in electrical resistance of an electrolytic film as it absorbs water vapor. Such a method has the advantages of speed, simplicity, high sensitivity and wide range. It is very flexible in operation and is readily adapted to numerous applications such as measuring the moisture-permeability of membranes, detecting minute concentrations of combustible gas in air or of oxygen in combustible gas, determining water vapor in aviators' oxygen or in liquid carbon dioxide, measuring the capacity of drying agents, determining the water content of organic liquids and solutions, and measuring the relative humidity in small or comparatively inaccessible spaces under rapidly changing conditions.

With this method a thin film of liquid—phosphoric acid, a solution of sulfuric acid or other electrolytic compounds in a gelatin or plastic binder—is spread over the surface of a solid insulator between metallic electrodes. The electrolyte tends to reach equilibrium with the water vapor in the surrounding gas and to form a solution, the electrical conductance of which is a measure of the concentration of water vapor in the gas. To utilize this phenomenon, some sensitive instrument for measuring or comparing electrical resistances and a means of calibrating the film by comparison with a gas of known moisture content are necessary. Because of polarization, alternating current must be used.

The apparatus developed by E. R. Weaver of the National Bureau of Standards, consists primarily of a "detector" (electrodes and the separating insulation on which the conducting film is spread, together with the necessary support), an indicating circuit involving an adjustable bridge with its power supply and amplifying device, and an indicating instrument such as a galvanometer or microammeter. Other necessary parts are a pressure-tight enclosure for the detector known as the "cell," a "saturator" for adding moisture to the reference gas, two pressure gages, a cylinder of compressed air or other gas, valves and connecting tubing.

The detector consists of concentric, glass-insulated platinum electrodes, mounted in a bushing which can be screwed into the cell. When either the gas to be tested or the reference gas is passed into the cell, the resistance of the electrolytic

Equipment for measuring moisture content by the National Bureau of Standards' method



Detecting unit of the NBS water vapor detector. The electrolytic film is spread on the glass insulator between the platinum electrodes

film varies with the moisture in the gas, and this variation in conductance is indicated by the meter. The pressures of the two gases being compared are then adjusted until the meter readings are the same. In this procedure, the pressure gages actually serve as the measuring instruments; the meter is used only to show a null point. However, when moisture concentrations are changing rapidly, these changes are followed by means of current readings which are interpreted with the aid of a calibration curve.

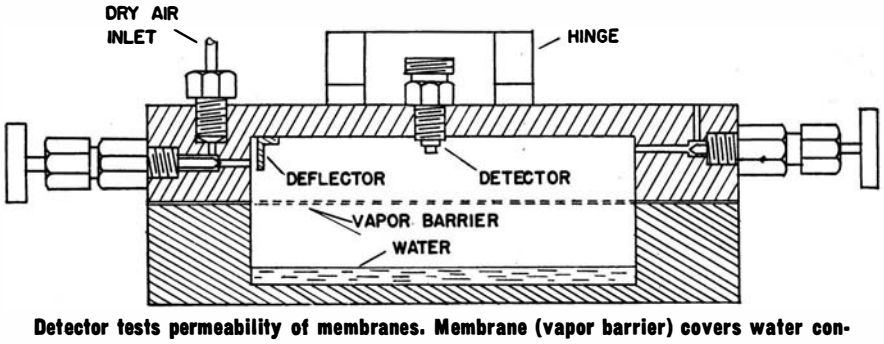
The material most frequently used for the detecting film is phosphoric acid. The gas of known water content with which the unknown gas is compared is conveniently obtained by saturating air with water vapor at high pressure and expanding to any desired extent. For humidities too low to be conveniently matched in this manner, the moisture content, well below saturation, of a cylinder of compressed air is determined by comparison with air from the saturator, and the cylinder is subsequently used as a secondary standard.

It has been found practicable for an observer using this method to determine the compliance of oxygen with an exacting specification for dryness at the rate of 100 cylinders per hour. By use of secondary standards with some sacrifice of accuracy, it is possible to work with greater speed and convenience as well as at much lower concentrations of water vapor. Changes of less than one part per million of water in Freon from a refrigerating machine have been determined in this way without difficulty at intervals of one minute.

A simple and convenient auxiliary apparatus has been designed at the Bureau, by means of which this method may be used to determine extremely small concentrations of water in such liquids as ether or gasoline in a few minutes. Since the water concentration of a liquid of otherwise constant composition bears a definite relation at any given temperature to the humidity of air with which it is in equilibrium, the moisture concentration of a liquid may be quickly determined by measuring that of the air above it. A spring clip is applied to the detector so that a glass "test tube" with a small opening in the bottom may be quickly attached, making a snug but not air-tight fit with the detector plug and covering the sensitive film. When the detector with this attachment is lowered into a bottle of the liquid to be tested, the glass tube fills with liquid from well below the surface at a rate which forces air past the detector under slight pressure. The detector is lowered until the detecting film is only a few millimeters above the liquid surface. The resistance of the detector changes rapidly at first but soon becomes practically constant when the small volume of residual air becomes saturated. Since this volume is almost isolated from the surrounding atmosphere, which is itself almost in equilibrium with the liquid, there is very little disturbance by diffusion from the outside. Two or three minutes is usually sufficient to obtain a steady reading, and successive tests are reproducible.

The instrument appears to be applicable to almost any liquid. With those which produce alkaline vapors, however, an electrolyte other than phosphoric acid must be used on the detector. It is expected that this device may also prove useful in determining the moisture content of many substances—such as fats or cellulose derivatives—which are soluble in organic liquids.

The general applicability of the method to liquids suggests the possibility of determining the water in solids also. Candy can be dissolved in alcohol, butter or other grease in ether or carbon tetrachloride, and the water in the solutions quickly determined. A sample of soil, molding sand, or concrete-making material shaken with acetone may be expected to transfer its surface moisture to the liquid at once. Thus it should be possible to determine quickly the surface moisture of numerous powdered or granular solids by shaking a measured sample with a suitable liquid and, without removing the solid, submerging the attachment for testing liquids in the resulting solution.



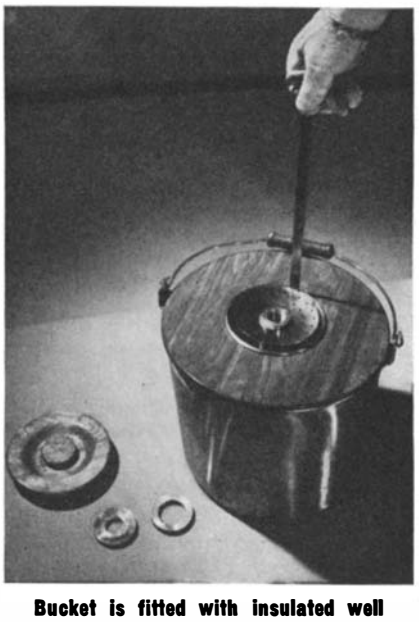
Detector tests permeability of membranes. Membrane (vapor barrier) covers water container. Time for air over barrier to reach given humidity indicates permeability

EXPANSION FITTING

Liquid Nitrogen is Used To Shrink Metal Parts

HIGH-PURITY liquid nitrogen, which can reduce the temperature of a piece of metal to 320 degrees below zero, F. in a few minutes, is now being used for expansion fitting.

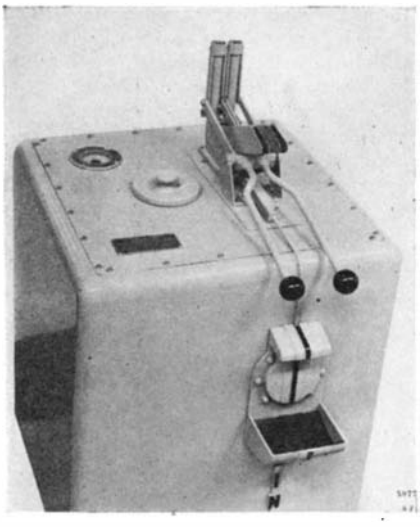
Though it is generally easier to expand the outside member of an assembly than to shrink the inside part, the size or hardness of the members or the possibility of distortion may make shrinking advisable. Fits such as valve seat inserts, cylin-



Bucket is fitted with insulated well

der liners and bushings are almost impossible to make by expansion. The outer members are usually too large or complex, have finished external surfaces or have been heat-treated.

Liquid nitrogen, being inert, is recommended for such shrinking applications. Liquid oxygen has been used for shrinking, especially during the war, but the properties of the oxygen-rich atmosphere create a potential hazard. Liquid air has also been used, but is not recommended since the nitrogen boils off first, leaving liquid oxygen.



A liquid nitrogen direct-immersion machine for the shrinking of small parts

For small-lot expansion-fitting operations, the most satisfactory arrangement is to use a stainless steel bucket having a well-insulated internal receptacle. The liquid nitrogen is placed in the inner container. The wooden cover is vented to avoid pressure build-up in the vessel. Tongs or a perforated ladle are used to dip small parts directly into the liquid.

For mass-production work, a machine is employed in which parts are fed either automatically or manually into the top and ejected after cooling as needed. As in nearly all such machines, the cold nitrogen vapor is used to pre-cool the part.

To supply the demands of large users, The Linde Air Products Company furnishes liquid nitrogen in 100-gallon mobile transfer tanks. These units are provided with heat exchanger coils enabling sufficient head pressure to be built for forcing the liquid nitrogen into the cold-treatment machine. For small users liquid nitrogen can be obtained in five-, 15-, 50- or 100-liter insulated containers.

Only a few precautions are necessary with this shrinking process. Care must be taken to assemble the parts quickly into final position. Parts warm up quite rapidly. Unless placed properly in position quickly the insert may become warmed sufficiently to bind.

Certain precautions for the operator should be observed. Good ventilation should be provided. Goggles are desirable and the operator should wear gloves for handling the cold parts. Great care must be taken in the handling of liquid nitrogen; if spilled on the hands, the material causes injuries similar to burns.

CHILLED BISMUTH DIES

Six to Ten Stampings Are Possible Between Chillings

A METAL that melts in hot water has been put to work by research engineers as a die material for making experimental parts. The soft metal—an alloy of bismuth, tin, and lead—ordinarily is too soft to stand the tremendous pressures imposed on dies. Ford Motor Company research engineers have overcome this obstacle by freezing the die in liquid nitrogen, which has a temperature of 320 degrees below zero, Fahrenheit.

This freezing action intensifies the hardness of the surface from a consistency comparable to dried putty to the far greater hardness of ordinary brass. From six to ten stampings can be secured between chillings in the frigid bath. In the past experimental engineers have had to wait from six to eight weeks for small steel dies to be made. Soft metal dies are now produced and sample parts obtained in from 24 to 48 hours.

FINGER-TIP AIRCRAFT CONTROL

Small, Light-Weight Unit Developed For Navy

FINGER-TIP control of an airplane is possible through the use of a new small control station. This control station is normally mounted between the pilot and copilot and is part of a new all-electric light-weight automatic pilot which was recently developed by the General Electric Company's Marine and Aeronautics Engineering Division for the Navy Bureau of Aeronautics. A similar type of automatic pilot is also in development for the Air Forces.

Finger-tip control in operation

This 100-gallon vacuum-insulated carrier is used to transport liquid nitrogen

New Products

SILENT MERCURY SWITCH

New Model Features Large Capacity And Long Service Life

HAVING a 10-ampere rating at 125 volts, a new silent mercury switch has been announced recently. A product of the General Electric Company's Appliance and Merchandise Department, Bridgeport, Connecticut, it replaces the five-ampere switch developed by that company. Doubling the interrupting capacity in the switch permits much wider application. While the five-ampere model could not control a load consuming more than 600 watts, the new model can be used in electrical installations of up to 1,200 watts. Operation of the switch is smooth and completely silent, and the unit is claimed to have an extremely long service life.

COTTON FIBER ANALYZER

Length and Uniformity of Fibers Are Accurately Determined

GUESSWORK is eliminated in determining length and uniformity of cotton fibers through the use of a new electronic instrument. This instrument, the Fibrograph, employs photo tubes to scan samples of parallel fibers and simultaneously traces a length-frequency curve. The geometrical properties of this curve indicate various average length intervals, variance and co-efficient of variation.

The Fibrograph, produced by the Fulton Sylphon Division, Robertshaw-Fulton Controls Company, Knoxville, Tennessee, operates on 110-volt, 60 cycle A.C. and is rated at 40 watts. However, units can be supplied on special order to operate other voltages.

Photo tubes scan fibers and simultaneously trace a curve which reveals variations

RESISTANCE-TUNED OSCILLATOR

New Instrument Covers a Frequency Range of 10 to 10,000,000 Cycles

SAID TO be the first commercial instrument of its kind to provide audio measurement speed, ease and accuracy for readings at radio, video and audio frequencies, a new resistance-tuned oscillator covers a frequency range of from 10 cycles to 10 megacycles, in decade ranges. No zero setting is required, and minimum adjustments are necessary during operation. The highly stable instrument, designated Model 650A, by the manufacturer, the Hewlett-Packard Company, Palo Alto, California, operates virtually independently of line voltage and changes in tube characteristics. Output is flat within one decibel from 10 cycles to 10 megacycles. Voltage range is .00003 to three volts. Output impedance is 600 ohms, but a six-ohm impedance is also available through an output voltage divider, supplied with the instrument.

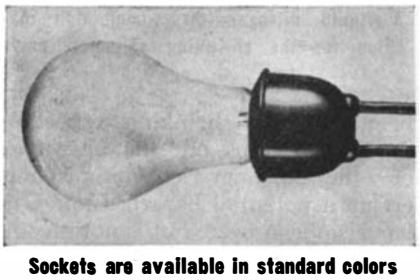
Other features of the new oscillator include a 94-inch scale length, a six to one micro-controlled vernier tuning drive and a complete vacuum tube voltmeter to monitor output in volts or decibels at the 600-ohm level. Continuously variable output voltage is obtained by means of an output attenuator of 50 decibels, variable in 10 decibel steps, and an amplitude control which adjusts the level to the monitoring vacuum tube voltmeter.

Operating entirely from a 115-volt A.C. power supply, the compact oscillator is provided either in relay rack or cabinet mounting. Panel size is 19 by 10½ inches and the instrument is 13 inches deep.

WATERPROOF SOCKET

Bulb and Receptacle Are Wholly Sealed in Rubber

THE UNUSUAL design and construction of a new all-purpose electric light socket make it completely waterproof, weatherproof and vaporproof. This



Sockets are available in standard colors

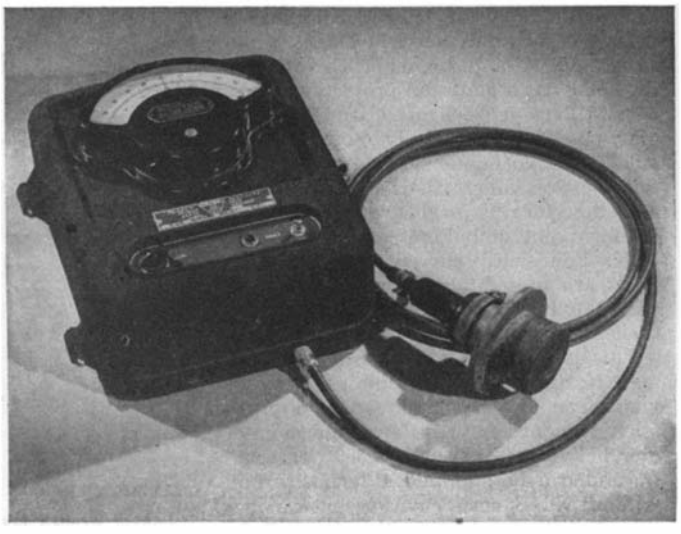
Neolite Weatherproof Socket "350," as it is designated, achieves its positive proofing against these elements through sealing with Neoprene. The phosphor spring bronze contact of the socket is embedded in Neoprene threads, while a moisture-tight lip of Neoprene seals the bulb, and the six-inch pigtail outlets are molded into the base. Absolutely no parts are exposed. The manufacturer, Neoline, Inc., Los Angeles, California, claims that with this sealing the Neolite may be submerged in water without fear of shock.

The unusual features of this socket make it well suited to outdoor decorative and utility lighting and for use wherever a lamp may be exposed to weather, oil or rough treatment. It is available in any standard color and in individual units or strung in sets of any length and any number of sockets, each socket being wired independently of the others.

DEPTH SOUNDER

All-Electronic Unit Measures From Zero to 600 Feet

A NEW all-electronic depth sounder for moderate-size commercial craft and yachts has been announced by Trident Products, Inc., Burbank, California. An



Complete sounder, excluding batteries, consists of two units — indicator (left) and transducer (right), connected by the flexible cable

extremely compact transducer employing a crystal sends a 50-kilocycle pulse and receives the echo from the ocean floor to determine depth. The transducer mounts inboard for easy servicing, and it requires a hole only three and one-half inches in diameter. To further simplify servicing, standard tubes and components have been used throughout. The complete installation, excluding batteries, consists of only two units. However, if remote indicators are desired, as many as five repeaters may be connected to the master indicator. Designated model DS-2, the instrument may be operated on six, 12, 32 or 110 volts, D.C. It draws only 30 watts. Depths from zero to 600 feet are continuously indicated on the large scale.

POLYACRYLIC ESTER

New Compound Has High Resistance To Heat, Ozone and Oils

CAPABLE of being compounded and vulcanized in a wide range of soft to hard compositions a new type American rubber is announced by the B. F. Goodrich Chemical Company, Cleveland, Ohio. The new product, to be known as Hycar P.A., is technically identified as a polyacrylic ester and is an elastomeric material resembling natural, pale crepe rubber in appearance. The vulcanized forms exhibit outstanding resistance to heat, oils, ultra-violet light, ozone and gas diffusion, and non-rigid compounds show extremely good flexing life. Compounding, molding, extruding, calendering and curing operations are readily accomplished with standard rubber processing equipment.

Available in both dry and latex forms, Hycar P.A. in the unvulcanized state is expected to find many applications as an adhesive and as a coating or impregnant for fabrics and papers. Vulcanized products have shown outstanding performance as heat-resistant coatings on fabrics, heat and oil-resistant gaskets, hose, belting, oil seals and other mechanical applications. As an insulation coating on electric motor coils, and as a heat and oil-resistant jacket for wire, polyacrylic ester shows promise of extending the usefulness of electrical products.

Hycar P.A., now in semi-works production, was developed after many years of experimental work by the company's research laboratories on flexible compounds for high-temperature service. When tested under an electric iron at 400 degrees, F., for eight hours, the new material showed no apparent loss in properties, whereas older rubber compounds were completely deteriorated in a much shorter time. After 720 hours at 300 degrees, F., the polyacrylic ester shows a change in elongation of only 35 per cent in comparison with 75 per cent in seven hours for good rubber compounds. Ozone resistance is even more striking, 600 hours exposure showing less effect on the new material than six seconds exposure on rubber.

FIELD REPAIR UNIT

Tractor Power Take-Off Drives Combination Tool

EASILY attached to the spindle shaft of a tractor's power take-off, a convenient field repair unit has been developed by Sherman Products, Inc., Royal Oak, Michigan. This unit, called the Farmcrafter, can be adapted in the field as a drill press or a grinder, and it is equipped with a flexible shaft that accepts many standard attachments. Sharpening tools and repairing of farm equipment can be done on the spot, and no power source other than the tractor itself is required.

Field repair unit used as grinder. Tool is driven by the tractor's power take-off

RADIATION EXPOSURE METER

Holding Instrument Up to Light Reveals Extent of Exposure

A POCKET dosimeter which provides an easily read indication of the amount of radiation to which the carrier has been exposed is announced by the Instrument Development Laboratories, Chicago, Illinois. This new instrument is designed for the safety of those working with X-rays or engaged in nuclear research. Designated model 8360, the dosimeter can be read merely by looking through its cupped eyepiece toward a light source. The amount of radiation to which the instrument and the bearer have been exposed is indicated in milliroentgens by an indicating line which is viewed against a magnified scale. The light-weight aluminum housing of the instrument does not appreciably distort the free-air reading. A molded conducting plastic cathode surrounds the ion chamber, and the anode of the instrument consists of a highly sensitive fused quartz fiber five microns in thickness.

SMALL ATTENUATORS

New Series of Bridged "T" Units Is Announced

A NEW series of small attenuators, said to be complete with all the quality features usually found in larger units, has been announced by the Shallcross Manufacturing Company, Collingdale, Pennsylvania. Measuring only 2⅛ inches in diameter, the new series of 20-step, bridged "T" units are designed to satisfy many important requirements for attenuators of highest quality which must meet space limitations.

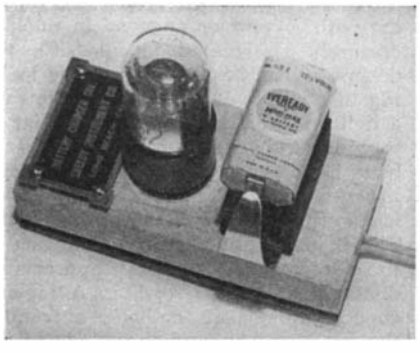
The various attenuation characteristics available make these new units

suitable for use as mixer or master gain controls. The attenuation characteristic is essentially flat from 30 to 15,000 cycles. Attenuation in "off" position is said to be 100 decibels or better. All resistors used are non-inductively wound and sealed against moisture and shock. The back-of-panel depth is two inches for all units, or 2 5/16 inches when equipped with detent mechanism.

HEARING AID BATTERY CHARGER

Reducing Internal Resistance Extends Service Life

"B" BATTERIES for hearing aids can now be charged by a new battery charger. This device, developed by the



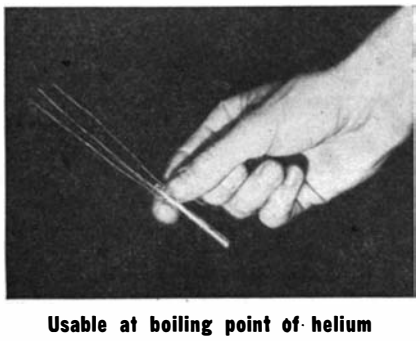
Battery in charging position

Selby Instrument Company, Long Beach, California, with the coöperation of the National Bureau of Standards and many leading battery manufacturers, decreases the internal resistance of the battery, thereby permitting fuller use of the pot[illegible] battery life. The suggested procedure for using the charger is as follows. Two batteries are used—one is put in the hearing aid and the other is put on to charge. Each morning the batteries are rotated. This plan is said to result in an increase in the batteries' service life of up to 75 per cent. The unit operates on 110 volts.

LOW TEMPERATURE THERMOMETER

Measurements in Region of 10 K Are Accurately Made

BASED on a design by Dr. H. J. Hoge of the National Bureau of Standards, a new platinum resistance thermometer



Usable at boiling point of helium

bulb is intended for calorimetric measurements at extremely low temperatures (10 K and higher). This thermometer has a platinum protecting tube 48 mm long and 5.6 mm outside diameter, and it can be easily mounted inside a calorimeter by casting in low-melting alloy. It is helium-filled and therefore is usable down to the boiling point of helium, approximately 5 K. Four-wire current and voltage leads are brought out through a glass seal. Nominal resistance at zero degree, C. is 25.5 ohms.

This instrument, a product of Leeds and Northrup, Philadelphia, Pennsylvania, can also be employed as a primary standard for resistance thermometer between — 190 and + 500 degrees, C., and can be supplied either with or without N.B.S. certificate for that range. When it is used with the type G-2 Mueller Bridge, temperature measurements can be made with an accuracy of ± 0.01 degree, C. in the calibrated range.

REGISTRATION CONTROL

Sensitive Unit Checks Positioning Of Wrapper in Packaging Machine

A NEW registration control for use with packaging machines which employ web-fed wrappers has been developed recently by the Ripley Company, Inc., Torrington, Connecticut. The control consists of a scanner, and amplifier and a built-in relay unit. Connections are provided so that the cam on the feed of the packaging machine automatically corrects the position of the label whenever the web of the material gets out of register due to the slipping and stretching inherent in material of this type. The control is said to be so color sensitive that correction in the positioning of wrapping material is possible on such low color contrasts as red or brown on yellow, even though the marks be as thin as .015 inch.

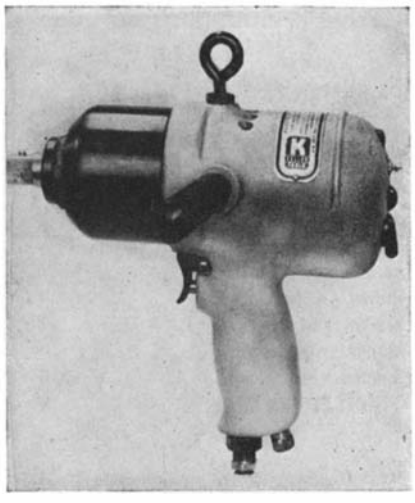
The same method of scanning may be used when changing over from an opaque material to one that is translucent or transparent. The control can operate on either a light increase or on a light decrease, so the unit can scan a dark mark on a light background or a light mark on a dark background.

The control can operate at a rate of 750 units per minute with the correction on any sequence of registration marks. The equipment is compact and uses standard tubes and lamps to simplify maintenance. It operates on either 115 or 230 volts, 25 to 60 cycles.

IMPACT WRENCH

Powerful Air-Operated Tool Sets Bolts Rapidly

OPERATING without springs, gears, clutches or complicated devices, a new air-driven impact wrench sets nuts which would ordinarily require nut setters of far greater size and weight. An air motor of the rotary type fur-



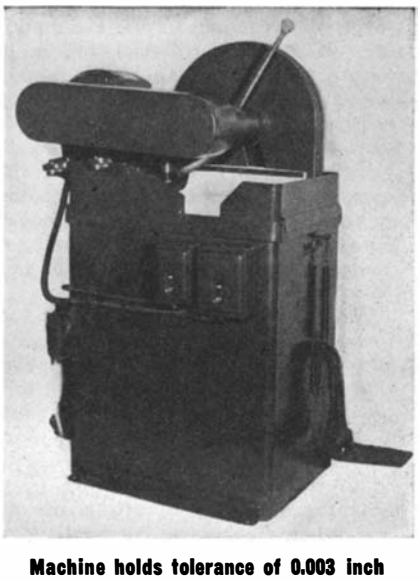
Impact wrench takes bolts to 5/8 inch

nishes the speed and power for fast nut running in this unit. A built-in torque regulator is easily adjusted to the torque requirements of the individual job. The tool can also be run in reverse for use in disassembling operations. This wrench, recently announced by the Keller Tool Company of Grand Haven, Michigan, is designated Size 18-6 and will take bolts up to 5/8 inch. Overall length is 8 7/8 inches and the unit weighs only nine pounds.

ABRASIVE CUT-OFF MACHINE

Coolant Used to Extend Wheel Life And Give Finer Surface Finish

INTENDED chiefly for production-line work where fast cutting is necessary and yet tool or wheel life must be considered, a new abrasive cut-off machine has a coolant tank and pump for wet cutting. The use of coolant in this type of machine reduces cutting speed slightly, but it assures far better wheel life and leaves a surface finish free from burr and discoloration from burning. Wet cutting also leaves an unhardened surface, a fact of prime importance if further machining is to be done. Toler-



Machine holds tolerance of 0.003 inch

ances of 0.003 inch are said to be possible.

This machine, a product of the Do-All Company, Des Plaines, Illinois, is designed to provide extremely high wheel speeds for the fastest possible cutting. The wheel is fully enclosed in a heavy cast iron guard for safety. A work vise operated by a foot pedal with sufficient leverage to hold work securely is standard equipment. Arbors are of one-inch chromevanadium steel mounted on pre-loaded ball bearings, sealed on the outside, and provided with adjustable take-up. Also included are stop gages for accurate cutting. This machine, known as Model W, uses a 16-inch wheel powered by a 7½ horsepower motor, and has a capacity of three-inch tubing or two-inch solid bars.

AIR FLOW METER

Rate of Air Stream Is Accurately Measured by Hot Thermopile

AIR VELOCITIES from five feet per minute to 6,000 feet per minute are accurately measured by a new air flow

Air meter requires no auxiliary equipment

meter. No other equipment such as stop watchs, hoses, leveling devices. manometers, orifices or pressure instruments is required with this air meter. It is a completely self-contained unit that operates on the hot thermopile principle. A noble metal thermopile is placed in the air stream to be measured. The hot junctions of the thermopile are heated by passing alternating currents through them. The cold junctions are prevented from becoming heated by lowering their resistance and by increasing the heat conductivity away from them. Therefore a D.C. thermal voltage is generated between the hot and cold junctions of the thermopile. The flow of air tends to bring the hot and cold junctions to the same temperature, thus decreasing the output from the thermopile. This output is a measure of the speed of the air flowing past the thermopile. An indicator or recorder operates from this difference voltage generated by the thermopile.

This instrument, known as the Air Meter, is produced by the Hastings Instrument Company, Inc. of Hampton, Virginia, and is said to be particularly free from errors due to temperature variations, radiation effects, and lead resistance. It can be operated either from a standard 110-volt, 60-cycle line or from a portable battery supply.

HIGH-VOLTAGE SUPPLY

Output Is Said to Vary Less Than .01 Per Cent

A NEW zero to 5,000-volt reactance-regulated D.C. supply is announced by Instrument Development Laboratories, Chicago, Illinois. This unit, designated model 1090, is arranged for mounting in a standard relay rack. It features extremely good regulation. The output is said to vary less than 0.01 per cent with input variation between 90 and 130 volts. The output voltage is continuously variable between zero and 5,000 volts, positive or negative.

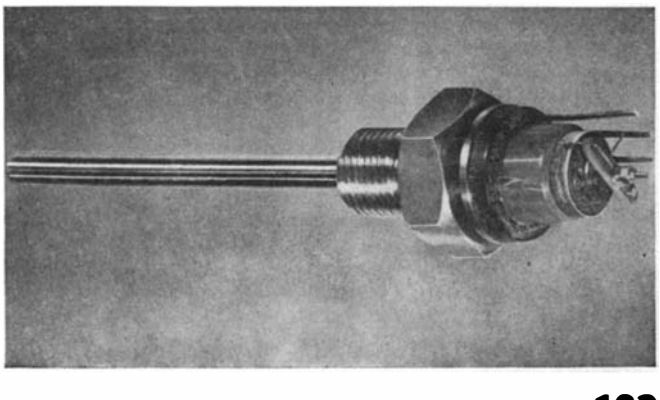
The unit contains only one vacuum tube, greatly simplifying maintenance and reducing the possible sources of failure. A large, easily read meter indicates the voltage output. This new supply is well suited for use with ion chambers, proportional and Geiger counters, and is especially well suited for use with the new high-voltage counters for soft beta radiation.

TEMPERATURE TRANSDUCER

Small Light-Weight Unit Features Accuracy and Quick Response

A NEW temperature transducer, only one inch in diameter, is designed for telemetering applications where space is at a premium. In this unit a temperature sensitive bi-metallic element encased in a small tube rotates a standard microtorque potentiometer. Any change of the bi-metallic element due to the slightest change of temperature results in a large voltage output from the potentiometer. These voltage outputs are sufficiently large to be recorded by an oscilloscope, galvanometer recorder or a telemetering system.

Standard resistance for this instrument, a product of G. M. Giannini and Company, Inc., of Los Angeles, California, is 5,000 ohms, but resistances are available from 100 to 20,000 ohms. This temperature transducer has a range from −65 to +150 degrees, C. The unit is accurate to 1 per cent and has a sensitivity of one degree or less. Standard response time is two seconds for a five degree change in temperature.



The transducer's output is sufficiently great to be recorded by an oscilloscope, a galvanometer or by a telemetering system. Temperature range is —65 to +150 degrees, C.

MAGNETIC HAND LIFT

Two Alnico Magnets Aid Handling Of Small Steel Parts

DESIGNED for the rapid handling of small parts of iron or of any magnetic alloy, a new light-weight magnetic

Hand lift will support up to 15 pounds

hand lift will support up to 15 pounds. Heart of the device are the two four-inch Alnico magnets housed in the aluminum and stainless steel case. It requires no external power source and needs no maintenance. Known as the Multilift Model S Magnetic Separator, the unit is a product of the Multilift Manufacturing Company, Detroit, Michigan. In addition to its materials handling applications, the hand lift can also be used to draw steel parts from tumbling media, to remove heat-treated parts from carbon, to salvage steel parts or particles from aisles or assembly lines or for any operation where small steel parts are to be separated from non-magnetic pieces. The device measures three by five and one-half by eight inches and weighs only three and three-quarters pounds.

CURRENT BULLETIN BRIEFS

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

CAST BRONZE BEARING ALLOYS. This is the first of a series of technical papers prepared to assist the engineer and designer in selecting the proper alloy for a given type of service. Complete engineering data on physical properties are included, and new material dealing with the hardness of cast bronzes is published for the first time. There is also a listing of characteristics and typical uses of different cast bronze bearing alloys. *The Bunting Brass and Bronze Company, 715 Spencer Street, Toledo 9, Ohio.—Gratis. 11 pages.*

ELECTROMODE UNIT HEATERS. Catalog EC-4. Describes in detail the complete line of Electromode Unit Heaters from 1500 watts to 60,000 watts. The book is fully illustrated with pictures of many installations heaters, controls and with wiring diagrams. It contains a Heating Analysis Sheet to assist in solving industrial heating problems. Includes a full page of illustrations of the complete line of Electromode portable and built-in-wall heaters. *Electromode Corporation, 45 Crouch Street, Rochester 3, New York.—Gratis. 15 pages.*

WILSON TUBE CLEANERS—Catalog No. 76. Covers the complete Wilson line of tube cleaners for use in refineries, power plants, marine boiler rooms, locomotives and chemical process plants. Described in detail is virtually every type of cutter-head, as well as brushes and air-, steam- and water-driven motors, electrically driven tube cleaning equipment and all accessories. All listings are organized for easy reference, and include application data as well as technical information, operating hints and other pertinent data. *Thomas C. Wilson, 21-11 44th Avenue, Long Island City 1, New York.—Gratis. 48 pages.*

CARBOLOY DIE ENGINEERING MANUAL (No. D-124) is a comprehensive presentation covering the design, fabrication, application and maintenance of carbide sheet metal dies. Designed specifically for the use of die manufacturers and large-scale users of carbide dies, the manual contains 36 pages of technical data, profusely illustrated treatments of "Designing, Assembling, and Finishing of Draw Dies", a similar treatment on Blanking Dies, a section on "Designing and Finishing of Punches" and an enumeration of the factors involved in ordering carbides for dies and punches, including tolerance specifications. Dimensional information as required for the manufacture of dies and punches of various sizes and types are given in tabular form in the various sections. *Carboloy Company, Incorporated, Detroit 32, Michigan.—Gratis. 36 pages.*

WALES TYPE "C" HOLE PUNCHING UNITS —Catalog C. The units illustrated and described in this new catalog are used primarily for punching rivet holes in sheets, angles and extrusions. Included are types "C," "CA," "E" and "EJ" units. Wales "C", "E" and "EJ" units are independent and self-contained with nothing attached to the press ram, providing rapid setup on press brake rails, and reducing press "down time" to an absolute minimum. The "CA" units are "C" units with built-in adjustable adapters which provide a front-to-back adjustment of 1½" maximum (¾" either side of center line). *Wales-Strippit Corporation, North Tonawanda, N. Y.—Gratis. 15 pages.*

SPECIALIZED TESTING AND MEASURING EQUIPMENT CATALOG. More than ninety modern equipments for specialized testing and measuring are presented in this book. Products are grouped under functional, or "use" headings, such as "Time, Speed, and Torque"—an arrangement which makes it easy to locate a product of specific interest. Covered in eleven sections are: Magnetic Equipment; Time, Speed, and Torque Measuring Equipment; Force, Strain, and Thickness Gages; Color, Light, and Spectro Equipment; Chemical Analysis Equipment; Resistance and Insulation Testing Equipment; Materials Testing Equipment; Fibration, Sound, and Balancing Equipment; Vacuum and Pressure Measuring Equipment; Electric Circuit Testing Equipment; Miscellaneous Equipment. *General Electric Company, Apparatus Department, Schenectady 5, New York. —Gratis. 43 pages.*

LINK-BELT BULK-FLO. This handsomely printed and illustrated bulletin describes Bulk-Flo—a combination elevator, conveyor and feeder for the mechanical handling of a great variety of bulk flowable granular, crushed, ground or pulverized materials of a non-abrasive, non-corrosive nature. Made in Separated-Run and Combined-Run designs, numerous arrangements are possible of Bulk-Flo Conveyors because of their interchangeable standardized casing elements. Suitable for the majority of installations are three main machines consisting of horizontal, L-path and loop-loading arrangements. Fully explained in the bulletin are the Separated-Run design; the Combined-Run design; Design Features; Installations. Engineering Data are comprehensively presented and documented. *Link-Belt Company, 2680 Woolworth Building, New York, New York.—Gratis. 47 pages.*

PATENTS AND HOW TO OBTAIN THEM—No. 64—1947 edition by B. M. Aldrich, Associate Professor of Mechanical Engineering at Oklahoma A & M College, may be had for the asking by writing the author or the *Engineering Experiment Station, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.—23 pages.*

Books

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

PRINCIPLES OF JET PROPULSION

By M. J. Zucrow

THE AUTHOR, Professor of Gas Turbines and Jet Propulsion at Purdue University, presents a discussion of the fundamental theory pertinent to an intelligent understanding of jet-propulsion engines and gas-turbine power plants. Workings of the continuous combustion gas turbine, the three basic types of air compressors, the axial-flow turbine, the combustion chamber, high-temperature metallurgy, the turbojet engine and the rocket are all given excellent coverage. This book contains a wealth of material for the serious student. But if it is a popularization of the subject you want, this is not your book. (563 pages, 6 by 9¼ inches, illustrated with charts and line drawings.)—$6.60 postpaid.—*N.H.U.*

MANUAL OF ASTRONOMY

By Shaw and Boothroyd

FROM THESE 47 practical exercises amateur astronomers would derive far better systematic knowledge of working astronomy than from reading textbooks alone. Lone wolves probably would bog down for lack of fellow inspiration but groups working in unison would provide this necessary motivation. Questions asked are to be answered in writing in spaces in the manual, often on graph paper bound with it. Coverage: stars; planets; sun; moon; time and position; meteors; clusters; instruments; spectra; nebulae; navigation. Manual is used in teaching elementary astronomy at Cornell and elsewhere. This is *not* a textbook but an accessory to one. (294 pages, 8½ by 11 inches, well illustrated.)—$3.10 postpaid.—*A.G.I.*

MATRIX AND TENSOR CALCULUS

By Aristotle D. Michal

MATRIX calculus is a purely analytic and algebraic subject. Tensor calculus is geometric, handling the transformation of coördinates and other geometric concepts. Matrix calculus helps solve problems of mechanical systems which have more than one degree of freedom. Tensor calculus helps solve the more intricate problems of the mechanics of fluids, and plastic and elastic media. Together they are powerful tools for the designers of airplanes, to whom Professor Michal (of California Institute of Technology) is a dependable and handy counsellor. (132 pages, 6 by 9¼ inches, illustrated.)—$3.10 postpaid.—*M.W.*

LIFE AND TIMES OF TYCHO BRAHE

By John Allyne Gade

RAPIDLY moving, thoroughly readable, lively entertaining account of the life of the most famous scientist of his day—astronomer (astrologer, alchemist also), the second link in the great chain Copernicus, Brahe, Kepler, Galilei, Newton. On his islet near Copenhagen he performed marvels of exact astronomical routine position observation without telescopes, none then existing. He was egocentric, difficult, imprudently combative, probably a paranoid. It is all here, good and not so good. (209 pages, 6 by 9 inches, 26 illustrations.)—$3.60 postpaid.—*A.G.I.*

FLEDGELINGS

By F. Regis Noel

THIS is a remarkably interesting collection of historical monographs written by outstanding authorities, thus: Nils H. Randers-Pehrson, formerly of the Division of Aeronautics in the Library of Congress, writes on Aeronautics in the District of Columbia and goes back as far as 1784, when an attempt was made to fly a Montgolfier type balloon. Mr. Randers-Pehrson deals with early balloon exploit and has first-hand information on Lengley's work.

Dr. Albert F. Zahm, who now holds the Guggenheim Chair of Aeronautics, Library of Congress, begins his article with the following striking paragraph:

"Of the nineteenth-century contributions to aviation art three are especially noteworthy: (1) invention of the airplane, (2) addition of three-torque control, (3) first man-flights with ample power. In 1842 W. S. Henson patented the airplane with all organs essential to pioneer flight. In 1884 A. Goupil portrayed it nicely streamlined and endowed with aileron controls. Both forms were monoplanes, well delineated and discussed but never actually constructed. In the ensuing nineties C. Ader developed successively three monoplanes with aerodynamic control and abundant steam power. Each of these he piloted in brief flight witnessed by assistants. Thus before 1900 the airplane was invented, refined, publicized, built and test-flown."

Other contributors in this historical review include Mrs. Gilbert H. Grosvenor, daughter of Alexander Graham Bell; John C. Proctor, Editor-in-chief of "Washington Past and Present"; and F. Regis Noel, President of the Columbia Historical Society and former President of the Bar Association of the District of Columbia.

The whole series of pamphlets and papers constitute remarkable historic records. As the discovery of aviation becomes more important, all history records should be made as complete as possible. (79 pages).—$1.60 postpaid.—*A.K.*

ELEMENTS OF RADIO SECOND EDITION

By Abraham and William Marcus

THIS well-known volume constitutes a home study course in basic radio theory. Presupposing no scientific knowledge whatever, the book begins with the most simple and concrete ideas before tackling the more complex principles. Revisions in this second edition include a new section on radar and television and a new chapter on modern radio receivers. (751 pages, 5 by 7½ inches, illustrated.)—$4.10 postpaid.—*N.H.U.*

MICROMETRICS

By J. M. DallaValle

TECHNOLOGY of fine particles, an uncommon corner in science and industry, in which is collected a mass of widely scattered information on methods of particle measurement, size distributions, packing arrangements, and general theory of the physical properties of finely divided substances, together with industrial applications. Is about 25 per cent mathematical (calculus). Second edition of work published 1943, revised, considerably enlarged. (555 pages, 6 by 9 inches, 131 illustrations.)—$8.60 postpaid.—*A.G.I.*

THE DECIBEL NOTATION

By V. V. L. Rao

THIS IS the American edition of a pioneering monograph on decibel notation by V. V. Lakshmana Rao published during the war at Madras, India. Some of the terms are Britishisms, *e.g.*, *aerial* for *antenna*, *valve* for *tube*,

The Editors Recommend

Best Sellers in Science and Technology

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

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

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

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

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

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

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

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

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

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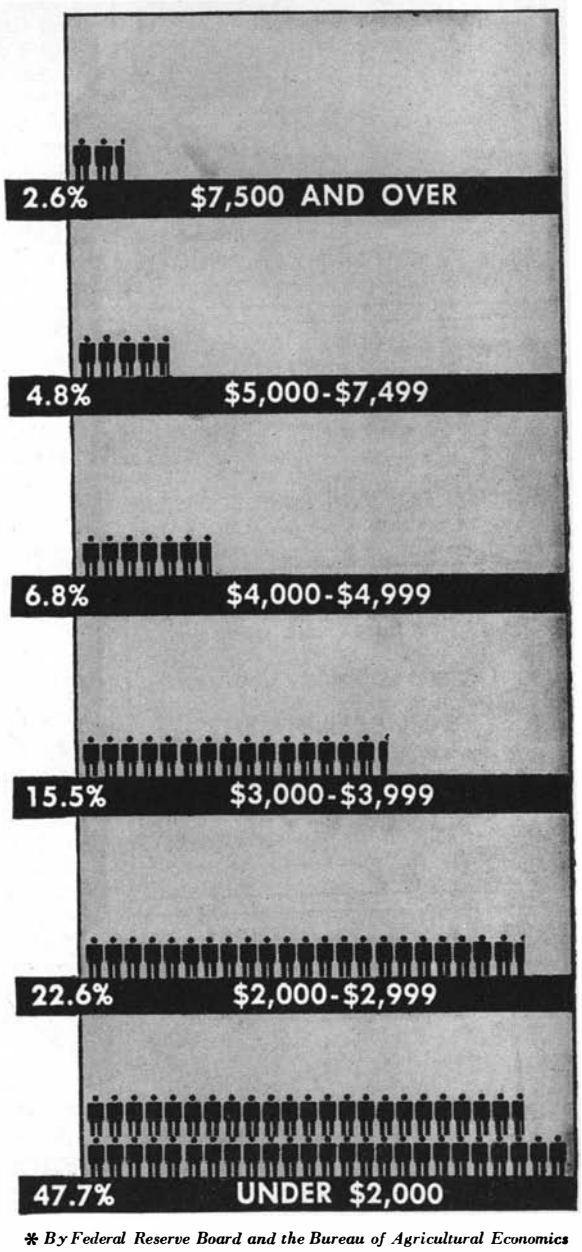

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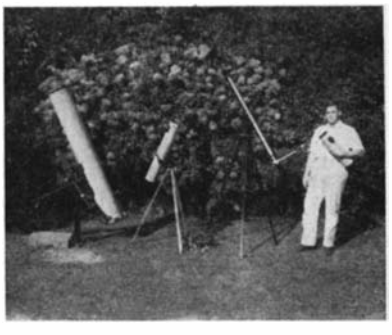
WHAT'S A "TN"?

Not Derogatory, It's A Compliment

JUST as amateur users and collectors of firearms show vigorous enthusiasm over their hobby and call themselves "gun cranks," so do many of the equally ardent followers of the amateur telescope-making hobby call themselves TNs, or telescope nuts, a term originally coined on the spur of an amusing moment by the humorist spouse of the hobby's patron saint, Russell W. Porter. The more staid, dignified minority of amateur telescope makers, perhaps suspicious of the underlying connotation of this equivocal term, do go so far as to call themselves ATMs, meaning amateur telescope makers, but an unregenerate TN wag named Pat Driscoll claims this means amateur telescope maniacs. It is good psychosomatic medicine to have something to be slightly crazy about, anyway.

The reader shown in the accompanying photograph qualifies both as ATM and TN by making four telescopes. "I think," he writes, "that I can lay claim to a maximum amount of variety in types of telescopes I have built.



A typical "TN"

"My first, the one shown at extreme left, was 8 inches in aperture with concave glass mirrors and was given a mounting of two-inch pipe fittings.

"To carry this rather bulky instrument from Philadelphia, where it was made, to Maine, where I summer, proved too much of a problem so I built the four-inch portable reflector shown on a tripod to right of the first. Loss of magnification was made up for by the advantage of portability; the weight was just 14 pounds.

"Having by now mastered more of the technique of making optical surfaces I next built the 2¾-inch refracting telescope shown third from the left, and I gave it the terrestrial (erecting) eyepiece shown at right angles to the tube. This one is not so powerful as the others but making it was a lot of fun.

"My latest venture was the short, stubby 'richest-field' reflector (shown in my arms) for observing broad fields of stars."

Few who make one telescope stop at one telescope. The mania leads in two directions: (1) larger telescopes (2) different types. First telescopes usually cost the spare time of three months; second jobs a month; third jobs a week and after that they almost make themselves.

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"

PORTLAND, Oregon, contains an energetic group of enthusiasts, the "Portland Amateur Telescope Makers and Observers," of which Howard Thomas, 2242 N.W. Hoyt Street, is the president. A 20½" Cassegrainian reflector (Figures 1, 2, 3,) designed by Col. Alan E. Gee (see "A.T.M.A." page 320) and built with the help of A. E. McIntosh, both of that group, is an ambitious job such as workers who have made half a dozen smaller telescopes may aspire to tackle as a climax.

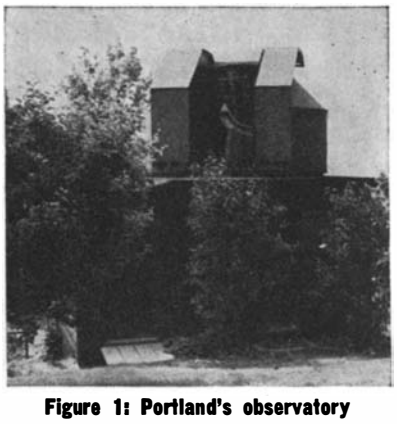


Figure 1: Portland's observatory

The massive, chunky polar axis unit (Figure 2) consists of a rectangular yoke like the one on the 200" telescope, at its bottom a central stub shaft, at its top a "horseshoe" permitting the telescope to view stars fully down in line with the axis, a design feature originated by Porter. The sides and bottom of the yoke are welded of 6" by 8" I- (C.B.) beams and the horseshoe is full 1" steel plate. It rolls on ball-bearing trunnions on a concrete pier. The stub shaft at bottom is 3½" in diameter and is carried in self-alining steel balls. It carries a 20" bronze worm drive wheel with self-computing slip ring (Figure 3).

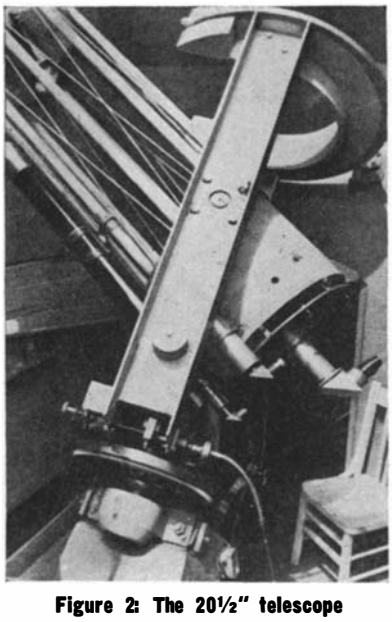


Figure 2: The 20½" telescope

The 20½" mirror is one made in 1936 by C. R. Tinsley and is a tenth-scale honeycombed Pyrex 716 replica of the 200" mirror. It has a 33-rib support system designed by Gee and built by McIntosh. Its 80" focal length gives focal ratio f/4 which a 6" convex secondary mirror extends to f/12 or à 4½" secondary mirror to a seldom used f/20.

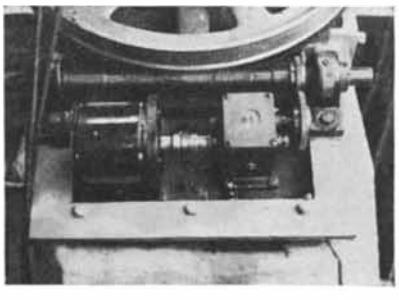


Figure 3: The drive and worm

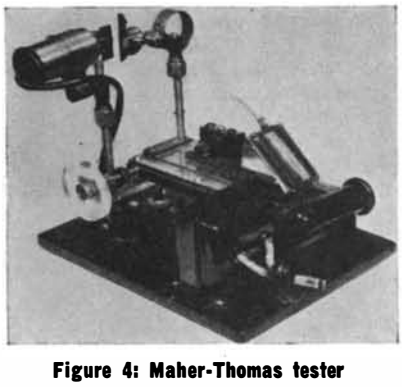


Figure 4: Maher-Thomas tester

For the famous Foucault knife-edge test, which reveals at a look irregularities as small as a millionth of an inch on a telescope mirror, a dulled razor blade mounted vertically on a weighted stick is sufficient—not alone sufficient but many old hands say just as good as something fancy. Nevertheless an apparatus like the one in Figures 4 and 5, built by T. P. Maher and H. D. Thomas of the Portland organization,

has points. Anyway, it is fun to build one.

The levitated drawing (Figure 5) reveals parts:

A: Knife-edge and lamp support.

B: Lucite (2½") hand wheel, block, eccentric bushing. Assembly held in place by 8-32 machine screws through to base plate of apparatus.

C: Way and slide of ⅛" brass. Pinion rack sweated to it.

D: Brass shims (0.015") for bearing plates to prevent slide from riding on Lucite scale.

E: Cross feed slide and way.

F: Bearing plate (⅛") for *E*.

G: Maple, ⅞" × 1½" × 4".

H: Base plate, ⅜" × 6" × 8" boiler plate, purposely heavy. Has three rivets beneath for stable support.

I. Prism (1¼") mounted on knife-edge slide to permit reading the Barr's scale ("A.T.M.A.," page 20) from a convenient testing position.

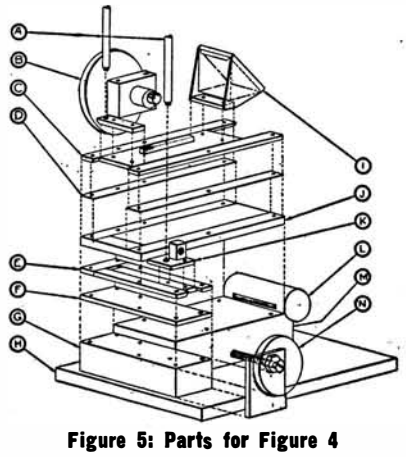


Figure 5: Parts for Figure 4

J: Barr's scale ruled on Lucite sheet, 2½" × 6". Black photographic tape acts as a light stop on three sides of this block.

K: Cross feed nut.

L: Lamp to illuminate Barr's scale through edge of Lucite block. Scale shows as bright line on black background, easy to read in darkened room. Use 6-8 volt radio pilot lamp.

M: Maple, 1⅛" × 2½" × 4⅞", doweled and glued to *G*.

N: Cross feed screw and Lucite hand wheel. This could be graduated and illuminated in the same manner as the Barr's scale.

The pinhole illuminator is a flashlight bulb in a brass mounting. A condensing lens, prism, and ground glass are in the train to pinhole. Spring clips on knife-edge holder and lamp permit quick change from pinhole to slit, knife-edge to Ronchi grating. Support clamps on lamp and knife-edge stand are common ¼" oil line compression Ts. The Ts are drilled out to pass the ¼" rod, and compression ferrule split so it grips rod on slight twist of nut. This feature has worked very satisfactorily, affording easy raising, lowering, and minor adjustments.

Door-bell transformer (Figure 4) supplies power for all lighting.

Instrument weighs eight pounds.

The same Portland group devised a

kind of Robinson Crusoe method of ruling divided circles without lathe or dividing head. A 50′ steel tape was laid out in a square 100″ on a side. To obtain square corners, and to avoid injuring the tape, a loop of excess tape was allowed at each corner, and each side of the square was stretched separately with strings tied on. The square was squared within 1/16″ by measuring the diagonals. Disk to be ruled was set at exact center. On it was set a 5-power telescope with cross-hairs at points based on tangents of desired angles.

An engraver made of drill rod running against a guide made the marks. Spacings down to five minutes of arc were obtainable without introducing fictitious accuracy. This method is also independent of tape expansion.

The circles made look like dividing engine jobs.

INTEREST in refractors steadily increases but crown and flint blanks have been almost unobtainable since the war. Check over the known sources. B. and L. hasn't acted interested in sales to amateurs. Corning now makes some 15 types of optical glass and will sell—if you need half a ton. A West Coast supply has petered out. A year's effort by this department to arrange a supply with the English Chance Brothers came to naught. The French Parra-Mantois glass is apparently unavailable and the German plant at Jena was lugged home by the Russians. "What is left," writes one amateur (G.D.H.), "for the poor Joe Doke who wants to grind a telescope lens?"

The pointed comment just quoted was shown, last August, to the Col. Alan Gee mentioned above in connection with the Portland group and who had just moved to Rochester, N. Y., (129 Seminole Way) sent there by the Army to study advanced optical design at the University of Rochester. He promptly went to Bausch and Lomb, talked with their Manager of Specialty Sales, J. F. Brandt, and on behalf of his fellow amateurs (once an amateur always an amateur), completed arrangements by which the amateur now may get his glass.

Available from Brandt after April 1 will be, not a wide selection of crowns and flints but the following as a post-war starter: A 3½" pair, BSC-2 (1.5170,64.5) and DF-2 (1.6170,36.6) $11 postpaid; optional: tool blank of C-50 at $3.25. Also 4½" same glasses, $21.75, postpaid. Tool blank, optional, $4.25.

"The disks," Brandt writes, "will be made of our regular instrument glass such as we use in all our instruments and due regard will be given to the quality demanded for astronomical objectives of this size. We have set the price on these and are putting in this stock entirely with the idea of being of some service to the amateur telescope maker. We are largely guided by the fact that you have felt that there should be more refractors made by amateurs and are making commercially available a stock of glass to back you up. We are sorry it has taken so long to accomplish anything, but

you can well imagine that under today's circumstances many a problem like this gets kicked around a bit before a chance comes to do something about it. The sets will be in stock April 1 at the latest. The sales will be made direct from the factory only, and not through dealers since this is entirely a service proposition."

Just why this particular glass? It was suggested by Col. Gee. "These," he writes, "are the two for which Baker gives all the curves for four different types of objectives in Dimitroff and Baker, 'Telescopes and Accessories', pages 28-29." Asked about these objectives, Dr. Baker indicated that nothing had been said in "Telescopes and Accessories" of their excellence; they were merely inserted poker-face.

"I had my tongue in my cheek, back in '44," he writes, "when I put the refractor designs in the book on telescopes with Dimitroff. For the separated doublet offers a correction within a very small fraction of the Rayleigh limit, both for spherical aberration and coma, and is as good as can be done short of special glasses not available to amateurs in general. I wonder how many amateurs took the design seriously. We made up a 6" of the kind during the war and had excellent luck. The design can be carried even to f/3.5 before departing from the Rayleigh limit."

Gee's selection of B. and L's Brandt's glasses for Baker's objectives looks like a happy inspiration. Another worker's comment is: "Of course, the glasses will not exactly match the general catalog index except in rare instances but will vary in the fourth decimal place. But this, while objectionable in the very finest possible objectives, can largely be accommodated by varying the separation of the two components. A really top-class design calls for trigonometrical ray tracing to eliminate some of the aberrations, as only spherical aberration can be eliminated by local figuring. Not 'any old design' calculated from the general formulas for curves with algebra will give highly satisfactory results."

NOW FOR some long overdue tactlessness. Let's be rough and get it over with. For many years large optical firms have received SOS letters from amateur telescope makers. No doubt the following is exaggerated. "I am making a telescope using your goods and my troubles this week are a turned edge, zones, scratches, pits. The enclosed beautiful drawing shows my shadows. If it weren't for the edge, the zones, the scratches, and the pits, would this be a paraboloid or must I go back to grinding? If so, to what stage? Answer soon by air. P. S.: Please include all you know about abrasives, pitch, strokes, pressure, and testing."

Men in these firms like amateurs, envy their fun, want to be agreeable, but aren't altogether free. Answering these Mr. Anthony letters takes long hours, costs money. Let's send them to Dorothy Dix or others and not spoil our "in" with the big boys.

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