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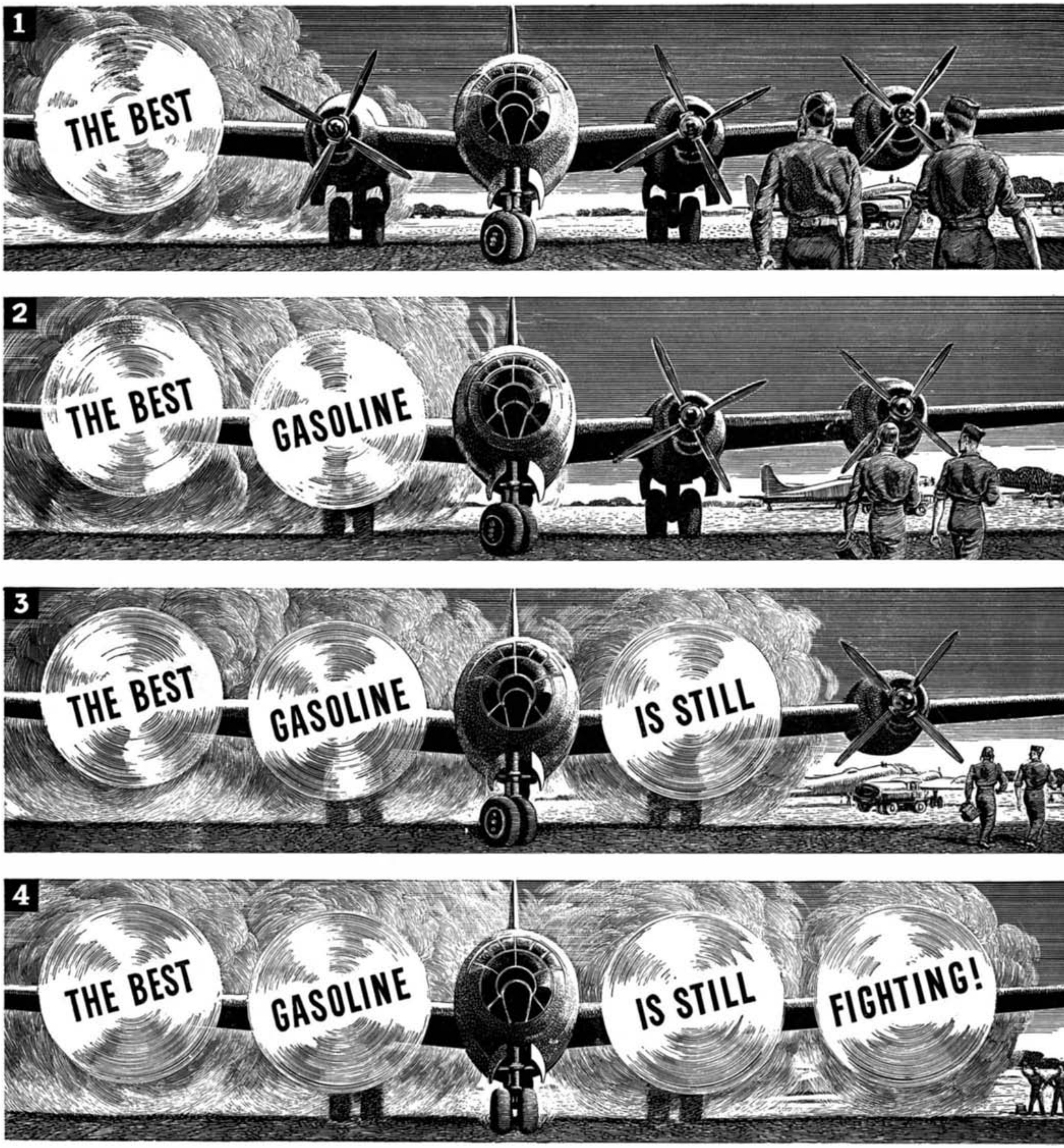
100th Anniversary Year

REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY

Dross is Skimmed from Molten Aluminum . . . See page 193

The Story of METALS IN INDUSTRY

Anniversary Issue No. 4



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Our Cover: After the dross has been skimmed from the top of a crucible of molten aluminum, the hot, liquid metal is poured into molds, skimmed again, and then allowed to freeze into pigs. Photograph used by courtesy of Reynolds Metals Company.

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Previews of the Industrial Horizon

By A. P. Peck

A WARNING ON PLASTICS

GREAT as are the uses and possibilities of plastics, it must not be forgotten that there is no one plastics that will fit all requirements. Herein lies a danger to the future of plastics. In the rush to make use of the valuable properties of plastics, there is a possibility that they will be misused, will not be properly selected for the purpose in hand. When the use of plastics is considered for a new product or as a replacement for some other material, due consideration must be given to the requirements. Strength, rigidity, color, temperature resistance, dimensional stability, and so on, must be considered first and then that plastics selected which most nearly meets the specifications. To proceed otherwise can only result in probable failure and the loss of a market for a plastics.

GYPSUM TOMORROW

WHEN the promised post-war building boom becomes a reality, one material that is really going to cash in on new construction and on renovation is gypsum. Where formerly gypsum was known only as a standard plaster for use on interior walls and ceilings, it now has expanded its usefulness to include gypsum lath, fire-proof sheathing, and prefabricated gypsum wall board that can be weather-proofed and will not change dimensions with changes in weather or temperatures.

By no means the darkest part of gypsum's horizon is the fact that, always low in cost, its cost has hardly changed since pre-war days, while lumber and other building materials have skyrocketed in price and have become scarce.

MODELS SHOW THE WAY

INDUSTRIAL engineers charged with layout projects for plants of all kinds are showing increasing interest in the use of models that save time, labor, and materials and at once permit accurate visualization of plans. While these models—three-dimensional plant layouts—are of tremendous help to engineering study, they have the added advantage of showing non-technical persons exactly what the engineer has in mind. Thus the executive staff of an organization can be kept completely informed regarding a proposed plant layout without having to wade through a welter of blueprints and a maze of technicalities.

MULTI-USE GLASS

MOLDING and welding glass by the use of high-frequency electrical waves point the way toward innumerable new uses of this old material, especially in the household. This latest Corning development holds promise of glass stoves, electric toasters made with glass, and a whole family of new glass cooking utensils. Add to these applications the possibility of insulating parts of intricate shape and with close dimensional tolerances and you have a peek at the glass horizon where many articles will be made of glass which heretofore have been only in the dream stage.

Like so many other developments of recent years, this new glass technology was born of war demands. It is being used today to fabricate parts for radar and other communications equipment where physical shock may be great and where previously known glasses and porcelains would not render satisfactory service.

By the new Multiform process, glass can be molded with accuracies to one thousandth of an inch: can be cut to complicated patterns and provided with threads, holes of all sizes and shapes, or metal inserts where required; and can be welded to form strong joints with itself or with metals.

To the conventional methods of producing glass parts—blowing, pressing, and drawing—must now be added a fourth. And this fourth method overcomes many of the limitations of the other three, bringing glass into an industrial prominence such as it has never known before.

CANS CAN DO IT

DUPLICATE machine parts and instruments packed in sealed cans are a distinct possibility post-war. Proof of the value of can containers for such jobs has been furnished by airplane starters, generators, instruments, and the like, that today are being shipped to hot, humid areas in the Pacific, and are arriving in perfect condition. It is reported that this protection given by steel cans is obtained with a 50 percent reduction in container cost.

NEW FIELDS FOR RAYON

RAYON capacity has not increased since the beginning of the war, but the probabilities are that it will burst forth with greater vigor than ever just as soon as conditions permit. Reason behind this is that the industry was almost ready to break into new fields when the war put a stop to expansion. Thus, there is a new rayon filament that looks like a strong competitor for wool in carpets; a high-tenacity rayon that will make better hosiery than present rayons, although not as good as silk or nylon; a short-staple rayon that is spun and used alone or mixed with cotton or wool to give a fabric with a wool-like feel; and the new high-strength rayons, one of which, made by Celanese Corporation, is said to be stronger than nylon but without nylon's elasticity.

ELECTRICITY ON THE FARM

LESS than half of the farms of the United States have electricity available. True, high-tension lines have brought this versatile servant to hundreds of thousands of farms, but the market has only been barely touched. High-tension lines are expensive and cannot be run everywhere.

Here, then, is a place where local generating plants, supplying power co-operatively to a group of farms, can do a real job. At present approximately 800 such co-operatives are generating power that is used by about one million farms, and plans call for at least doubling this capacity in the near future. Many of these co-operatives, using Diesel-powered generators, are giving farmers uninterrupted electric power at lower operating cost than any other method.

FOR FUTURE REFERENCE

ALGIN, product of seaweed, has vast chemical possibilities in such diversified fields as leather finishing, hand lotions, boiler compounds, film bases, and custard puddings. Electric trackless trolleys have shown a 1628 pereent increase in passengers carried since 1934. . . A new Bendix "air position indicator" that gives continuous readings of latitude and longitude is completely automatic and has vast implications for post-war world-wide air transportation.

50 Years Ago in . . .

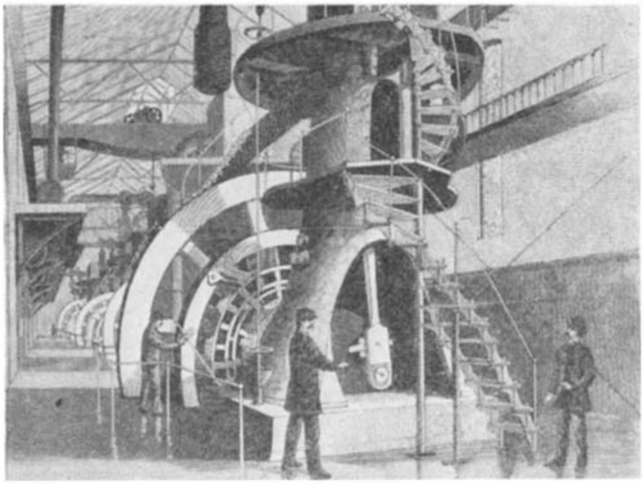
SCIENTIFIC AMERICAN

(Condensed from Issues of April, 1895)

MICRO-ANALYSIS — "At a recent conference, held under the auspices of the French Society for the Encouragement of National Industry, M. Osmond described a method for the microscopical analysis of steel. . . M. Osmond examined four types of steel, possessing a known proportion of carbon, to discover the manner in which these combinations varied. As a result of that investigation, M. Osmond states that the thermic treatment of the steel leaves in the structure of the metal, when cooled, characteristic indications sufficiently precise to form a useful guide in the manufacture of steel, and also to enable consumers to determine the quality of the metal supplied to them."

HELIUM — "Lord Rayleigh, who so recently discovered 'argon,' a new constituent of the atmosphere, has succeeded in finding helium in a Norwegian mineral. This substance was believed to exist only in the sun and in a few stars. . . From its associations and the particular region of the sun where helium is found, this gas is looked upon as being one of the lightest materials composing that body, possibly almost as light as hydrogen."

CHICAGO "EL" — "There is now in process of construction an electric elevated road in Chicago. . .With a track carried on an open-hearth steel elevated way, with plate girders throughout, built upon land owned in fee simple by its projectors, except for street crossings, and operated by the most advanced electric system of propulsion, the road will occupy a unique position. The entire length of the road is nearly 18 miles. . . A view of the electric generating plant



is given in one of our illustrations. The immense generators are of the multipolar type and are direct driven, the armatures being on the main engine shaft. They are of the type built by the General Electric Company especially for street car work. . . The engines are Allis Corliss, and are compound inverted vertical, direct acting, standing some 50 feet high with 25 foot flywheels."

ASBESTOS — "The uses of asbestos are almost innumerable. Ground fine and combined with colors and oils by a secret process, it makes a beautiful paint, which is said to go far toward fire-proofing the surface to which it is applied. Various kinds of roofing are also made by treating strong canvas with a combination of asbestos and felt and backing it with Manila paper. It is extensively used for roofs of factories, railroad shops, bridges, steamboat decks and other places where there is danger of fire."

HUMAN HORSEPOWER — "A French scientist has recently made some experiments which show the amount of force developed by some of the bicycle experts in a hard race. Windle and Zimmerman have maintained for two minutes a speed to continue which required the expenditure of energy representing two-thirds of one horse power. For six seconds they were able to exert the astonishing force of one and a fourth horse power."

AMERICAN MECHANICS — " 'Regarding the comparative skill of mechanicians. . . American, French, British, Spanish, German. . . it would be impossible for me to mention one nation that excels in everything. Each nation has its own peculiarities and its own specialties. . . I should say that the New Englanders are the finest mechanics in the world. I think any one who has investigated the subject will have to admit this. The tools which are designed and made in New England are incomparably ahead of those made in any other country. There is nothing in Europe that can at all compare, for instance, with the tools made by Brown & Sharpe, of Providence, R. I., Pratt & Whitney, of Hartford, Conn., and the American Tool Company, of Boston.'— Hiram S. Maxim."

PLATINUM — "The Ural platinum deposits in Russia are the only ones in the world, as this metal is worked nowhere else, and is known simply as a mineral finely disseminated in certain rocks. Platinum occurs in the Ural government of Perm, where it is found on various private properties and state lands. . . The metal is found in the form of alluvial deposits or platinum-bearing sands."

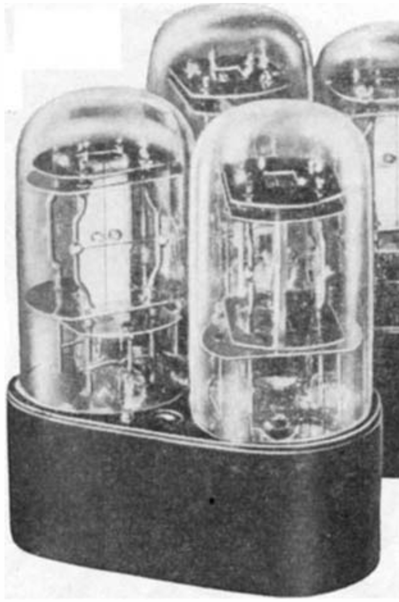
ARMOR PLATE HOLES — "The success attained of late in hardening the surface of armor plate has made it necessary to devise some especially effective method of boring holes in the plate for the bolts which are to hold it in position. . . The successful method consisted in placing the two electrodes of a dynamo current on the surface of the plate a certain distance apart, so that the intervening part of the plate completed the circuit. The plate is found to offer enough resistance to become heated, in the part selected, to an annealing temperature."

RARE METALS — "A glass case, said to be worth $50,000, was one of the attractions at the London Royal Institution recently. The contents were a variety of globules and cast bricks of unpretending appearance, used to illustrate Professor Roberts-Austen's lecture on the rarer metals and their alloys. A slab of palladium, the largest in the world, was valued alone at $35,000. . . The value of these metals, even if they could all be produced commercially on a large scale, is still doubtful, although indications of their usefulness are not wanting. Chromium, for instance, has made a revolution in steel projectiles, while aluminum threatens to become a popular craze."

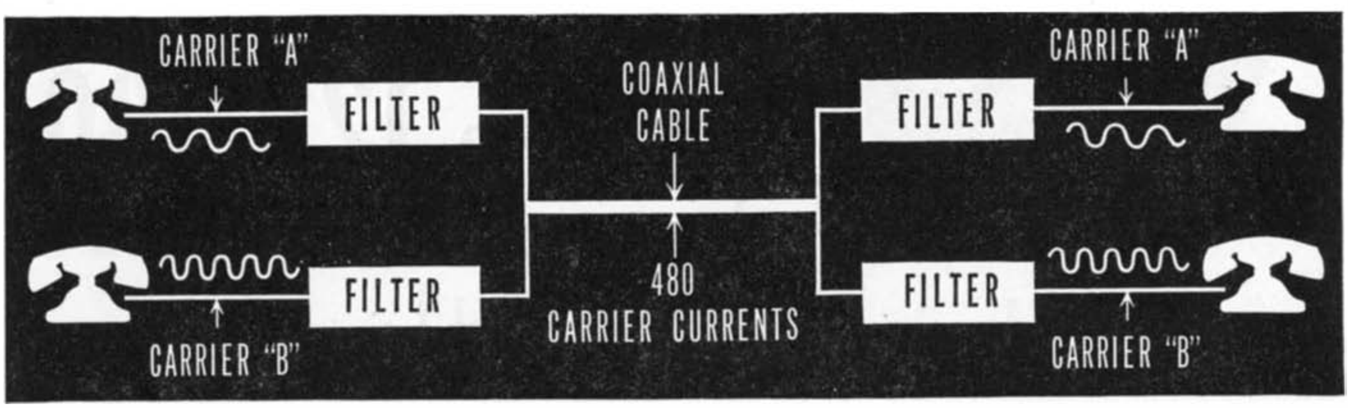
DYES — "Aniline colors were first made in France, while the tar whence they were derived was made in England. Latter the manufacture of the dyes themselves was taken up in England. Germany, however, gradually came to the fore, attaining undisputed supremacy in the manufacture in 1862. . . There was immediate and profitable employment in Germany, for all chemists who had any knowledge of anilines. About 1880, however, the supply of coal tar chemists turned out by the universities exceeded the demand for home consumption, and, the home markets becoming glutted, they turned toward America for a field."

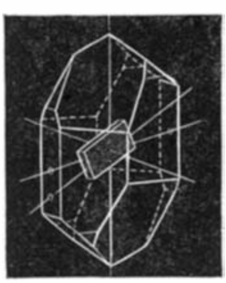
GOLD — "A correspondent of the Mining and Scientific Press says the largest piece of gold, free of quartz, in the world was taken from the Byer & Haltman gold mining claim, Hill End, New South Wales, Australia, its weight being 640 pounds."

TRANS-SIBERIA — "Two sections of the great Russian railway across Siberia are now in operation. The aggregate of the two is 761 miles."



Crystal gateways for your voice





Four hundred and eighty telephone conversations over a coaxial cable was one of the last peacetime achievements of communication research in Bell Telephone Laboratories. In this multi-channel telephone system, each conversation is transported by its own high-frequency carrier current. At each end of the line are crystal gateways; each opens in response to its own particular "carrier" with the message it transports. In telephone terminology, these gateways are filters.

The ultra-selective characteristic of these filters is made possible by piezo-electric quartz plates, cut in a special manner from the mother crystal, and mounted in vacuum. Each set of plates is precisely adjusted so that the filter responds only to the frequency of its assigned channel, rejecting all others. In the coaxial terminal equipment, such crystal gates sort out messages for delivery to their four hundred and eighty individual destinations.

In recent years, Bell Telephone Laboratories research has provided the Armed Forces with many types of electrical equipment in which frequency is controlled by quartz crystals. Notable is the tank radio set which enables a tank crew to communicate over any one of 80 different transmission frequency channels by simply plugging in the appropriate crystal. The future holds rich possibilities for the use of quartz crystals in Bell System telephone service.

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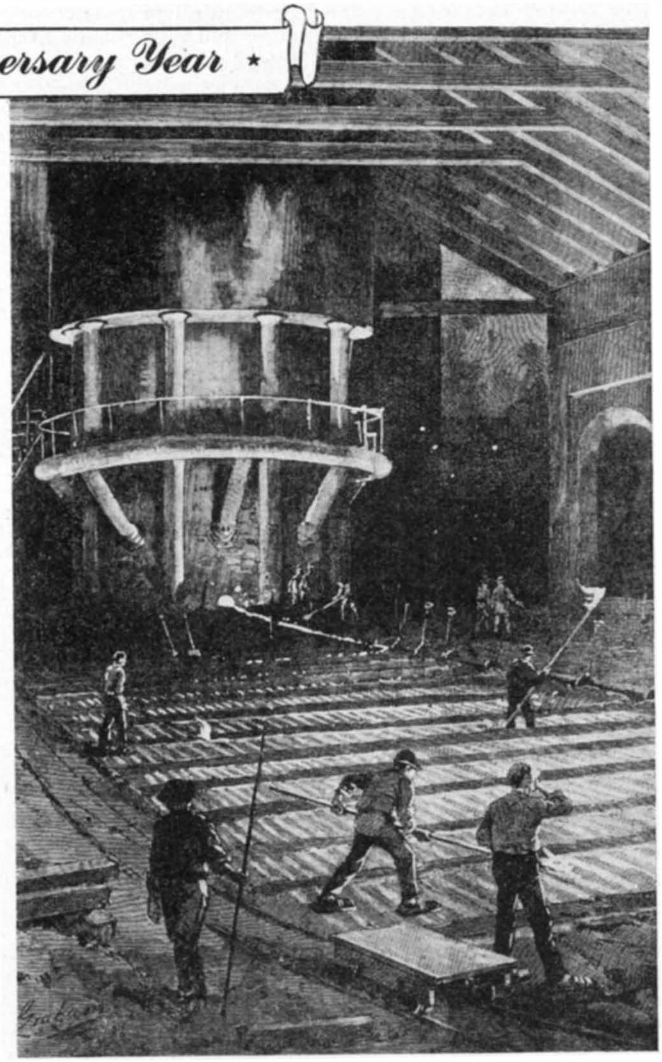


Early blast furnace in Birmingham, Alabama. Illustration courtesy of American Iron and Steel Institute

Into The Alloy Age

Agonizingly Slow Was Man's Early Development of the Use of Metals. But During the Last 100 Years, and Especially the Last 50 Years, Alloys Have Changed the Whole Picture of Metallurgy. Progress has been Breathtaking and Today Points the Way to the Unfolding of The Alloy Age

By FRED P. PETERS

ALTHOUGH many of the fields of scientific and industrial endeavor being reviewed in Scientific American's series of historical articles did not exist before 1845, this can hardly be said of metals and metal-working. True, by modern standards the world's "metallurgical" status 100 years ago was still a lowly affair but it represented a dizzying eminence in contrast with some of the positions on the long climb from Tubal Cain (seven generations after Adam and evidently the first metal-worker) up to the year this magazine was started.

For metals are literally as old as the hills and the stuff of many of them. The story of metals is indeed the story of mankind: Out of them he has made his swords and his ploughshares; their progress has profoundly affected his living and his dying; and whether he knows it or not man has mastered the metals only to leave them still in control of his destiny.

Throughout the ages power and prosperity have been the reward of those tribes or nations that possessed important metals and metal-working knowledge. Thus is modern times it is axiomatic that that nation or group of nations which dominates the world's iron and steel supply will be militarily supreme. With a steel production capacity of some 28 million tons, Germany in recent pre-war years topped all the European nations including England, and the Nazis' early military success in this war reflected not only this but the formidable total of 60 million tons of steel-making capacity which Germany attained through conquest, up to 1943. From that time, however, the full weight of America's 90 million tons of steel has been thrown against her; Germany's capacity has shrunk to some 40 million tons and the final issue is no longer in doubt.

These present-day metal-making capacities are the result of intensive scientific progress in the last 100 years. No one can say what the next hundred years in metals will unfold. But one trend is significant: For thousands of years, up to about the middle of the last century, man with agonizing slowness improved his application of *simple metals* to his peace-time or war-like needs; since that time and especially in the last 50 years he has learned something new—the production and treatment of *alloys*—and the results of that evolving technology on our whole civilization have been breathtaking. Of a certainty we have entered The Alloy Age and, because of this, life in 2045 will be as different from today's as ours is from our great-great-grandfathers'.

NINE METALS—In 1845 there were but few metals of commercial or industrial importance—chiefly iron, copper, lead, tin, zinc, gold, silver, and platinum. Before observing how they were multiplied into the hundreds of alloys that are the basis of today's engineering, let us chart the milestones along their road of progress before 1845.

Although the transition from the brass age to the iron age is generally placed around 1350 B.C., iron was anything but unknown prior to then. Tubal Cain is purported to have forged both brass and iron, and wrought-iron blades evidently made about 3000 B.C. have been found in one of the pyramids. Indeed, for many centuries the Egyptians (and the Chinese, too) seem to have been advanced in the metal-working art, especially in the making of copper, brass, and bronze implements.

We probably will never know exactly where or when iron became an important metal. The three outstanding claimants are (1) Asia Minor (the Hittites), before 1300 B.C., (2) Austria (Styria and Carinthia), about 1300 B.C., and (3) India, about 1370 B.C. (2000 B.C. according to some).

There are early evidences of the potent military influence of iron, too. Through the Hittites, iron was introduced into Assyria; the Assyrian armies were the first large forces to be equipped with iron weapons, and a single arsenal room in the palace of Sargon II, who had raised Assyria to her greatest glory about 700 B.C., contained 200 tons of iron implements. Again, some 200 years later, the Etruscan king Porsenna defeated Rome and in his peace terms imposed one of the first "mineral sanctions"— a ban on the use of iron by the Romans except for agricultural purposes.

This wrought iron used in antiquity and up to about 1350 A.D. was produced by virtually the same process (a commentary in itself on progress over an approximately 3000-year period): mixing iron ore with charcoal and burning under a natural or forced (bellows) draft. This was the Catalan forge, and the product was a spongy mass often more than 99 percent pure (like the astonishingly well-preserved Delhi pillar of 310 A.D.) but usually contaminated with 3 to 5 percent of slag.

Pliny reports in the 1st Century A.D. that iron and steel of good quality were being made. The "steel" was produced by packing iron in charcoal and heating so that the carbon penetrated the surface of the metal and gave a hard, springy material. This is the "cementation" process, which persisted on a tiny scale into the present century. He also records that tin was used for coating both copper and iron by the hot dip process, and of course gold and silver were established items of art and commerce. Pliny's *plumbum negrum* was undoubtedly lead, for which some use existed at that time.

From The Bettmann Archive

Bronze Age craftsmen casting weapons and utensils

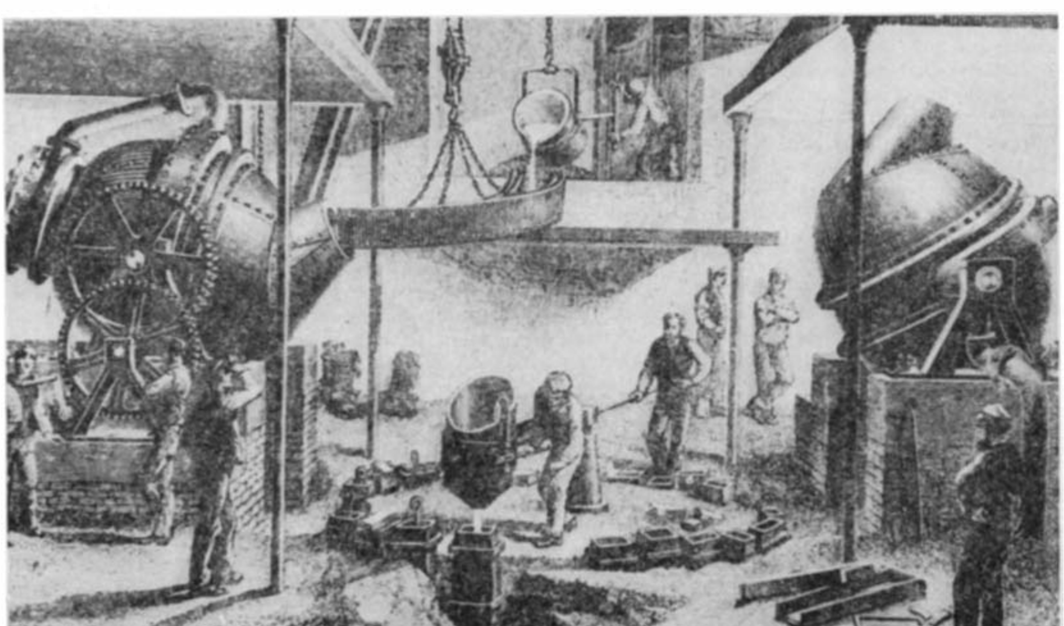
DAMASCUS BLADES — This was the period in which were made the fine steel swords of Damascus and Toledo and the "wootz" steel of India, produced by reducing ore with charcoal in crucibles, which warriors of the early Christian era used to advantage. By the 11th Century the martial importance of metals had reached such a point that one of the world's decisive battles—the defeat of Harold of England by William the Norman in 1066 A.D. at Hastings—went to the victor because his soldiers carried better armament. Other things being approximately equal, this has been the case ever since and is still the rule.

The "wrought-iron" period may be said to have merged into the "cast-iron" era shortly before 1400 A.D. The commercial manufacture of cast iron really began in Germany in the early part of the 15th Century, when blast furnaces were operated in Siegerland and Westphalia. These early furnaces were simply Catalan forges with extended stacks, into the tops (rather than on the hearth) of which were charged ore and charcoal, the latter in such large excess that a higher carbon, lower melting mixture than wrought iron resulted. The resulting cast iron was somewhat brittle but could be cast into shapes or used for larger articles than could be wrought. The basic metallurgy of this cast iron has not changed even to the present day, although now we know how to control and adjust it to make cast iron that is a first-class engineering material for many uses.

Immediately the Germans cast the iron into cannonballs. In 1510 Bunde, a Frenchman, and van Cullen, a Hollander, made for Henry VIII of England mortar shells of cast iron, with iron-screw fuses. These same gentlemen some 33 years later collaborated with Hogge in constructing cast-iron cannon and shells therefor.

The successful production of cast iron led to such a demand for charcoal in England, by 1600 a leading iron producer, that timber for making charcoal was approaching exhaustion and it was necessary for Queen Elizabeth drastically to restrict the production of iron. The Swedes undertook a planned planting of timber that even up to the present time has permitted them to maintain a steady production of high-quality charcoal iron. In 1619, Dudley successfully smelted iron with pit or sea coal, obtaining more iron per furnace per week than by charcoal smelting and, of course, circumventing the timber shortage. Although his process was opposed by the charcoal ironmasters and he never profited from it, he did succeed in staying in the iron business with it for some 50 years.

COLONIAL METALS — The beginning of the metal industries in America seems to have been at Lynn, Massachusetts, about 1640. Governor Winthrop built a furnace there, which by 1644 was making brass castings, and in 1645 made the first cast-iron article produced in the Colonies—a one-quart iron kettle. The Lynn furnace, which was able to smelt about eight tons of iron a week, was also the seat of the first patent granted in the Colonies—to one Joseph Jenks in 1646 for a scythe. Jenks, the manager of the furnaces, distinguished himself on several fronts in the next 20 years: He made the first fire-engine, the first dies for coinage, and the first drawn wire produced in the Colonies.



Reproduction of a copper engraving made in 1875, showing the various steps in the process of manufacturing Bessemer steel

From The Bettmann Archive

The first really good steel in America was made in Connecticut, by Samuel Higley of Simsbury and Joseph Dewey of Hebron, about 1728. In Pennsylvania the great iron industry that we know today had its small beginnings in 1716 with the Pool Forge Iron Works, three miles above Pottstown, and the Colebrookdale blast furnace, built in 1770 and also near Pottstown.

About this time there occurred one of the fundamentally important developments in the history of metals—the discovery that coke could be made from coal and that this coke could serve in place of charcoal as a reducer of iron ore. The latter invention is generally attributed to Darby, about 1713, and the first coke blast furnace was blown in by John Wilkinson in England in 1754.

There were two immediate and important results: (1) England rose to world leadership in iron production, becoming an iron exporting nation instead of an importer and (2) a need developed for means of transporting coal to the furnaces and it precipitated the beginning of the railroad industry. In turn, the railroad industry subsequently became the biggest factor in the expanding market for iron and was the impelling force behind many important quality improvements in steelmaking.

Between 1740 and 1750 there came another outstanding advance—the development by Benjamin Huntsman of a commercially successful process for making steel by fusion; the process involved placing the age-old carburized iron ("cementation steel") bars in a refractory crucible and melting them, giving a metal of homogeneous instead of irregular composition. More expensive than iron-making, Huntsman's crucible steel process gave an exceptionally high-grade material and until this century it remained the leading method for making the very best steels.

Note that the metallurgy of iron has advanced from wrought "charcoal" iron to cast "charcoal" iron to cast "coke" iron and from cementation steel to crucible steel. The steel age was dawning, though not yet here. Its advent was hastened in the 18th Century by many other developments—the invention of puddling in 1766, which improved the quality of wrought iron; the invention of the steam engine and its application to driving a slab rolling mill in 1784; and the discovery by the Englishman Mushet in 1798 that cast steel could be made directly by adding carbon to iron.

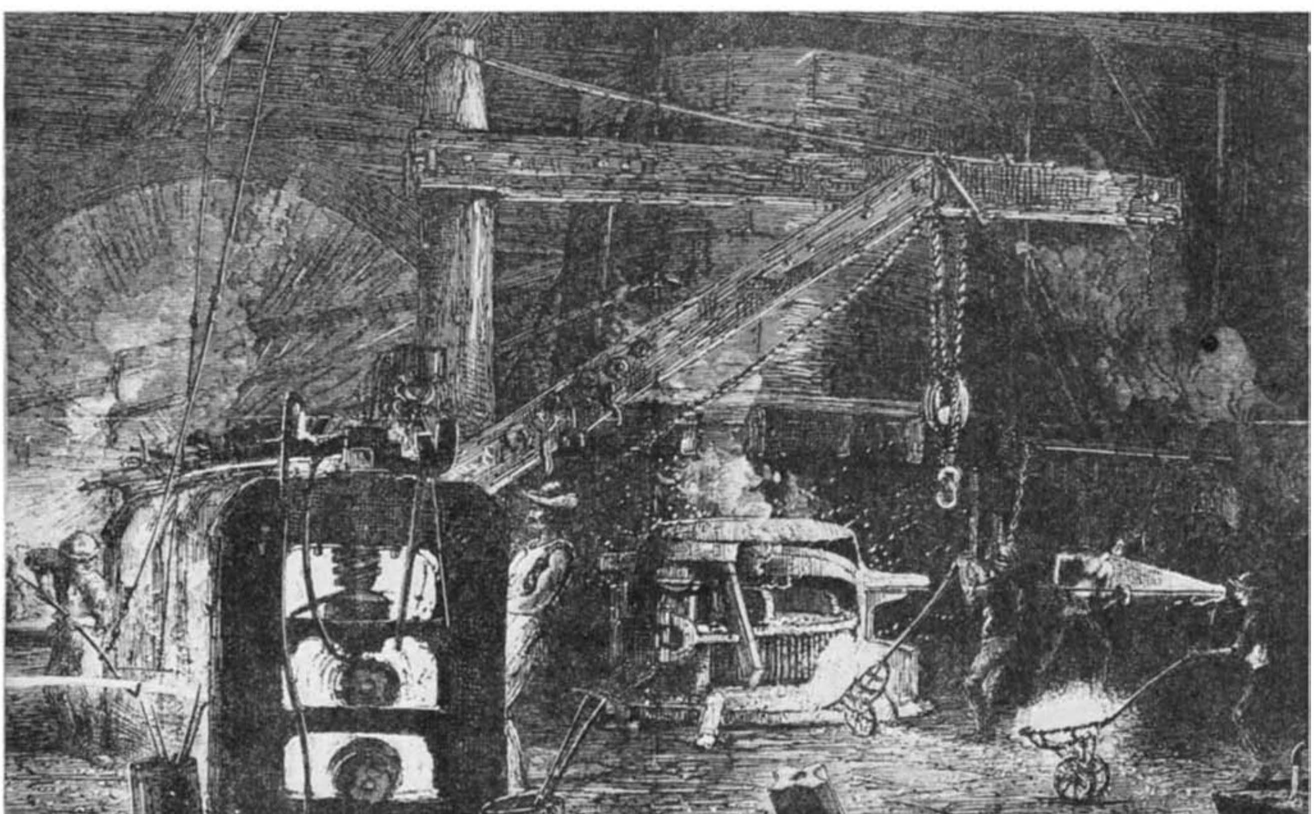
The iron industry was one of the early causes of friction between England and her American Colonies. Worried by the competition from American iron in the colonial market, the British Parliament in 1750 prohibited the refining of pig iron and the construction of rolling mills, hammers, forges, and so on, in America. The edict was ineffectively enforced, however—and fortunately so, for the developing American iron industry was a potent factor in the ultimate success of the American Revolution. Indeed it was so important as to be the basis for one of the earliest draft deferments on record -New Jersey's act of October 7, 1777, exempting from military service men to be employed at Mt. Hope and Hibernia Furnaces and reciting the necessity of providing the Army and Navy of the United States with cannon, cannon shot, and so on.

NONFERROUS PROGRESS—Although even then subordinated to iron and steel in production tonnage, the nonferrous metals hardly stood still during the 18th Century. In 1728 the French described a reversible rolling mill for making lead sheet and for rolling seamless pipe. The first Colonial copper coinage was made by Joseph Higley in 1737, and in 1750 John Allan started the brass industry of Waterbury, Connecticut. Paul Revere, a descendant of one of the owners of the Lynn furnaces, was famed as a silversmith and copper fabricator. In 1746, Dr. Roebuck of Birmingham, England, built the first lead chamber for sulfuric acid manufacture, the latter used primarily for pickling wire and other metals.

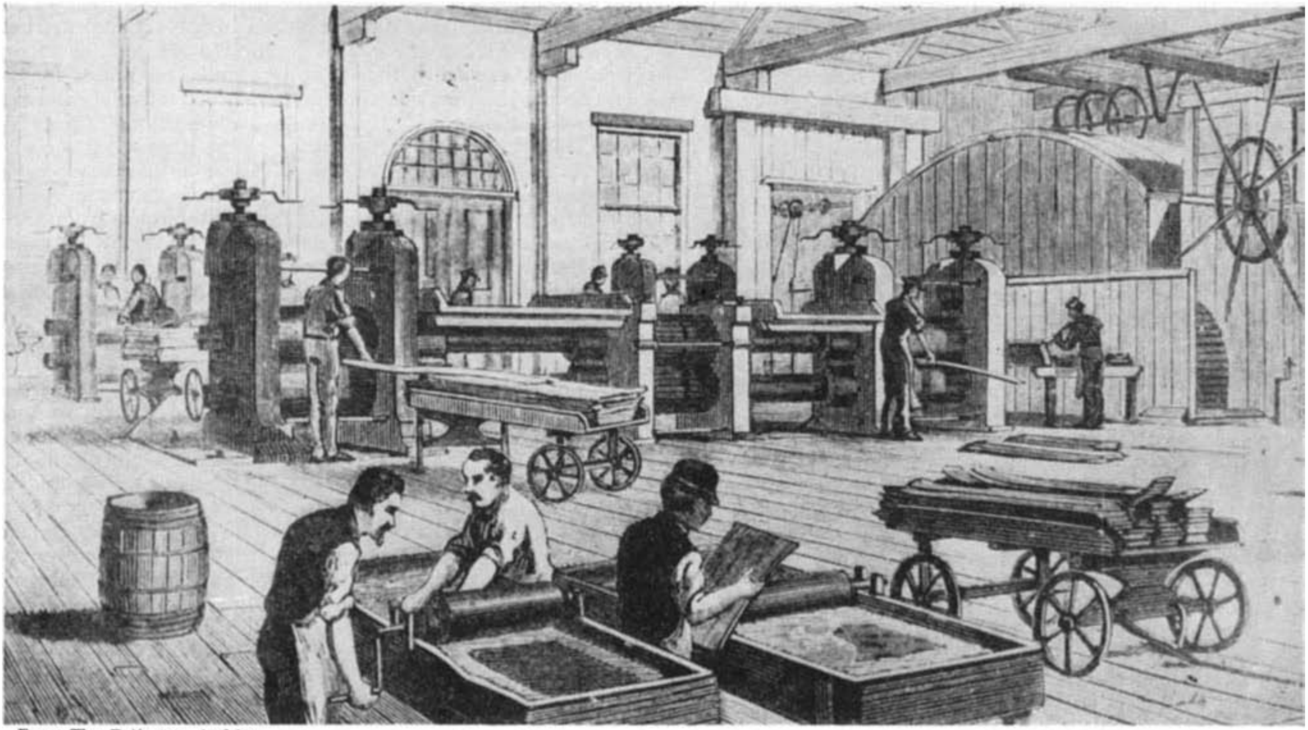
Sir Wm. Watson in 1750 first described platinum. The following year H. F. Cronstedt isolated nickel in Sweden. Another Swede, S. Rinman, discovered in 1773 that the manganese he had reduced made iron non-magnetic. Tungsten metal was isolated in 1783 by two Spaniards, J. J. and F. de Elhujar. Metallic molybdenum was successfully prepared in 1790 by still another Swede, Hjelm. The Alloy Age, still undreamed of, was having its foundations set.

Powder metallurgy, the wonder-boy of modern metalworking, probably had its beginnings in 1786 when Rochon made malleable platinum from powdered platinum. Later (1805) Tilloch produced a forgeable platinum bar by packing platinum powder inside platinum tubes and heating. It was not until 1829 that Wollaston, commonly called the father of powder metallurgy, published his important work on platinum powder.

Simultaneously with all this and obviously resulting from it had been much general engineering progress. Europe's



Interior of a steel rolling mill of about 1870. Courtesy American Iron and Steel Institute



From The Bettmann Archive

Rolling copper, about 1880

first cast-iron bridge had been built in England by Abraham Darby. The American revolutionists' forged iron chain stretched across the Hudson River at West Point had served its purpose in keeping British vessels below that place. John Fitch's steamboat in 1787 was followed by Robert Fulton's in 1807. Iron ships were made by a few builders, and in England appeared the first stirrings of what was to be Manchester's vigorous machine-tool industry from 1815 on.

From 1800 until 1845, almost breathlessly as though time were short, there were evolved the major remaining developments on which rested the transition from the metal age to the alloy age (or, if you wish, from the iron age to the steel age, for steel is an alloy of iron and carbon). In 1802 the brass button industry in America was started by Able and Levi Porter in Waterbury, using the method of directly melting copper and zinc invented by Emerson in England in 1781. In 1808 Davy attempted to isolate magnesium. By 1810 acid copper electroplating was in use. In 1811 steel was first made in Pennsylvania, by Morris Truman at Brownsville, and sold for $240 a ton. In 1812 John Stevens designed ship armor and for years continued to develop the armored ship idea with fanatical zeal.

IRON ALLOYS—Hassenfratz in 1814 studied iron alloyed with cobalt, titanium, tungsten, and chromium; in 1816 (O, unhappy day!) the Krupp works at Essen began the manufacture of steel by the crucible process. In 1820 Faraday and Stodart published a paper which may be considered the basis of much subsequent alloy development, for it described a method of etching metals to show their grain structure.

Israel Holmes in 1822 and 1831 performed the remarkable non-technical feats of purchasing in England brass-rolling machinery not supposed to be sold to Americans and then smuggling into this country several British workmen to operate his expanding plant. By 1836 rolled brass clocks had created a heavy demand for sheet brass, "nickel silver" rolling had been introduced, and the "battery" process of fabricating brass was started.

In 1826 Seth Boyden started making "malleable" cast iron in Newark, New Jersey. The first passenger railroad charter in this country was granted to the Baltimore and Ohio; by 1830 there were still only 23 miles of steam railroad in this country. In 1832 Baldwin Locomotive Works built its first locomotive, "Old Ironsides," largely out of wrought iron.

About this time there appeared another important milestone in the march of steel—the invention of the hot blast for blast furnaces by J. B. Nielson of Glasgow in 1828. The hot blast reduced the coke requirements and substantially increased the output of blast furnaces to which it was applied. The first practical use of the hot blast in America was made at Oxford Furnace, New Jersey, in 1834.

The Dane, Oersted, prepared some aluminum in 1825 and in 1827 it was produced as a fine powder by Wühler. Pure magnesium was obtained by Bussy in 1830, the same year in which Osann described one of the earliest uses of powder metallurgy—the pressing of copper, silver, and lead medals from their powders. The British platinum industry was started, on a powder basis, by Johnson and Cock, and remained a powder-metallurgy industry until Deville applied the oxy-hydrogen torch to the melting of platinum in 1859.

Zinc production, now a great American industry, may be said to have been conceived in 1835 when the Bureau of Standards, seeking a highly accurate set of brass standards for weights and measures, commissioned F. R. Hassler to produce zinc and brass of the required purity, which he did by setting up a small zinc distillation plant at the Arsenal in Washington.

In 1842 Serrell operated a continuous mill for rolling lead, copper, and iron pipe and on it was rolled the copper wire employed by Morse for his first telegraph line, from Washington to Baltimore, in 1844. In 1843 R. Boettger had described nickel electroplating and the English process of making seamless brass tubing had been invented and was being introduced in America. In 1844 was made one of the most important geological discoveries of modern times—the finding of iron ore in the Lake Superior region by Wm. A. Burt, a surveyor, whose compass was being annoyingly diverted by the deposit. From that day to this a total of more than two billion tons of high-grade iron ore have been extracted from that region to make our iron and steel.

FROM 1845—One hundred years ago today, then, where did America stand, metal-wise? Compared to our primitive ancestors we were expert in the manufacture of wrought iron and cast iron on a comparatively gigantic scale (about 400,000 tons of pig iron per year in America—but compare that with today's 62 million tons), and of steel on a much smaller, specialty-product scale (less than 10,000 tons). There were about 4000 miles of railroad rails in use, mostly wrought iron or cast iron.

A few nonferrous metals—copper, zinc, tin, lead, silver, gold, and platinum were commercially important. Many other nonferrous metals were known and under close study, but as yet only promising—aluminum, magnesium, nickel, chromium, cobalt, tungsten, titanium, molybdenum, manganese, and others. We had no alloy steels or irons; indeed the only "alloys" of real importance were brass and steel, with the former more widely used. But the stage was set!

Approximately in the order of their appearance, the actors who have dominated the unfolding drama of the alloy age in these last hundred years are William Kelly, Sir Henry Bessemer, Robert Mushet, H. St. Claire Deville, Robert Bunsen, Sir Wm. Siemens, John Fritz, Henry Sorby, E. and P. Martin, Robert Hadfield, Paul Heroult, Charles Martin Hall, Capt. Wm. Jones, Henry Marion Howe, Albert Sauveur, Strauss and Maurer, Sir Harry Brearley, Elwood Haynes, Alfred Wilm, Albert Marsh, E. F. Northrup, P. D. Merica, E. C. Bain, and E. S. Davenport.

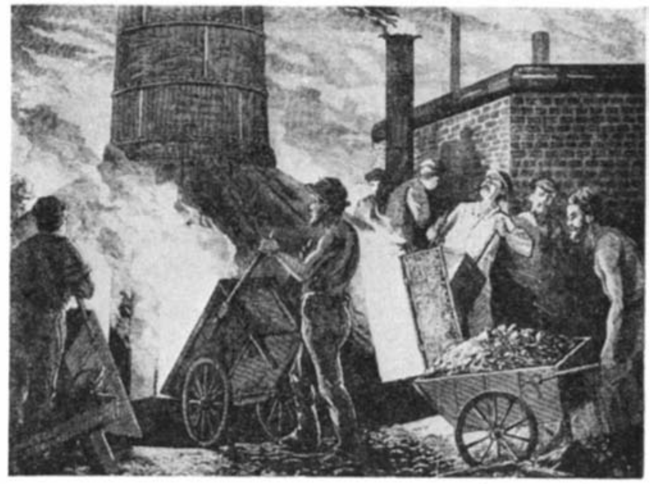
The first of these—William Kelly in America and Sir Henry Bessemer in England—were independently responsible for the invention of the so-called Bessemer converter and process for making steel, whereby molten pig iron is "blown" with air to burn out the carbon and give a relatively pure, low-carbon material. Kelly, in 1846, discovered that blowing air through liquid high-carbon iron refined it. In 1854 Bessemer, seeking an improved gun material, made the same observation. Their converters were the first mass-production steel-making units devised and were without question the beginning of the steel age that we know today.

Their vicissitudes in establishing their strikingly similar processes, both here and in Europe, represent a fascinating story all alone. Suffice it to say here that the technical problem of overcoming the brittleness of early Bessemer steel and making it harder was solved by Robert Mushet, in 1856, through the addition to the melt after the blow of spiegeleisen (high-carbon ferro-manganese). Because of these inventions, the 12,000 tons of American steel of 1860 became over 50,000 tons by 1870 and 1¼ million tons by 1880—largely Bessemer steel in the latter two cases—and the United States pulled alongside Great Britain to challenge the latter's supremacy in iron and steel production.

In 1857 Kelly patented his converter in the United States and installed his eighth converter at the Cambria works in Johnstown, Pennsylvania. At this same works and in this year John Fritz, then the company's chief engineer and manager (and later to become president of Bethlehem Steel Company), invented the three-high rolling mill, an innovation that markedly increased the productivity of our steel mills in subsequent years.

From The Bettmann Archive

Oil tempering steel springs in 1850



Charging an iron furnace in the 1870's

Also in 1857 Bessemer patented what is now known as "continuous casting" or direct rolling—the pouring of molten metal between water-cooled rolls and withdrawing solid, rolled plate from them. The process has been intensively developed within the last 15 years and is now used in the light metal and copper alloy field.

The nonferrous metals, too, were hammering hard at the gates of progress. In 1848 the Frenchman Junot patented chromium plating, and the New Jersey Zinc Company was started, primarily to make pure zinc for the Bureau of Standards' weights and measures. Hayden of the Scovills in Connecticut developed the spinning process. By 1850 dentists were using powdered nonferrous metals, chiefly silver and tin powders mixed with mercury, and a workable gold sponge made from powders.

$545 TO 14 CENTS—Aluminum took a great stride forward in 1855 when H. St. Cl. Deville exhibited the metal at the Paris exposition and Napoleon started its commercial production. In 1852 aluminum cost $545 a pound; by 1856 Deville had brought the price down to $34, and by 1859 (in which year the world production was about two tons) to $17. The price today is 14 cents a pound and American production is in the neighborhood of one million tons a year.

The step that led to the development of what is now the world's greatest metallurgical production unit—the open-hearth furnace for making steel—occurred in 1856 when Sir William Siemens patented in England the regenerative heating principle as applied to furnaces. In 1864 two French brothers, E. and P. Martin, with Siemens's help, succeeded in producing steel in a regeneratively-heated open-hearth furnace, which is the reason that most of Europe today calls open hearth steel-making the Siemens-Martin process.

The first open-hearth steel furnace in America was installed by F. J. Slade at Cooper Hewitt's Trenton works in 1868. In 1870 the annual production of American open-hearth steel was about 1300 tons—approximately 1.9 percent of our total steel production of 69 thousand tons. Today, open-hearth steel represents 88 percent of a total steel ingot production of some 90 million tons.

A steel item of commercial importance in 1857 was crinoline wire, which was tempered continuously and of which some 1500 tons were made in that year. In 1858 the first transatlantic cable was laid, using 22-gage charcoal iron wire. In the same year the brass manufacturers adopted what is now the American Standard or B. and S. wire gage.

Joseph Wharton began making zinc at Bethlehem (the Lehigh Zinc Company) and in 1860 American zinc production amounted to 800 tons; today it is nearly a million tons and of incomparably higher quality. In 1864 Joseph Wharton also began the manufacture of nickel at Camden, New Jersey.

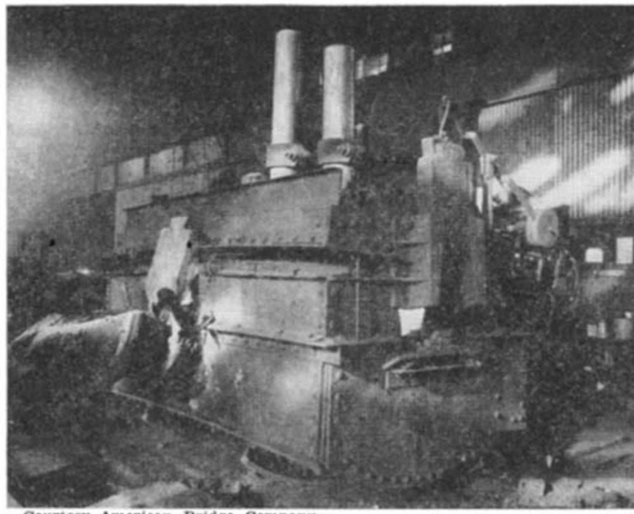
A significant (though at the time unappreciated) development of 1863 was Henry Sorby's use of the microscope for studying the structure of metals. The application of this tool and the science of metallography based upon it have been primary factors in our modern understanding of the nature and behavior of alloys and in our development of new alloys. Sorby was the first of a procession of distinguished metallographers that included Tschernoff in Russia, Roberts-Austen in England, Henry Marion Howe in America, Osmond in France, Brinell in Sweden, Stead in England, Rosenhain in Australia, and Sauveur in America—all long since passed away—in addition to a few living men whose actual contributions cannot yet be dispassionately appraised.

Magnesium had its commercial conception in 1869, when the German chemist, Robert Bunsen, produced it by electrolyzing a fused bath of anhydrous magnesium chloride in a porcelain crucible. The only use for the metal at this time was for photoflash powder and pyrotechnics generally. Gwynn in 1870 gave powder metallurgy a push forward by pressing tin powder with oil to form journal linings—probably the first self-lubricating bearing.

Engineering developments of this period that stemmed from progress in metals included the development of the motor-generator by the Siemens brothers; the growth of the American railroad industry and completion of the first transcontinental line; the demonstration by the Prussians that chilled cast iron had remarkable resistance as armor plate; the founding of the American Institute of Mining Engineers; the erection at the Cramp yards of the first iron ships for transatlantic passage; and the replacement of iron by steel in Pennsylvania Railroad axles and in horseshoes.

By 1870 American pig-iron production had skyrocketed from 820,000 tons (in 1860) to 1,865,000 tons, with a third of the product going into iron rails. Bessemer steel rails were making impressive inroads, however, and in 1872 the iron rail reached its installation peak (about 800,000 tons), declining thereafter to the vanishing point early in this century. Steel (mostly Bessemer) passed iron as a rail material in 1876, the quality and availability of Bessemer steel rails being a leading factor in the astonishing growth of our railroad system in this period.

COMMERCIAL INVASION—In 1875 American iron and steel products invaded the British market. From then until 1889 America and England were neck-and-neck in the race for iron and steel supremacy. The pattern of the 20th Century, with America the world's greatest industrial and (if necessary) military and naval power, was beginning to take shape.

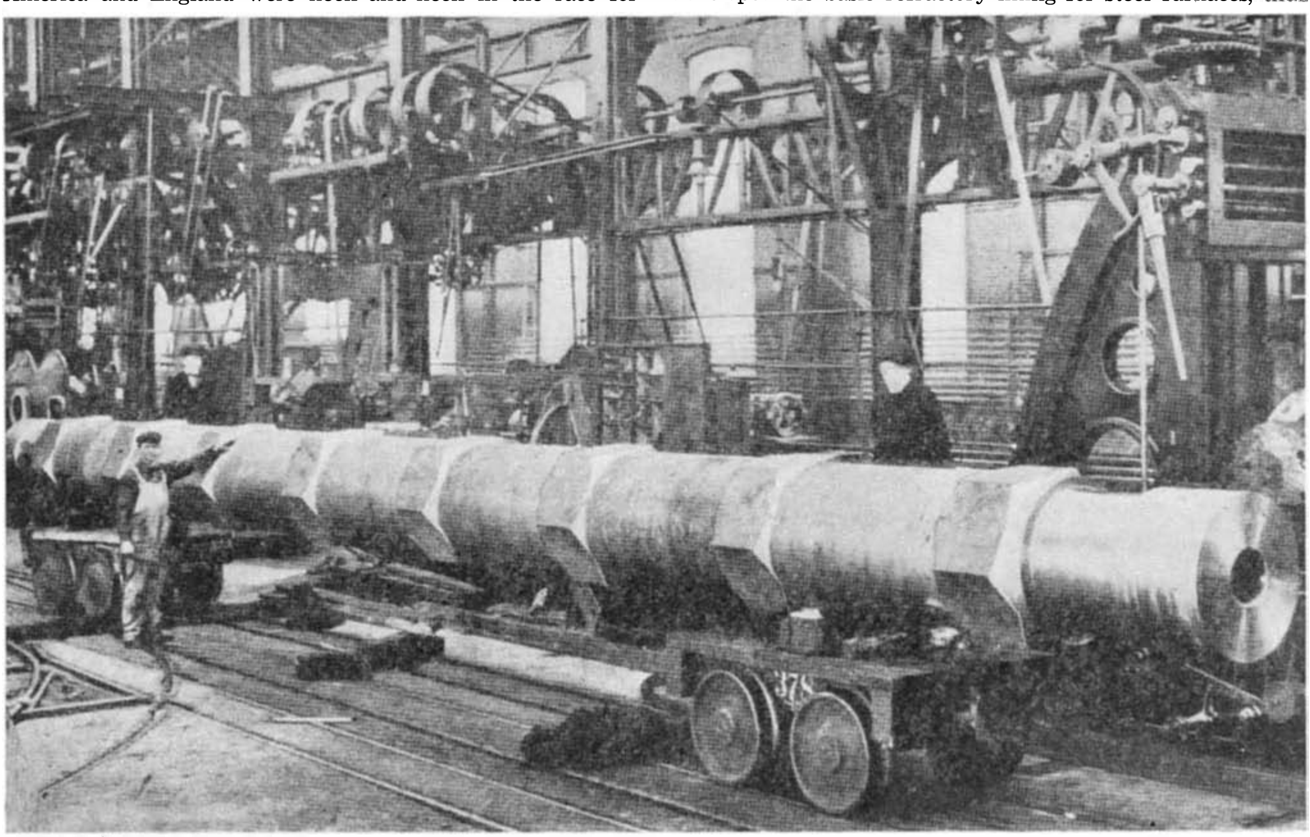


Courtesy American Bridge Company

One of the first single-phase Heroult electric arc furnaces built in the United States in the early 1900's

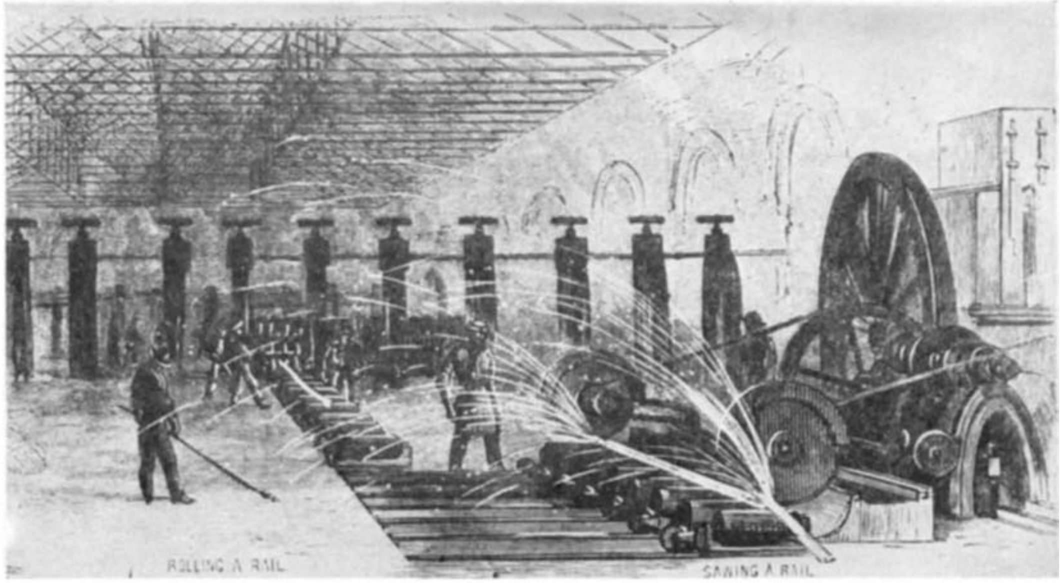
The steps in this race were closely spaced. In 1873 Carnegie, McCandless and Company, later the Edgar Thomson Steel Works and the nucleus of today's United States Steel Corporation, was formed. Carnegie hired Capt. William Jones as his manager, and Jones is now recognized as having been one of the greatest production managers of all time, developing as he did the hot metal mixer and introducing numerous technical and labor-relations innovations that brought the output of a typical blast furnace from about 525 tons a week in 1873 to more than 1500 tons at the time of his death in 1889. Typical evidence of his production genius was the fact that in 1876, three years after its inception, his plant was producing more steel rails than the entire industry made in 1870.

In 1877 S. G. Thomas and P. C. Gilchrist in England developed the basic refractory lining for steel furnaces, thus



Courtesy Bethlehem Steel Company

First hollow-forged nickel-steel shaft for a stern-wheel steamer, made in the late 1890's



Rolling and hot-sawing rails, the steel industry's first great product, in about 1875. Illustration by courtesy of American Iron and Steel Institute

permitting the refining of pig-iron containing high amounts of sulfur and phosphorus and vastly extending the utility of the steelmaking process. The year 1879 saw fast development of basic practice, especially in Germany. The Germans set up a high protective tariff and began the intensive development of their iron and steel production that brought them to the world's Number 2 position in this respect before the present war.

At about this time the telephone was being readied for practical use, Edison was introducing his incandescent lamp, and Otto his four-cycle gasoline engine. New Caledonia was now the Number 1 nickel producer. St. Mary's Ship Canal, chiefly by virtue of its iron ore traffic, was fast becoming one of the most important waterways in the world and by 1885 had surpassed the Suez Canal in annual tonnage passed.

In 1878, Sir William Siemens made the first electric melting furnace and in 1882 successfully melted 20 pounds of steel in an electric unit. This was a major step toward the development of the alloy steel industry, which subsequently depended heavily on the electric furnace for production. Another step was the invention by Robert Hadfield in England of "manganese" steel. Although important, Hadfield's steel was not the first high-alloy steel, for the latter honor undoubtedly belongs to Mushet's tool steel, developed in 1857 and containing 7 to 12 percent tungsten with carbon and manganese.

In 1886 Paul Heroult patented his electric melting furnace and put that development on a commercially practical plane. There was much metallographic research activity, and in 1888 Henry Marion Howe described the essential constituents of steel and christened them pearlite, ferrite, and cementite. Krupp's at Essen had become the world's largest steel plant but America was the greatest iron- and steel-producing nation, to the tune of nine million tons of pig iron a year.

ALUMINUM STEPS OUT—The light metals, now major materials and very much in the public eye, enjoyed the most important of their early commercial developments just before 1890. In 1886 Charles Martin Hall, a 22-year-old student at Oberlin College, Ohio, succeeded in producing aluminum by dissolving alumina in molten cryolite and electrolyzing the bath. This process, on which was built the aluminum industry of today, was independently discovered in France in the same year by Heroult, in one of those astonishing coincidences of which the history of science is so full. In 1888 Hall became one of the founders of the Pittsburgh Reduction Company, forerunner of today's Aluminum Company of America.

Also in 1886, the Germans started producing magnesium at the Wintershall-A. G. in Hemelingen, using a modification of Bunsen's process mentioned earlier. Ten years later the Elektron works at Bitterfeld, Germany, employing a process similar to that used at Hemelingen, began large-scale production of magnesium and Germany remained easily the world's largest magnesium producer until 1942 when this country not only surpassed Germany in that respect but actually dwarfed the German output—with about 75,000 tons of magnesium to the German's 25,000.

The tinplate industry came of commercial age around 1890, with the passage of the McKinley tariff. Bethlehem Steel Company made armor plate for the United States Navy and the first pieces of "Harveyized" (face-hardened) armor plate were proof tested. Mond patented carbonyl nickel in 1891, starting the nickel industry on its road to greatness. In 1894 E. L. Frisbie imported into America the method and machines for making seamless tubing by the Mannesman process and two years later the brass industry earnestly tackled the problem of making extrusions—a problem that took years to solve completely but whose solution early in the 20th Century was one of the most important developments in copper and brass technology.

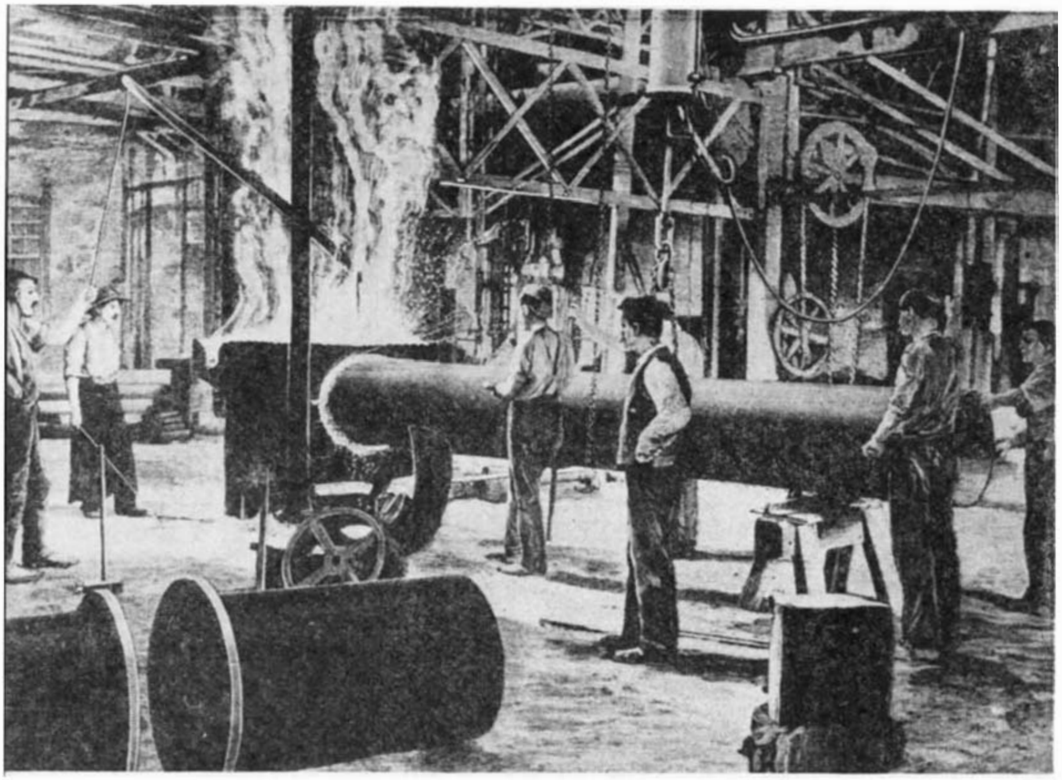
Dr. Langley's aerodrome flew in 1896 and seven years later the Wright brothers' flight near Kitty Hawk, in a plane with an engine weighing 21 pounds per horsepower, completed the stage-setting for an industry that was some 40 years later to be America's greatest and the chief market for over a million tons of the new light metals. And because of the light metals and strong steels used in their construction, today's aviation engines weigh only one pound per horsepower.

The last years of the 19th Century were years of merger and expansion. The leading wire producers affiliated to form the American Steel and Wire Company, while Carnegie and his associates developed a vast system of from-ore-to-finished-product steelmaking. This trend carried into the new century, and in 1901 the billion-dollar United States Steel Corporation was formed. American pig iron production shot up two million tons in each of the next two years.

TOOL STEELS—Outstanding developments of these years were the discovery by Frederick Taylor and Maunsel White (of Bethlehem Steel Company) of high-speed tool steels containing tungsten, chromium, carbon, and manganese, and of heat treatments for them that permitted cutting metals at speeds that heated the tool red hot. These steels and their use were demonstrated at the Paris Exposition in 1900, and literally revolutionized the art of cutting metals from that time on.

By 1900 there were 250,000 miles of rails in America, of which over 90 percent were steel. New steel rails were 99 percent the Bessemer product, despite the fact that a third of our total steel production was now made in the open-hearth. But traffic was so heavy on the rails and wear so serious that about this time the railroad industry urgently besought the steel industry for better rails. The result was an astonishing jump in open-hearth rail production from 1333 tons in 1900 to 1,751,360 tons in 1910 and a drop in Bessemer rails from 2,380,000 to 1,884,000.

Thus began the real rise of open-hearth steel in America. From this point on open-hearth steel developed its own



Welding a flange on a 22-inch steel pipe in 1897. The end of the pipe and the flange were placed in a special gas-fired furnace built in two semicircular halves, the upper one of which was removable. The welding-up was then completed on a concave anvil. Illustration reproduced from Scientific American

markets, rising in 40 years to a peak production of over 70 million tons while Bessemer steel climbed slowly to five million tons in the same period.

In the nonferrous field 1902 found leadership in nickel production going to Canada, a position she has since maintained. In 1904 Just and Hannaman patented tungsten filaments, made from the powdered metal and a binder. Coolidge in 1909 obtained his patent on thoriated tungsten, which became the basis for the electric lamp industry and later of the electronic tube.

The brass industry in 1908 began investigation of hot pressing and by 1914 had succeeded in developing this technique to one of major importance. Notable changes were occurring in the precious metal field, too. Up to this time jewelry metals had been chiefly gold and silver with copper and zinc added. Now platinum came in for both jewelry and dentistry and by 1915 platinum and its cousins palladium and iridium had become the royalty of the jewelry field.

Electric steel melting continued to increase in importance. The first Heroult electric furnace in an American steel plant was installed at the Halcomb Steel Company in 1906. By 1909 there were 105 electric furnaces in the world, 10 of them in the United States, and in 1915 American electric furnace steel capacity was nearly half a million tons a year. From that time on the United States' electric furnace steel capacity remained the world's largest.

HEATING ELEMENTS—A 1906 development of indirect but profound importance in the development of modern metallurgy was the invention by A. L. Marsh of the 80-nickel 20-chromium alloys possessing superlative heat resistance and high electrical resistivity. Originally applied as a heating element material, Marsh alloy was modified by himself and others to be the basis for wrought and cast heat-resisting materials that found immediate and growing applications for pots, burners, muffles, conveyors, and other parts of heat-treating furnaces. The existence of these alloy castings has made possible the modern mechanized, close-control heat-treating furnace without which American steels would not have the properties they do today and without which, indeed, full utilization of the National Emergency steel program would have been impossible.

About 1912 activity started in at least three countries that led to the development of the materials that we know today as stainless steels. In Germany Strauss and Maurer developed and patented high nickel-chromium steels on whose mechanical properties, corrosion resistance, and metallography they reported in detail in 1914. Almost simultaneously Sir Harry Brearley in England, while studying gun steels, discovered the remarkable corrosion resistance of the plain chromium steels of the type now used for cutlery and related uses.

In America Elwood Haynes had experimented with the cobalt-chromium and cobalt-chromium-tungsten alloys that we now know as Stellite and he patented these in 1913. This work led him to study the properties of the straight iron-chromium alloys and he must share with Harry Brearley some of the credit for independently discovering the corrosion resistance of the iron-chromium alloys.

The first strong aluminum alloy, progenitor of several which now form the sinews of the world's war planes, was invented by the German Wilm. It was an alloy of aluminum, copper, and manganese, which he called Dural or Duralumin and which we know in this country as 17 S. The high strength of the alloy, hitherto unknown in such light materials, was obtained by heat treatment but the further development of this idea in the light metal field had to wait until 1922 when Merica, Waltenberg, and Scott published their paper explaining why Wilm's alloy could be heat treated and promulgating the metallurgical doctrine on which was based the development soon thereafter of many other heat-treatable nonferrous alloys.

HUNDREDS OF IMPROVEMENTS—Since World War I, progress in alloys and in metal processing has come not as a few fundamental and long steps forward, but as hundreds of commercially important small improvements covering the whole field of metallurgy. Thus, the World War I years saw the steel industry just about double its capacity. Magnesium was first produced in America in 1915, The Dow Company starting its operations a year later. By 1918 there were five manufacturers of magnesium, of whom only two survived the post-war period.

In 1923 the American Rolling Mill Company installed the first continuous sheet mill in this country and by 1926 several companies were using continuous rolling for the production of hot and cold rolled strip steel. The development of these mills unquestionably was an important factor in the subsequent expansion of the automobile industry; the steels provided a low-cost, workable, strong auto body material on a mass-production scale and filled perfectly one of the greatest needs of the automobile manufacturers up to that time. The cold rolling process also drastically improved the quality and uniformity of tinplate. making possible much better tin cans at lower cost than before.

In 1922 and 1923 the behavior of molten magnesium was systematically studied. Sulfur and boric acid were shown to inhibit the oxidation of the liquid metal and this permitted casting magnesium in green sand molds. By 1925 Dow had developed its fluid flux, all these advances constituting as a group the basis of the magnesium casting industry as known today.

In 1924 Colin G. Fink developed successful commercial chromium plating and opened up an entirely new field of materials engineering. The automobile industry quickly adapted bright chromium to its styling needs and American automobiles became famous for their "luster."

In 1927 the Krupp laboratories devised the method of bonding tungsten carbide powder with cobalt to make extremely hard tools and dies. Cemented carbides were rapidly adopted in this country and in England and have been responsible for two revolutionary changes. The first was an increase in the speed of machining most metals (recently including steel), and the second was the introduction of tungsten carbide dies for wire drawing, replacing tool steel dies for larger sizes and cutting into the diamonds for some of the smaller sizes.

The science of steel treatment was pushed ahead significantly in 1930 when E. S. Davenport and E. C. Bain published their research on the constant-temperature transformation of steel as distinct from the conventional quench and temper process. This has lead to an entirely new approach to heat-treating problems and to the development of new treatments that have immeasurably advanced this important art.

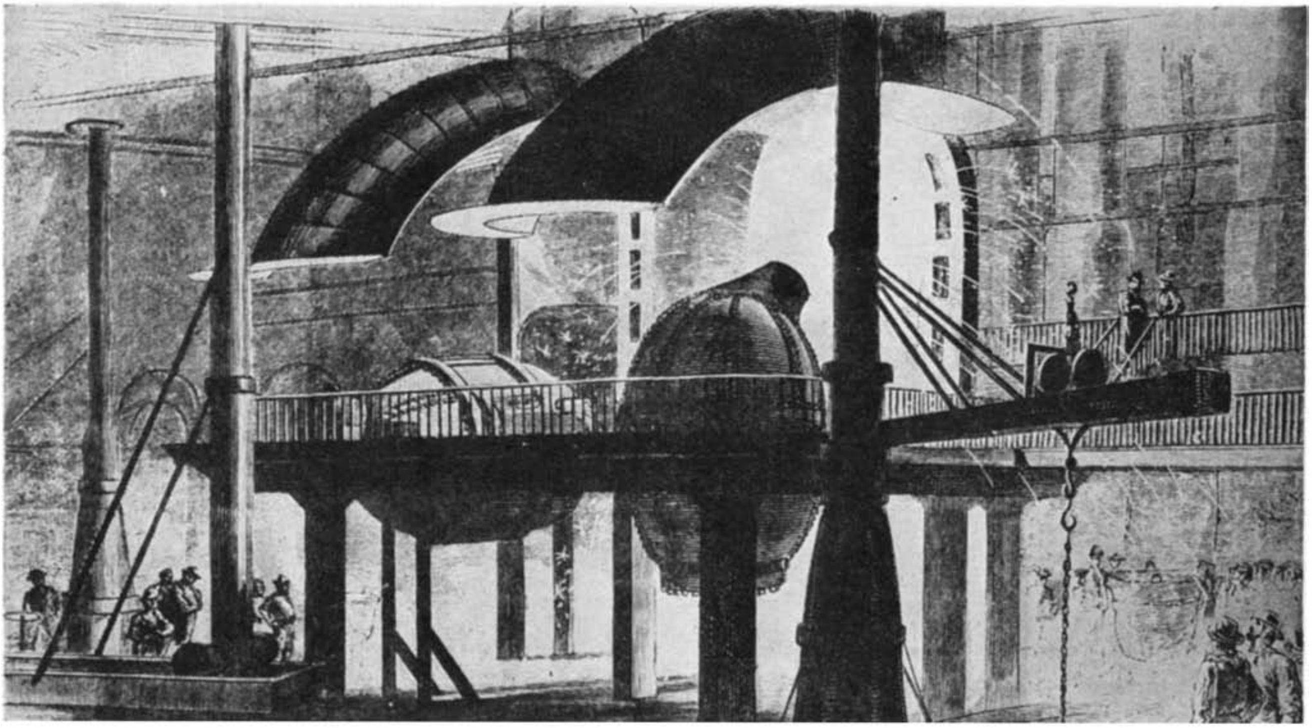
In the early 1920's less than 20,000 tons of high-grade zinc were used for die castings. Today zinc die castings are employed to the extent of about 100,000 tons. Aluminum and magnesium die castings are growing in importance too—both of them leaders in a parade toward precision fabrication of metal parts, either by casting or by solid-working methods.

Charles Martin Hall, aided by his sister, discovered an inexpensive process for making aluminum in 1886. From a dramatized movie version of this highly important discovery, "Unfinished Rainbows," presented by the Aluminum Company of America

HIGHER PRECISION—Indeed the outstanding characteristics of the present period, with respect to metals and alloys, are this tendency toward greater precision of metal products, the development of metals of ever higher purity, the formulation of alloys of continually better properties, the application of modern knowledge of the microstructure of metals to their practical processing and fabrication. Some of the most recent of these specific advances were described in Scientific American for January. Many others are still under wraps until the defeat of our enemies.

Of them all the most important is unquestionably the emergence of the series of metals that is based on the specialized properties of myriad *alloys*. Where once there was iron we now have not just "steel," but steels galore. To copper and brass have been added countless brasses and bronzes containing—in addition to copper and zinc or tin—aluminum, silicon, beryllium, manganese, nickel, lead, chromium, and others. Zinc, lead, tin, nickel, aluminum, and manganese have themselves graduated from the simple "metal" class to become the parents of numberless alloy series based upon each of them.

These trends, the salvation and power of America at war, will be the basis for the industrial activity and general well-being of America at peace. For the lessons of history should teach us not only that we must, for strategic reasons, maintain the growth of our metal industries between as well as during wars, but also that developments in the creation, fabrication, and use of alloys snowball in number and importance in our peace-time life with each passing year Metallurgically, America's future is bright indeed.



A general view of the Bessemer converters in a steel mill of the 1870's

Engineering Thinking

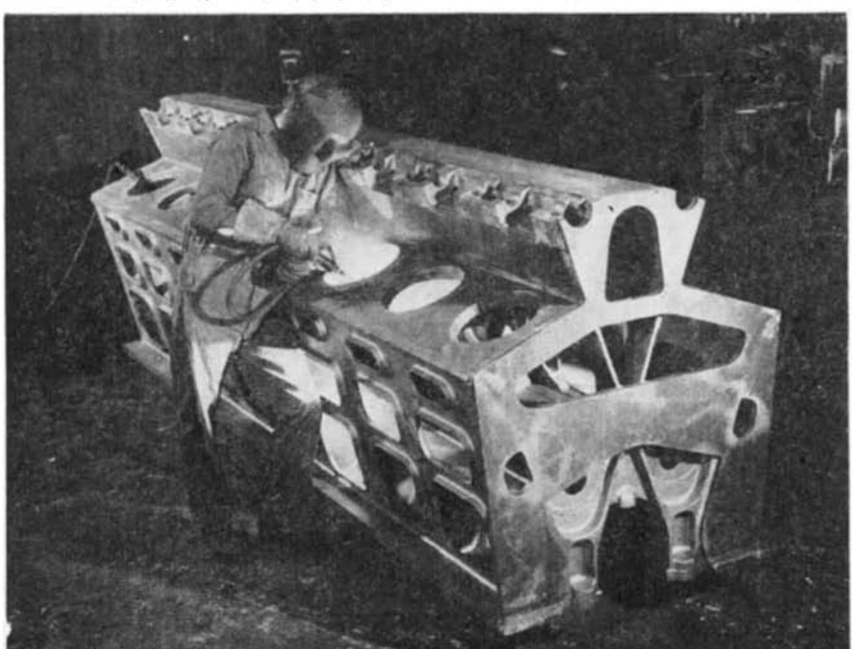
Automotive Engineers Shun Discussion of Post-War Automobiles, But Point Significantly to Such Developments As Redesign for Lightness, Multiple Power Plants, Air Conditioning, Power Steering, and the Increase in the Life of Cars. In the Meantime, They Work Day and Night on War Orders

UNDERLYING all other reasons why the automotive industry has been superlatively successful in manufacturing weapons of war is the long tradition of yearly automobile model changes. A recent survey of engineering thinking in the Detroit area disclosed no apprehension that secret projects underway at hell-bent speed would fail of achievement, and no doubts were expressed that production "impossibilities" would be overcome in the automotive industry's usual stride. After a series of conferences with dubious Government spokesmen in Washington, few of whom even understood the intricacies of mass production or the weapons under discussion, the Detroit peregrination was refreshing.

Ingenuity, the linguistic root of our word *engineer,* is one of the symbols of the American way of life. Stemming from the desperation of our immigrant forefathers and fostered by their fights for bare existence on the frontiers of new territories, ingenuity has developed to a degree that amazes Europeans and even occasionally gives pause to American engineers themselves. This is the background to the arsenals of democracy, as well as the background of the post-war automotive engineering to come.

In scores of off-the-record interviews, engineers shied away from discussion of the post-war automobile. Their intense interest in licking the task at hand in the shortest possible time was assurance enough, for this writer at least, that the motorist may look forward to improvements beyond the average expectation of things to be.

Unfortunately, those interested in specific engineering developments must wait until after the war for detailed disclosures. The extreme censorship view taken by some of our military leaders is that even hints might aid and abet the Axis scientists and engineers working for our defeat. But some of the work already disclosed may serve as a guide to thinking of the future, even if it does not form a precise mosaic. There is no borderline between automotive and armament thinking today. Peace-time developments made mobile weapons a fact, and military engineering developments, being made jointly in many cases by Army, Navy, and civilian engineers, will have an important function in post-war automotive advances.



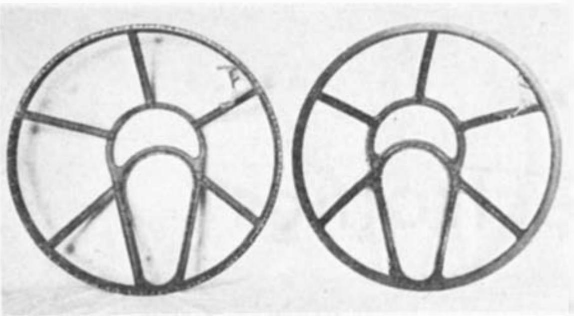
Courtesy Lukens Steel Company

Diesel-engine weight can be reduced and maintenance simplified through the use of welded steel plates, rails, and forgings in fabricating the crankcase. Illustrated is a 2000-horsepower Diesel frame being constructed in a plant of Lukenweld, Inc., from parts flame-cut and formed by By-Products Steel Corporation

MULTIPLE ENGINES — As an example, the multiple engine idea is seen today as an important post-war possibility for trucks and buses. Several engineers presented this idea at the recent War Engineering-Annual Meeting of the Society of Automotive Engineers in Detroit. One pointed out that two engines of 150 horsepower each, properly installed, would outperform the average 175 horsepower motor-coach engine in every respect. Only one engine would be used by the driver when but one was needed, and the other would be held in reserve for highballing. Another engineer at the same meeting showed that as high as 50 percent savings in power-plant costs could be achieved, cited substantial weight savings, and pointed out that engine failures on the highway could be almost completely eliminated.

Light-metal advocates were given food for serious thought when another engineer told a large meeting that steel parts had frequently replaced aluminum and magnesium units at a saving of weight and cost and had proved to be of greater strength. Case after case was cited, together with design details and manufacturing cost figures, to show that a great deal was yet to be learned about the proper selection of materials. Thus the extensive participation of non-aircraft manufacturers in the nation's huge airplane program again proved that, like lightning, one can never tell where a good engineering idea will strike next.

This thinking follows that which fostered the Navy's current project of using welded rolled steel plates, rails, and steel forgings to build up a huge Diesel-engine crankcase to reduce weight, increase the speed of manufacture, eliminate rejections entirely, and to simplify maintenance immeasurably. A few years ago steel castings constituted the only known method of manufacturing units of this character, but



Paradoxical as it may seem, steel was substituted for magnesium in this B-29 bomber nose frame to save weight. The new welded and pressed steel frame is at the left and the obsoleted cast magnesium frame at the right

Courtesy A. O. Smith Corporation

the engineering thinking of a small and aggressive steel mill broke a serious bottleneck for the Navy. Already, welded steel plate structures are competing with castings for many purposes.

POWER STEERING—Automotive engineers expect to lean heavily upon the experience of military equipment in future development of power steering for trucks, buses, and the larger passenger cars, just as the Army and Navy engineers adopted vacuum, hydraulic, and compressed air power boosters from other applications in American industry. Here again the line of demarcation between weapon and peace product engineering is faint and at times invisible.

Immediate demands for improved power devices brought about a coördinated workout of the best brains of the military engineering staffs and prime and subcontractors. Engineering thinking from coast to coast was activated on this project. Again, contributions were made by university faculty members versed in the theory of hydraulics, by automatic tool designers, pump and compressor engineers, and the nation's leading consultants in this type of work. This mass of technical information will be available after the war to everyone interested.

Less specific, apparently, is the possible application of some phases of supercharged aircraft cabin engineering to the passenger car of the future. High altitude flying has intensified research and development in this field, and a number of aeronautic engineers have sketched schematic layouts for air-conditioned automobiles for this writer on paper napkins at lunchtime. There will be rich technical fare for engineers interested in this idea to improve refrigeration equipment in food and product trucks, and increasing passenger comfort in buses and automobiles.

More specific will be the many applications of advanced manufacturing techniques stimulated by the demands of war production. As production requirements expanded at a rate approaching an explosion, armament orders poured into automobile, truck, and component part factories, as well as into factories of every other American industry. It was this transition from military arsenals to American factories everywhere that brought to arms production the best practice developed by a highly competitive economy, and added something new in redesign of weapons for mass production, in metallurgical improvements, and unheard-of speed of production.

CARS LAST LONGER—Thus production experience of the past was correlated, and the demand for great speed in output focused the attention of production engineers in every corner of industry on every possible improvement in production techniques. This is the background in considering the statement made at the recent SAE meeting by an automobile engineer that the demand for 6,000,000 automobiles in the immediate post-war period will be met readily. But a challenge to continued output at that level was expressed in a study that revealed prolonged ownership of automobiles had proved successful in the present war period. Surveys indicated that the pre-war cars had stood up under the longer-than-usual ownership, and that the pre-war frequency of trade-ins may be reduced in view of this experience. It was pointed out that average age of passenger cars in service today is about eight years.

This enforced prolongation of passenger-car use also has disclosed that such things as obstinate door locks, malfunctioning window regulators, ignition troubles, and failure of steering equipment to maintain alinement—to mention a few faults—will have to be overcome if long-time use of cars becomes established practice. Some engineers believe that frequent trade-ins will again be the rule as soon as the immediate demand for new automobiles had been satisfied, but most agree that this sort of guessing approaches clairvoyancy, a subject not taught in engineering schools or practiced in engineering departments.

Earlier this year when Government officials announced that arms output for 1945 must be larger than the 1944 totals, engineers in the Detroit area were unimpressed by doubters. What has them going on a night-and-day basis is some of the new requirements for weapons not yet publicly announced. The details, in terms of new tools, component parts, and dollars, are astronomical. But no one even hinted that the orders could not be met, and most of them have promised themselves that they will be met ahead of schedule.

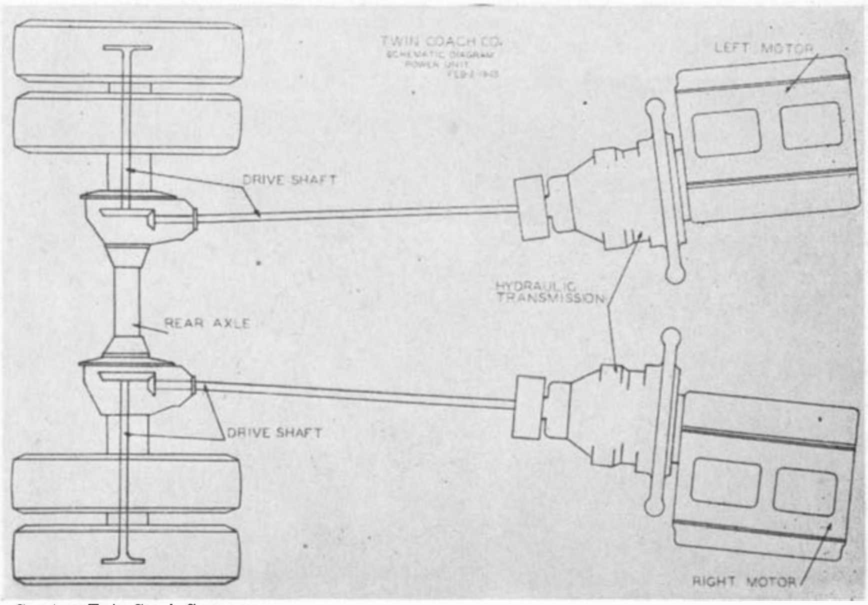
* * *

FUTURE ENGINES

Must Give Greatest Value Regardless of Form

ENGINEERS attending the War Engineering-Annual Meeting of the Society of Automotive Engineers in Detroit were challenged by the organization's former president, Charles F. Kettering, vice president of General Motors Corporation, to "find the best combination of engine and fuel to give the greatest value per total dollar."

Mr. Kettering told his audience that it makes no difference whether the engine is for gasoline or Diesel fuel; whether it is a two-cycle or four-cycle engine; whether it be reciprocating or non-reciprocating. "Engines are made of metals and brains," he said, "and they need as much of the latter as we can get into them."



Courtesy Twin Coach Company

One method of installing twin engines in a bus is shown by this schematic drawing, which indicates the use of hydraulic transmissions. A pre-war development, multiple engines are widely used in many military vehicles. From the success obtained, they appear destined to find wider and more varied application in the post-war period

Metals By Electronics

In Mines and Mills, Electronics Speeds Production, Increases Safety, Improves Quality. Some of the Applications Described Point the Way Toward Even Greater Diversification of the Uses of Electronics

By VIN ZELUFF
Associate Editor, *Electronics*

SAFETY devices, automatic controls, induction heating units, power-conversion substations, and a host of weighing, sorting, measuring, and automatic inspection devices are among the many forms of electronic equipment being used in mining operations and in metal refining and rolling mills. These tube-operated units have played a major role in producing the vast tonnages of metals needed for mechanized war.

AT THE MINE—Photoelectric relays control the dumping of ore trucks in a Minnesota copper mine. The truck backs onto a ramp. For full safety two photoelectric relays are installed; the truck must intercept both beams. The breaking of the beams by the truck energizes a solenoid air valve, opening a dump pocket. If the truck is not in proper position to intercept both light beams, the pocket remains closed.

In another example a large power shovel in an open-pit mine changes its operating position on an average of once every 45 to 60 minutes. It does not move far, and it moves slowly. The weight of the shovel is 1500 tons or more, supported on four large crawler trucks, one at each corner of the machine.

During normal operations of such a large stripping shovel, the lower frame must be close to level. Otherwise, the rotating motion will be severely handicapped, because it will work against gravity in one direction, and with gravity in the other.

Therefore, all modern, large stripping shovels are now built with four hydraulic leveling jacks—one at each corner directly over the truck. The leveling unit on many shovels is controlled by photoelectric relays. The operator merely presses a button in the cab. A signal light indicates when the operation is completed. Leveling is accomplished to an error of less than a half a degree in a half minute or less.

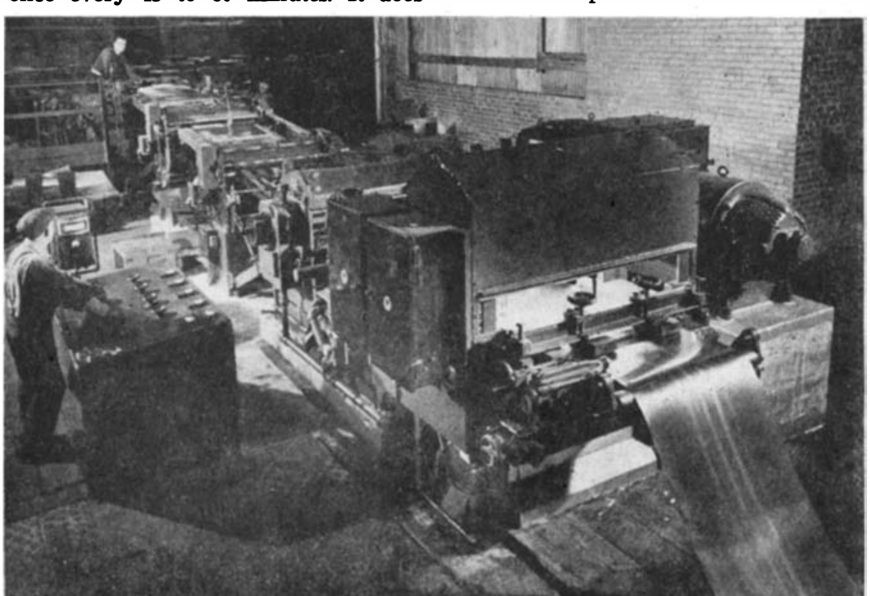
IN THE MILL—In one steel plant, a flying shear is located between the intermediate and finishing stands of a 10-inch hot strip mill. This shear cuts off the relatively cold front end of the bar before it enters the finishing stands. Formerly an operator had to start the shear when the strip was in the proper position, so as to cut off a definite crop length. Now phototube equipment automatically starts the shear. An adjustable time relay is used to determine the time interval between the interruption of the beam of light and the starting of the shear, thus compensating for changes in the strip speed, since the strip speed when it reaches the shear is adjustable from about 400 to 550 feet per minute.

In a Chicago steel mill, the soaking pit crane operator opens the soaking pit cover from his crane cab through the action of photoelectric equipment. When the crane is over the soaking pit from which the operator desires to lift an ingot, he steps on a foot-operated pushbutton which will momentarily illuminate a "light box." Opposite the light box is a phototube unit with amplifier. When the light strikes the phototube the cover opens. As soon as the ingot clears the pit, the operator again steps on the pushbutton to illuminate the light box and the pit cover automatically closes.

A photoelectric unit in another steel strip mill slows down or speeds up one of the sections of the mill to maintain a constant loop in the strip being processed. Normally the loop is of such a length as to block about half of the light-beam system. If the loop shortens, the phototubes get more light and the associated electronic motor control system adjusts the speed of one motor to make the loop longer. Correction is made in the opposite direction when the loop gets too long and blocks all of the light beam. With this ingenious arrangement, two separate motors can operate two different sections of a conveyor or two separate stands of a mill acting on the same continuous sheet of hot or cold steel.

HOLE DETECTOR—Not all photoelectric applications are for regulation purposes. An important steel mill application of another type is one that detects holes in strip steel. This application is particularly desirable on steel which will later be tin-plated for use by the canning industry.

Prior to the use of pin-hole detectors, it was difficult visually to inspect the strip effectively, and food spoilage often resulted. The modern photoelectric pin-hole detector will inspect steel strip at speeds up to 1500 feet per min-

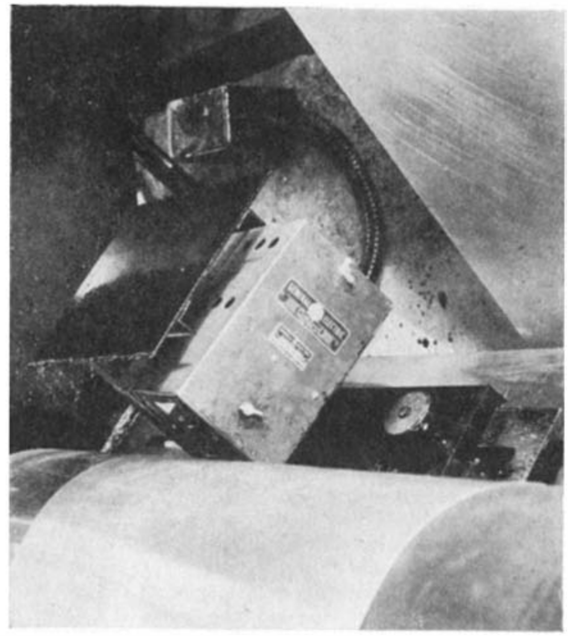


Westinghouse installation (foreground) of pin-hole detector in shearing line ute and detect 1/64-inch or smaller holes. Some operators have reported consistent detection of holes as tiny as 1/200-inch diameter. The detector operates a marker which places a visible mark on the strip at the location of the hole so that it can be readily located later. In many installations, the detector also operates a classifier that automatically rejects defective sheets after they have gone through the shear which usually immediately follows the pinhole detector.

Before tin-plate is shipped to the can manufacturer, it is gaged for thickness and sorted into piles, each containing a definite number of sheets. Gage is now measured electronically. If the thickness varies beyond the allowable tolerance, a signal from the gage, electronically amplified, actuates a contactor which in turn operates a reject gate to divert the off sheets.

An electronic counter is used to determine the number of sheets going into the prime pile. Sheets intercept a light beam directed on a phototube feeding an amplifier and contactor. Each time the light beam is intercepted by a sheet, the contactor is energized and in turn operates a magnetic counter. After a predetermined number of sheets reach the piler, the conveyor stops automatically.

A side-register control installed in steel mills automatically shifts a steel-strip winding reel back and forth, compensating for lateral variations so as to obtain a coil with smooth ends. A light beam makes a continuous check on the strip's position, and a variation of even a few thousandths of an inch is sufficient to bring about a corrective action. This equipment is installed on many electrolytic tinning lines.


Uniformly wound coils of strip metal are being produced in steel mills by the use of photoelectric controls that scan the edge alinement of the strip before coiling. The protecting cover has been removed from this General Electric unit to show the scanning head

HEAT MEASUREMENT—The General Electric photoelectric pyrometer provides a dependable method of indicating and recording the temperature of a hot bar of steel. Radiant energy from the hot body is directed toward a phototube, causing the tube to pass a current bearing a definite relation to the temperature of the hot body. The current is amplified and passed through an indicating instrument which charts the temperature. High speed of response makes the pyrometer extremely suitable for indicating the temperature of successive pieces passing in process, such as bars or billets passing through a steel mill.

One of the early installations of the photoelectric pyrometer was on a piercing mill where steel billets are made into seamless steel tubes. Three furnaces served the mill, and there was much variation in temperature of billets from the different furnaces. The pyrometer indicated billet temperature, with the good result that both mill operator and furnace man had a measuring stick with which to guide their operations. Spoilage was greatly reduced.

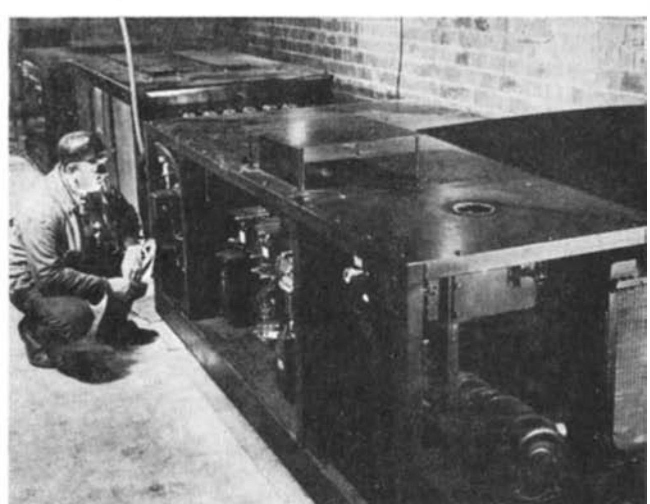
In another steel mill a pyrometer indicates bloom temperature as blooms leave the mill. The instrument is provided with two control points, so connected that signal lamps light in the operator's pulpit if the temperature of the bloom is too high or too low. Thus, if temperature is too high, the operator waits until the temperature-recording instrument shows that the bloom has cooled sufficiently before he sends it on to the billet mill.

When the pyrometer was installed on a spinning machine for manufacturing cast-iron pipe by a centrifugal-casting process, a better and more uniform product was obtained and the machine's productive capacity was boosted.

After the spinning machine has been started and brought up to speed, hot metal is poured in. The pyrometer then is arranged to indicate temperature inside the pipe. When the pipe cools below a critical temperature, the pyrometer causes the spinning motor to be stopped. Human error is avoided, and the spinning machine runs no longer than is necessary to permit solidification of the metal.

Since its invention, the Bessemer converted has depended upon the human eye for control of temperature and determination of the end point of the blow. Catching the end point exactly is a matter of utmost importance. If a few seconds of overblowing takes place, the iron oxidizes rapidly. If the blow is stopped too soon, excess carbon may make the steel unusable.

The Bessemer flame control, an invention and development of the Jones and Laughlin Steel Corporation, using



Photographs courtesy Westinghouse

Shop-testing a huge ignitron rectifier assembly that is now being used in the electrolytic production of aluminum

D.C. end of a portable ignitron unit, with a capacity of 300 kilowatts, designed especially for use in a coal mine

G-E photoelectric equipment, now watches the flame unflinchingly through a series of carefully selected filters, records the progress of the blow, and makes it possible to halt the process at a preselected end point.

AUTOMATIC TESTS—Instead of laboriously watching through a microscope to measure the rate at which metals flow when heated and stressed, metallurgists have substituted a photoelectric unit for the human eye and can now go about more important work while these tedious metallurgical tests go on automatically.

In the new technique, a thin wire sample of the metal to be tested is enclosed in a glass cylinder. Electric current is sent through the wire to heat it to perhaps 2000 degrees, Fahrenheit, and a weight is attached to one end of the wire to keep it taut as it expands. Also attached to the wire is a glass grid ruled with opaque horizontal lines 1/250 inch wide and the same distance apart. An identical grid, nearly in contact with the first, is rigidly attached to the glass cylinder. At the beginning of the test, the grids are adjusted so the lines on one just fill the spaces on the other, and no light can pass from the lamp on one side of the setup to the phototube on the other side.

As the test wire stretches, it slowly moves one grid, allowing more and more light to reach the phototube. The resulting output of the phototube is amplified and fed to a recorder that inks in the amount of stretch on a moving calibrated paper scale. By this electronic technique it is readily possible to measure a stretch or creep as small as 1/10,000 inch in a metallurgical sample.

RECTIFIERS—The hesitancy of some industrial companies to use ignitron-type mercury arc rectifiers is fast disappearing. Electronics is now being put to work on a really big scale. In the five-year period from 1938 through 1942 the total sales of electronic rectifying equipment in this country was of the order of 120 million dollars.

In one western steel plant alone, these rectifiers, with a capacity of 14,000 kilowatts, are supplying power for driving auxiliary machines in the steel mill. Also, an ignitron rectifier is supplying the power to the main-roll motors in another western steel mill. Direct current is used underground in all mines, and more and more of them are discarding motor-generator sets in favor of more efficient and more reliable electronic rectifiers.

Some of these metal-clad rectifiers require a vacuum chamber eight feet in diameter, and stand seven or eight feet high. Such electronic giants have played a very important role in the recent tremendous expansion of the aluminum and magnesium producing facilities for war use. The tubes can be made with far less critical material than corresponding rotating-type converters, and their used saved an estimated 20,000 tons of steel and 3,750,000 pounds of copper at a time when the metals were extremely critical. They provide the vast quantities of D.C. power needed to produce aluminum from mud and magnesium from sea water.

The close working relation developed between electronics and the metals and alloys industry in wartime shows every sign of continuing after the war, to the mutual benefit of all concerned. Here, as in its many other fields of usefulness, electronics is making it possible to turn out a better product faster and at lower cost, and is thereby rendering a service to industry that cannot economically be discarded on reconversion day.

* * *

CLOUD CEILING

Measured by Brilliant Light Plus Photocell

HEIGHTS of clouds from zero to two miles up can be measured accurately and automatically in daylight or darkness with an electronic ceilometer jointly developed by the United States Weather Bureau and General Electric Company. A tiny high-intensity mercury arc lamp mounted at the focus of a searchlight mirror throws a 120-cycle pulsating beam vertically upward. Although the flickering spot thus produced at the cloud ceiling is not visible to the human eye in daylight, it is readily picked up by a phototube and amplifier unit located 1000 feet from the projector and tuned to the same flicker frequency of 120 cycles. A Selsyn motor drive between the various units translates the output meter reading into cloud heights indicated directly on a recording unit.

The new G.E. ceilometer obtains cloud ceiling data valuable to all aviation

FRACTIONATION

Speeded by Electronic Recorder

IN MODERN oil refineries, accurate boiling points of the various vapors to be separated in fractionation must be predetermined in the laboratory.

An electronic instrument for this purpose, made by Brown Instrument Company, consists of a continuous-balance potentiometer pyrometer which is mechanically connected to a conventional recording potentiometer.

A special high-sensitivity fine-wire thermocouple, consisting of six individual couples spaced about one half inch apart, is located in the reflux zone of the fractionating column. The electromotive forces produced by these thermocouples are amplified by the electronic tubes and recorded continuously by pen on a time-temperature strip chart.

The electronic recorder and a special Podbielniak fractionating column make possible rapid and accurate separation of compounds whose boiling points are only one and one half degrees apart, a feat which cannot be accomplished by the older type of apparatus.

The new electronic development considerably reduces distilling time, with increased accuracy, and opens up a new field in the fractional distillations required for producing the new "100-plus" octane gasoline. Richfield Oil Corporation has installed this electronic equipment in its newly expanded refinery near Los Angeles.

STENCIL CONTROL

Provided by Electronic Timer

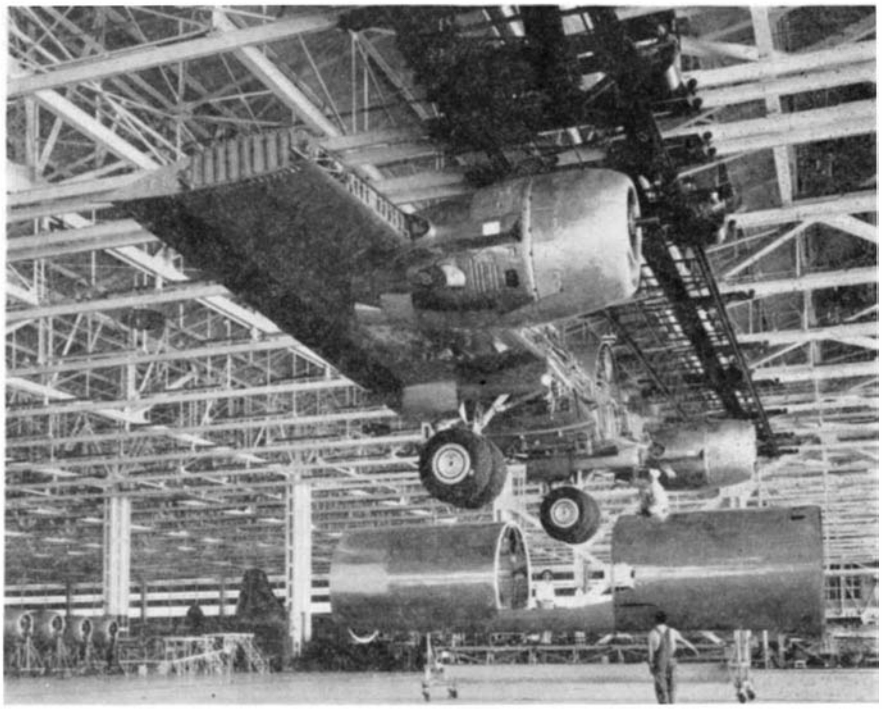
IN A BLANKET factory in Massachusetts, the plant superintendent needed to stencil certain letters on blankets uniformly. In this operation, an electromagnetic mechanism had been used to press the blanket against a paper transfer. Addition of a General Electric electronic timer to the solenoid circuit now allows automatic control of the length of time the blanket is held against the transfer.

FLAW DETECTOR

Prevents Tool Breakage In Machine Shop

IN ONE New England plant, invisible flaws and inclusions in brass bar stock were causing tool breakage losses amounting to over $2000 a week. A complete solution to the problem was achieved by installing an electronic flaw detector to inspect all stock before machining. This device, developed and manufactured by Sperry Products, Inc., detects flaws as short as 1/16 inch, many of which are not even noticeable at the surface. In the first six weeks of electronic inspection, not a single tool was broken, tool life was considerably increased, and over-all production increased 60 percent.

The Sperry flaw detector consists of an electron-tube oscillator that supplies high-frequency alternating current to a detector coil through which the bar stock is passed at rates as high as 80 feet per minute. If a flaw is present, a sensitive electron-tube indicator circuit signals the operator and actuates relays that stop the machine which pulls the bars through the coil. The detector works equally well on both ferrous and non-ferrous metals and on welded or seamless tubing.



Lowering the 17 ton main center wing section of a Superfortress to fit into the fuselage bomb bay section at Boeing's assembly plant in Wichita, Kansas

AVIATION Conducted by ALEXANDER KLEMIN

Metals In The Air

Aviation's Present Achievements Are Based on the Quantity Production of Strong, Lightweight Metals. Of These, Aluminum Is Most Widely Used Because It Combines the Necessary Qualities of Toughness and Lightness with Low Cost. But Steel and Magnesium Are Coming into Wide Use

NOT THE least of the wonders of the modern airplane lies in the airframe or structure. Other branches of industry call for strong, reliable metals, readily fabricated, but the airplane is unique because it demands, in addition to all other qualities, the supreme quality of lightness. If the airframe of the Superfortress were built of mild steel with the same disregard for weight that is shown in the construction of a bridge, it could only carry a fraction of the bomb-load that is now being showered so generously on Japan.

Wood was the first airplane material, but it has largely been replaced by metal. Of recent years, there have been many attempts to return to wood in airplane construction, particularly with the aid of plastics-bonded plywood. The DeHaviland Mosquito, probably the fastest bomber in the world, has a structure almost entirely of wood, and it has been successful in its task of bombing Berlin. Airplane fuselages built of a plastics incorporating Fiberglas have shown remarkable strength in tests at Wright Field. But World War II is drawing to its final phase with metal aircraft holding the predominant position, and plastics still mainly used for non-structural elements.

ALUMINUM IN FLIGHT — The material most important in airframe construction is aluminum, and its application in American aviation began quite early. In 1923, Charles Ward Hall, a consulting civil engineer of note, converted a Navy twin-float seaplane to metal construction, and reduced its frame weight from 358.25 pounds to 164.5, a saving of almost 54 percent. This was such striking evidence of the possibilities of aluminum that, with the financial support of the Aluminum Company of America, there was formed the Hall-Aluminum Company with ample resources for a program of research in aluminum airplane construction.

But no amount of research, no energy in sales engineering, would have given aluminum its splendid position were it not for certain inherent qualities. Aluminum, particularly in its pure state, has excellent resistance to corrosion. It is available in many shapes and forms, and it is easy to fabricate. Moreover, it is very easy to give this bright metal a pleasing finish, and where painting is necessary, the number of filling coats is small compared with that required in steel or wood construction.

But its most important characteristic from an aviation point of view is its low weight compared with that of a steel component of equal strength. The specific gravity of steel is 7.8, and the tensile strength of mild steel as used in general construction is around 50,000 pounds per square inch. On the other hand, the specific gravity of 24 S-T aluminum alloy is only 2.77, and its tensile strength is 68,000 pounds per square inch. So aluminum is only one third as heavy as mild steel, and some 36 percent stronger.

Of course, there are much stronger steels. Some run to strengths of approximately 200,000 pounds per square inch. There are, however, wonderful newer aluminum alloys in the offing to maintain superiority for the lighter metal. Moreover, in the airframe, and particularly in its cover, a light and relatively bulky material has the local strength against buckling which very thin steel cannot readily attain.

FABRICATING ALUMINUM — Aluminum enters into the airframe in many forms. It is used in sheets, tubing, angles, channels, Z-sections, U-sections, and so on, with sheet or strip form as the most popular. A widely used form is Alclad, an aluminum alloy coated with pure aluminum as a protection against corrosion.

There are many alloys and many methods of heat treatment. The fabrication of aluminum has led to the development of a special technique making use of the hydro-press, the drop-hammer, and the stretch press. All the alloys can be easily formed in any desirable shape, if the material is in the soft (S.O) condition, but there are penalties attached to this simple solution. The high-strength alloys require subsequent heat treatment followed by a rapid cold-water quench. This sometimes causes warping, entailing a consequent costly and time-consuming straightening process.

Aluminum is employed in all parts of the airplane. It is most prominent in wings, fuselage, tail surfaces, and ailerons. An outstanding example is the fuselage of the Boeing B-29, or Superfortress. To speed production, the huge fuselage is built in five sections. The main elements of the structure are the circumferentials or bulkheads or rings, as they are variously called, made of stamped, pierced, and channelled sheets. Through cuts or recesses in these bulkheads pass long channels or stringers. The circumferentials cannot all be of the same size since they must conform to the streamlined form of the fuselage.

After the skeleton structure has been riveted together the fuselage is ready for its outer skin. It is an impressive fact that our constructors have found a way not only of building splendid superbombers, but of building them accurately in quantity and at widely separated plants.

A consideration of one of the steps in assembling the Superfortress affords a clear insight into the accuracy and boldness now employed in metal aircraft construction. Complete with the huge dual wheels of the main landing gear and two of the four 2200 horsepower engines, the 17-ton main center wing section of the Superfortress is lowered to join the fuselage bomb-bay section. Because the two units are manufactured for a perfect fit, it is necessary to jack up the center of the bomb-bay section to allow a quarter of an inch tolerance "spread" as the center section and the fuselage nestle together. Removal of the jacks takes up the quarter-inch slack, and a joint follows in which the pre-bored bolt holes are in perfect alinement.

Another example of aluminum construction is found in the vertical fin of the B-24 Liberator as constructed by Consolidated Vultee. The ribs of the fin have holes stamped out and sides flanged in one operation on the hydraulic press. Rivet holes are later drilled by hand. This indicates that whatever tools and processes may have been developed in aluminum construction, careful hand effort is still an indispensable part of the task.

Aluminum has played a big part in the development of mass-manufactured airplanes. But its story is not finished. New alloys still on the secret list are emerging with tensile strengths greater even than any of the aluminum combinations in general use today.

STEEL IN AIRPLANES — In the use of strip steel in aircraft construction, we have lagged far behind the British. In World War I, tentative orders by aircraft manufacturers for steel called for hundreds of pounds instead of hundreds of tons. The manufacturers consequently decided that steel in aircraft was not worthy of serious attention.

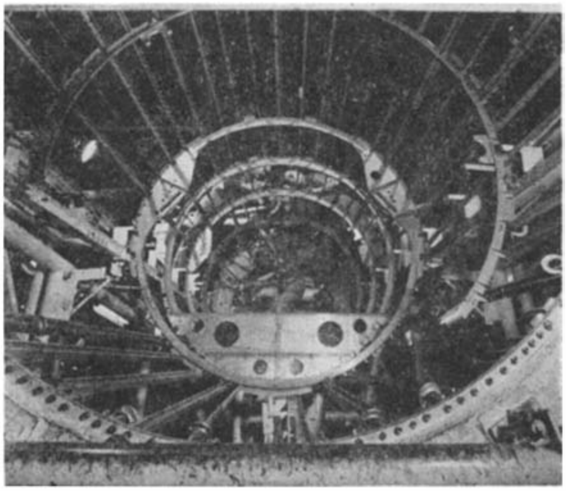
In England, considerably more attention was given to the production of special steel strip and the like. In the United States, even to this day, comparatively little has been done in using strip steel except in the form of stainless steel.

On the other hand, a great deal of steel tubing has been employed, mainly chrome-molybdenum, in engine mounts and in landing gear struts. In the engine mount, the steel tubing probably gives greater concentrated strength and more resistance to the fatigue that follows on engine vibration; and since landing gear struts are exposed, there is advantage in using steel tubing with its smaller cross-section. The fuselage is another place where steel tubing is used. It is generally conceded that Anthony Fokker, the Dutch designer, originated the use of the welded tube fuselage.

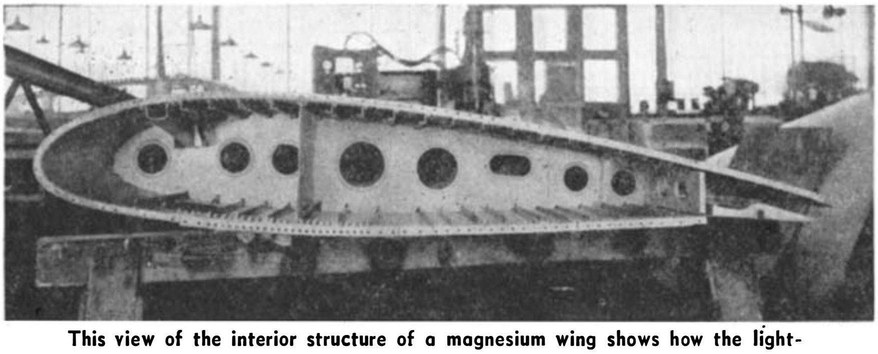
At the time the tubular fuselage was introduced, the strongest argument in its favor was that in case of a crash, wooden members break and splinter whereas steel members usually bend and buckle but do not split, thus giving greater safety to crew and occupants. The argument does not apply when a fuselage is built of aluminum, but a welded steel tubing fuselage is cheaper to build, and easier to repair and maintain, than a monocoque fuselage in aluminum. Hence, for relatively inexpensive private aircraft, steel tubing has always been popular.

Outside of the chrome-molybdenum tubing, the steels which have attracted most attention from aircraft constructors are corrosion-resisting steels, often popularly called "stainless steels." These are generally chrome-nickels or chromium steels. Both groups are characterized by high resistance to corrosion, as by salt water, and high resistance to hot exhaust gases, and both groups can be made to develop enormous strengths, over 200,000 pounds per square inch, coupled, however, with rather poor elongation or ductibility.

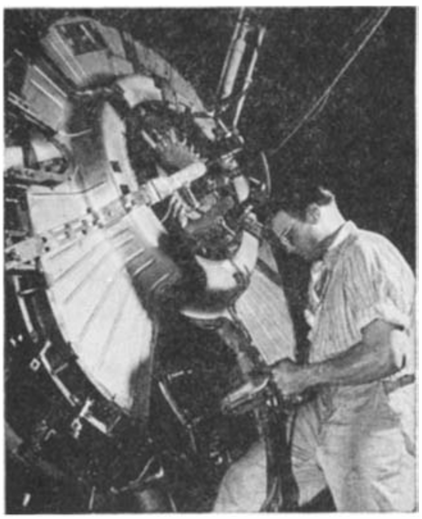
Moreover, while the stainless steels are difficult to drill and fabricate in general, they can be electrically spot-welded with great success—removing the bugaboo of riveting. Stainless steels have proved, first of all, very useful in such non-structural parts as exhaust colleotors and stacks, and it is difficult



The skeletal structure of a Boeing Superfortress, showing the stringers being riveted to the circumferential rings



This view of the interior structure of a magnesium wing shows how the lightness of the metal permits the use of bulky stringers with great local strength to see what material could replace them for these purposes. Owing to their corrosion-resisting properties, stainless steels have been employed with success in the building of floats and hulls. Fleetwings has built an amphibian entirely of stainless steel which was popular with private owners. Stainless steel in the structure of the airplane has not achieved great popularity. This is true in spite of the fact that, in addition to Fleetwings' pioneering in this field since 1926, Budd after many years of research, has recently built an excellent all stainless steel cargo airplane. The probable reason is that, while stainless steel has enormous tensile strength, it has less local resistance to buckling because its sections are extremely thin. A stainless steel wing cover is far too thin to be as satisfactory as an aluminum skin. But the last word has not been said. In the larger aircraft that are coming shortly, the enormous



Stainless-steel segments are here being tack-welded for inner rings and muffs on a Consolidated-Vultee plane

loads at the root of the cantilever wing may have to be taken up by deep and solid steel spars.

THE LIGHTER METALS—Magnesium has long been used in aircraft construction in Germany where it is called "Elektron." In the United States it has been employed in many aircraft engine parts, mainly as castings, but it is only within the last few years that it has been utilized as a structural aircraft material and then only in experimental form. Magnesium is being obtained from the sea water by Dow Chemical Company so that it is available to us in great quantities. It has a specific gravity of only 1.8, about two thirds that of aluminum, and a tensile strength up to 50,000 pounds per square inch. Magnesium offers certain difficulties. When it is being machined, protection against fire hazard must be taken. Its fatigue resistance is not perfectly assured and, because it is not as hard as other alloys, its resistance to corrosion is not as high. Hence, in spite of its attractive strength weight ratio, it was viewed with some suspicion by aircraft constructors.

Today, however, machining problems have been largely solved, and chemists at Consolidated Vultee have developed "pickling" or electro-chemical anodizing of magnesium so that it becomes splendidly resistant to corrosion. Dow Chemical, pioneer in production of magnesium, is also doing fine development in building wings and fuselage for a SWJ-2 Navy Trainer. Load tests to destruction have proved completely satisfactory with some saving in weight as compared with the basic aluminum wing.

Because magnesium is so light, it is possible to use bulky sections in the stringers without excessive weight but with local strength. A smooth exterior finish can be obtained with this material because the local stiffness eliminates all skin-wrinkling, and also because fewer rivets are needed. Aircraft construction in magnesium also has great possibilities in saving cost. Because of the greater local stiffness previously mentioned, magnesium will render possible true monocoque construction; that is, a hollow shell cumbered with a minimum of internal parts, spars, stringers, or ribs.

THE IDEAL MATERIALS—F. S. Stewart, in a book on airframe materials, outlines the properties desirable in materials for airframes and within the realm of possibility. His ideal specifications are a fine challenge to metallurgists and inventors. Here they are:

Tensile Strength: 200,000 to 500,000 pounds per square inch.
Specific Gravity: Less than 3.0.
Availability: Unlimited.
Modulus of Elasticity: Above one million pounds per square inch.
Fatigue Resistance: High.
Corrosion Resistance: Excellent.

The day is not far distant, perhaps, when the combined labor and ingenuity of the world's metallurgists and aircraft designers, working in a peace-time atmosphere following a United Nations' victory, will bring forth a material equal to Mr. Stewart's specifications.

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PROPELLER ICING

Reduced by Use of Simple Lacquer

THE ACCOMPANYING photograph shows part of an American Airline flagship in flight, with wing edges and propeller dome "icing-up" while the edges of the propeller itself are still free of ice. This is due to a recent development by engineers of Hamilton-Standard Propellers, which increases flight safety.

The safety measure consists in painting or spraying the propeller blades with a chemical lacquer called Icelac, which, black in color, has a consistency something like that of glycerine, and paints or sprays freely to give a shiny, tacky surface.

A satisfactory icing protective surface is maintained for several thousand hours, according to M. G. Beard, Director of Flight Engineering for American Airlines.

The application and maintenance of

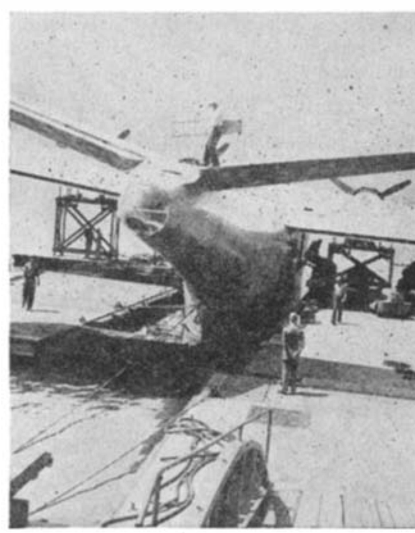
The edge stays ice-free

Icelac is simple. Previously, propeller blades were protected by a slinger-ring which distributed an anti-freeze fluid over the propeller blades. The advantages of the new protective method are evident. There is saving in weight, increased simplicity, and a greater assurance of anti-icing protection.

SEAPLANE DOCK

Offers Advantages in Servicing Large Craft

TO FACILITATE handling mail and cargo carried in vast quantities by the Martin Mars and to simplify servicing and maintenance of this giant flying boat,



A tail view of the Mars at its dock

the Navy has constructed a special U-shaped seaplane dock at a west-coast naval air station.

The basic structure consists of standard navy pontoons, over which a three-inch wire-mesh concrete deck is laid after covering the crevices between the pontoons with tar construction paper.

The floating dock provides platforms at either side of the flying boat which may be raised or lowered to a convenient height by changing ballast.

The Mars is berthed in its dock by cables running to fixed electric winches anchored in concrete foundations.

Metals Of The Future

Chemical Industry Provides the Base from Which Spring the Marvels of Metallurgy. Important to Tomorrow's Applications of Metals Is the Developing Knowledge of the Rarer Elements and Their Value in Extending the Usefulness of the More Common Metals in Use Today

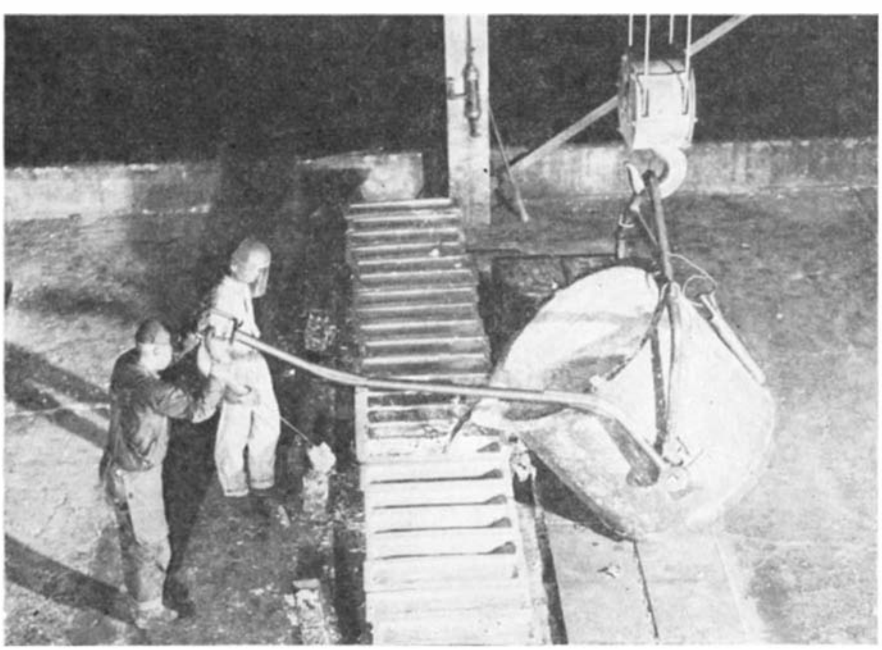
METALLURGY advances by adopting and adapting chemical discoveries and processes, and operating them on a huge scale. Indeed, metallurgy can be defined as that division of chemistry and chemical industry concerned with metals and their ores. While that definition serves admirably to characterize the principal fields of metallurgy, and to differentiate them from the remainder of the chemical domain, it leaves a large area of uncertainty. The gigantic iron and steel industry clearly belongs to metallurgy, but proper classification of magnesium production, for example, is not as simple as that and must be dated to have meaning. As recently as a decade ago, metallurgists were still inclined to look down their noses at magnesium and its production in a chemical plant, and few indeed considered it worth serious metallurgical study. Today, that situation is substantially changed and magnesium has grown up among metals. Before our very eyes, martial necessity transferred this expanding section of chemical industry into metallurgy.

Similar transfers have in the past continually enriched metallurgy with territory acquired from chemical industry. And the process continues.

Just as the metallurgy of today is differentiated from that of a century ago by its acquisitions from chemistry, so will the characteristics of tomorrow's metallurgy depend upon what of today's chemistry can be adapted and applied to the problems of metals. We may, indeed, expect to find among the specimens in today's chemical museum the important metals of tomorrow. The methods by which their evolution will most probably be accomplished resemble those recently developed and applied in chemical operations.

MAKING THE MOST OF METALS—The principal preoccupations of present-day chemistry and metallurgy are the development of the techniques necessary to concentrate desired metals from even excessively dilute ores and the economical application of huge concentrations of energy to their recovery. A further consideration, whose significance is being emphasized more and more, is the necessity of using to the utmost the most abundant elements as the base metals of alloys and adding other less common elements to modify their properties in desired directions. This results from rapid depletion of high-grade ores and directs special attention toward the most plentiful elements composing the earth. Aluminum, magnesium, and iron thus become especially important since these three are the only metals presently used for structural purposes among the eight elements constituting 98.6 percent of the earth's crust. Others of these eight, each of which makes up more than 2 percent of the earth, are oxygen, silicon, calcium, sodium, and potassium. The other 84 known elements form together less than 1.4 percent.

The basic pattern of the long-range future of metallurgy thus becomes clear: Alloys of more common elements with relatively minor amounts of other scarcer elements will form the bulk of our future metals.



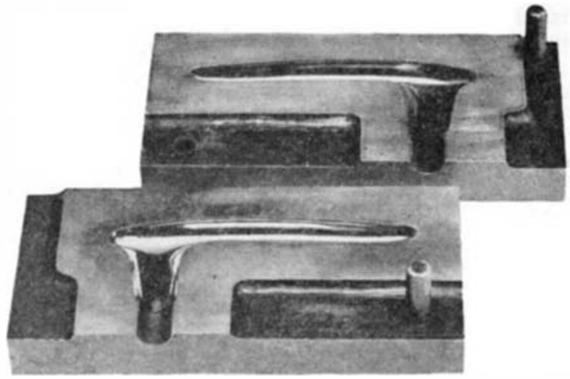
Before the aluminum solidifies in these molds in the casting building of a Reynolds Metals Company plant, a worker skims the surface to remove the dross

RARE METALS—Less remote in time is the increasing use of many metals, some of them considered excessively rare, to perform specific functions. The stringencies of our war-time economy have brought out many of what may be classed as "chemist's" metals and given them important war-time jobs. Some of these are strange to the metallurgical world but most of them are further developments of less important applications in minor use before. While the total amount of all these newer metals is insignificant in comparison with iron or the other common metals, yet the services they perform are quite disproportionate to their amounts. The number of these metals, too, is relatively large.

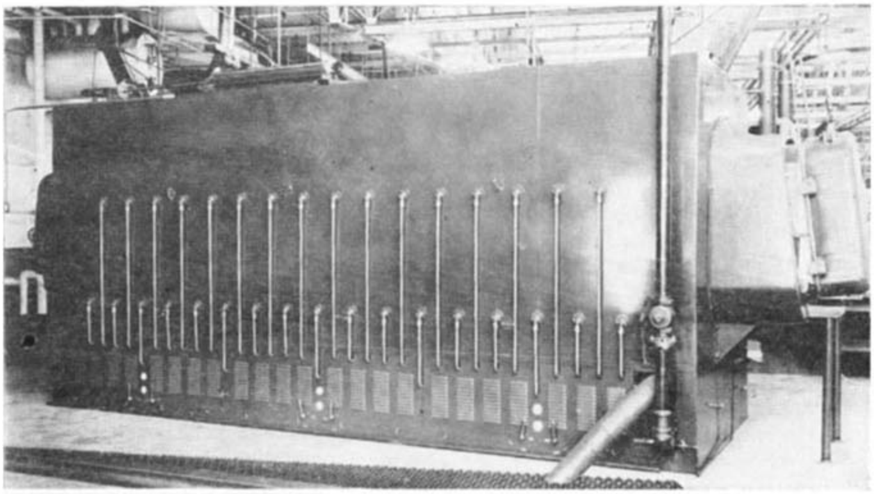
The metal indium, for example, has proved to be extremely valuable in bearings of aviation engines where its resistance to wear and corrosion as well as its low frictional resistance makes it particularly valuable as a surface layer. Furthermore, thin plates of indium on silver reduce the latter metal's tendency to tarnish and preserve its high reflectance characteristics. Minimum amounts of indium added to soft solders made of lead and silver impart better flow properties to the alloy and otherwise improve it.

Lead-silver alloys, containing only small amounts of the more valuable metal, are proving as good as or better than the accustomed lead-tin alloys as soft solders. While their present use is necessitated by a war-time shortage of tin, they may well survive competition with tin solders when these are again available.

Beryllium possesses properties of high value in alloys, particularly with copper. Soft malleable copper, to which 2 percent or so of beryllium is added, remains non-sparking and otherwise retains copper's properties



In certain types of molding, and with most plastics, beryllium-copper makes possible molds having extremely smooth surfaces and from which the molded parts emerge with a good finish



Courtesy The Lithium Company

In this heat-treating furnace, lithium is vaporized in amounts sufficient to absorb all oxygen and water vapor in the air or on the steel being treated, thus providing a protective atmosphere which is completely neutral and therefore harmless to steel

but in cast form has a hardness of about 400 Brinnell. That places the alloy in the class of hardness of cast steel and permits it to be used for molds for plastics, for example. The ability to cast molds for plastics, instead of cutting and machining them laboriously from tool steel, materially cheapens this expensive part of the molding business. Copper-beryllium alloys also possess high elasticity and can be fabricated into springs which are both non-magnetic and resistant to atmospheric corrosion. Furthermore, beryllium affects copper's electrical conductivity only slightly as used.

Beryllium also imparts hardness to other metals even when added in small percentages. Aluminum and nickel are susceptible to beryllium additions and become hard and wear-resistant thereby.

Lithium is used as an alloying element for imparting stiffness to aluminum, in high conductivity copper, welding light metals, and for a number of other uses.

Tantalum possesses extraordinary resistance to corrosion, particularly by hydrochloric acid. For this reason it has found important usefulness in the construction of plants for the manufacture of this acid. The fact that it is a metal possessing high heat conductivity, in contrast to previously used stoneware, permits the tantalum plant to be much smaller than accustomed installations and to attain high efficiencies through effective cooling of the reaction zone.

This corrosion resistance of tantalum also makes it valuable in orthopedic surgery. Splints of the metal attached directly to the fractured bones are not affected by body fluids and hence need not be removed after healing is complete. Tantalum, in addition, has the property of electrical rectification when used as one electrode in an electrolytic cell.

Columbium, a metal associated with tantalum and resembling it in many ways, is useful in high-temperature alloys as well as in electrolytic rectifiers. The need for high temperatures in internal-combustion turbines and other machines makes this metal important.

These metals are still rather definitely in the chemical category, but show important promise of development into metallurgical metals. Their special properties give them unusual value in modifying and amplifying supplies of more common elements for metallurgical purposes. They are typical of a larger number finding new usefulness in the rapid development of special metals to meet urgent war needs.

THE LIGHT METALS—Pure electrolytic manganese is similarly a chemical metal which has recently become vitally necessary for alloying with magnesium and aluminum. Manganese is by no means new to metallurgy and in the form of ferro-manganese is a valuable refining agent for steel and a toughener for alloys. The development of aluminum and magnesium on a highly extended scale has greatly emphasized their alloys, among which those with manganese are particularly important. The iron content of ferro-manganese prevents its use with these metals because the iron, which can be neglected in steel manufacture, is highly objectionable in aluminum and magnesium.

Thus necessity has fostered the development of electrolytic manganese on a substantial scale to help in the applications of light metal alloys. This fact has had further significance because the electrolytic operation uses a solution of manganese as its raw ma-

The heavy machinery operations in connection with magnesium production, according to The Dow Chemical Company, use equipment which is essentially standard, the variables being in procedures rather than in machine design. Magnesium tubing can be extruded on equipment used for producing brass tubing; magnesium sheet is being rolled on mills designed for copper and brass and, if necessary, could be produced on steel strip mills with few complications

terial and this can be readily prepared from relatively low grade ore.

Flotation, one of the most significant processes of modern beneficiation, intimately binds chemical industry and metallurgy together. The original process, depending upon the selective ability of foam to float out particles of one kind alone from a mixture, was developed for the improvement of low-grade ores otherwise unprofitable to work. It uses a variety of flotation and foaming agents to accomplish its selections and these are produced by the chemical industry especially for the purpose. Thus metallurgy depends upon chemistry in this field.

But chemical industry also uses flotation in its own operations. Removal of sulfur of colloidal dimensions from the setting baths of the viscose rayon process can be successfully accomplished by flotation, an important fact, since more usual methods are ineffective. A special application of a similar technique is the removal of metallic particles from the emulsions used as cutting oils in machining operations. In a way much more like the customary metallurgical operation, chemical industry employs the flotation principles and process to concentrate certain of its raw materials (phosphate rock, for example) and to remove impurities from certain of its solutions undergoing processing.

MAGNETIC SEPARATION — Modern developments of electromagnetic and electrostatic separations have had important implications in the chemical as well as the metallurgical fields. The separation of minerals which come as mixtures from other separation processes (tabling, flotation, and so on) can sometimes be accomplished by taking advantage of slight differences in either magnetic or electrostatic susceptibilities. It is not necessary, for example, that either of the materials separated be what is ordinarily considered magnetic. A slight difference in susceptibility to charge or magnetism is often sufficient to deflect particles of two kinds into slightly different paths and hence effect their separation.

Clearly a large part of metallurgy is indistinguishable from chemistry and one must look closely to find a basis for differentiating them. Most often the principal distinctions in the area of overlapping lie in the point of view of the one conducting an operation rather than in any characteristic of the operation itself. Continual borrowing and adaptation of the processes primarily designed for one purpose fit them for wider usefulness in the other field.

FUEL TABLETS

Ignite Readily, Give Hot Flame

FIELD rations of the United States soldiers will be heated (if at all) by tablets of metaldehyde, a polymer of acetaldehyde, according to a recent announcement by the Quartermaster Corps. Acetaldehyde, the raw material for these fuel tablets, is not on the critical list as are alcohol, formaldehyde, and other raw materials used in making competitive fuels. Army tablets of metaldehyde are one inch in diameter and one quarter inch thick. In that form the material does not absorb moisture nor does it evaporate. It also possesses high heating value and ignites readily to give a practically invisible blue flame.

BUTADIENE TACKINESS

Increased by New Phenol Materials

ONE OF the drawbacks of synthetic rubber, and especially of the oil-resistant butadiene type used in oil hose, gasoline hose, and other products exposed to oil or gasoline, has been a lack of stickiness or tack of the unvulcanized material. As a result, it has been difficult and expensive to unite parts or plies of synthetic rubber products because they would not stick together during preparation for vulcanization.

It is pointed out by The B. F. Goodrich Company, that, while softeners of synthetic rubber had been previously used in compounding the material, they did not provide tack, and that various tackifying solutions had later to be applied to the surface of the composition. Even this treatment did not give satisfactory tack to some compounds.

In a new Goodrich development, materials of the alkyl phenol class are incorporated into the compound by conventional factory methods either with the rubber as a solid or in dispersion. Use of the materials reduces the difficulties in handling synthetic rubber in manufacturing processes, such as calendering, extruding, or plying-up of successive layers of rubber or rubberized fabric.

BROAD FARM RESEARCH

Urged by Director Of Experiment Station

SCIENTIFIC research will, in the long run, lead to the most direct and reliable solution of farm problems, even though at first there may seem to be little immediate economic gain, according to Dr. A. J. Heinicke, Director of the New York State Experiment Station.

"The knowledge gradually developed by experiment station workers during many years of investigation concerning various phases of production, handling, and utilization of crops," he said, "has been an important factor in enabling a relatively small proportion of the total population engaged in agriculture to provide the large quantities of food required by our military forces and by civilian workers in this country and in many other parts of the world.

"We have had an abundant harvest of practical fruits of agricultural research, and it is fitting that we make the best use possible of all available fruits in this time of emergency even if some of them are still somewhat inmature or imperfectly developed. However, the tree of knowledge upon which we depend for these fruits may fail to produce year after year unless the roots have nourishment and room for spreading. Advantage should be taken of every opportunity to explore new and promising ideas, even if they do not show immediate practical value."

CLOTH TAPE

Treated Against Fungus For Tropical Shipments

A FUNGICIDE treatment is now used in manufacturing Mystik Self-Stik Cloth Tape, making possible the protection of shipments and products against fungus growths, which have proved ruinous to many war materials, particularly those shipped to the South Pacific area. Such precision equipment as radio, radar, and aircraft instruments as well as aircraft fuselages are among the many items that must be protected against fungus attack.

The fungicide is applied to all components of the tape: the cloth, the adhesive, and the backing which impregnates the tape against water, moisture, salt spray, gases, and other damaging elements. The tape is used as a seal in packing and as a protective covering when applied directly to the product itself.

WEED KILLER

Offers Boon to Grass Lawns

NEW control of weeds is promised by a chemical which can be sprayed on a grass plot without injury to the grass itself. Experiments by the Bureau of Plant Industry of the United States Department of Agriculture show that 2, 4-dichlorophenoxyacetic acid (2-4-D for short) in a concentration of five parts in 100,000 of water is effective in killing broad-leaf weeds but harmless to grass.

PLATING ALUMINUM

Accomplished by Means of Surface Treatment

A NEW process for pre-treating aluminum gives it a surface upon which copper or silver can be electroplated. After the usual cleaning, the aluminum is dipped in a solution of a patented mixture of salts which form a plateable alloy on the surface. The treated metal can then be plated with copper or silver in the usual manner. On this first plate other metals may be subsequently plated if desired. Not only can decorative and corrosion resistant platings be made in this way, but the adherent plate can be soldered in the ordinary manner. The process, called "Alumon," is now employed in war work.

Microradiography

A Powerful New Tool And Technique, The Microradiographic Application of X-Rays in Metallurgy, Not To Be Confused with the Familiar Radiography to Which It Is An Auxiliary, Is Giving Aid in the Improvement of Existing Alloys and the Development of Many New Ones

By S. E. MADDIGAN
Research Physicist, Chase Brass and Copper Company

METALLURGISTS, in the examination of metal surfaces with the optical microscope, have long recognized two serious weaknesses in this procedure: (1) The polished surface under observation provides only a plane cut through the details of the metallic structure; this very frequently does not offer adequate evidence of the true shape of the details and in many cases is misleading. (2) The identity of chemical composition of phases, inclusions, or other details under observation can be determined only as a result of long experience and by the use of complicated etching techniques.

As a result, the methods of metallographic microscopy have retained much of the nature of an art rather than an exact science.

The newly developed microradiographic technique, on the other hand, is able to give an indication of the three-dimensional contours of details in the metal structure and is able to indicate the distribution and identity of the chemical components in a precise manner.

The new technique may be considered as an extension of the normal radiographic process. Radiography as commonly practiced reveals the presence on a gross scale of voids, blowholes, and cracks in the metal. Microradiography, on the other hand, discloses the distribution on a microscopic scale of minute voids and even of the alloy constituents. In the latter respect it closely resembles the commonly used optical microscopic methods, but the information obtained is more extensive.

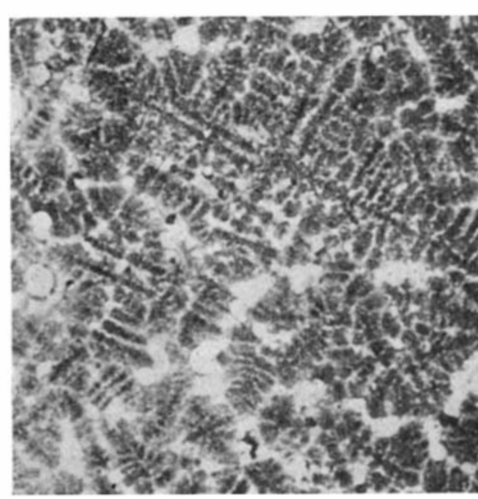
Photomicrographs of polished, etched metal surfaces made in the usual way reveal the metal structure and distribution of phases in the surface only. This information is of extreme value in the development and production of alloys. The microradiograph, however, goes still further in showing the distribution throughout the interior rather than on the surface alone and at the same time provides a definite identification of the chemical elements in the various phases. [A phase is a physically distinct, homogeneous part of an alloy. —*Ed.*]

The additional information provided by this new technique is amply demonstrated by Figure 1. The photomicrograph on the left shows that in the alloy of 80 Cu-10 Sn-10 Pb two phases exist, in addition to the dark particles of segregated lead. The microradiograph on the right shows the actual distribution of the elements copper, tin, and lead. The improvement inherent in the new process over the old method is clearly indicated to the experienced metallurgist.

POTENTIAL USES—The previous discussion at once makes evident the wide potential fields of use for the microradiographic method. In any application of metals where the shape or distribution of phases or segregated particles is of importance, such as, for example, machinability, then it must be recognized that the older methods of investigation using optical microscopy were insufficient, and the microradiographic technique becomes essential. In the development of new alloys involving ternary, quaternary, or even more complex systems, this new technique provides a clear picture of the distribution of the alloying elements and, when used for comparison with photomicrographs, offers extensive information not otherwise directly obtainable. After some experience the method may even be used to identify the composition of unknown microscopic inclusions under conditions where the spectroscopic methods of analysis are of no value.

The microradiographic method depends on the difference in absorption of x rays by the different chemical

Figure 1: An alloy of 80 percent copper, 10 percent tin and 10 percent lead. Left: Photomicrograph (75X) showing a two-phase system, in addition to black lead particles. Right: Microradiograph (100X) taken with cobalt radiation at 30 kilovolts. Copper-rich regions are dark, while tin-rich regions, also lead particles, are light



elements. Thus, in an alloy structure, constituents having different chemical compositions will absorb different percentages of the incident x-ray beam and can be recognized by the different degrees of blackening in the resultant shadowgraph. For optimum contrast, however, special precautions must be taken. A better understanding of this can be obtained by analogy with photographs taken by visible light.

Both x rays and visible light are manifestations of the same phenomenon of electromagnetic waves. The region of x rays and of visible light both consist of a range of wavelengths; in a beam either of x rays or of visible light a considerable range of such wavelengths will be found. In x rays, however, the wavelengths will be very much shorter than in visible light. A beam of ordinary sunlight or white light consists of a large range of wavelengths, identified by differing colors, which when mixed together, are identified as white light. Suitable apparatus can readily split up this white light into its component colors.

HOW IT WORKS—A simple experiment, using equipment available to the average person, will serve to demonstrate the underlying principles involved in microradiography. This requires some pieces of colored glass and the nearest traffic signal light. Observation of the traffic signal through a piece of deep red glass reveals that, while the operation of the red light can be seen with normal clarity and the yellow light with moderate ease, it is almost impossible to tell whether the green light is on or off. In a similar way a piece of deep blue glass will allow one to watch the operation of the green light but will almost completely obscure the red light. This means that the red glass obtains its color because it transmits red light unimpeded but almost completely absorbs contrasting colors such as green or blue. In like manner, blue glass transmits similar colors such as green but absorbs contrasting colors such as red.

Suppose, now, that an amateur photographer wishes to photograph a scene containing quantities of the color red and the complementary color blue-green. The record obtained on the photographic film will be of rather poor quality since both the red and the blue-green light will affect the photographic film and low contrast will be obtained. However, if a red filter is placed over the camera lens, high contrast is obtainable since the light from the blue-green regions is absorbed and does not reach the photographic film. The light from the red regions, on the other hand, passes through the filter unimpeded to strike the photographic film, and one thus obtains strong black and white contrast. Equal contrast could be obtained by using a blue filter which would absorb the red light but allow the passage of the blue-green light. In this way a strong contrast would again be obtained but the regions of black and white would now be reversed on the negative.

In a similar manner in microradiography, a beam of x rays with wavelengths chosen indiscriminately will probably reveal the alloy constituents with rather poor contrast. High contrast can be obtained in a manner analogous to that used for the photographic case described above. In the case of x rays, however, the control of wavelength is accomplished not by the use of filters but by suitable selection of x-ray target material, or the use of appropriate tube voltage.

The emission from an x-ray tube, as shown in Figure 2, consists of two parts: (1) The "white," or "continuous," background radiation (shown in dotted lines) which covers a considerable range of wavelengths and which shifts to shorter or longer wavelengths depending on the voltage. (2) The "characteristic" radiation (shown in solid lines), superimposed on the "white" radiation, which consists of discrete wavelengths depending on the material of the x-ray target but not on the voltage.

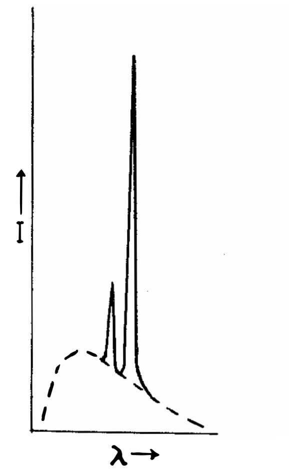


Figure 2: A typical distribution of wavelengths from an x-ray tube. Dotted curve shows the intensity of white radiation, while the solid line that of characteristic radiation

As will be disclosed, both types of radiation must be considered in obtaining conditions for optimum contrast in the radiograph.

THIN SPECIMENS—The basic procedure for microradiography consists of passing an x-ray beam through a small region of a thin, almost foil-like, specimen and allowing the transmitted beam to impinge upon a special photographic plate placed in close contact with the specimen. The x-ray target material and operating voltage must be carefully selected to give the best contrast. The Eastman Type 548-0 spectrographic plate possesses sufficient resolution to allow the resulting radiograph to be magnified optically by 100 diameters or more. At such magnifications the microscopic distribution of the alloy constituents is clearly revealed in the characteristic shadowgraph.

In order to accomplish the purpose of the technique it is necessary to prepare thin sections of metal of the same order of magnitude as the details or inhomogeneities to be examined. This is necessary for two reasons: (1) The exposure time increases rapidly with the thickness of specimen and, depending upon the constituent elements, thicknesses should be from 0.010 down to 0.001 inch. (2) It is obvious that the overlapping of shadows from a large number of inhomogeneities occurring at different depths in the specimen would cause considerable blurring of detail. Therefore the specimen must be thin enough so that there will not be too much overlapping of shadow details.

From the latter standpoint the necessary specimen *thinness* depends on individual conditions such as size and concentration of inhomogeneities, also on the degree of contrast produced by the difference in absorption between inhomogeneity and adjacent material. For most copper alloys it is desirable to have a specimen thickness of less than 0.005 inch in order to reduce exposure time, but it is seldom necessary to have less than 0.002 inch.

PREPARATION—Such thin specimens are best prepared by a grinding and polishing technique which closely resembles the methods used for the preparation of metallographic specimens. Upon first consideration the preparation of such thin specimens may appear to present great difficulty. However, with a little practice the preparation technique is not unduly arduous and should not deter anyone from using the method.

Specimens should be flat and of essentially uniform gage as first received. Samples of sheet stock satisfy these requirements very well. If castings or large sections are to be studied, specimens should be cut from them so as to satisfy the requirements. This can be accomplished by making parallel cuts on a milling machine or on a cut-off saw provided with a suitable guide or clamping mechanism. As thus cut the specimen will be relatively thick (1/16 to 1/8 inch) and with a surface too rough for direct use and must be subjected to further preparation.

One side is polished on emery papers of varying grades to a final finish at least equal to that obtained on 3/0 French paper using an oil film. The specimen should then be mounted in a Lucite molding with the polished face inward and one unprepared face outward. Then in a lathe the second surface is turned down parallel to the polished face until the sample reaches a gage of about 0.010 inch. From this thickness it should be hand polished until approximately the desired final gage is reached (0.005 inch or less) The surface should then be finished off on French papers to the same degree as the first surface. The entire procedure requires about the same time of preparation as for a good metallographic specimen. The foil-like specimen, after removal from its mounting, is radiographed as previously indicated.

The radiographs may be enlarged by the use of a microscope with transmitted light. This is accomplished with a metallographic microscope by placing the radiographic plate on the stage of the microscope and directing rays from the light source through the radiograph by means of a 45-degree mirror attached to the stage.

The difference between the absorption of x rays in two materials is in general greater for x rays of longer wavelengths.

The absorption coefficients of metals when plotted against the wavelength of x radiation yield discontinuous curves. The sharp changes or discontinuities occur at different wavelengths for different metals. Also, when used as x-ray emitters, different metals yield, in addition to a general radiation of many wavelengths, one or two wavelengths of high intensity which are characteristic of the particular metal, as shown in Figure 2. By matching these characteristic radiations against the absorption discontinuities for the elements to be examined, it is possible to obtain high differences in absorption between the constituent elements of the alloy without having recourse to the long wavelength, long-exposure time techniques. X-ray tubes with cobalt, copper, and molybdenum targets provide radiations satisfactory for most work with copper alloys.

PARTICLES IDENTIFIED—With several x-ray tube targets available, it is possible to make a chemical identification of inhomogeneities in the alloy by the absorption effects observed; for example, in Figure 3, which shows a copper-zinc-iron alloy, it was possible to identify the small segregated particles as containing iron, since microradiographs with a copper tube showed these particles with strong contrast whereas those with either copper or molybdenum tubes did not show the particles. A consideration of the absorption curves for copper, zinc, and iron showed that such results would be characteristic of iron particles contained in a copper-zinc alloy. In this particular case it was already known from other information such as magnetic tests that the particles shown were iron; however, application of this principle to other cases where the composition of inclusions or segregated particles is not known becomes evident at once.

The author has used the technique for the examination of samples too numerous to be described here. These, however have demonstrated beyond any doubt that the microradiographs give distinctly new and valuable information.

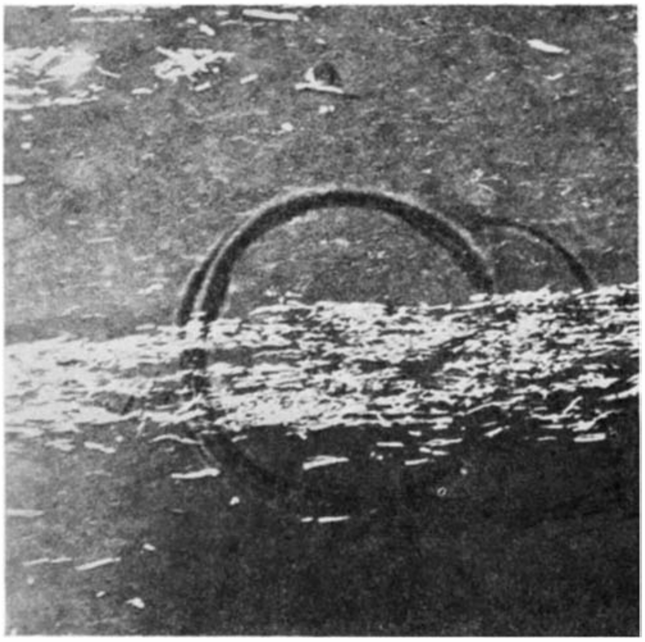
As an example, in studying lead-bearing free machining brasses, photomicrographs usually showed the lead segregated into more or less rounded particles. Microradiographs showed that in many cases the lead was actually distributed in elongated, irregularly shaped stringers. Even the lead particle size indicated by the photomicrographs was frequently quite misleading. Apparently the manifestations seen in the photomicrographs were merely cuts through various parts of the main stringers or their links.

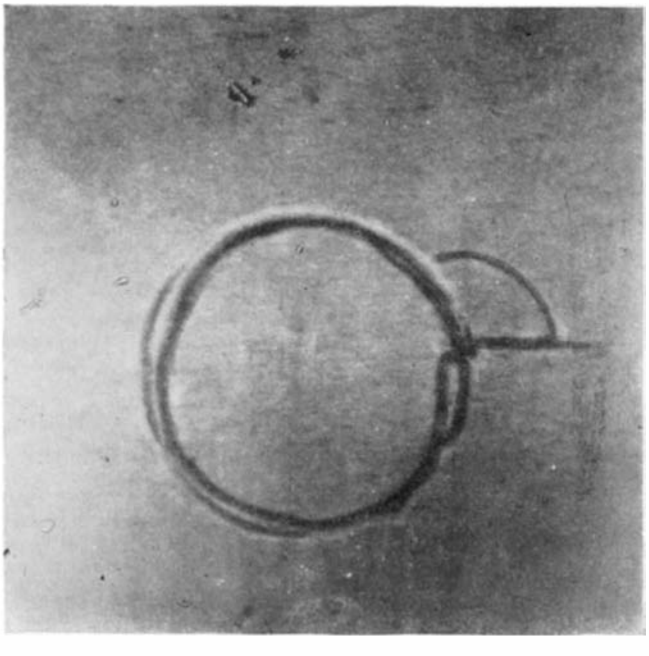
Again, in the examination of a forged copper-zinc-tin alloy, the photomicrographs showed the tin-rich phase as isolated lakes in the alloy structure. The microradiographs, on the other hand, revealed that the tin-rich areas of the photomicrographs were linked together by further tin-rich material along sinuous subsurface paths.

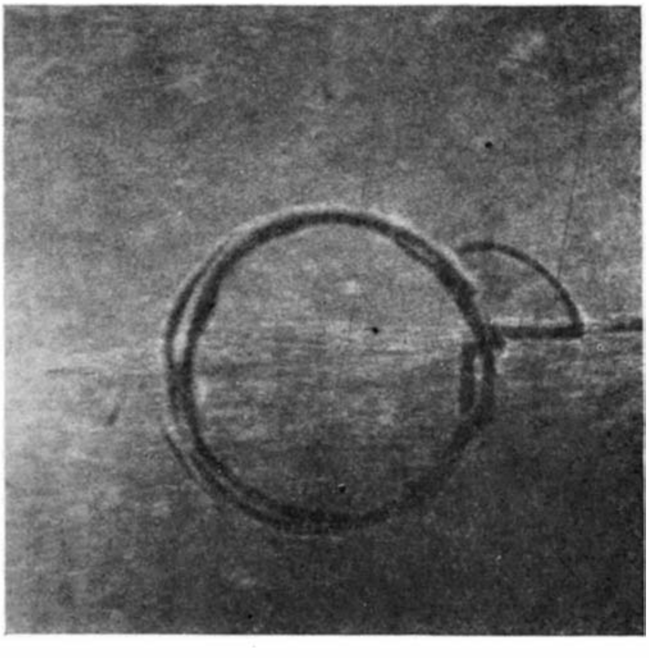
In some cases the new method has been used where normal metallographic methods were very arduous due to etching difficulties. In such cases, since no etching is required for the microradiographic examination, it was possible to obtain evidence of particles which, when examined by optical methods, were either obscured or dissolved away during the etching.

This discussion should give some indication of the possibilities inherent in the new technique. The method is probably not destined to replace the well established procedures of metallographic microscopy. Rather, it should be considered that it is a new tool auxiliary to the optical microscope and that, by proper correlation between the two, much new information will be gained.

Figure 3: Three microradiographs of an alloy of copper, zinc, and iron. Right: Taken (100X) with copper radiation at 30 kilovolts, this one shows segregated iron particles as white against a dark background. Below, left and right: Taken respectively with molybdenum and cobalt radiation at 30 kilovolts, these show practically no trace of the iron particles





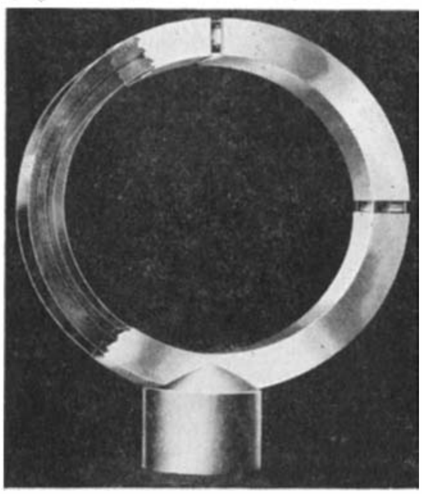


Plastics Plus Metals

Additional Uses for Both Materials are Supplied by Skilful Application of Techniques Now Developing. Metal Coatings for Plastics Take Advantage of Characteristics Not Found in Either Material Alone. Metal Inserts and Assembly Devices Offer Diversity to the Designer

START a discussion on plastics and metals and in a matter of seconds the subject is no longer "plastics and metals" but "plastics versus metals." It is the all too general opinion that an advancement for one of these materials means a set-back for the other.

The long list of products—in large part of a military or essential civilian nature—in which plastics have replaced metals during the last few years



A pure silver shield, electroplated on the plastics housing surrounding the coil of this loop antenna, eliminates the effects of the operator's body and near-by metal objects, at the same time protecting the unit under severe operating conditions

has tended to confirm this opinion. And it has completely overshadowed the fact that these two materials, when skilfully combined to take advantage of the characteristics of each, provide additional outlets for *both* metals and plastics that would not exist for either one alone.

A case in point is the plastics-metal cylinder which constitutes one of the most vital parts of the fire interrupter for a .50-caliber machine gun mounted on certain Curtiss-Wright airplanes. This device prevents the turret gunner from firing into his own plane. The problem was to construct a plastics cylinder, approximately eight inches long and six inches in diameter, whose surface is entirely covered with a layer of silver except for one small area in the shape of the profile of the airplane. When the part is complete and installed, an electric current of about ⅛ ampere at 24 volts, supplied through a fast-acting relay and solenoid, passes through the metal layer. The line of demarcation between the plastics and metal surface must be very sharp to insure an accurate and complete make or break of the electric contact when an exploring point passes over it.

ELECTRICAL USES — Some of the most valuable plastics and metal applications have been in the electrical field. For example, instrument boards on a plane must have a metal backing which serves as a shield. Until recently, large rectangular phenolic laminated sheets, with holes of varying sizes cut out from a large part of the surface, were backed by an aluminum panel. Satisfactory shielding can now be obtained by metal plating the reverse side of the plastics panel.

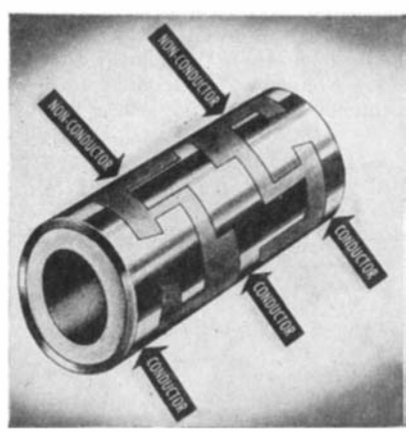
In this same field, metal plating is now being extensively used in the manufacture of intricate commutating surfaces, both flat and cylindrical. This is accomplished by molding or machining grooves in an insulator, then electroplating the desired metal in these grooves until they are filled, and finally machining or grinding the surface. A wide variety of designs is obtained by this method—some having grooves as narrow as 0.005 inch. The need for soldered joints may be eliminated by electroplating connectors between specified conducting surfaces in the same operation.

In the electronics field, the sensitive loop antennas for direction-finding are also shielded by metal plating to eliminate the effects of the operator and nearby metal bodies. This type of shielding is also found advantageous on molded junction boxes, commutator housings, and conduits in aircraft to keep brush arc noises and other interference out of the communication systems.

In the civilian field, the combination of plastics and metal offers many interesting examples. The possibility of partial plating, of design plating, or of covering the plastics entirely by the electrodeposition of metals—deposited singly or in such combinations as gold and silver over nickel or copper, to mention but two combinations—gives new latitude to the designer of household or personal items.

METAL COATING — While these examples illustrate the use of metals on plastics, not all coating operations are carried on in the same manner. The methods of applying a metal surface to plastics can be classified into those which apply the metal without electroplating and those which involve electroplating. The former division includes metal spraying, metal evaporation, cathode sputtering, and chemical reduction to yield a metal film.

In metal spraying, the metal in the form of a wire is atomized in a special oxy-gas or air-gas gun and blown onto the plastics being coated. This method produces a brittle coat with a granular surface which limits its application. A further disadvantage is that each piece must be individually handled by an experienced operator. Another limitation is the necessity for using a low-fusing alloy, such as lead-tin, so that



Electroplated plastics commutators have no gap between insulator and conductor, common in assembled units

the plastics will not be burned or softened. If coatings of other metals are desired, they must be plated on top of the initial coat.

Metal evaporation and cathode sputtering methods are relatively expensive and are used only in special cases where the exact duplication of the contours of the underlying surface is necessary—as for sound recording or light reflection—or for production of a film of a metal which cannot be applied by other methods. Both methods involve the use of vacuum chambers.

In metal evaporation, the metal is contained in a small crucible or is in the form of a filament. It is subjected to high heat which causes the evaporation of metal atoms that condense on the plastics and all other cool surfaces in the vacuum chamber. In cathode sputtering, the plastics is placed on or near a metal surface which is made the anode. The metal to be deposited is made the cathode. Under the influence of a high voltage—10,000 volts or more —metal ions leave the cathode and deposit on the plastics.

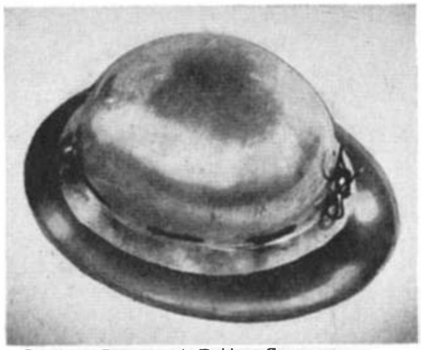
ELECTROPLATING METHODS — When electroplating is used, the surface of the plastics must first be made conductive. This can be accomplished in several ways: By applying waxes and then coating with graphite; by applying lacquers or varnishes containing metal powders; by chemical reaction to yield an electrically conducting compound; or by chemical reduction to produce a metal film or bond coat. The conductive coat is often called the bond coat.

To form the bond coat, application of conducting waxes, lacquers, or varnishes is the oldest of all the procedures, but is gradually being replaced by other methods which require less time or produce more even deposits. The wax method involves coating the object with warm liquid wax, allowing it to cool, and then dusting with graphite or spraying with a graphite suspension. Graphite is employed because it is attracted by the wax. The lacquer or varnish method involves brushing or spraying the plastics with a bronzing mixture which contains a relatively large amount of copper powder. An alternative procedure is to coat the object with a tacky substance and then to rub in a metal powder.

The application of conductive chemical compounds has interesting possibilities, but has not yet proved commercially feasible. One method involves coating the object with shellac, then immersing it in a solution of silver nitrate in alcohol, drying, and exposing it to hydrogen sulfide. This produces a film of silver sulfide which conducts electricity sufficiently well to permit electroplating.

The Metaplast process involves the production of silver films by chemical reduction and is the most widely used method today for coating plastics with metals. The major application for this film is as a conductive coat for electroplating. In this process, the plastic is sensitized with a solution of stannous chloride and then immersed in a silvering mixture composed of freshly mixed ammoniacal silver nitrate and a reducing solution, the main ingredient of which is formaldehyde. Many special variations for plastics have been worked out.

The electroplating process itself follows standard practice with minor variations. For example, since the conductive coat is very thin, a very high current density cannot be used initially on a large piece unless a number of contacts are made for distribution of the current. Furthermore, since the conductive coat is usually porous, highly acid or alkaline plating baths are avoided for the ester type plastics, such as cellulose acetate.



Courtesy Paramount Rubber Company

A plastics fireman's helmet, copper plated by Monroe Auto Equipment Co.

Metal as a coating on plastics is but one of the ways in which these two materials can be used in combination. In addition, there is the use of metal for inserts in all types of molded plastics parts and its use as a decorative inlay.

METAL INLAYS — Among metal embellishments for plastics, metal inlays are important since any design which can be cut from thin stock can be inlaid in plastics by one of several methods which have been developed for the purpose. Inlays may be molded into the plastics pieces or they may be put in after the piece has been molded—the latter procedure having proved to be the more popular.

In one well-known process for inlaying metal, the following steps are involved: A recess following the design of the inlay is made in the plastics material by use of a pantograph or engraving equipment; a thin strip of base metal, about half as thick as the depth of the recess, is then placed in the bottom of the recess; the inlay, which is made slightly convex, is placed above and supported by the thin metal strip, which is harder than the inlay; pressure is applied to the top. When this happens, the base metal causes the inlay to spread out on all sides, permanently locking the inlay in place.

ASSEMBLY DEVICES — There are many types of metal assembly devices that can be used to fasten plastics pieces together or to fasten a plastics piece to other materials. Which device is used in any particular instance depends upon considerations of strength, appearance, and adaptability to mass production. One method—metal inserts molded directly into the material —originated almost with the inception of the plastics industry.

Threads in molded plastics smaller than 1/4 inch in diameter are normally designed for screw machine inserts. Above this size, the designer may have his choice, the final decision resting upon the following rules:

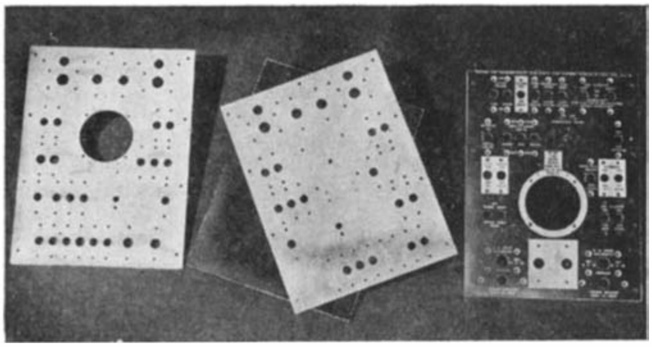
1. Is the assembly to be permanent or must the parts be disassembled at various times? If it is permanent, a molded or tapped hole in the plastic will be satisfactory. If not permanent, a metal insert is recommended.

2. Will a continuous substantial stress be placed upon the threaded assembly? If so, a metal insert is recommended. If not, tapped or molded threads may be used.

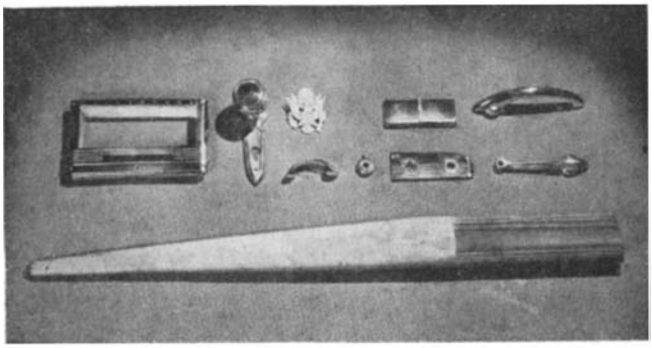
3. Must a close tolerance be specified for the female thread? If so, a metal insert is recommended.

4. If a choice is open to the designer, which means of assembly is less expensive?

On the basis of the answer to these questions a designer may use any of a variety of devices. Ordinarily, machine screws are used with inserts, but they can also be turned into holes tapped or molded directly into the plastics material. Metal inserts, instead of being molded directly into the



Instrument panels once made of phenolic laminated sheet backed by aluminum (center) are being replaced by plastics panels that are metal-plated on the reverse side (left). At right is front of new panel, plated by Metaplast Corporation



The successful metal-plated plastics articles shown here include handles, a chime frame, a knob and escutcheon combination, and an antenna mast. The mast (bottom) is made of compreg plated with copper. Base of mast is not plated plastics, may be pressed into machined holes. The greatest drawback in the use of ordinary molded-in inserts has been the fact that, once molded in the material, they cannot be replaced, since removal would damage the parent material. However, a newly developed replaceable molded-in insert has overcome these difficulties.

When it is not feasible to have molded-in metal inserts, and when holes molded or tapped directly in the plastics lack sufficient holding power, self-tapping or thread-forming screws that make their own threads in the plastic material can be employed. For the same reasons, hardened metallic drive screws which are hammered, pressed, or otherwise forced into a hole cored or drilled into the plastic material, may be used to assemble plastics parts.

When impact-resisting plastics are employed, riveted assemblies often prove acceptable. Speed-nut assembly is not widespread. Constituting an entirely different approach to the problem of attaching plastics to other materials, speed nuts and clips provide the necessary tension after assembly to compensate for any creep in the plastic material. The speed nut is an arched spring-steel fastening device with cam-like prongs which grip studs molded integrally with plastics parts.

Teamwork between plastics and metals has resulted in some interesting developments in a great many fields. With the experience gained during the war period behind them, it is evident that tomorrow's designing engineers will turn more and more to combinations of materials—utilizing each for its most valuable traits.

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DYED PLASTICS

Now Make Use of Water Dyes

DYEING clear plastics is by no means new, but use of water dyes is a distinct innovation. In the past dye usually was applied from a solution in acetone diluted with water. This dye, however, requires the most painstaking care because acetone, being a solvent, is likely to attack the surface of the transparent plastic sheeting and cause it to haze and craze.

Danger of harming the surface of a material during the coloring process has been mitigated by the Great American Color Company's introduction of a water dye which deposits color evenly and permanently without destroying the surface luster even though it is applied hot.

The dye has been worked out in yellow, rubine, red, sky-blue, royal blue, orange, black, amber, scarlet, purple, violet, green, and brown. It comes in a thick concentrate having the consistency of paste and this paste is instantly soluble in water. About 12 ounces of dye mixed with a gallon of water makes a little more than a gallon of the desired coloring. On this basis, one pound of dye will color 16 square feet of plastic material to maximum color strength.

The concentrate is added to cold water, then brought to the proper temperature for the best dyeing results. For acrylics the best temperature is 190 degrees, Fahrenheit; for acetate, under 140 degrees, Fahrenheit. The depth of color is controlled by the length of time the piece is submerged in the bath

SALT-TABLETS

Dispensed from All-Plastics Unit

FOR workers in industry, salt tablets are sometimes a year-round necessity. To meet the needs of these men and women for an efficient sodium chloride

It's made entirely of plastics

tablet dispenser, the Standard Safety Equipment Company has produced an all-plastics unit which provides protection against moisture and dust, resists salt corrosion, and stands up under hard usage.

Eleven parts—two formed of methyl methacrylate and nine of wood-flour filled phenolic—make up this unit. Despite the many joints and junctures, tablets are always dry and in good condition. This is because each piece is carefully designed to make a perfect match with adjoining pieces. In fact, only one rubber gasket is used in the entire unit.

DRINKING CUPS

Molded of Plastics, are Light and Rustless

ONE OF the more interesting civilian items to be made of plastics in the recent past is a collapsible drinking cup. Molded in a two-unit, ten-cavity die of Tenite II by the Plastic Die and Tool Company, these cups have the advantage of being extremely light in weight and impervious to the rust that often renders collapsible metal cups useless after a few encounters with water. These brightly colored Zip-sip cups, as they are called, are marketed by Plastic Molded Products.

PLASTICS SCREEN

Outlasts Metal Wire, Is Strong and Fire-Proof

WHEN our men began fighting in the Pacific area they found that they faced not one enemy but two. Tropical disease—carried mostly by insects—threatened to account for nearly as many casualties as enemy gunfire. It soon became apparent that a screen cloth was needed which would withstand the rigors of tropical climate and yet have strength and durability at least equal to that of metal. The answer to this problem was finally found in plastics insect-screen cloth.

Early in 1942, after testing various monofilaments, the Chicopee Manufacturing Company—well known in the cotton textile trade—began production of millions of square feet of insect-screen cloth extruded from a powder into a monofilament and then woven into a screening from the Saran monofilaments. A unique feature of this company's weaving process is the fact that standard textile equipment common to ordinary cotton textile operations is employed. Because of differences in characteristics of the plastics material as compared to cotton, some adjustments and modifications of the machinery have been necessary. The warp can be prepared on a warp beam or the warp filaments can be brought into the loom directly from the creel (the racks on which the spools of filament used in the warp are placed). This latter method, however, has distinct limitations because of the large amount of space required. In either operation, no sizing of the warp is necessary.

The screen cloth now being used by the Navy, for such applications as tents, is woven in 20 mesh and in a 29-inch width.

The success of this plastics in malaria control is attested by the fact that, by request of the Bureau of Medicine and Surgery of the Navy, it is now installed in the side walls of tents in the Pacific area. Experience to date has shown that this screening will outlast the tent canvas to which it is sewn as well as any type of metallic screening which has been used thus far in the Pacific area.

An unforseen virtue relates to the material's flame-proof qualities. The canvas used for the tents is treated with a fire-proofing compound during the process of manufacture. However, when subjected to repeated rains, this compound has a tendency to wash out—and the tent will burn to some extent. However, it has been discovered that if the bottom part of the flap to which the screen cloth is sewn does catch on fire, the flames will be halted when they reach the plastics material.

DUREZ

PHENOLIC RESINS

- MOLDING COMPOUNDS
- INDUSTRIAL RESINS
- OIL SOLUBLE RESINS

MOLDING COMPOUNDS

WORTH GETTING "STEAMED-UP" ABOUT

Ideal for home and hospital use, the Spartan (Minneapolis) vaporizer is a brand-new development in humidifying equipment. Entirely automatic, this streamlined product holds a full half-gallon of water and gives off steam immediately, even though the water is ice-cold. The unusual design and ingenious mechanical principle of this unit typify the progress being made by American industry in developing new products and improving old ones with Durez phenolic plastics. The unusual versatility of the more than 300 Durez phenolic molding compounds has resulted in their extensive use by manufacturers in practically all fields of industry. Their outstanding properties, such as excellent moldability, diversity of finishes, dielectric strength, and resistance to moisture, heat, acids and alkalies, render them invaluable to the progressive manufacturer with post-victory markets in view.

INDUSTRIAL RESINS

MAKING THE DUCK LOOK LIKE A PIKER

"Like water off a duck's back" doesn't half describe the waterproofness of a Durez 12688 bond. This room-temperature resin adhesive which sets at 75° F. was developed especially for assembly gluing and is completely impervious to water—whether it be ice-cold or boiling-hot. In fact, bonds produced with Durez 12688 are just as waterproof and durable as those in hot-pressed plywood. This remarkable resin opens up many new fields of which laminated lumber, keels, prefabricated housing, and framework parts for aircraft, boats, and buildings are but a few.

OIL SOLUBLE RESINS

HEADACHE CURE FOR A TAP DANCER'S WIFE

Durez phenolic resins lend toughness, mar-proofness, gloss retention, soap resistance, and fast-dry to floor paints . . . make for virtually indestructible floor finishes. The remarkable properties which these Durez phenolic resins impart to paints, varnishes, and enamels, render them invaluable to the manufacturer with a weather-eye on the future.

Although the above constitutes but a brief glance at the vast scope of Durez operations, it nevertheless may suggest an idea to the imaginative mind of a scientist. Durez technicians welcome intelligent ideas which may lead to practical industrial applications of Durez phenolics. As a matter of fact, they have actively participated in the successful development of many such ideas during the past quarter century. Because of the unusual versatility of Durez phenolics, this has been on a scale that is practically universal throughout industry. Durez molding compounds, industrial resins, and oil-soluble resins are all the result of intensive research . . . research which is carried on continuously so as to insure the leadership of Durez phenolics in their respective fields. For further information, write to Durez Plastics & Chemicals, Inc., 524 Walck Road, North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

Partners In Production

A Series of Pincers Attacks by Mechanical Engineers and Metallurgists Has Resulted in High-Speed Copper Machining, Better Band Saws, Tougher Cams, Improved Metallizing Methods, and a Number of Other Industrially Important Developments—And the End Is Not Yet in Sight

FOR A GREAT many years, no one tried to machine copper if he could avoid it. The tools would cut all right—tool steel will go through copper like so much cheese. But the trouble was that, unless production speeds were kept low, the copper would tear at the cut surface. Threads intended to be smooth would have jagged edges or even be stripped from the work on which they were being produced. Contours would be pitted and gouged. Work would be spoiled.

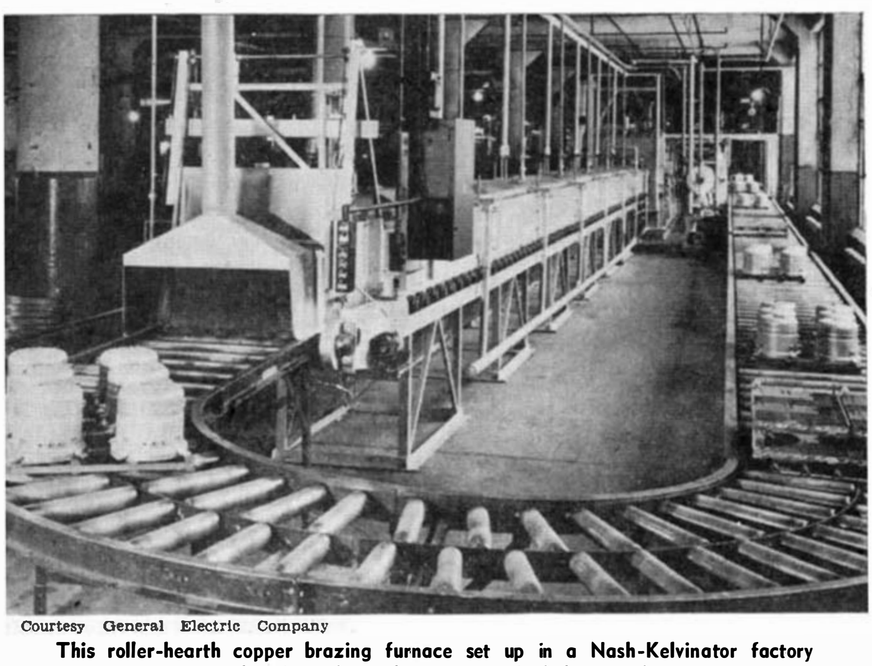
Mechanical engineering never stopped trying to lick this problem. Copper resists corrosion so well and is such a good conductor of both heat and electricity that it was needed in machined forms in plenty of assemblies.

Tools were ground to one rake angle and then another, various combinations of machining speeds and feeds were tried, cutting oil research men contributed all they could. Slowly the ability to machine copper was improved. But it was not improved enough to make machined copper parts as useful to industry as they might be.

While the mechanical engineers were doing all of this work the metallurgists were busy, too. In fact, copper machining was to be one of those classical examples of a pincers attack upon a production problem—the mechanical engineers operating one jaw of the pincers and the metallurgists the other.

TELLURIUM HELPS — Metallurgy found that alloying tellurium with the copper would improve the machining properties. In one case a production machine which had been running at 924 revolutions per minute while machining copper was stepped up to 1161 revolutions per minute by changing the stock to Revere tellurium-alloyed copper, with no change in the value of the product.

This is more than a 25 percent increase in speed. In peace-time, with the time of a production machine worth from $2 to $5 an hour, such an increase would be worth from $.50 to $1.25 an hour for every machine used on this operation—it could be worth from $1000 to $2500 a year for each machine. And in war-time, this means that four machines will do the work for which five formerly were required, thus freeing the fifth machine and its operator for other badly needed work, or that copper parts desperately needed at the firing lines can arrive there 25 percent faster.



Courtesy General Electric Company

This roller-hearth copper brazing furnace set up in a Nash-Kelvinator factory is one more example of mechanical engineering's help to fabricators of metal

At this point the mechanical engineer stepped in again. The machine was adjusted to increase the feed; the tools were re-ground to produce a finer finish. Soon the machine was turning out 63 pieces in the time formerly needed for 36. And this was not the end. The machine in use was turning as fast as its gears and spindle bearings would permit and was cutting as deep as its motors had the power to force the tools. Only stronger, faster, more powerful machines will find out all that tellurium in the copper can do for this operation.

These more powerful machines are available. If they were not, then new ones would be designed. For this is the nature of the co-operation between mechanical engineer and metallurgist. Each in turn improves his work until he poses a serious problem for the other. The mechanical engineer will bring out a machine to cut tellurium copper faster than the metal can "take it," then the metallurgist will bring out another alloy which is better than the machine, and in a few years the machining of copper will be no problem at all.

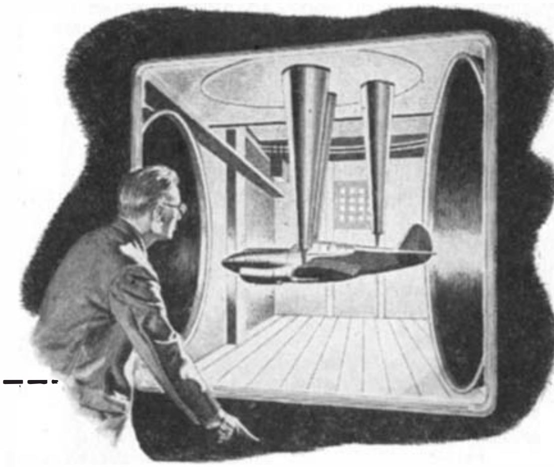
SAWING METALS—Metal-cutting band saws are another example of what happens when metallurgists and mechanical engineers make a pincers attack on a problem.

More than 15 years ago the metallurgist brought out a specially tough and strong steel which would permit metal-cutting band saws to be narrow enough for contour cutting. There were limits to the speeds at which cutting could be done. The saw teeth would not clear themselves of chips if traveling at too many feet per minute through the work.

Mechanical engineering designed a Buttress type saw tooth which would clear itself. The saw is of coarser pitch (has fewer teeth per inch of length) than the types formerly in use. With coarser pitch the deep, sharp gullets

In a wind tunnel an AERONAUTICAL ENGINEER uses a 40,000 horsepower electric motor to create a 400-mile-an-hour tornado for testing war planes.

... the name on the MOTOR is Westinghouse.

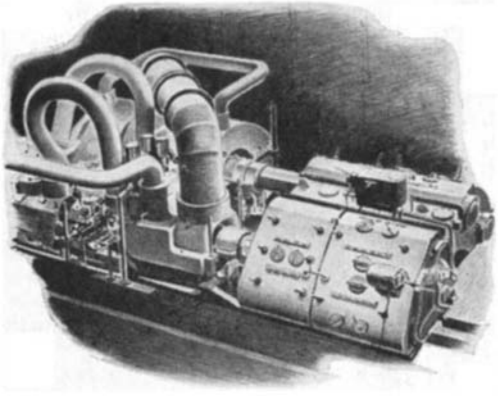


In a factory a WORKER assembles delicate bomb-sight parts in air made dust-free by the Precipitron* electrostatic air cleaner.

... the name on the PRECIPITRON is Westinghouse.*

In a penicillin plant a SCIENTIST uses a Sterilamp* bactericidal tube to protect this life-saving drug from contamination by air-borne bacteria.

... the name on the STERILAMP is Westinghouse.*



On America's largest aircraft carriers the NAVY uses steam turbines which make our carriers the world's fastest.

... the name on the TURBINES is Westinghouse.

TODAY – These are some of the ways in which Westinghouse products are serving in the war effort.

TOMORROW – Existing and new products of Westinghouse research and engineering will serve industry and the home.

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

*TRADEMARK REG. U.S. PAT. OFF.

Tune in: JOHN CHARLES THOMAS—Sunday 2:30 pm, EWT, NBC. TED MALONE—Mon., Tues., Wed. Evening, Blue Network between the teeth could be eliminated. This made the saw stronger, permitted the saw maker to take more advantage of the strength of the steel which the metallurgist had given him.

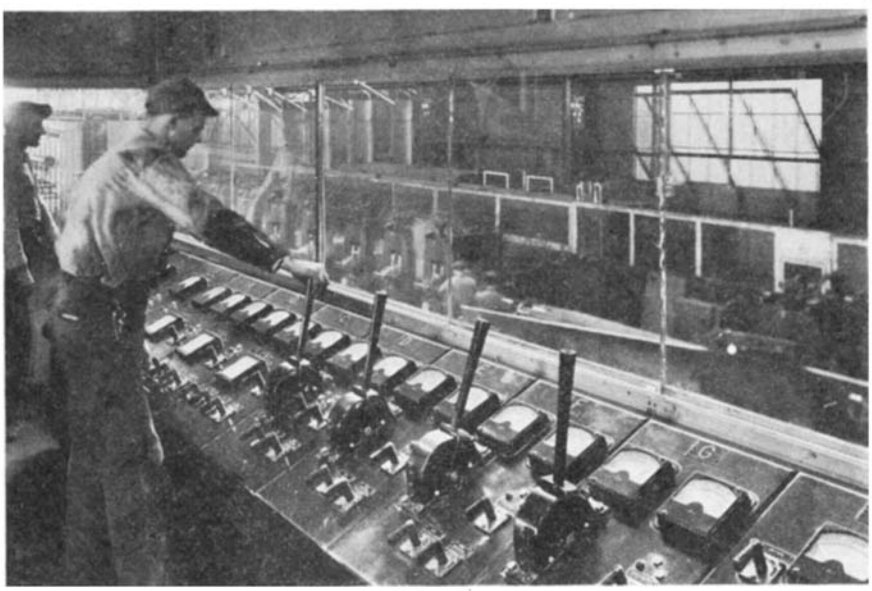
Now the engineers had a saw capable of working at far higher feet per minute, but did not have a machine to pull it. The design and research men solved this problem, too. They had to make their machines more accurate than ever before, put more power at the command of the machine operators, and, beyond anything else, get rid of all vibrations. But they got their machines.

Soon the saws were working at 4000 feet per minute, and 5000, and even 10,000. This opened brand new fields to straight line and to contour band sawing.

No one knows where the limits of this improvement will be. While the mechanical engineer is finding out what can be done with his faster sawing speeds the metallurgist is peering over the shoulder of the saw operator and dreaming up a new kind of saw steel which will make the engineer go running to his drafting board to work out a still more powerful machine.

Welding is another field in which the mechanical engineer and the metallurgist are pinching off problems.

The manufacturer of a mechanical refrigerator wanted to have intricate shaped but rust-free condensing units.



Operating pulpit of a continuous strip mill in a big Bethlehem Steel plant. Metallurgy developed a steel uniform enough to be rolled in this way while mechanical engineering worked out the machinery and the temperature controls

Brass was one material which would not cost much, could readily be stamped or drawn into the desired shapes, and would not rust.

But could the brass parts be fastened together by any such inexpensive method as stitch welding? The refrigerator engineers put this problem up to the metallurgists of a copper and brass company.

Stitch welding depends upon the generation of heat by electrical resistance in the materials to be welded. Ordinary brass would not do; it would generate far too little heat for welding.

The metallurgists solved this by putting a little silicon into the brass. This gave the metal all the electrical resistance needed and did not harm the rust resistance nor create any problems for the brass forming machines. In fact, the brass now can be welded at higher production speeds than the welding machines are prepared to handle. And so once more the metallurgist has put the engineer on his mettle.

METALLURGY IMPROVES CAMS—Control mechanisms for automatic machines are less costly to vary now that the metallurgist has taken his part in the production of them.

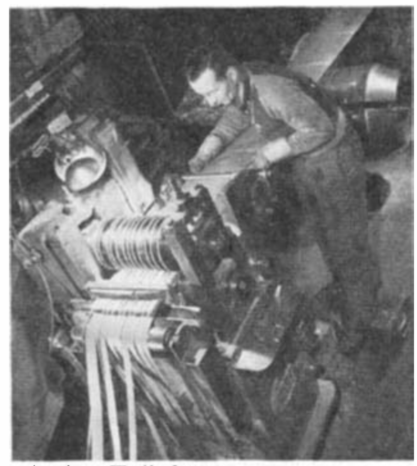
Many automatic controls are actuated by cams. Cams accordingly are found on automatic screw machines, woodworking machines, candy-making machines, brick-making equipment — it would be a rare factory which had none of them. Their odd shaped contours are easy enough to design. The trouble is that these contours often must be accurate enough so they will actuate motions which are figured out to several decimal places. This means expensive machining processes if those contours are to be generated from solid round or square pieces of metal. And with just a little wear many of the cams would be useless. Hence they must be made of hard, tough, abrasion-resisting materials which are difficult to machine.

Metallurgy stepped into this difficult situation with an air-hardening steel which can be cast to shape. Cam shapes from companies like Allegheny Ludlum Steel Corporation are cast so accurately that, even though they have both interior and exterior working surfaces so that several cam followers will move simultaneously along different parts of the same cam, the machine builder or the repair man can finish his cam by removing less than one eighth of stock from any working surface of the casting. Better still, this steel hardens with very little distortion and is extremely resistant to abrasion.

One result of this is to lead the mechanical engineer to design more intricate cam-actuated controls. He knows that the cams can be made cheaply enough so their cost will not make his machine too high in price.

Another result is to permit the production engineer to step up his operating speeds, and to redesign his cams for more exact controlling of special machine indexing and other motions. He knows that he can replace his cams at low enough cost — if indeed these tough cast alloys wear out and need replacing — so he dares to work to unusual accuracies and to place heavy loads on these mechanisms.

When the mechanical engineer has gone far enough in these directions he will be demanding still tougher and stronger cast cam shapes. But then, with metallurgy developing as it is right now, he will be getting them



Courtesy Westinghouse

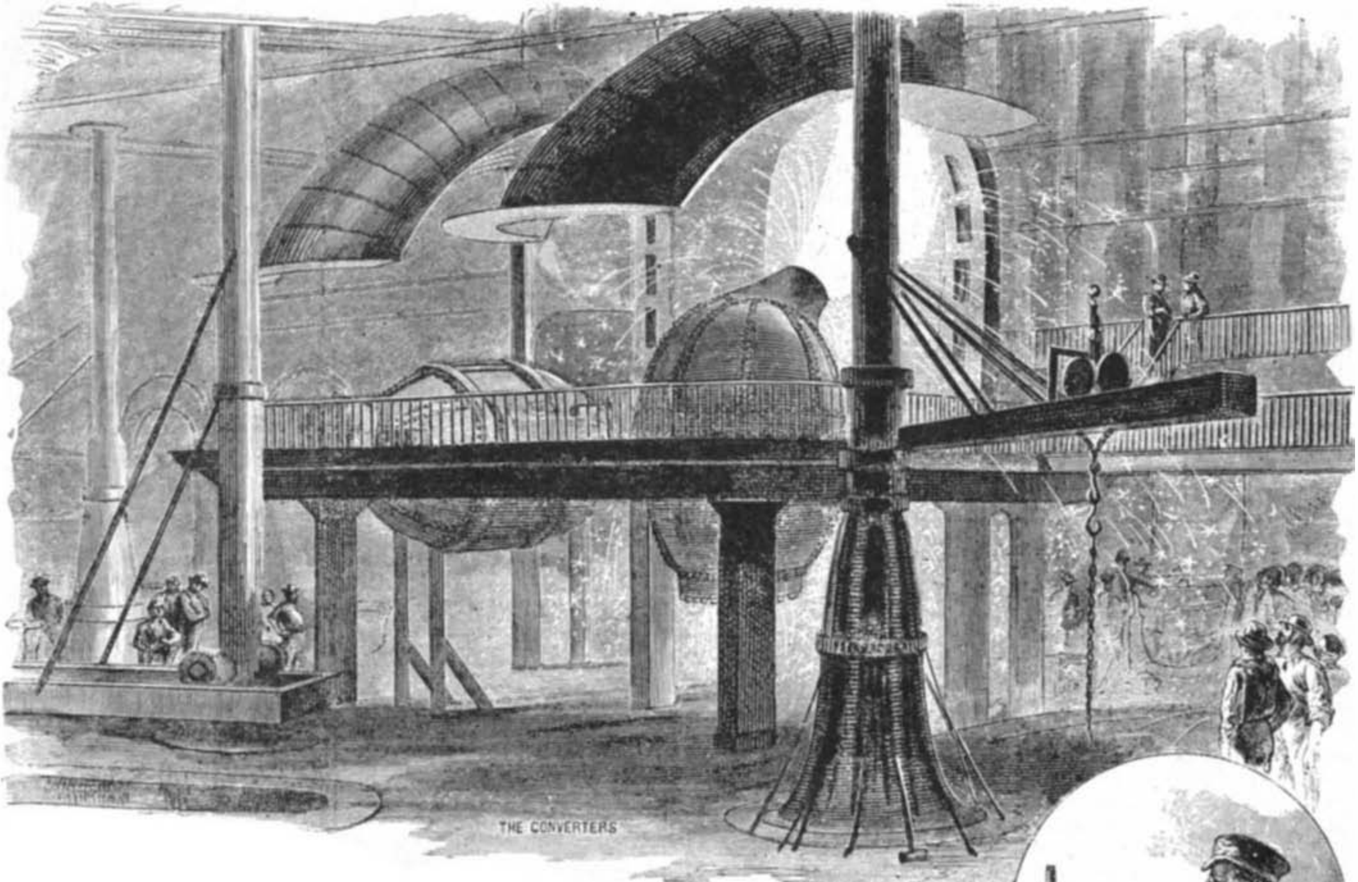
Hipersil steel is here being cut in a slitting machine for use in transformers, saving other scarcer metals

even before he is ready to use them.

Cast to shape tool steel dies, such as those made by the Jessop Steel Company, are a similar case. They take some of the worst burdens from heavily overloaded tool rooms. Punch press dies can be replaced at minimum cost; the fear that these dies might be mishandled and ruined disturbs the sleep of production men far less than it used to. And tool and die troubles do not stand in the way of planning for low cost stamping, drawing, or extruding, the way they formerly did. The cast to shape electric tool steel dies can be finished with a minimum of machining operations, then hardened, and they are ready to mount.

Cast to shape punches, special rolls, knives, and other tools are figuring in hundreds of war product reconversion plans, thousands of post-war schemes. Somewhere along the line the mechanical engineers will ask for qualities which present cast tool steels do not have.

METALS IN WRAPS — Coated metals, such as the copper coated strip steel made by the Thomas Steel Company, are results of dual attacks by metallurgists and mechanical engineers. The metallurgists worked on the alloys and the means of making those alloys



Above, reproduced from an old steel engraving, is one of the first successful converters constructed during the last half of the 19th century.

STEEL AND CRANE CO. STARTED TOGETHER

Ninety years ago, when R. T. Crane opened his little foundry, men were just learning how to convert iron—that age-old metal—into steel.

It is an interesting coincidence that the first patents for making steel were granted in 1855—the year R. T. Crane founded his business. At that time few realized the tremendous part this newly developed metal would play in America's great industrial expansion.

It is a far cry from the simple little charcoal-burning converter of R. T. Crane's time to the giant steel mills of today. And during the years that saw this growth, Crane Co. grew, too—providing valves and fittings that were essential to the vast industrial expansion of the last 90 years.

Today modern industry is inconceivable without valves, fittings and pipe. Crane—the world's largest manufacturer of piping equipment—is a familiar name wherever water, steam, air, oil or gas flows. No matter what the piping system, Crane can equip it 100%.

CRANE CO., 836 South Michigan Avenue, Chicago 5, Illinois

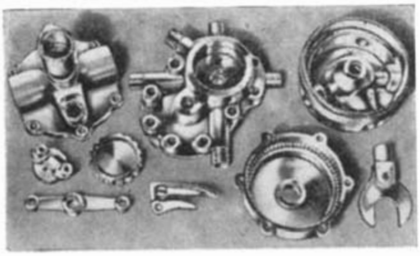
CRANE

90 YEARS OF PROGRESS 1855 1945

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

BRANCHES AND WHOLESALERS SERVING ALL INDUSTRIAL AREAS cling together; the mechanical engineers produced the rolling and the coating equipment.

Now that they are here, the coated metals are finding no end of uses. Put two pieces of copper coated steel together, apply heat, and a brazed joint is produced to make a corrosion-resistant assembly. Steel is especially coated to improve welding, soldering,



Mechanical engineering made possible these hot pressed forgings produced by the American Brass Company. They have many advantages over castings

tinning, and plating. Lead coated steel can be drawn to unusually fine dimensions.

Metallizing (spraying of molten metal) is constantly finding new uses with the help of metallurgists and mechanical engineers.

When the process first arrived some 25 years ago, only a few low melting point metals such as aluminum and tin could be sprayed. But mechanical engineers went to work on improving the metal heating and spraying equipment, and metallurgists brought out special alloys which sprayed well.

Soon the process was being used to apply hard surface coatings and stainless steels and bearing metals. Engineers added lathe techniques, tumbling barrel methods, and others to handle the parts being sprayed. Deep threading of parts so that the sprayed metals could take better grips and fusing welding rod to hard surfaces to help the sprayed metals to take hold, are recent helps which the engineer has given the metallurgist. But the metallurgist has new alloys coming along; he soon will be opening new opportunities to the mechanization of metallizing.

At Westinghouse, the mechanical engineer has developed a "millionth of a second" x-ray photographing technique for studying machine parts in action. High speed engine valve stems, for example, are "shot" while in full speed operation. From such pictures the engineers will redesign the valves to give more strength where strength is needed, take out some of the weight, stiffen a section here, and overcome the tendency to bend and distort elsewhere.

Attacking the same problems as revealed by the same pictures, the metallurgist will show how to make the same improvements and get better results by changing the alloys and the heat treatments. Metallurgists and engineers will share the problems between them, and each will challenge the other by giving him new opportunities to apply his art.

Such is the path of mechanical progress. The mechanical engineer makes one kind of attack on a problem, the metallurgist another. Between them the problem is reduced.

MAINTENANCE

Costs Railroads Far More than Factories

RAILROAD maintenance bills for the nation as a whole run from 28 to 30 percent of total railroad income. This is just ten times as high—percentage-wise—as the 3 percent or less which is common to large factories.

The total main line railroad maintenance bill for 1943 was $2,546,309,009. This is as big a target as modern maintenance-reducing products ever have had to shoot at. Reduction of this bill, both percentage-wise and dollarwise, will keep the best mechanical engineering brains of our nation busy for many a post-war year. There is practically no mechanical product which railroads do not buy and use, and therefore almost every industry will find a market for its most durable products in the railroad field.

GLASS INSULATION

Increases in Use Through New Applications

IN THE pre-war year of 1938, Westinghouse Electric and Manufacturing Company used $38,000 worth of fiber glass for coil insulation. In 1944 this company used $1,500,000 worth. Nearly all the increase was due to new applications, only a little being accounted for by greater use for old applications.

Glass insulation is permitting the manufacture of dozens of special motors which could not operate if insulated with the materials formerly used. Main benefit of the glass is to allow the motors to operate at higher running temperatures.

INSPECTION TOOL

Provided by Torque Wrench

TORQUE wrenches have scales built into them by which their users can tell the exact amounts of torque which are applied in tightening nuts. Use of these wrenches has added high degrees of precision to the assembling of automobiles, aircraft, and fine machines. But the wrenches are slow, as any hand tools must be. Therefore, assembly departments have built automatic torque control devices into electrical and other powered nut runners, screw-drivers, and similar devices for applying threaded fasteners.

The trouble is, these devices do not have human intelligence. They will stop turning the threaded device at a predetermined number of pounds or ounces of torque but they can be fooled by a speck of rust on the threads, a change in the amount or lubricity of the oil on the threads, slight roughness on a surface, and the like. They do not always tighten the threaded devices to exactly even tensions.

An answer to this is to use powered wrenches for assembly and manual torque wrenches as inspection tools. The inspector may check up every nut, bolt, or screw on an assembly, or he may spot-check a few of them.

Back of the torque wrench is the mechanical instinct, the "feel," the personal know-how of the inspector. It is the old story of mechanical devices never displacing the craftsman, but merely taking from him the drudgery tasks and moving him along to the work which takes brains as well as training.

MATERIALS HANDLING

Expedited by Use of New Angle Rails

GUIDING of dollies, trucks, assembly stands, and other wheeled materials-handling devices to the exact locations desired has long been a materials-handling problem.

If these devices were wheeled along the floors, they tended to create ruts, spall out, or otherwise break up patches of hard flooring materials and do other damage. Furthermore, they could be deflected from straight-line travel or be spotted in such locations as to be hazards to workmen or interferences to aisle traffic.

One answer to these problems has been to roll the wheels on steel tracks. But the tracks brought problems of their own.

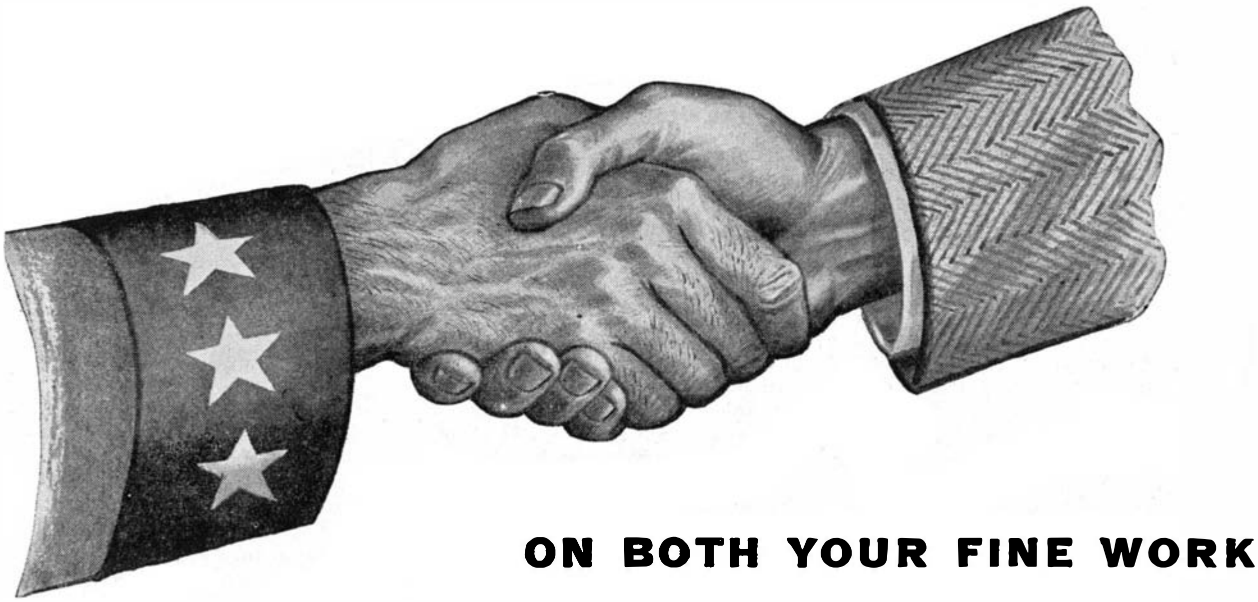
An answer to these problems, provided by the Bassick Caster Company, is a flat strip of steel with an angle iron welded apex-upward to one side of it. When the strip is laid on the floor the angle iron becomes a sloping sided track on which grooved wheels can run.

The grooved caster wheels can have wide enough treads on both sides of the grooves so they can be rolled on floor as readily as on the angle irons. Thus trucks which move along these tracks can be removed and rolled to places which the tracks do not reach.

The tracks are not dirt-catching hazards; due to their sloping sides they offer little tripping hazard to workmen; other wheeled traffic can be moved across them.

These angle-iron tracks with the grooved caster wheels to run on them are not "cure-alls" for wheeled factory traffic. There still are plenty of materials-handling problems which are best solved by wheels that roll directly on the flat floors, plenty of others for which the flanged wheel, which is certain to keep on the track, will be preferred. But in these days of dolly and truck assembly-line methods, this new angle on wheeled traffic control is finding plenty of use.

CONGRATULATIONS...



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Drawing It Out Fine

Wire Drawing Today Is a Complex Series of Precise Operations Which Depend Upon Accurate Dies and the Careful Regulation of Lubricants and Drawing Speeds. The Drawing of Fine Wires Necessary in Many Electronic Devices is Expected in Itself to Grow into a Major Industry

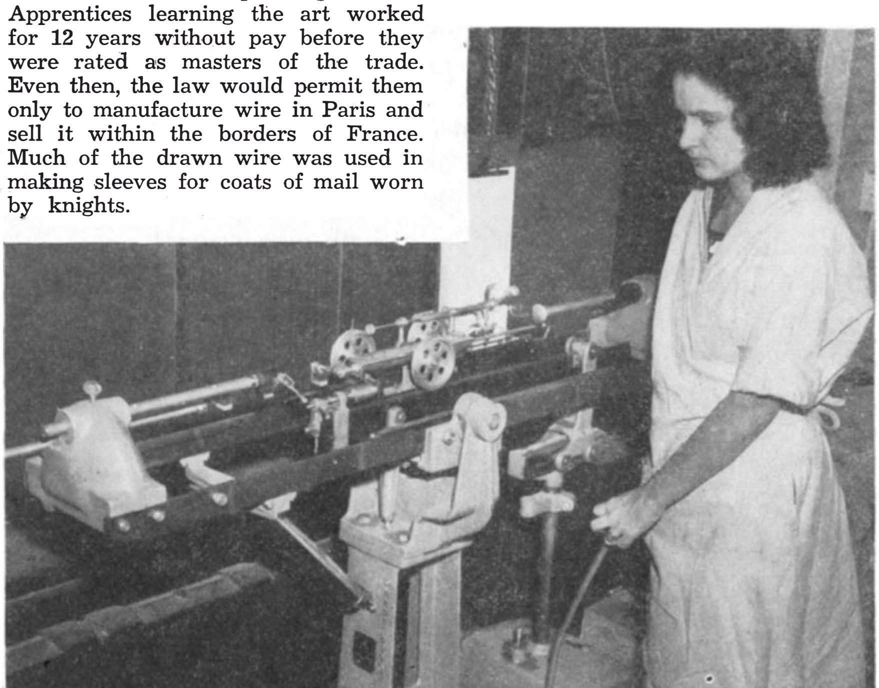
By ROBERT L. ZAHOUR
Technical-Commercial Manager, Wire Division, North American Philips Company, Inc.

WIRE DRAWING is an ancient skill. The monk, Theophilus, writing about 1000 years ago, described a wire-drawing die in these words. "Two pieces of iron, three or four fingers wide, smaller at the top and bottom, rather thin, pierced with three or four rows of holes through which wire may be drawn." In those days the work was performed on crude wooden draw benches. Where heavy gage wire was being drawn, the pulling was accomplished by a shaft or drum driven by a water wheel, capstan, or a system of hand levers. Finer wire was drawn through a die by hand from one drum to another. Small dies were made by piercing holes of desired shape and diameter in a steel plate. Larger ones were made in two metal sections held tightly together with metal bolts. Butter or lard was used for lubrication.

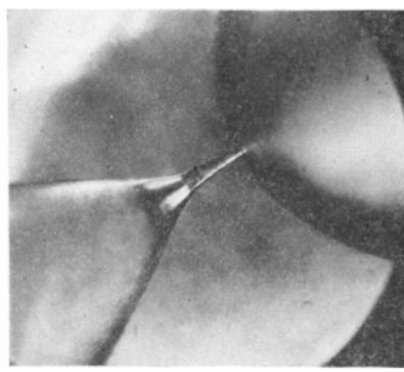
By 1270 A.D., eight wire-drawing establishments were operating in Paris. Apprentices learning the art worked for 12 years without pay before they were rated as masters of the trade. Even then, the law would permit them only to manufacture wire in Paris and sell it within the borders of France. Much of the drawn wire was used in making sleeves for coats of mail worn by knights.

In 1350 A.D., Rudolph of Nuremburg, Germany, established a wire-drawing mill which he extravagantly claimed to be the first in the industry. The modern industry of wire drawing, however, began in Denmark in 1564 when Queen Elizabeth and Queen Anne authorized wire-drawing mills in order to make pins for the royal household. Earlier, pins had been hammered from thin metal strips.

In America, the wire-drawing industry began in 1666 when Nathaniel Robinson of Massachusetts applied to the Commonwealth for financial assistance and permission to start a mill. He was turned down. Similarly, in 1667, Joseph Jenks applied and met with a refusal. In 1775 Nathaniel Niles set up the first wire-drawing mill in Norwich. Two years later, White and Hazard started a plant in Pennsylvania. From that time on, the industry progressed rapidly throughout the nation. Today, wire ranging from heavy cable to sizes below .001 (made of various metals and alloys) has become a vital part of our daily life.


This Scott tester measures the elongation and tensile strength of fine wire

DRAWING FINE WIRE—Many critical factors must be considered when fine wire is drawn accurately and uniformly round to narrow physical and electrical tolerances. In general, these factors cover selection of proper lubricants and diamond dies, careful regulation of drawing speeds and annealing


A long channel die is used for drawing fine, hard wires. The one shown here is magnified about 40 diameters

processes, as well as exacting determinations of draft—reduction—of diameter. Many refinements have been made to accomplish greater precision in physical and electrical characteristics of fine wires. This is particularly true where narrow tolerances must be met in electronic applications. A modern motor-driven machine for drawing fine wires is equipped with 16 or more dies arranged in alternate series. Wire to be drawn is pulled through the dies by means of coned pulleys and is spooled at its smaller diameter—all within a few feet of space. For some types of fine wire the draft (or reduction) through each die is approximately .0003 inch. One machine, for example, can draw from .0046 inch to .0012 inch at a speed of nearly 3000 feet per minute. However, this toler-

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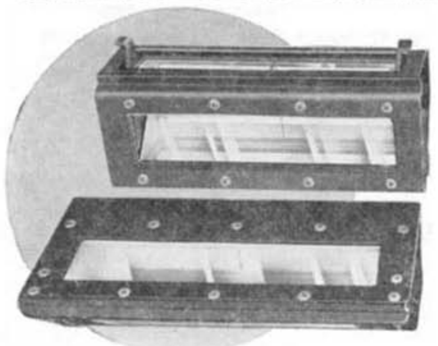

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able reduction will vary, depending on the hardness characteristics of the metal alloy. In general, fine wires have a small reduction per die while larger wires are given heavier drafts.

Since some wire alloys harden faster and create more heat and die-wear than others as they pass through the dies, hard alloys must be drawn at speeds slower than those for soft ductile metals. For this reason, drawing speeds for different wires vary from 100 feet to 5000 feet per minute.

Accurately drilled diamond dies are

An operator threads wire through one of the several diamond dies on a modern power-driven wire drawing machine

carefully selected for the type of wire to be drawn (hard or soft), and are held in rectangular boxes constructed to permit constant circulation of pumped lubricant around each die. This method minimizes die wear since it provides constant and thorough lubrication of the dies at all times and carries away much of the heat generated during the drawing operation.

COLD WIRE DRAWING—With the exception of molybdenum and tungsten, most fine wire alloys are drawn cold. In other words, they are given no preheating auxiliary treatment before the wire enters the die. Careful preparation of dies and selection of effective lubricants is therefore extremely important. Here are a few pertinent facts:

(1) In manufacturing diamond dies, a great deal of attention is given to drilling the channel. For drawing hard alloy wire, the channel is made long and narrow. For softer, more ductile metals, the channel is short and wider. Care and skill must be applied in shaping the channel so that wire of a given hardness can be drawn with the least die-wear and wire breakage.

(2) In drawing fine wires of .002 inch diameter and smaller, the reduction seldom exceeds .0002 to .0005 inch for each die. Particularly where ductile metals are involved, heavier drafts may develop non-uniform diameters due to excessive elongation or stretch.

(3) Channel walls of the die must be polished smooth and must be absolutely circular. A die that is defective in this regard will impart a rough, scratched surface to the wire and produce wire of non-uniform diameter.

(4) Use of proper lubricants is extremely important so as to avoid rapid die-wear, heating, and hardening of the wires drawn. In drawing wire of a large diameter, fatty or heavy oil emulsions are used. For fine wires, light lubricants (such as soap and water) are constantly applied. Hence, the size of wires drawn, their degree of alloy hardness, and drawing speeds all have a definite bearing on the choice of lubricant.

(5) Some alloys harden quite rapidly after passing through a few dies. For this reason, the wire will soon break if not annealed. Where this condition develops, as in the case of resistance wires, the metal must be annealed. This is done in a specially constructed oven that utilizes a reducing atmosphere coördinated with constant temperature regulation.

CHECKING FOR TOLERANCES—Even the slight or varying pressures exerted by a micrometer, when used for measuring the diameter of fine wires, introduce a large percentage error. This usually results in exceeding permissible tolerances. Hence this method is never used. Accurate measurements are made by means of a precision torsion balance that is calibrated to measure to 0.2 milligrams or less. A unit length of fine wire is weighed on this balance and average diameter is computed from weight and density of the alloy. Roundness of the wire is checked by viewing a cross-sectional area through a micrometer microscope.

Tensile strength and elongation characteristics are measured on a Scott tester which charts the results on a card. This information is very vital in determining rapidity with which fine alloy wires harden when drawn through a series of dies. Thus, the drawing operation may be regulated to allow for annealing stages in the entire run. Failure to recognize this alloy-hardening property will cause much die-wear and wire breakage. Then, too, the customer's specifications frequently call for definite elongation limits in the finished wire. These requirements must be met with proper annealing followed by tensile and stretch tests.

Ohmage of resistance wires is accurately checked on a Wheatstone bridge

Fine resistance wires, used in the manufacture of precision resistors for electronic devices, must be held within specified tolerances in ohms per linear foot. As the wire progresses through various drawing stages, periodic tests are made. A sample, accurately cut to one foot of length, is measured on a Wheatstone bridge.

The rapid advances in recent years in the field of electronics have greatly increased the demand for precision-manufactured fine wire products. It is safe to predict that this field of the wire-drawing technique will soon become a major industry in itself. In this development it will make a great contribution to the new ways of production and of living that the increasing application of electronics in industry will bring to the world.

FUNNYISM

Results if Designers Do Not Understand Engineers

"Engineers must know more about and give more attention to esthetics in design and be ready to work with the modern architectural or industrial designer," said Professor J. K. Finch, Renwick Professor of Civil Engineering and Associate Dean of the School of Engineering at Columbia University, in an address delivered recently before the Metropolitan Section of the American Society of Mechanical Engineers. "At the same time," Professor Finch stated, "the modern designer certainly must know more about engineering unless he is satisfied to create a false, make-believe, pseudo-functional type of design."

In a paper entitled: "The Evolution of Design," Professor Finch said that the modern trend in design involves both the engineer and the artist, but it "very clearly originates in the approach and methods of the engineer. The modern designer—industrial, architectural, or artistic—cannot undertake functional design with success unless he has a keen and clear understanding of the engineering approach to design. Functionalism leads only to funnyism unless it is based on understanding."

VISUAL STANDARDS

Should be Raised for Post-War Jobs

Prominent among the many problems of readjustment to post-war jobs that will face millions of men will be that of visual handicaps, points out M. J. Julian, president of the Better Vision Institute.

"In striving for more efficient production, industry increasingly is paying attention to job qualifications of individual workers. After the war there undoubtedly will be carried out extensive screening of employment applicants in many fields of endeavor," says Mr. Julian. The visual abilities of workers will receive closer scrutiny in the selection of men for jobs. It is now recognized that sight qualifications of workers often have an important influence upon productive output.

"There seems to be little question that industry generally will raise visual standards and that workers with neglected eyesight in the competitive post-war period of readjustment will be forced to tune up their eyes to get and to hold jobs.

"Besides a demand for sharp vision for the general run of jobs, workers with above-average visual skills will be sought for certain specialized tasks. Greater attention will be paid to choosing workers with good eye coördination, or muscle balance, for jobs that require precision workmanship, or which call for long periods of close focusing. In some factory operations, persons with poor muscle balance are hazards to themselves and other workmen.

"Depth perception is another visual skill that will be sought in the eyes of men working around moving machinery. Depth perception is the ability to judge distances and the relative position of objects. It is very desirable in truck drivers.

"On some jobs good color perception is essential, both for safety and productive efficiency. Unfortunately," continues Mr. Julian, "there are many men who cannot distinguish colors easily. While eyes can be sharpened with glasses to see clearly, relatively little can be done for color-blindness, which is a hereditary condition. Even so, visual training is said to improve the ability of some color-blind persons to distinguish colors.

"Very probably more attention also will be given to the seeing habits of workers. Persons have habits or patterns of seeing just as they have habits in holding tools, or gaits in walking. Efforts will be made to coördinate desirable patterns of seeing with certain jobs. For example, some persons see things faster than others. Slow eyes that might be entirely satisfactory for a clerical position would be unsuitable in many machine operations.

"After the war," concludes Mr. Julian, "America undoubtedly will strive for new goals of productive efficiency. Eyes right for the job will be needed by the post-war worker."

BEAUTY BUSINESS

Will Build Firmly on Lowly Coal

A BILLION-DOLLAR post-war business in women's daytime and evening apparel, accessories, perfumes, and cosmetics, all stemming from coal by-products, was presaged recently at a preview of advance fabrications given by the Bituminous Coal Institute. The theme of the showing was a forecast of the future availability of such personal feminine luxuries as softer lingerie, frillier dresses, sheerer hosiery, lighter weather-proof outer wear, and finer costume jewelry to almost every woman, through reduced manufacturing costs made possible by the chemical transformation of coal and its by-products into women's apparel and articles of adornment.

A feature of the exhibit was a filmy dance frock, fashioned from a chiffon-like material derived from coal and chemically treated with its by-products to make the dress wrinkle- and spot-proof. Silk and rayon fabrics similarly treated to render them water- and fire-proof as well as wind-resistant also were displayed.

Woolens, made moth- and shrink-proof with coal derivatives, attracted special attention. When so treated, it was reported that the finest woolens can be washed with cottons and other materials without shrinkage. The treatment is said to be permanent and to make no appreciable change in the appearance, texture, or warmth of the fabric while the color fastness and wearing qualities are stated to be improved.

Many new plastics, reported to be less brittle, stronger, and more heat- and wear-resistant than any previously produced, have been developed primarily for military purposes. Although the widespread civilian use of such materials must wait until the end of the war, shoes having plastics tips, soles, and heels already are obtainable.

To demonstrate the hardness and permanence of plastics finishes, a table with a surface made from coal derivatives was used as an ash tray by guests at the exhibit. This was pointed up as a promise of the durability of new laminated plastics-bonded furniture soon to be available.

New Products and Processes

PHENOLIC RESIN

Aids in Producing Hard Synthetic Rubber

ONE of the toughest problems confronting the synthetic rubber industry is the processing of synthetics to reproduce the characteristics and properties of hard and semi-hard natural rubber stocks. Chemical science has now found an answer to this problem. Research engineers of the synthetic rubber manufacturers and the plastics industry have evolved a method of processing most synthetic rubber with a Durez phenolic resin whereby very excellent hard and semi-hard rubber stocks can be produced. To date the use of this resin has been confined to Buna S and Buna N, but it is known that the resin is compatible with neoprene and also with natural rubber. Its use with other synthetics is being investigated.

The Durez resin which has been formulated possesses the very useful characteristic of softening synthetic rubber during the milling or processing of semi-hard and hard rubber compounds. Because of the peculiar stiffness of synthetic rubber as compared with that of natural rubber during such processing, it has been extremely difficult to add sufficient loading during milling to produce the semi-hard and hard rubber stocks. In the production of these stocks from natural rubber this loading with reinforcing materials such as carbon black was not a problem because of the natural plasticity of the rubber on the mill.

The Durez resin, being thermosetting and completely compatible with the synthetic rubber, also reinforces the rubber in much the same manner as carbon black. It therefore produces stocks of high tensile strength, a high degree of hardness, good elongation, and low-temperature flexibility. Depending entirely upon the amount of resin used, the amount of reinforcing agents normally required to give a definite hardness can either be entirely eliminated or reduced proportionately.

PREHEATER

Warms Buses on Cold Mornings Before Passengers Get Aboard

AFTER standing overnight in zero weather, buses now receive a quick boost in temperature from a "Janitrol" portable heater of the type developed to preheat airplanes at Alaskan air bases.

Comfort for passengers on the first run is the object, and, according to Surface Combustion, manufacturer of the unit, the interior of a cold bus can be warmed to a degree pleasant to riders within five minutes before the first trip is started.

Gasoline, kerosene, or light oils, including Diesel oil, can be used as fuel for the portable unit, which has an output sufficient to warm four average-sized homes. Its heat rise of 230 degrees enables it to deliver positive heat in sub-zero temperatures.

NEOPRENE RUBBER

Will Be Widely Used In Home Applications

RELEASE of neoprene from war's demands is expected to bring greater durability and practicality to many household products. Sponge cushions and mattresses, tile-like flooring material, carpet backing, and numerous structural parts for household equipment are named as possible applications of this synthetic rubber. Its return will also again make available such pre-war items as household gloves, sink strainers, mats, and crib sheets.

Sponge rubber cushions, upholstery, and mattresses made of neoprene by a new process remain firm and even, and have long life. Foam sponge, as it is called, is made by converting rubber latex into a foam and setting it to form a sponge-like mass of any desired shape and degree of springiness. Neoprene foam sponge, unlike that of natural rubber, can be made flame resisting. While it will burn in contact with flame, it ceases to burn when the flame is withdrawn.

Another type of mattress material in tomorrow's home will be made of goat's hair and neoprene. In making this mattress, an open mesh is formed by bonding goat's hair with neoprene latex. The mesh is folded to form a spring layer about an inch in thickness. Several layers of this material are built up to the desired thickness.

A durable backing for carpets and rugs will be made by applying neoprene cement to the floor side of rugs, firmly anchoring the nap in place. The coating, which is especially valuable for the commonly used "U"-shaped naps, adds but little to the over-all cost of the rug. The use of neoprene will permit cleaning with solvents that would readily attack rubber backings.

There is also prospect of a new type of terrazzo flooring made by stirring marble chips into colored neoprene latex, pouring the mixture over the floor foundation, and troweling it down. Satisfactory installations in shipboard shower stalls, staterooms, and galleys indicate that this tile-like flooring may be adaptable to home bathrooms, cellar playrooms, kitchens, swimming pools, and terraces.

While neoprene will still be a premium priced product, as compared with natural rubber, the premium will be substantially less than before the war, due to increased production and the fact that rubber manufacturers have gained more experience in processing the material.

TIGHT-SPOT CELLOPHANE

Proves Useful in Electrical Insulation

CELLOPHANE so thin that it would take approximately 1000 sheets to make a pile an inch high is finding increased use in industrial tight spots, where a space-saving wrapping material is re-

High-efficiency heater rapidly warms a bus quired, according to Sylvania Industrial Corporation, which manufactures this very thin cellophane. The material goes into wrapping wires in electric cables, where it not only saves space but acts as a fire retardant as well, the company reports.

Cables of this kind were originally designed for airplanes and needed to be as small and compact as they could be made. Since each cable contains several individual wires, the material for wrapping each wire had to be as thin as possible, and still be tough and durable enough to withstand hard industrial use. This thin cellophane proved so satisfactory in the air that it is now extensively employed in Navy cables as well. Because it saves both space and weight it is expected to find ready use in other wires and cables, so that the maximum number of them can be placed in the metal conduits that lace the walls of modern office buildings and twist their way beneath the streets.

One of the many different types of cellophane that have been developed to meet the requirements of specific industries, this very thin sheet does the required space-saving job, and in addition acts as an aid to insulation inside the cable, protecting the covering of the wire from the asphaltum which surrounds it. Since the cellophane is manufactured in different colors, it is also used as a coding device inside the cable, each color indicating a different strand of wire.

HEAT RESISTANCE

Increased in New Plastics Formulation

A NEW molding compound of "Lucite" methyl methacrylate resin, combining heat-resistance 30 to 40 degrees, Fahrenheit, higher than general-purpose powders with other desirable properties previously unobtainable in a single formulation, is announced by the Plastics Department of E. I. du Pont de Nemours and Company.

The new formulation, designated as HM-122, is outstanding for ease and economy in molding, the company says. Its faster setting properties, when properly heated dies are used, contribute to a shorter molding cycle. The material from this new formulation has added resistance to breakdown from heat at molding temperatures, producing not only better moldings but improved clarity.

The entire output of formulation HM-122 now is allocated to essential uses, such as colored caps for switchboard light signals, parts for sextants and stethoscopes, blackout lenses for military vehicles, airfield landing light lenses, relay box covers, battery adapters, and control wheel knobs.

Moldings of the new "Lucite" are distinguished by unusual clarity and brilliance. They also possess excellent reflecting properties and are exceptionally free of distortion when molded properly. This new formulation can be obtained in a wide range of transparent, translucent, and opaque colors for both indoor and outdoor use.

Though not "boilable," the material produced from this new formulation may be used in many installations where substances with a lower heat-distortion point would fail.

LEATHER-LIKE PLASTICS

Has Many Uses As Covering Material

A NEW leather-like plastic that has great resistance to abrasion and scuffing has been announced by the Firestone Tire and Rubber Company.

Called Veloflex, the new material has a vinyl base. It will be produced as a sheet or coated fabric in a large number of surface patterns such as cowhide, alligator, boxed calf, pin-point morocco, and new designs. In addition to its patterns, it can be produced in various weights and thicknesses and in any shade or color.

Completed laboratory tests, according to Firestone, have shown that the tensile strength of the new plastics is from 2000 to 4000 pounds per square inch and elongation from zero to 300 percent. In flexural strength, it has withstood more than 3,000,000 flexes without cracking. The new material is an excellent non-conductor of electricity. It resists acids, alkalis, and organic solvents and will not absorb moisture.

The field of uses for Veloflex includes luggage, upholstery, men's and women's purses, desk tops, book bindings and covers, water-proof cases, shoe uppers, gloves, clothing, military kits, pads, seat covers, and many more.

This new material can be sewed, heat-sealed, or cemented. Water and dirt can be safely removed from it with a damp cloth or with ordinary cleaning fluids.

GRANITE SURFACE PLATES

Will Not Warp Or Distort

SURFACE plates employing black granite, a material that is molecularly inert, cannot be warped or otherwise distorted by any conditions to which a surface plate is normally subjected.

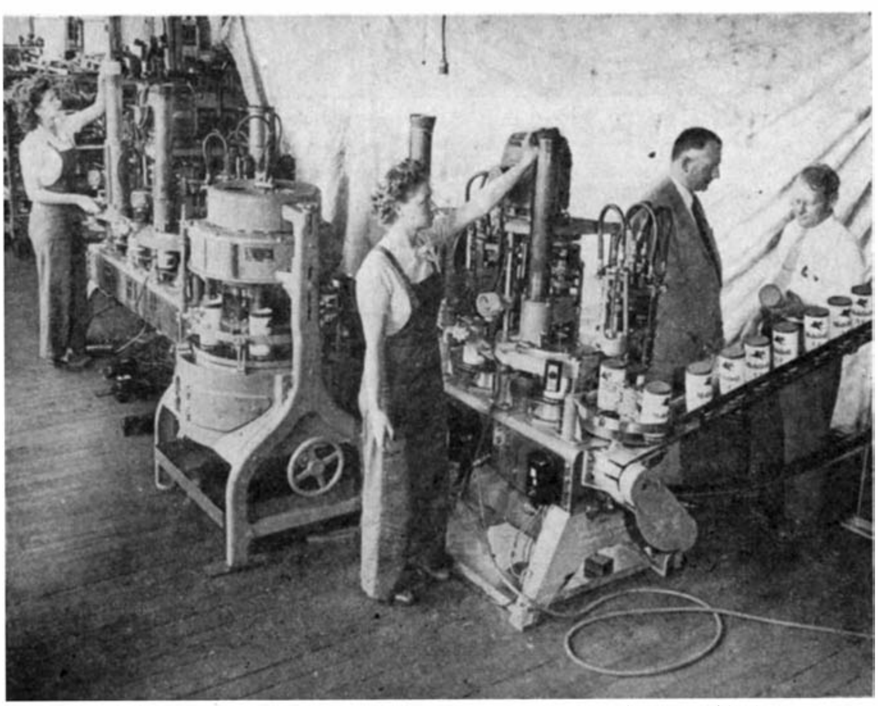
These Velsey surface plates, as they are called, are lapped in series to a tolerance of .00005-inch surface flatness which is never changed by shock or temperature fluctuation. The material is harder than tool steel and consequently cannot be scratched by instruments. Even if the surface were nicked by a heavy blow, the adjacent material would not be upset. The base of an instrument would surmount the nick without affecting the precision of measurements. It is claimed that these surface plates will last for many years since they do not corrode, abrade, or warp.

LUBRICATING OIL

Now Packaged in Paper Containers

LUBRICATING oil is now being packed in one quart paper containers at the rate of 70 quarts a minute by high-speed packaging machinery. Perfection of the packaging method breaks a bottleneck of metal shortages, since the paper container is made entirely of non-critical materials, the paperboard used being exempted from the Government's container limitation order. The container is weather-proof and oil-proofed on the inside. In appearance and service, it is similar to the ordinary metal container.

The high-speed packaging machine, a product of the Package Machinery Company, is set up in combination with standard paper working equipment to complete the process from fabricating the container to filling and sealing it. The paper working equipment takes ordinary board paper in roll form and, in combination with adhesives, spirally winds it into a cylinder, open at each end. The packaging machine itself consists of three units: bottoming, filling, and closing—all completely automatic.



Paper containers of lubricating oil are packaged on this assembly line

PLASTICS MOLECULES

Measured Accurately By New Instruments

AS A first step in providing the plastics industry with a better method of investigation through sorely needed standard instruments for quick determination of the size and shape of molecules, two instruments have been constructed in the Highpolymer Laboratory of the Polytechnic Institute of Brooklyn. These instruments for the first time offer a direct visual procedure for determining the shape of molecules and a short cut for determining the weight of polymer molecules. The most important processes for manufacturing various types of rubber, plastics, and fiber are extruding, molding, casting, and spinning. To produce the best results, it is necessary to know the size and shape of the molecules of which the material is built. At present, chemists use viscosity as a rough criterion for these fundamental properties but this method is far from being satisfactory.

The two new instruments, the turbidimeter and the rayleighometer, based on simple visual observations, employ the scattering of light to learn about the size and shape of large organic molecules such as those used in making tires of synthetic rubber, lenses of synthetic resins, and stockings of synthetic fibers.

The principle of light scattering was discovered in 1910 by Dr. Albert Einstein, originator of the Einstein theory of relativity. In 1943, Dr. Peter Debye,

Pipetting a sample of a test solution into the chamber of the turbidimeter

of Cornell University and a Nobel Prize Laureate in Chemistry, discovered how to use this principle to compute the molecular weight and shape of giant molecules and proved that it had a practical application. As a result of these findings, it has been possible for Dr. Paul M. Doty, research associate and instructor in physical chemistry at the Polytechnic Institute, in collaboration with Dr. Herman F. Mark, Polytechnic's professor of organic chemistry, to design an instrument, a kind of photometer, which allows a quick and reliable measurement of the light scattered, by spinning and casting the solution in various directions. Eventually it will be possible to use this method in industry on a routine standard basis to produce fibers of high fatigue resistance, plastics of high impact strength, and rubbers of high endurance against abrasion.

COLOR DETECTIVES

Provide Precise Tool for Industrial Chemists

CHEMICAL color-detectives so powerful that they can detect iron atoms forming only one part in 1,000,000 parts of water were described to the American Chemical Society recently by Prof. G. Frederick Smith of the University of Illinois.

These color-detectives, used in analyses in a number of important industries, are organic reagents—organic ring nitrogen compounds known chemically as orth-phenanthroline and substituted phenanthrolines.

Their most important property is their ability to react with a number of divalent metal ions—electrically-charged atoms—such as iron, cobalt, copper, nickel, zinc, chromium, and ruthenium.

Three molecules of one of these compounds, Prof. Smith explained, will react with one divalent iron cation, a positive ion, to form an intensely red water soluble product.

A minute amount of this product can color "a comparatively enormous amount of solution to which it is added. The presence of one part of iron in this form is easily detected in the presence of 1,000,000 parts of water."

One milligram of iron can be detected by its color in one cubic meter of water by another color-producing compound, and one ounce of iron converted to this complex "would color to a discernable hue the water displaced by a battleship."

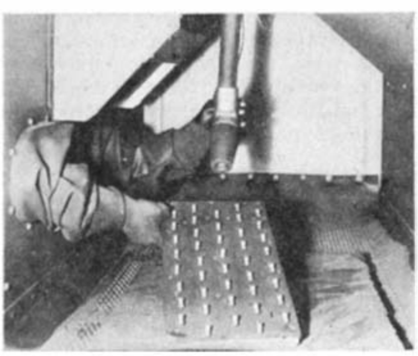
Prof. Smith said that this type of compound also can be used as reaction indicators by changing their red form to a blue form. "The change in color is vivid, precise, and reversible. At the point of color change, the chemical reaction being carried out is shown to be complete."

These compounds are used in various kinds of analytical work in iron and steel production; special alloy steel manufacture; rock ore and mineral utilization; limestone, cement, and glass technology; and drug, medicinal, food, and wine processing and preserving.

COMPAR LINING

In Sandblast Cabinets is Better Than Boiler Plate

FULL-TIME operation of sandblast cabinets has been made possible by an application which was first tried out to protect the perforated bottom of a



Compar lining protects bottom of sandblast booth, as well as the parts tray

much-used device of this kind. Experience had shown that the force of the steel grit, driven over the parts in the cabinet under 90-pound pressure, quickly wore through the boiler-plate which was the customary protective covering, necessitating frequent replacement.

A sheet of compar, the plastics developed by Resistoflex Corporation, fastened securely to the bottom of the cabinet, proved the solution to the problem, with a resistance to abrasion said to be 250 times that of the boiler-plate, assuring continuous operation for several months with no stoppages for replacement. Likewise, the wooden tray which holds small parts to be sandblasted is covered with a sheet of flexible compar. Although this tray is held directly below the nozzle, the compar covering shows no wear after months of continuous use.

ADHESIVES

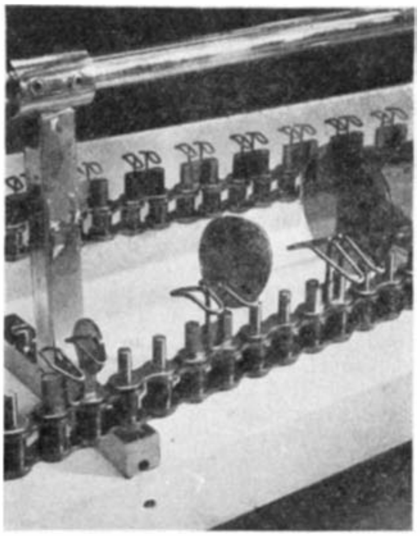
Are Important to a Number of Industries

ADHESIVES derived from starch enter into the manufacture of an almost limitless variety of products, according to Lee T. Smith and R. M. Hamilton of the Eastern Regional Research Laboratory.

Starch adhesives were used by the Egyptians. In the latter part of the 18th Century, the manufacture of starch adhesives and sizes became important in industry. In the United States the growing need for starch was realized by John Biddis of Pennsylvania, who devised a method of manufacturing starch from potatoes and was granted a patent in 1802.

The introduction of postage stamps in 1840 and the subsequent invention of gummed envelopes stimulated the demand for adhesives.

About the same time the development of photography created new uses for adhesives in mounting photographs. The introduction of matches offered another use for adhesives in the manufacture of the cardboard match box. Through the use of the cardboard tubular cartridge, adhesives aided in revolutionizing the shotgun from the muzzle- to the breech-loader type.



Above: Special clips hold different size filters on the conveyor belt of the automatic laminating equipment. Right: Placing filter blanks between glass. The resulting "sandwiches" then go to the automatic laminator

From this beginning, tubes for various purposes were developed.

The introduction of the paper bag was the first step toward modern packaging. The almost instantaneous sealing of paper seams made possible the high speed of the adhesive sealing machines.

PRECIOUS METALS

Recovered from Waste Fluids By Anion Exchange

A PROCESS by which valuable and war essential metals may be removed from waste solutions by absorption on anion exchange resins was announced at a recent meeting of the American Chemical Society. While primarily intended for the recovery of scarce and valuable metals now being lost in waste waters, the new method is also expected to be beneficial in reducing stream and harbor pollution in the vicinity of electro-plating and other metal working plants.

According to chemists of The Permutit Company, anion exchange resins, under special conditions will completely absorb certain metal salts from very dilute solutions. When complete absorption is no longer obtained, the resins are treated with appropriate chemical solutions to effect recovery of the metals in the form of solutions which may be 25 or 30 times as concentrated as the original waste liquors. The anion exchange resins undergo no permanent change in the process and may be re-used indefinitely.

LIGHT FILTERS

Made Automatically by Ingenious Equipment

AUTOMATIC laminating equipment, developed initially to meet the increasing demand for laminated filters to be used as lenses in the Polaroid Dayglass, has proved valuable in the production of many other kinds of light filters made of a combination of glass and plastics.

In one continuous automatic operation, the equipment manufactures a continuous roll of adhesive material, adheres it to both sides of a plastics sheet, and stamps out the adhesive plastics in the desired shape and size. The stamped plastics travels on a belt to a wheel where operators sandwich it between two pieces of glass. The sandwich is carried automatically to

be pressed and then conveyed by belt to quality control inspectors.

Over 30 million filters of a variety of shapes and colors, polarizing and non-polarizing, have been turned out on this equipment, which is reputed to have produced by far a greater volume of light filters than any other production unit occupying a comparably small area.

The filters are used in conjunction with many military aiming and sighting devices including bombsights, sextants, binoculars, and gunsights. They eliminate reflected sun glare, penetrate haze, permit the viewing of three-dimensional vectographs, and perform a number of other tasks affording increased vision.

MOLDING PRESS

Uses Electronic Heat on Thermosetting Plastics

A VERTICAL hydraulic "hyspeed" press that molds plastics items and utilizes electronic heating of the plastics material to effect sensational economies in production time, has been announced by Ralph Kelly, president of The Baldwin Locomotive Works.

Held secret until now, experiments have been conducted for months by The Bryant Electric Company on ureas and melamines, vital to the process. Also working with Baldwin's Southwark Division to create the method were Westinghouse Electric and Manufacturing Company and Monsanto Chemical Company.

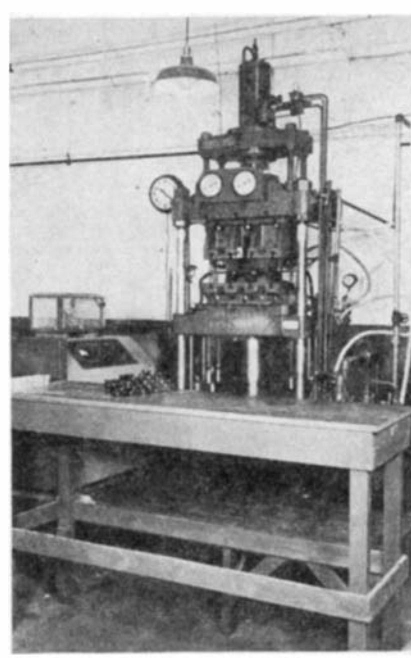
The first electronic heating unit and forming press, set up to operate manually, have proved entirely successful, according to Charles J. Smith, head of the Plastics Division of the Bryant Electric plant, which built special molds for the experiment. He said that "high frequency heating is a proved success on small parts." The plant, he added, has been able to reduce the curing time on a particular product from minutes to seconds.

"By reducing this time, workmen have been able to turn out 20 percent more pieces from an experimental six-cavity mold than were previously turned out from a standard 24-cavity compression mold." Mr. Smith estimated the mold savings in this one experiment between the six-cavity and the 24-cavity molds, at $6000, in addition to a 12½ percent saving in plastics materials since the Baldwin-designed press does a precise extrusion job.

Smith said the method of squeezing the preheated plastics into the mold and changes in mold design make high-speed thermosetting molding practical. Therefore, the production from a small press with a small number of cavities is just as great as, or greater than, that of a large compression press with a large number of cavities.

In the first production experiments, one workman operated both the two-kilowatt heating unit and the molding press. The plastics, in the form of thick wafers, was placed in the heating device where it was exposed to short-wave radio beams for a few seconds. Then the workman lifted out the hot wafer, transferred it to the press, and a plunger forced it down against the mold. It remained only a few seconds under pressure of six tons per square inch, then was released. When removed, the particular product in this case turned out to be a series of clean, shiny plastics electric outlet plugs such as the average American is accustomed to buy in the appliance department of any store.

Because the heat is established inside the preforms as quickly as outside, there is no opportunity for the outer portion to overcure before the inside gets hot. Because the preforms go into the mold hot, much lower pressures



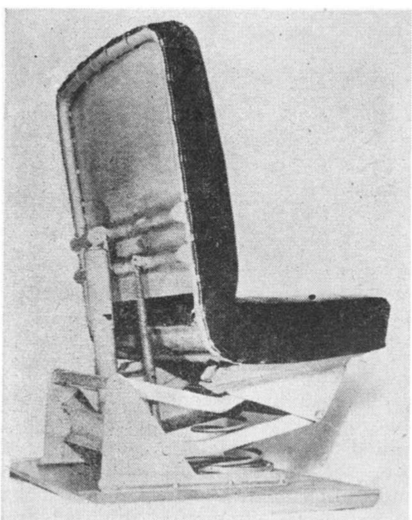
Heating equipment and molding press that economize on production time can be used. This means smaller presses. It is estimated, as a result of lowered pressure that, for a particular job, the press would cost approximately one third as much as a straight compression press; that maintenance costs would be reduced to a fifth; and that the molds would have 30 percent longer life.

TANK SEATS

Adapted for Trucks to Permit Smoother Driving

RELIEF from fatigue and the danger of falling asleep at the wheel has become possible for truck drivers as a result of the war-time production of more than 200,000 tank seats for the armed forces of the United Nations. At the request of truckers, who had learned of the level, comfortable ride made possible by the tank seats, the Monroe Auto Equipment Company, manufacturer of the seats, adapted them for use in trucks.

The truck seat features a variable-rate coil spring which reacts equally to a large man or a small boy. A long auxiliary spring, used in conjunction with a double-action hydraulic shock absorber, limits the height of the seat in the free position and affords a resilient limit to its action.



The spring has a variable rate

The shock absorber, resisting any sudden or sharp action of the spring due to travel over bumps or rough roads, levels off the ride regardless of jolts. Because the seat eliminates rhythmic pounding while the truck is in motion over a long period, it reduces the tendency of drivers to fall asleep at the wheel.

FARM WASTES

Provide Extensive Source Of Industrial Cellulose

CORNCOBS and other farm wastes are being converted into sugars by a continuous process which makes use of the special chemical and physical properties of the farm wastes or residues. Chemistry is transforming such waste into money for the farmer and into a rich "bank" of cellulose reserve against the day when many natural and irreplaceable national resources are depleted.

J. W. Dunning and E. C. Lathrop explain the process in "Industrial and Engineering Chemistry," American Chemical Society publication.

"It is estimated," they point out, "that 100,000,000 tons of farm residues might be available in this country for industrial purposes each year, with an equal amount left on the farms for plowing back into the soil. In view of the decrease in irreplaceable natural resources, it is becoming clear that at some period all countries must look to products of annual plant growth for the production of many materials now derived from other sources."

The Department of Agriculture, they continued, is seeking means of using such residues not mainly as substitutes but rather as raw materials that can do industrial duty better than other raw materials.

The bulkiness of most farm wastes, their higher content of pentosans—a complex carbohydrate—and lower cellulose content as compared with woods heretofore have prevented considering them as a source of raw material for sugars, the report said.

The researchers reasoned that what might be needed in utilization of farm wastes for sugars is some "added ingredient" which would be produced concurrently and command a higher price than fermentable sugars.

This might be furfural, now manufactured to the extent of about 20,000 tons a year, or xylose (a sugar) which has potential uses if priced near sucrose. Both of these chemicals are derived from pentosans which generally occur in higher amounts in agricultural residues than in wood.

Working with corncobs, sugar-cane bagasse, flax shives, oat hulls, and cottonseed hulls, the chemists developed a continuous, two-stage process in which the pentosans in the wastes first are hydrolyzed or decomposed by dilute sulfuric acid. Then the cellulose is turned to sugar by a new concentrated acid method which uses less than one fourth the amount of acid required by other known concentrated acid processes. Lignin remains as an insoluble residue.

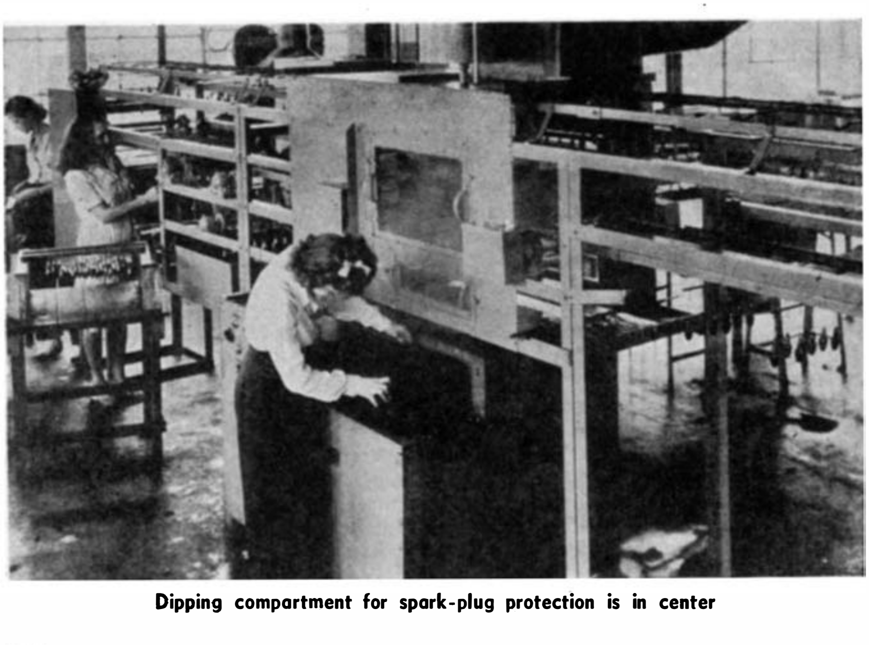
PLASTICS COAT

Protects Spark Plugs Until Used

Ethyl cellulose, which forms a tough, water-proof, corrosive-resistant coating that can be quickly and easily removed by slitting and stripping from the part, is now being used to protect spark plugs after manufacture and until put into service.

The conveyor used for this work is shown in the accompanying photograph. An operator hangs six plugs on each cross bar. After being immersed in the dip compartment of the Youngstown Miller Company's plastics coater, the plugs are returned overhead to the end from which they start. This system permits the uniform dipping of 4500 plugs an hour.

Indirect heat is employed to melt 100 pounds of the plastics per hour without danger of breaking down the ethyl cellulose by excess heating. Thermostatic control is maintained over both the heat exchange medium and the plastics to insure that neither rises over its maximum allowable temperature. The plastics is melted and preheated to proper temperature for dipping before entering the dip tank section of the unit. Extremely close control (2 degrees, Fahrenheit, maximum variation) and uniformity of temperature is achieved with low heating surface temperature.



Dipping compartment for spark-plug protection is in center

GASOLINE SYNTHESIS

From Natural Gas Put On Commercial Basis

Production of gasoline with a clear octane number of 75 motor (83 research) from natural gas for about five cents per gallon, bringing gasoline synthesis from natural gas definitely within the range of successful commercial operation by the American refining industry, is said to be possible through recent improvements of the Fischer-Tropsch process. The new process is equally adaptable to the economical production of high-cetane Diesel oil.

The five cent cost is based on natural gas at five cents per thousand cubic feet and a plant depreciation rate of 10 percent per year. The gasoline produced can be easily leaded for post-war consumption.

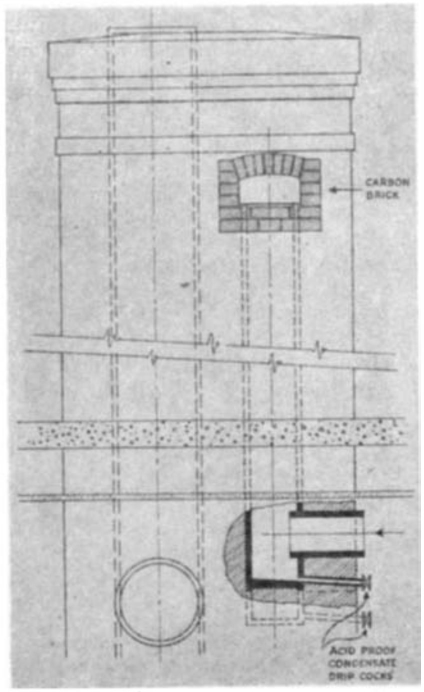
Based on technical exploratory and development work in the M. W. Kellogg Company laboratories in Jersey City, the new method successfully overcomes the problems of heat dissipation and accurate temperature control.

CARBON CHIMNEY PIPES

Prevent Seepage of Noxious Gases

Construction of a new laboratory for the St. Lawrence Alloys and Metals, Ltd., required that gases from furnaces and testing tables in the basement be dissipated through a brick chimney running up through the center of the building. Due to the corrosive action of the gases on the chimney brick, it was felt that periodic and expensive repair jobs would be required if the gases were exhausted directly through a chimney of the customary brick design. Also, if indiscriminately released, the noxious gases would have constituted an explosion hazard, as they contained ammonia, ether fumes, ethyl acetate, chlorine fumes, and hydrochloric, sulfuric, hydrofluoric, nitric, and perchloric acids. Not least of the considerations was the desire to eliminate seepage of fumes into the building which could result from disintegration of the ordinary brick.

Utilizing the well-known principle that carbon is resistant to corrosive fluids and gases, two eight-inch flues of carbon pipe were built into the chimney to carry the gases and protect



Flue construction for safe disposal of corrosive gases from laboratory

the brickwork. Two flues were constructed to keep separate those gases that might produce an explosion if permitted to mix. Metal hoods mounted over the testing tables and furnaces and connected to the horizontal carbon tubes carry ammonia, hydrochloric acid, ether, and ethyl acetate gases into one flue. Hydrofluoric, sulfuric, nitric, perchloric acid gases, and chlorine fumes are directed into the other.

The gases are exhausted through the flues by mechanical means. To minimize condensation, and a liquid back-drip of acid solutions that might be caused by rain or snowfall in the flue openings at the top of the chimney, roofed chambers with side outlets were built of carbon brick. The bottom of each flue consists of a slanted carbon disk covered with a built-up layer of carbon cement.

If there should be condensation and the formation of acid solutions in the bottom of the flues, the solutions will flow out through a small carbon pipe spillway located directly under the inlet section, when the carbon dripcock is opened.

Each of the carbon flues is 31 feet in height and is formed of threaded lengths of carbon pipe. Joints are sealed with a carbonaceous cement with the female threads in the upward position, thus providing an added protection against seepage. According to reports released by the St. Lawrence company, the exhaust system is highly efficient, and the gas fumes originating in the laboratory are undetectable on the floors above. Carbon material for the flues were supplied by the National Carbon Company, Inc. Its engineers believe that the flues should remain in maintenance-free service for a minimum of 30 years.

FILTRATION UNITS

Make Chemical Equivalent of Distilled Water

ORDINARY water can now be transformed into the chemical equivalent of distilled water by a simple filtration process made available in portable and stationary equipment designed for all types of users. With these units, trademarked Filt-R-Stil, water which is virtually mineral-free is made readily accessible for research laboratories and industrial use. The principle utilized is one of filtration by skilful utilization of melamine-derived and other resins, developed by the American Cyanamid Company. Water is passed through beds of these ion exchange resins which transform the dissolved salts in the water to the corresponding acids and in turn absorb the acids. The process may be visualized by picturing water as containing flowing metals which are attracted by a magnet except that the magnet, in this case, is chemical rather than electrical.

The final demineralized water has an average salts content as low as two parts per million of calcium carbonate, and has been produced as pure as one-half part per million. The process also removes dissolved carbon dioxide from the water, a feature of particular importance in its use in the electronic and electrical fields.

ALUMINUM ALLOY

In Oil Breather Caps Cuts Service Charges

SUBSTITUTION of a combination of aluminum alloy wire crimp in engine oil breather caps has eliminated a service problem on buses and trucks, has effected a saving of critical copper, and has reduced excessive oil consumption.

The new material is composed of 96 percent aluminum and 4 percent magnesium wire. It originally was adopted as a war-time expedient to replace hard-to-get copper crimp. But results have been so satisfactory that it will be retained when peace-time production is resumed.

The prime advantage of the aluminum alloy crimp, developed by Ford engineers, is that it does not promote varnish, whereas copper actively helps this formation because copper acts as a catalyst and accelerates the formation of injurious gum deposits in the oil itself.

Heavy varnish deposits on oil breather packing accumulate rapidly on buses and trucks because of their higher operating temperatures. Thus, servicing is made more difficult, due to cap sticking, while excessive oil consumption may result from increased internal pressure forcing the oil past the rings or retainers.

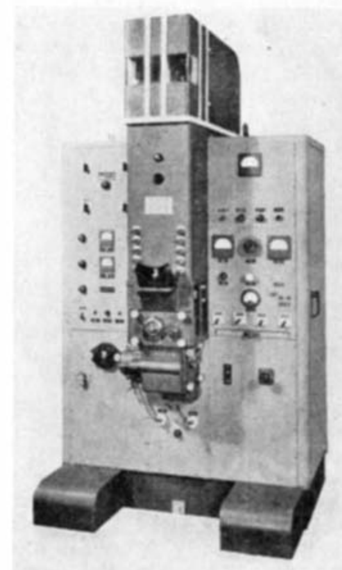
ELECTRONIC OSCILLOGRAPH

Records Extremely Short Electrical Phenomena

A SELF-CONTAINED industrial electronic oscillograph capable of recording characteristics of electrical phenomena lasting as little as a fraction of a millionth of a second is announced by Westinghouse.

An instrument of the cold cathode type, the electronic oscillograph is capable of recording single electrical transients with respect to time, or two electrical phenomena with respect to each other, such as voltage versus current, in the form of diagrams produced by two pairs of electrostatic deflecting plates disposed at right angles to one another. The cathode of the tube is energized from a 50 kilovolt D.C. rectifier with a control to correct for line voltage variation. The beam is normally blocked by a target. An impulse synchronized with the phenomena will trip the relay which bends the beam around the target so that it will strike the fluorescent screen or film placed below it and thus be rendered visible or recorded.

The new streamlined unit consists of the oscillograph proper in front of the cabinet and the cabinet proper which houses all energizing and control circuits. Energizing terminals are enclosed except one bushing connected to the source of synchronizing impulses. Concentrating coils, beam current meter, and leak valve, control the intensity and size of the trace on the film. Deflecting coils move the zero



Oscillograph for industrial research

position of the beam so as to use the whole area of the exposed film for the record.

In addition to the fluorescent screen for direct observation, the instrument contains a stationary film holder taking a standard film for recording electrical phenomena lasting 1/1000 second or less, and may be operated with a rotating film drum for phenomena lasting from 1/1000 to 1/10 second. A photoelectric control which makes it possible to take an oscillogram in one revolution of the drum, regardless of speed, eliminates the possibility of superimposed waves.

ELECTRICAL STABILIZER

May be Used Post-War On Many Vehicles

THE post-war automobile and train ride may be easier because of an intricate device called the gyro-stabilizer now being used for accurate aiming of high-powered guns on battle tanks as the machines move over rough terrain.

Electrical manufacturers say this is the way the gyro-stabilizer works on United States tanks:

"A piston in a cylinder attached to the breech of the tank's gun moves up and down to stabilize the gun's movement. The piston is moved by oil under 200 pounds pressure, fed from a gear pump. The amount of oil fed to either side of the piston is controlled by two magnetic waves.

"A 'silverstat' varies the voltage—or electrical pressure—flowing to the valves and consequently the oil flow to the cylinder. A gyroscope is attached to the breech of the gun where its rotational direction is subject to violent change every time the tank rolls over stone or pitches into a ditch.

"At the first sign of jolting of the gun, the gyro complies with the law governing its nature; in resisting the downward or upward jerk of the gun barrel, its own axle rotates at right angles to the up or down movement, and in effect 'waggles' the gyro.

"With each waggle to right or left, a pencil-thick stub of plastics attached to the gyro and centered in the cluster of silverstat leaves squeezes together one or the other group. This increases or decreases the voltage, and consequently the current, which flows to—and activates—the magnetic oil valves."

It sounds a little complicated, the electrical experts admit—but it may add up to a downy-soft post-war ride, even over bumpy rural roads in a car, or over rough roadbeds in a train.

SHRINKAGE CONTROL

Applied to Woolens by Use of New Resin

WOOL, which retains its original appearance, yet is protected against shrinkage, even after repeated laundering and dry-cleaning, is now commercially available through the use of a new synthetic resin manufactured by American Cyanamid Company and trade marked under the name "Lanaset."

Lanaset, a melamine resin, has already been tested with success by a number of leading mills and finishers. Lanaset wool shrinkage control has also been used by the United States Army

Two hours in soap and water did not change the sock treated with Lanaset

Quartermaster Corps for treating, among other items, three quarters of a million yards of wool sleeping-bag fabric.

Lanaset stabilizes wool and wool blends without affecting the absorbency normally characteristic of wool. The usual chemical methods for controlling shrinkage actually alter the wool and destroy some of its valuable properties. Lanaset, on the contrary, is an additive and takes away none of these desirable qualities. It also reduces felting and prevents fuzzing. Wool treated with Lanaset has a much higher resistance to alkali than untreated wool.

Another advantage of Lanaset, according to reports, is the simplicity of its application. The fabric is passed through an aqueous bath containing the resin, squeezed uniformly through a mangle, dried and heat cured, and given a light wash to remove surface resins. The application is permanent for the life of the fabric.

This stabilizing finish for wool fabrics is expected to be of particular value in the processing of dress materials, blends of wool and spun rayon for sports wear, tropical worsteds for men's suits, sweaters, children's wear, blankets, and socks.

COPPER ON ALUMINUM

Made Practical by New Preparatory Dip

ADHERENT, uniform copper plating is now made possible on aluminum and its alloys by a preparatory dip at room temperature. The dipping solution may be used in a steel, wood, or ceramic container. There are no fumes, it is said, and venting is not required. This solution has a long life, is stable, and is not sensitive to drag-out, normal contamination, or dilution.

Practically any copper electrolyte can be used as the plating solution except the sulfate types or those having a high degree of acidity. High-speed, bright-copper can be deposited with ease.

Copper plating on aluminum brings greater utility to this light metal. Aluminum is difficult to solder, but a flash coat of copper eliminates this trouble. Aluminum also has a strong tendency to develop an oxide coat on exposure to air. While aluminum itself is a good electrical conductor, this oxide coat reduces conductivity considerably. When aluminum is copper plated, this difficulty is overcome and the light metal becomes useful for electrical contacts and high frequency conductors where weight is a factor to be considered.

When aluminum is copper plated and polished, it eliminates the usual dull aluminum finish. Also, copper plated aluminum can be used to build up worn surfaces, over-sized diameters,

and so on. The process consists of a specified means of aluminum cleaning and preparation, followed by a 10 to 30 second immersion in a simple dipping solution at room temperature, and then plating from the copper electrolytes.

GAGE BLOCKS

Now Available in a Versatile Set

THE growing use of precision gage blocks throughout industry has created a demand for a master series of gage blocks, capable of producing any combination of sizes required in precision

Designed for duplicate combinations in a wide range of precision gaging

measurement. Designed to fill this need, DoAll Gage Set Number 118 not only provides for more duplicate combinations of the same size, but makes possible a wide range of combinations. The set contains thin blocks ranging in size from .010 inches to .090 inches, including a thin block series in steps of ten one-thousandths of an inch from .010 inches to .090 inches.

Standard gage sizes are well represented in the set which, in addition, contains a series of three fractional size gages.

Special gage blocks, called wear blocks, protect the regular gages when they are used under conditions which might cause excessive wear. Every gage is etched with its individual size clearly and legibly marked and is of uniform depth. The etched markings are free from even the tiniest burrs. In addition to the size marking, each gage is individually etched with its own serial number so that it can always be identified from similar size gages of other sets.

WATER PUMP

Operates in Both Deep And Shallow Wells

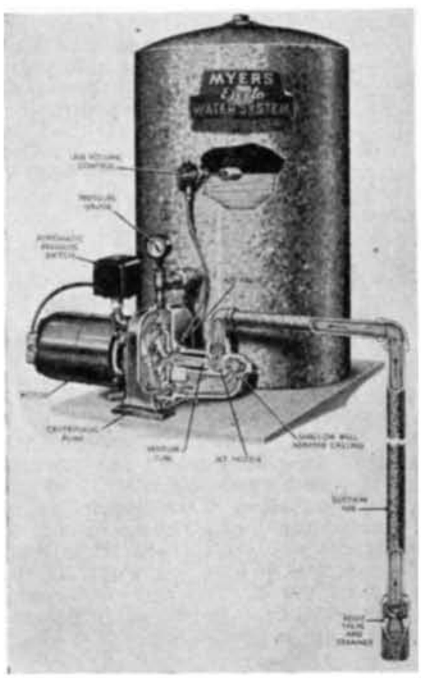
A PLENTIFUL supply of water is one of the basic needs of civilized existence. In fact, the rate of water consumption may well be taken as a fair index of a household's standard of living. To insure a bountiful supply is always the concern of the country dweller who must depend on his own well. Better pumps are always news to him.

A new type of centrifugal pump, based on the ejector principle, has been designed so that each pump with its fittings may be used in both shallow and deep wells.

When in operation in a shallow well,

part of the water circulated in the pump case by the centrifugal impeller is diverted to the nozzle. Water passes through the nozzle at high velocity into the venturi tube, creating a partial vacuum, causing water to be drawn from the well and from the ejector nozzle. Passage through the venturi tube converts velocity into useful pressure. The effect of the ejector nozzle and venturi tube is to increase both suction lift and discharge pressure.

For operation in a deep well where the water must be lifted more than 28 feet, the shallow well ejector unit is removed from the pump case. A pressure pipe is then connected to the lower opening in the pump case and the delivery pipe fitted directly to the impeller opening. The two pipes are inserted side by side to a proper depth below water level where they are connected with the deep well ejector unit containing a jet nozzle and venturi tube. This, when needed, may be purchased separately. Manufactured by the F. E. Myers and Brother Company, under the trade name of Ejecto, the pump is



This picture shows the shallow well ejector bolted to the pump case. It increases suction lift and pressure

driven by a standard type electric motor of dual voltage and with overload protection.

The capacity of the new pump for use in both deep or shallow wells is an advantage in the event of the water receding in the same well, or if the owner wishes to shift over from one kind of well to the other.

POLYTHENE INSULATION

Seen Widely Used When War Ends

POLYTHENE PLASTICS may be used for insulating undersea electrical cable after the war. The material is reported to be fungus-resistant and it is not attacked by salt water, a Du Pont expert says, explaining its advantages at a symposium on polythene insulation and radio-frequency cables. Its use as an insulation on submarine cable, and in other applications where contact with salt water has deleterious effects on other materials, is being investigated. Protective coatings for metal parts which corrode in salt water also are being studied.

"Polythene has very largely replaced all other materials in the insulation of military wires for high-frequency use," the speaker said. "After the war it is expected that the use of polythene in electrical equipment will continue and expand, and that further varieties and modifications of it will be developed to meet specific needs."

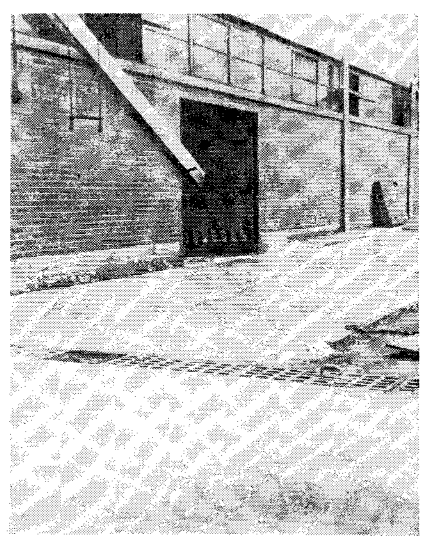
Once the material becomes available in quantity for civilian uses, there will be many fields of application in which its unusual combination of properties will make it valuable. Its good resistance to chemicals points to its utility in chemical equipment as a coating and gasketing material, while its impermeability to moisture indicates a broad utility in containers and the packaging of foods. In this field it may be used as sheeting, as molding powder, or as an impregnant or coating of paper.

RADIANT HEAT

Keeps Outdoor Pavements Free from Snow

RADIANT heating, already functioning in many indoor installations, is now being brought out-of-doors to put an end to shoveling snow or chopping ice from walks and drive-ways. Such outdoor installations have been made at factory plants, one at Bethlehem, Pennsylvania, and the other at Buffalo, N. Y. Designers of some post-war filling stations also have incorporated similar use of radiant heating in drive-ways leading to gas pumps.

At the Bethlehem factory, employes had to walk out of doors a considerable distance from the main plant to the cafeteria. Since it was not feasible to erect a covered walk-way, a concrete footpath was installed, with wrought-iron heating coils installed beneath. A



Steam pipes under the pavement melt snow before it can block the yard

Installing wrought-iron pipe coils for melting the snow by radiant heat

snow- and ice-free walk resulted. Hot water is circulated through the 1¼ inch pipes, for melting the snow which falls on the footpath, or to prevent the formation of ice during a freezing rainstorm.

In the Buffalo installation, low-pressure steam from the plant's boiler is fed into similar size wrought-iron pipe coils whenever it is necessary to melt and remove snow from the loading strip in the plant's yard, before the fall has had a chance to pile up. The installation is 80 feet long and 8 feet wide.

Because of its ease of fabrication, its weldability, its resistance to underground corrosion, and its high heat emissivity, wrought-iron pipe is used in both installations.

COOLER TIRES

Made Possible by Process Utilizing Epsom Salts

MAGNESIUM sulphate, sold in thousands of drug stores under the less technical name of epsom salts, is the key material used in a new rubber compounding process developed to reduce the heat failure of heavy-duty synthetic rubber tires. Chemical engineers have long known that the addition of zinc oxide would make tires cooler running, but no method had been found to mix properly enough zinc oxide with the rubber.

Firestone engineers developed the magnesium sulphate process to solve this difficulty, and now equal parts of synthetic rubber latex and zinc oxide can be mixed together and coagulated easily and quickly. Sufficient quantities of the new rubber have been produced for large-scale development and road-testing work.

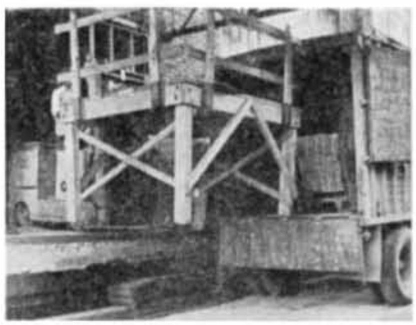
PORTABLE PLATFORM

Solves a Factory Unloading Problem

THE problem of unloading motor trucks on a narrow and congested street has been neatly solved by R. J. Reynolds Tobacco Company. When incoming loads were backed up at right angles to the receiving room door they blocked traffic badly and were a possible source of nuisance accidents. The Reynolds plan made it possible for the delivery truck to park lengthwise of the street for unloading, by building a rugged yet portable loading and unloading platform, which can be kept inside the building and out of the way when not in use.

When a loaded truck arrives at the plant the driver parks near the entrance, close to the wall, and lowers the tailgate. Then an Elwell-Parker fork-type power truck picks up the portable platform and spots it on the pavement so that it provides a continuous runway from the floor of the truck to the floor of the receiving room.

The unloading crew brings in an empty skid on a conventional hand truck. The skid is loaded by hand, pulled into the receiving room, set down just inside the door, picked up by the power truck and transported to destination. A typical load is die-cut and



Makes truck unloading easier

ready printed blanks for cigarette cartons, in bundles weighing 55 pounds and containing 500 cartons each. An average skid load weighs 3850 pounds.

WATER PURIFICATION

Now Includes Taste and Odor Treatment

A PROCESS for water purification, developed by The Mathieson Alkali Works, for the removal of "chlorphenol" taste and odor has been described by G. P. Vincent, of the Mathieson research and development department. The process consists of pre-treatment with chlorine to sterilize the water, followed by treatment with chlorine dioxide to remove taste and odor caused by phenolic waste. The chlorine dioxide is generated by dispensing a sodium chlorite solution into the discharge line of a Wallace and Tiernan chlorinator. A constant dosage of 0.5 parts per million available chlorine is maintained, which, it is claimed, is sufficient to remove all taste in a severely contaminated water.

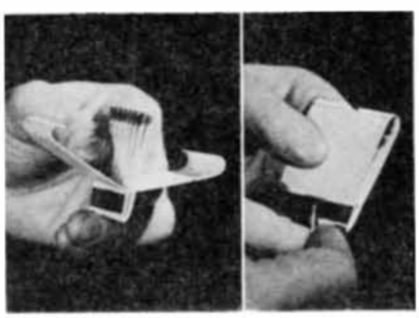
Following experiments with the process on a laboratory scale, plant-scale operations were carried on at an auxiliary filter plant of the City of Niagara Falls Water Department. This plant, which supplies three to eight million gallons of water per day, has an "on-shore" intake which often became so contaminated with phenolic compounds, according to Dr. Vincent, that the customary method of treatment was inadequate. Variations in the degree of contamination aggravated the problem.

Three months of operation with the chlorine dioxide process demonstrated that it destroys phenolic taste and odor permanently and completely, Dr. Vincent stated. Additional advantages claimed for the process are considerably reduced chemical costs and simplified plant operations. The process is now used for purification of the entire Niagara Falls water supply.

SAFETY MATCH

Cover Must Be Closed Before Striking

INTERESTING is the mechanical construction of a new safety match "card" recently developed by Mr. Giuseppe Russo. The cover is in one



Left: New match folder with cover open. Right: The cover locks closed

piece, but both sides are hinged at the bottom as shown in the illustrations. The top edges are turned in an arc and crimped with heat and pressure so that they retain their shape. As the cover is closed after removing a match, the natural movement of the fingers holding the case causes the curved sections to snap into a locked position. Thus it is almost impossible for anyone to strike a match with the cover open—an obvious safety feature in view of the number of accidents that have occurred with conventional match cards.

Although this newest match development is not yet on the market, it presents possibilities in paper saving, since the lower end of the match section can be made shorter than in the usual design and the cover correspondingly smaller.

Current Bulletin Briefs

Conducted by K. M. CANAVAN

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

QUALITY CONTROL is a 140-page book designed as a gage reference text by a prominent manufacturer of precision measuring instruments. Over 200 photographs, diagrams, charts, and tables make the explanation of scientific industrial inspection both interesting and informative. Conversion tables and measuring data give pertinent information on precision measuring methods. The text gives a comprehensive working knowledge of quality control as it should be used in modern production. *Continental Machines, Inc., 1301 Washington Avenue South, Minneapolis 4, Minnesota. Single copies gratis when requested on company letterhead.*

HARCO MASTS AND TOWERS—EASY TO ERECT is a 24-page catalog presenting general information, construction details, and complete specifications for nine types of masts and towers, ranging from 20 to 500 feet high. Among the installations described and illustrated are: mobile and portable units; permanent installations; guyed, self-supporting, square, triangular, and tapered towers. *Harco Steel Construction Company, Inc., 1180 East Broad Street, Elizabeth 4, New Jersey.—Gratis. Request this catalog on your business letterhead.*

B. F. GOODRICH RECHARGEABLE STORAGE BATTERY FOR FLASH-LIGHTS is a six-page catalog section describing a recently introduced rechargeable wet storage battery, which is built on the same principle as the automobile storage battery. A complete description of the battery, chargers, and testers is given, with figures showing the operating savings in battery costs when flashlights are in constant service. *B. F. Goodrich Company, Industrial Products Division, Akron, Ohio.—Gratis.*

SOME PROBLEMS INFLUENCING THE DRAWING OF FINE WIRE, by H. P. Edinga, is an eight-page folder describing the industrial importance of fine wire and discussing its drawing problems. The relationship of die wear to length of wire drawn is pointed out in chart form. *North American Philips Company, Inc., Publicity Department, 100 East 42nd Street, New York 17, New York.—Gratis.*

THE "HUNDRED" SERIES is a four-page catalog describing a line of face shields all designed for safety, with the primary premise of comfort. Complete specifications and prices are given for various models of different thicknesses and sizes of cellulose ace-

The Editors Recommend

Best Sellers In Science

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

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

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

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

TECHNIQUE OF PLYWOOD — *By Charles B. Norris.* Technical information on all phases of plywood manufacture and use, compiled for engineers, designers, and users of plywood. Important to many phases of wartime housing and manufacturing problems. **$2.50**

OPTICAL WORKSHOP PRINCIPLES — *By Col. Charles Dévé.* War-time translation of a French work on precision shop optics, with heavy emphasis on actual handiwork. Covers glass, abrasives, cements, mechanical theory of working optical surfaces, surfacing, tests, centering, and so on **$6.10**

HANDBOOK OF CHEMISTRY AND PHYSICS — A classic reference book recently revised and brought up-to-date to keep pace with recent research. Includes material on all branches of chemistry, physics, and allied sciences. Used in laboratories and by engineers throughout the country. Flexible binding. 2571 pages. **$4.10. Foreign $4.50 postpaid**

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

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

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

PRISM AND LENS MAKING — *By F. Twyman.* A wide variety of notes based upon a long lifetime of practical optical shop work. Not a full step-by-step manual but a valuable working aid to the advanced telescope maker and others in optical work. While the text deals ostensibly with professional quantity production, much of it is basically applicable to single-piece work. **$4.60**

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

A PRACTICAL COURSE IN HOROLOGY — *By Harold C. Kelly.* Definite, outright, practical instructions on watch making, repairs, and adjustment. **$2.85**

SLIDE RULE SIMPLIFIED — *By C. O. Harris.* How to use a slide rule without any of the mystification that often surrounds this important tool of the engineer. Excellent illustrations make everything clear. **$3.60** including a slide rule; for book alone. **$2.60**

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

A COURSE IN POWDER METALLURGY — *By Walter J. Baeza.* A sound view of the overall subject of powder metallurgy which will serve as an excellent guide and reference book. **$3.60**

THE PHYSICS OF MUSIC — *By Alexander Wood, D. Sc.* Technical scientific treatise covering the border-line between science and music. Nature of sound, resonance, pitch, the ear, musical quality, and so on is its scope. It gets down to tangibles in a scientific sense. **$8.10**

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

THE FUNDAMENTALS OF CHEMISTRY — *By Monroe M. Offner.* This text introduces the reader to elements, electrons, acids, alkalis, and so on, and then covers chemistry and its relationship to everyday life. **80 cents.**

ELECTRONIC PHYSICS — *By Hector, Lein, and Sconton.* A simplified text for those who desire to acquire a sound basis for following the advance of applied electronics. **$3.85**

A LABORATORY MANUAL OF PLASTICS AND SYNTHETIC RESINS — *By G. F. D'Alelio.* How to prepare many of the well-known resins and plastics in the laboratory. Understanding of the text requires a knowledge of organic chemistry. **$2.10**

FUNDAMENTALS OF OPTICAL ENGINEERING — *By Donald H. Jacobs.* This new work starts out at the very beginning, is mainly non-mathematical, and is probably the best suited of all existing books as an introduction to optical design. Author is a physicist at Bureau of Standards. **$5.10**

FUNDAMENTALS OF PERSPECTIVE — *By Theodore DePostels, A.I.A.* A method of showing the order, or sequence, in which lines of a perspective are drawn. Use of colors, numbers, and arrows eliminates much text found in other books on this subject. 20 loose sheets in binder. **$2.60**

MACHINERY'S HANDBOOK — *12th Edition.* "Bible of the mechanical industry," 1815 pages of latest standards, data, and information required daily in the shop and drafting room. **$6.10**

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

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tate general-purpose windows, 24-mesh screen windows for heat protection, and fiber fronts for scarfing and welding. *The Boyer-Campbell Company, 6540 Antoine Street, Detroit 2, Michigan.—Gratis.*

BULLETIN No. VL1-44 describes a line of new hydraulic straightening presses, for handling both finished and rough work, made of rugged reinforced welded steel construction with built-in motors. *Colonial Broach Company, P. O. Box 37, Harper Station, Detroit 13, Michigan.—Gratis.*

ILG RESEARCH LABORATORY, DEVOTED TO THE SCIENTIFIC STUDY OF AIR, is an eight-page brochure showing testing and research scenes in this new laboratory which makes available to engineers, scientists, and laboratory technicians the very latest instruments for measuring air, electricity, sound, light, and vibration. *Ilg Electric Ventilating Company, 2850 North Crawford Avenue, Chicago 41, Illinois.—Gratis.*

MICROMAX ELECTRIC CONTROL—DURATION-ADJUSTING TYPE is a 25-page catalog describing a new control system for regulating heat-input of electrically-heated units. Request Catalog N-00A(2). *Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pennsylvania.—Gratis.*

AT EASE ALOFT is a 32-page booklet designed primarily for Pan American passengers. This booklet contains facts on Latin America; global geography; information on aviation; air mail and express; famous flights and aviation progress; and pages of games and puzzles. *Pan American World Airways, Advertising Department, 135 East 42nd Street, New York 17, New York.—Gratis.*

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By Matthew Luckiesh

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By Cleveland and Neville

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By C. A. LeMaster

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Telescoptics

A Monthly Department for the Amateur Telescope Maker

Conducted by ALBERT G. INGALLS

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

THE FOLLOWING is a continuation of the article on making objective lenses without recourse to an optical flat, begun last month by Patrick A. Driscoll, of Rochester, N. Y.

So far we have tested only for radius of curvature. In testing for figure or irregularities we revert to the small pinhole and we may use the edge of the frosted glass as the knife-edge.

When the test plate has been polished to a curvature of —935.51 and corrected for irregularities (we want the even gray shadow of the sphere) we turn it over and on a new polisher proceed exactly as before to polish the —2884.64 curve. This will not in any way affect the figure of the first side.

The —666.46 curve of the flint glass will be our next surface to polish. Since this surface is to be used not only as a temporary test plate, but is also our flint component, it then follows that it must be polished completely, leaving no pits. A scratch on any of the surfaces should be ignored, as the time expended to regrind or polish it out is not worth the infinitesimal amount of light lost in transmission.

TEST PLATE READING—Having all our minus curves polished, we are now ready to polish the plus curves, and now at last comes the application of test plates. We shall start to polish the back side of our flint component (the +2884.64 side). As soon as we have a reasonable polish on it we are ready to test, and we must now enter into a short study of the behavior of interference fringes, or Newton's rings. We place the —2884.64 side of the test plate on the flint lens and, using a sodium light ("A.T.M.," page 244), if we have ground tightly to our gage, and if we have entirely freed both surfaces from dirt or lint which would prevent the ring pattern from forming, we shall immediately see the rings.

We place the thumb and forefinger of each hand on the edge of the test plate, making a roughly four-cornered application of pressure, and press lightly. The rings, under pressure, will appear to well up, or roll into the center of the lens. If the rings well up out of the center and roll to the edge, the lens is "high," too convex, or overcorrected. If, under pressure, they roll in toward the center and seem to disappear down into the center, then the lens is "low," too concave, or undercorrected. The simple and easily remembered rule of test plates can be memorized by this mnemonic: "Since high is *up* and low is *down,* then it follows: if the rings come up the lens is too high, if the rings go down the lens is too low."

If the lens is high, or too convex, we must polish the center more than the edge. If low or too concave we must polish the edge more than the center.

On this job all surfaces are permitted to be as much as five rings higher or lower than the test plate that fits them. This will give us a ten-ring range for smoothing out irregularities. For every ring (consisting of one bright band plus one dark band) we are 1/100,000" away from our test plate curve.

If the rings are even and concentric, then the lens also will be spherical and have no zones.

If, under Foucault's test, the test plate showed no zones, then any zones that show in the rings will be on the lens surface we are testing.

Now for the contour test, or using the test plate to show what the surface is by an actual picture. It is not necessary to know this method but it will help the worker in understanding how his test actually looks. We place the test plate on the lens and, when the rings have appeared, apply pressure with one finger on one side of the lens at the edge. The rings appear to roll either toward or away from the point of pressure. They roll apparently right off the edge of the lens and then leave curved bands (Figure 3).

If the rings roll away from the point of pressure they will show such a series of bands as in 1; if toward the point of pressure they will show a pattern such as in 2.

If we regard the drawings as round, framed pictures and the point of pressure as its bottom, then 1 is a picture of a lens that is too low and 2 a picture of a lens that is too high.

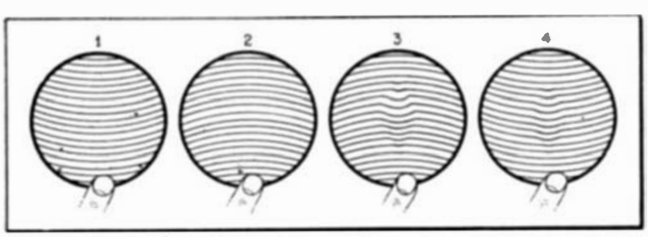
Again, 3 is a lens that is high, with a hole or low zone in the center, and 4 a lens that is low, with a still lower hole or zone in the center.

CENTERING— When the lenses or components have all been polished and show approximately five or less concentric rings above or below the test plate (ignore turned edge if not over ⅛" wide, as the cell mounting will hide it), we are ready to center or true them up and bring them to equal diameter. I believe that a centering spindle should be vertical, to minimize chance of the lens falling off while its optical axis is being lined up to make it run true with the axis of the spindle. The flint lens will be centered first, as the possibilities of developing prism or "wedge" in it are much greater than in the crown. Unless our measurements around the edges of the components, to eliminate wedge in grinding, were very lax, the crown will be so close that it will unquestionably center down to the flint; whereas the flint usually loses more in centering, due to the long radius of curvature of its back.

The spindle may be anything that ingenuity may devise. Figure 4 gives an idea of one such setup. The target used in alining the optical axis of the lens may be an ordinary flashlight with a "T" cut in a black paper mask placed over its end. Spindle speed should be about 250 rpm. The target should be about 2' above the spindle.

The flint lens is mounted on the spindle in the following manner: Take it upstairs to the kitchen and, over the little woman's or girl friend's protests, place it in the cold oven. With the gas turned low bring it *slowly* to a temperature that could be called "good and warm"—say, 140 degrees, Fahrenheit.

Next, heat the spindle with a bunsen burner, smear ordinary sealing wax around its edge, and place the warm lens on it. Rotate it slowly and note the reflections of the target light. There will be two, one from each surface of the lens, and these reflections will appear to rotate as long as the optical axis of the lens remains eccentric with the axis of the spindle. Revolve the spindle and move the lens this way and that (warming the spindle occasionally with the burner to keep the wax soft) until the reflections are stationary. Now the respective optical axes coincide but, unless the lens edge was ground more uniformly to thickness all around than is likely in spite of care, the lens itself is off center and must be centered. The actual centering is accomplished by applying slow abrasive pressure on the lens edge, by means of a brass band controlled by a turnbuckle,



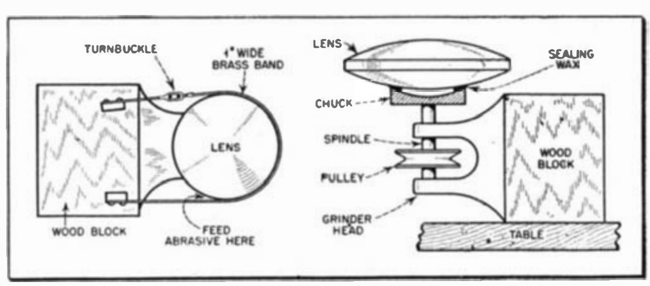


Figure 3: Above: Interpretation of interference fringes
Figure 4: Right: A simple spindle for centering lenses

using No. 180 emery or Carborundum. If you prefer a smoother finish, give the edge about two minutes additional of No. 500.

Stop the centering of the flint as soon as the edge shows no flat spots. Stop the crown as soon as the diameter of the flint lens is reached. The remainder of the excess diameter can be taken up by the cell mounting, as this lens is calculated to give the very best results with a finished diameter close to 4⅞". It is unnecessary to grind off excess diameter. Removing glass that can do no harm to the objective's ultimate performance can be a long and tedious process.

CEMENTING—Procure from your druggist a piece of pure Canada balsam and a half pint of alcohol. Place both lenses in the *cold* oven and warm them *slowly* to a point at which the balsam, under trial, will melt instantly upon application. This will be very hot, since we do not want the balsam to be merely glue-like; *it must be liquid.*

Remove the flint lens from the oven, place it on a clean paper and apply about one half teaspoonful of melted balsam to the center of the concave.

Now, using gloves, remove the crown lens from the oven and place it straight down on the flint. *Do not slide it.* Press down with considerable pressure. The balsam in the center will spread evenly out to the edge and the excess will run down on the paper. Pressure on one side or the other will persuade bubbles to disperse to the edges and disappear.

The crux of the operation is heat and lots of it *but do not hurry it;* apply it slowly. A good way to keep the lenses hot while eliminating trapped air bubbles is to rest them on the flat, level face of an inverted and braced electric flatiron.

Clamp the achromat around the edge with a simple metal band to keep the lenses from shifting off-side and let it cool until cold—naturally, not assisted, since to hurry the cooling is to ask for a cracked lens.

When it is cold, remove the band and clean the excess balsam from the edge with alcohol and, behold, you are now the proud possessor of a perfect telescope objective!

ANOTHER DESIGN—I chose the specifications named because I have produced this achromat and found it gave excellent results on all tests for all aberrations, with a minimum of secondary spectrum. As an alternative I submit specifications for a smaller but equally good lens for the amateur who does not wish to tackle a larger achromat as a first attempt.

Diameter 95 mm, a little over 3⅝".
Focal length 1226 mm.
Focal ratio 12.9.
Blank sizes: each 15mm thick, 100 mm diameter, Bausch and Lomb.

Crown: C—2 1.5125 60.5
Flint: EDG—2 1.6890 30.9
r_1 +750.00 mm
r_2 +545.29 mm
r_3 —545.29 mm
r_4 +1503.81 mm
t_1 14 mm
t_2 12 mm

May I wish the amateur success in this undertaking. I shall be glad to answer any questions regarding these instructions.—*P.A.D.*

No reader need be left wondering whether Driscoll claims to have originated the above-described testplate method (sometimes it is called proofplating). Fearing this might happen, he asks that its true antecedents be made as plain as day. This basic method of reproducing lenses was used long ago by Zeiss and others. It is described in Dévé "Optical Workshop Principles," also in Twyman's "Prism and Lens Making"—not, however, with added instructions for making objective lenses. Driscoll's true contribution to fellow amateurs consists essentially—in addition to the valuable specifications for two achromatic objectives which he donates—in the preparation and offering for publication of a rounded, organized, systematic sequence of operations for making objective lenses for refracting telescopes by amateurs, employing the testplate method as its most characteristic part. Nor has anybody actually published such a procedure for that specific method, so far as is known. (But it does the public no practical good to be told by someone in a commercial industry, after a given method has been published, that it has previously been in use in a given shop, if no one in that industry has ever bothered to make it available to all.

When Driscoll's manuscript was received, it was shown to Dr. D. Everett Taylor, 191 Prospect St., Willimantic, Conn., author of a chapter on the refractor in "A.T.M.A." He took an immediate interest in it and, with a copy of the manuscript constantly at hand, made a 4" objective lens strictly according to the steps of the testplate procedure. His comment while making it was: "The Ronchi bands, which permit of being reduced to one in number, thus revealing almost maximum distortion, are straight." At the completion of the job he wrote: "Shop and indoor testing of the unmounted lens for star image and definition give this method a high rating. It offers every opportunity for the most precise craftsmanship, since at all times one can know the exact condition of the surfaces. It eliminates two big items: iron tools (difficult to machine accurately) and an optical flat. In short, after following it through, I would switch to Driscoll's procedure if tomorrow I were to start the most important objective of my experience."

Further notes on the Driscoll procedure will follow next month, including details of a method of reducing the size of the objectives he has specified, if this is desired.

Optical glass specified in these articles cannot yet be had—needed for war. Have to wait a little.

News note: Thus far two Maksutov telescopes have almost been completed, out of the 19 entrants. Most of the 19 are doing war work, which comes first. Have to wait a little here.

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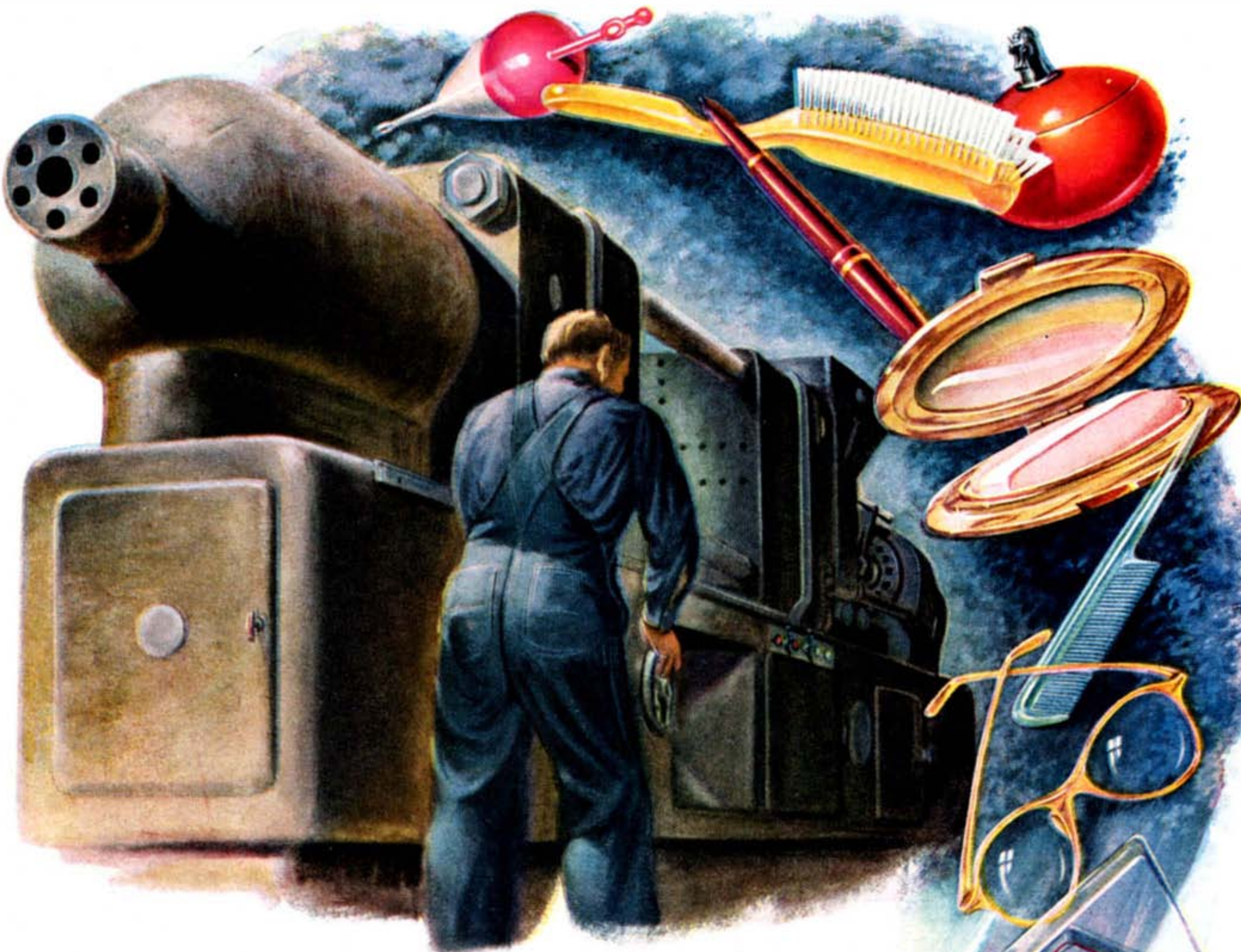

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