FEBRUARY · 1945

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Scientific American

★ 100th Anniversary Year ★

REPORTING THE PROGRESS OF SCIENCE AND INDUSTRY

Precision Inspection . . . See page 65

The Story of MECHANICAL ENGINEERING

Anniversary Issue No. 2

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Our Cover: Precision methods in industry have been largely responsible for many important developments. Our cover picture, used by courtesy of Thompson Products, Inc., shows an optical comparator that aids precision inspection of aircraft parts by throwing greatly enlarged images on a screen.

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Previews of the Industrial Horizon

By A. P. Peck

TECHNOLOGICAL ERAS

FREQUENTLY attempts are made at neatly cataloging differing eras in technological progress, the tags depending upon the interests of the one who attempts to set up the divisions. Latest of these to pass across this desk analyzes the past 80 years in four 20-year periods, assigning them respectively to civil engineering, electrical engineering, mechanical engineering, and chemical engineering.

But such an analysis, which its author admits is over-simplified, loses sight of the complete interdependence of all branches of technology. True, in the early days of this country, at the beginning of the age of rapid transportation as exemplified by the railroads, most spectacular emphasis was on the civil engineer. Behind him, however, was the mechanical engineer—the man who designed the rolling stock—side by side with the metallurgist and the chemist. Often, of course—more often than in the present day of specialization—many of these functions were combined. The point is that through all ages the greatest achievements have been possible only through the greatest coördination of knowledge and effort.

Perhaps World War II has brought home more forcefully the need for this coördination. In any event, there looms on the horizon an era that probably cannot ever be catalogued by any future historian without the coining of some such phrase as "the era of good feeling in technology." This era is foreshadowed in the editorial pages of Scientific American and especially so during the 100th Anniversary Year when each issue presents a feature historical article that gives the background against which to evaluate the present and future.

LITHIUM ON THE WAY

KEEP an eye on lithium and its industrial applications in the near future. One fifth the weight of aluminum, this lightest of all metals is yielding to the probe of research.

Although lithium, in its pure state, has a marked affinity for oxygen and hydrogen, it has long been used in minor ways in metallurgy. Under the demands of war-time needs, production of this metal has been increased many fold and the number of possible applications has jumped almost in like proportion. Today, lithium and its compounds are finding uses in copper castings, tin bronzes and other alloys, as well as in the ceramic, glass and air-conditioning industries.

If the progress of lithium continues, as seems probable at the moment, it will be fortunate indeed that the world's richest deposits are located within the United States.

BETTER BEARINGS

CRANKSHAFT and connecting-rod bearings that will last as long as the rest of the engine are distinct possibilities as a result of Ford experimentation. By using an alloy containing lead, silver, iron, and copper, bearings have been made that show no measurable wear after 50,000 miles of heavy-duty use. Translated into terms of post-war prime-movers of all kinds, this means longer operation between overhauls and, of course, greater efficiency from a dollar-and-cents angle.

SILICONES TOMORROW

STANDING out from the plethora of technological developments of the past year are the silicones, and particularly silicone rubber. (See also page 114.) This rubber, highly resistant to heat, cold, and the deleterious effects of sunlight, will enter tires, printing-ink rollers, chemical processing equipment, even the lowly garden hose. In these applications, and others, it will out-rubber rubber, synthetic or natural. And the silicone resins promise new horizons for the finishes industry, with surface coatings that will come so close to perfection as to leave little to be desired.

PACKAGING IN WAR AND PEACE

DESPITE remarkable developments that have been made in the packaging field to meet military requirements and to circumvent materials shortages, some new packaging methods will face tough sledding when normal times return. Many pliable packages have been perfected as containers for all kinds of materials, both liquid and solid. These packages are doing a splendid job on battle-fronts and in civilian markets alike. But they lack the eye-appeal, the substantial feeling, of the containers to which people have become accustomed during the past couple of generations.

Several manufacturers of consumer goods have already stated that they will go back to the familiar tin cans and boxes just as soon as possible. This they will do regardless of the fact that completely satisfactory containers of pliable materials will cost much less. The manufacturers base their reasoning on the irrefutable logic that post-war competition is going to be greater than ever before and that the package which will sell the most goods is the one to use. If the public will not accept containers that look like "a brown paper bag," and will accept cans and boxes, much of the war-developed technology of packaging will go out the window.

THREAD DESIGN

THE LOSS in hours and dollars that has been brought about by differing standards of machine-screw threads is tremendous. American and British ordnance parts are not interchangeable even though the completed products are of identical design. And the lowly screw thread is the reason. Because there has never been international standardization of these important mechanical elements, many phases of military production and repair have been sadly delayed.

The same thing can and has happened in civilian life. Because of variations in thread design, many a machine has been laid up for weeks while waiting for a special screw with which to make a repair that takes only minutes.

Here is one of those industrial problems that should be tackled. It is a post-war job that should not be laid away in moth-balls and forgotten.

FOR FUTURE REFERENCE

BAGASSE, sugar-cane by-product available in huge quantities, is a potential paper-making material . . . In a new design for cargo planes of the "tractor-trailer" type, the cargo section of the fuselage is detachable for loading while the rest of the plane is flying another load . . . Sheet iron and steel, hot-dipped in aluminum, comes out with all the appearance of the light metal, but is less expensive than an equal thickness of aluminum; it will have applications where surface characteristics of aluminum are desired yet added weight is not objectionable . . . Rayon has proved itself so completely in heavy-duty truck tires that its post-war use is a certainty . . . Your next radio set may be equipped with a simple time dial, controlling an electric motor, that will make it possible to preselect the time at which the receiver will be turned on automatically.

General Electric answers your questions about

TELEVISION

Q. What will sets cost after the war?
A. It is expected that set prices will begin around $200, unless there are unforeseen changes in manufacturing costs. Higher priced models will also receive regular radio programs, and in addition FM and international shortwave programs. Perhaps larger and more expensive sets will include built-in phonographs with automatic record changers.

Q. How big will television pictures be?
A. Even small television sets will probably have screens about 8 by 10 inches. (That's as big as the finest of pre-war sets.) In more expensive television sets, screens will be as large as 18 by 24 inches. Some sets may project pictures on the wall like home movies. Naturally, pictures will be even clearer than those produced by pre-war sets.

Q. What kind of shows will we see?
A. All kinds. For example: (1) Studio stage shows—dancers, vaudeville, plays, opera, musicians, famous people. (2) Movies can be broadcast to you by television. (3) On-the-spot pick-up of sports events, parades, news happenings. G.E. has already produced over 900 television shows over its station, WRGB, in Schenectady.

Q. Where can television be seen now?
A. Nine television stations are operating today—in Chicago, Los Angeles, New York, Philadelphia, and Schenectady. Twenty-two million people—about one-fifth of all who enjoy electric service—live in areas served by these stations. Applications for more than 80 new television stations have been filed with the Federal Communications Commission.

Q. Will there be television networks?
A. Because television waves are practically limited by the horizon, networks will be accomplished by relay stations connecting large cities. General Electric set up the first network five years ago, and has developed new tubes that make relaying practical. G-E station WRGB, since 1939, has been a laboratory for engineering and programming.

Q. What is G. E.'s part in television?
A. Back in 1928, a General Electric engineer, Dr. E. F. W. Alexanderson, gave the first public demonstration. Before the war, G. E. was manufacturing both television transmitters and home receivers. It will again build both after Victory. Should you visit Schenectady, you are invited to WRGB's studio to see a television show put on the air.

TELEVISION, another example of G-E research

Developments by General Electric scientists and engineers, working for our armed forces in such new fields as electronics, of which television is an example, will help to bring you new products and services in the peace years to follow. *General Electric Company, Schenectady, N. Y.*

FOR VICTORY BUY AND HOLD WAR BONDS

Hear the General Electric radio program: "The G-E All-Girl Orchestra," Sunday 10 p.m. EWT, NBC—"The World Today" news, every weekday 6:45 p.m. EWT, CBS.

GENERAL ELECTRIC

952-623-211

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of February, 1895)

ENGINEERING — "The profession of a mechanical engineer, to the uninitiated, holds forth big inducements, and the young man who starts in college works his way along, graduates, and nine cases in ten is assigned a position over the drawing board. Draughting, in its higher forms, is one of the most interesting subjects in existence, especially when other conditions are such as to promote the interest. It rests in the hands of the draughtsman whether the machine will be pulled down several times in order to correct mistakes, and in many cases whether the machine goes to the 'scrap heap' or is shipped away a success."

BICYCLE LIGHTS — "Among the [new bicycle] lanterns are two classes of electrical ones. One is supplied by a dynamo driven from a friction wheel bearing against one of the tires; the other is provided with a battery."

WOOL CLEANING — "In a new method of scouring wool, naphtha is employed as the cleansing substance. By means of a pump the naphtha is forced through and through the wool, extracting all the natural oil. It is claimed that the naphtha does not injure the fiber of the wool, as alkali cleansing, but leaves the fleece in better condition than when cleansed by any other process."

AIR CONDITIONING — "It must be something like fifteen years since the air of the Madison Square Theater was artificially cooled in the summer by passing it over ice; and refrigerating apparatus is in use in every large city in the civilized world, for cooling rooms for the storage of provisions. Many attempts have been made to introduce refrigerating apparatus of the same sort as that used in the cold storage buildings into dwelling houses, but they have failed to please the public."

ACETYLENE — "A chance of putting acetylene to a practical use is afforded by the growing need in many places and for numerous purposes, of a self-contained source of gas of high illuminating power. The bare fact that a portable solid substance can be caused to generate a gas of the required quality by mere contact with a sufficiency of water suggests numerous applications of this order."

RUBBER TIRES — "An experiment has been made recently in New York of much importance concerning the relative value of rubber-tired wheels on ambulances. . . It has not as yet, however, been determined whether the solid or the pneumatic tires are preferable. . . Several inconveniences have been experienced in the use of both forms of rubbr tires. The ambulances are so heavy that the pneumatic tires collapse very often. And the solid tires are likely at any moment to be torn from the wheels, since the strain is unusually great. These difficulties, it is thought, however, can be remedied in time."

SEA SALT — "Extensive works have recently been established at Oldbury, near Birmingham, for the electrolytic preparation of chlorine and caustic soda from sea salt. . . The establishment contains 30 pans, which permit of the daily production of 1,300 pounds of caustic soda and 1,100 of liquid chlorine."

DANGEROUS ARCS — "Over the street doors of one of our most extensively patronized dry goods stores arc lights are suspended for purposes of illumination. Throngs of ladies are constantly passing to and fro under these lights. We noticed a narrow escape for a lady the other evening. Fire fell from the arc lamp and just grazed her dress as she passed under the lamp. The inflammable nature of women's apparel is such as to render it dangerous for them to stand or pass under arc lights. There should be a law to prohibit the use of open arc lights. It would be easy to arrange a glass basin or plate under the lamp to catch and arrest any falling bits of the ignited carbon."

JET PROPULSION — "Instead of the ordinary screw propeller, jets of water are used to drive a new steam-propelled lifeboat. The water jets are produced by means of rotary pumps, and when the jets are discharged from the stern the boat is driven forward. The discharge nozzles are capable of being shifted, so as to direct the jets laterally, in which case the vessel may be turned around or made to move sidewise."

OIL BURNING — "Hundreds of patents have been secured for different methods of spraying and burning liquid fuel. The great secret of success seems to lie in so arranging matters that the flame will not burn itself out and prevent the oil from being properly consumed."

RAIL WELDING — "The electric welding of railway rail joints has, from its inception, attracted the especial attention of street railway managers, particularly those operating trolley lines. In the accompanying illustration we present another method of welding rail joints, recently brought forward by the Falk Manufacturing Company, of Milwaukee. It consists in casting around the meeting ends of the rails, in heated metal moulds, a large body of melted iron, the principal portion of the metal being directed about the base and web of the rails, and thus effecting, it is claimed, a good weld between the iron and steel of the rail."

Rail joint cast-welding outfit ready for work

BLAST FURNACES — "The number of blast furnaces in activity in the United States at the commencement of November, 1894, was 181, their aggregate weekly productive capacity being 158,866 tons. The corresponding number of furnaces in operation at the commencement of August, 1894, was 135, their aggregate weekly productive capacity being 115,356 tons."

TYPEWRITER RIBBONS — "The manufacture of ribbons for typewriting machines is an industry which gives employment to a large number of people. On nearly all the first-class typewriters these inked ribbons are used. There are at least forty different styles of American typewriters, and more than 400,000 machines are in actual use. . . Each manufacturer has a secret process for making his particular style of ribbon, and the secret is guarded with the greatest possible care."

FUTURE FOOD — "According to Professor Berthelot, the distinguished French chemist, the time may be approaching when the farmer will go out of business, and bread and beef and milk, or their equivalents, will be produced artificially in the laboratory of the chemist."

War shortages crop up in strange materials. Mica, for instance. Once seen principally in the windows of stoves, and in small boys' pockets, it is now used extensively as electrical insulation. In some war products, it is virtually indispensable: capacitors for radio, spark-plugs for airplane engines, insulators in electronic tubes.

With demand mounting, manufacturers were desperate. A four-man technical mission flew to London to help ration the world's supply between the United States and Great Britain. The shortage was serious.

The War Production Board, convinced that much mica was classified too low when judged by appearance alone, asked Bell Telephone Laboratories to develop a new method of electrical tests. The Laboratories were able to do this quickly and successfully because of their basic knowledge and experience in this field.

The new tests were made available to manufacturers in this country and abroad—the supply of usable mica was increased 60% — and a difficult situation relieved.

Skill to do this and other war jobs is at hand in Bell Laboratories because, year after year, the Laboratories have been at work for the Bell System.

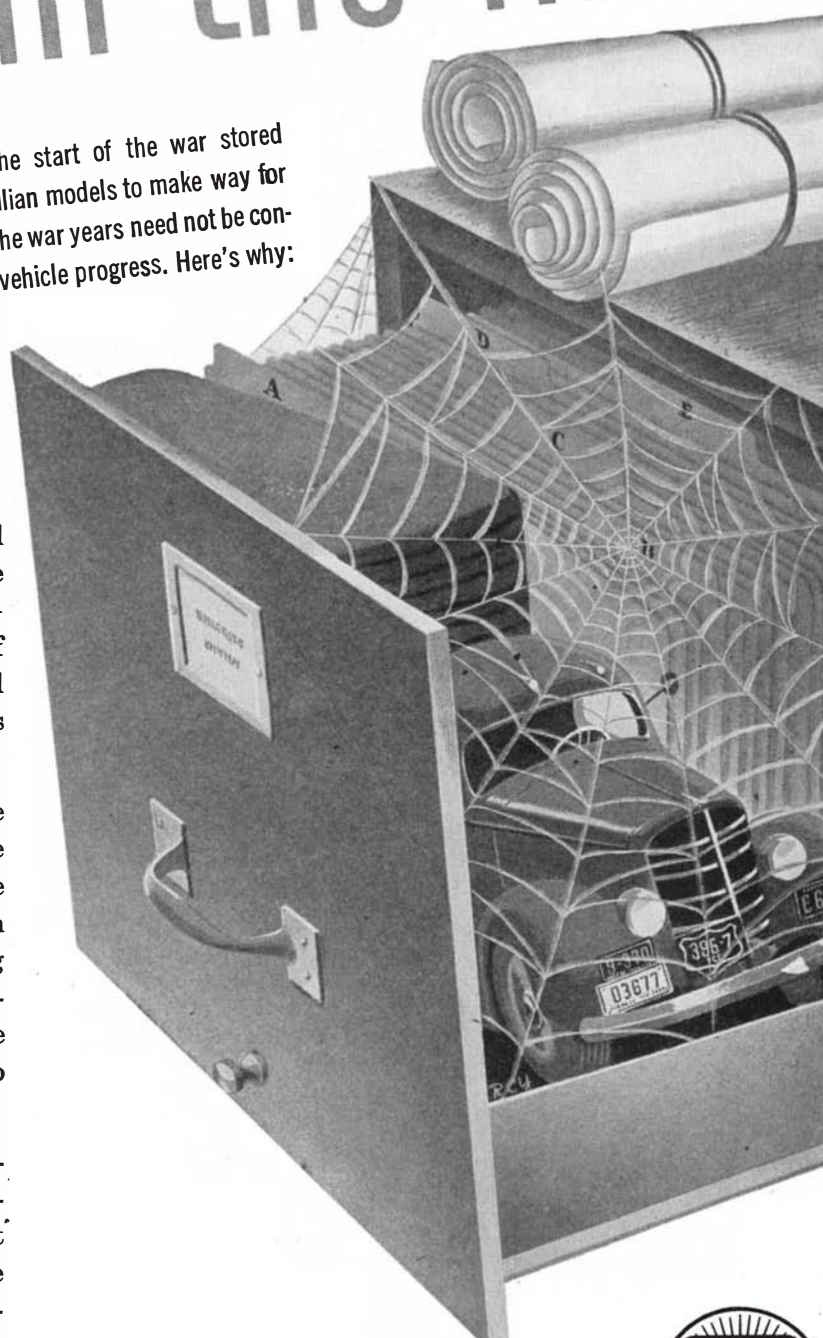
BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for our Armed Forces at war and for continued improvements and economies in telephone service.

ALL COMMERCIAL CAR PROGRESS WASN'T

stuck in the files

Truck and bus manufacturers at the start of the war stored away designs and ideas for new civilian models to make way for production of military vehicles. But the war years need not be considered lost in terms of commercial vehicle progress. Here's why:



The engine of a motor truck or bus and the gasoline that powers it are not separate things, but are two parts of a single unit—power for motor transportation. Thus, if the antiknock value of gasoline is improved and engines can take advantage of this improvement—progress has been made.

The requirement for aviation gasoline for the war effort has necessitated the building of a tremendous capacity for the production of high octane fuels. Although at the present time this equipment is being used exclusively for the production of aviation fuel, it is readily adaptable to the production of motor fuels far superior to those marketed in the pre-war period.

Immediately after the war the petroleum industry will be able to supply gasoline of far higher quality . . . gasoline that in engines designed to utilize it will give more power, more mileage, better performance. Thus, the foundation for more efficient engines is already laid.

ETHYL CORPORATION

Chrysler Building, New York City

Manufacturer of Ethyl fluid, used by oil companies to improve the antiknock quality of aviation and motor gasoline.

ETHYL BRAND OF ANTIKNOCK COMPOUND ETHYL CORPORATION TRADE MARK REG. U.S. PAT. OFF.

Wartime progress by America's petroleum industry has paved the way for fundamental progress in post-war automobile engine design.

Scientific American
FEBRUARY • 1945
★ 100th Anniversary Year ★

An installation, in 1880, of Babcock and Wilcox boilers in a Standard Oil refinery

A Century Of Engineering

By **EDWIN LAIRD CADY**

By Reviewing the History of Mechanical Engineering and Its Effects on the Industrial Era of Today, a Background is Established Against Which Many of the Possibilities of the Future Can Be Evaluated

IT WAS NO mechanical wilderness into which Scientific American was born in 1845. In fact, power and the machinery with which to use it—the main concerns of the mechanical engineer—had advanced far enough so there was real need for a magazine devoted to the progress of science in industry.

The steam engine, invented by James Watt in 1769, was 76 years or four mechanical generations old. It was hauling trains in England and the United States. Oliver Evans (1790) had built high-pressure steam engines in Philadelphia. Fulton had proved his steamboat (1807), and the world had decided that it was not the man who first thought of an idea, as had Evans and Fitch before Fulton, but the one who made it useful to the world, who was to be credited with it. This was important because in that era hundreds of mechanical advances were being kept secret and no one will ever be sure who first developed them.

The first Baldwin locomotives were being built in 1832. In 1823 the French Government had determined the temperature and many of the properties of steam up to 350 pounds pressure, and "dry" steam techniques were on their way. By 1840 every type of fire-tube boiler was in use.

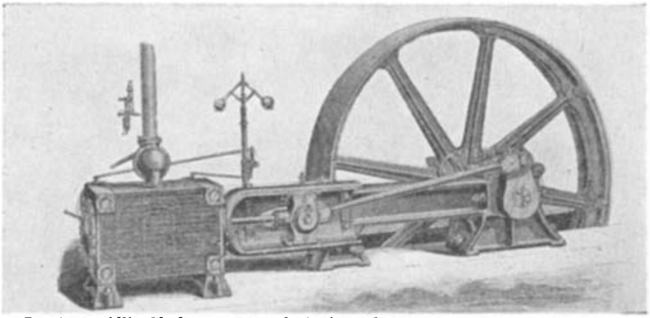
TURBINES—Power as a by-product of other processes was known in 1838; the flame-ignition gas engine was running on waste gases. The principle of the steam turbine was well known; it was regarded as interesting but impractical. On the other hand, inventors worked day and night on the gas turbine.

Electrical power had made something of a start. Faraday (1821) had converted electrical current into mechanical motion. Sturgeon's rotary electric motor (1832), Jacobi's electrically propelled boat (1839), a five-ton electric locomotive in Aberdeen, Scotland, (1839), and Morse's telegraph (1837) were showing how electricity could be made useful to mechanical engineering.

Water wheels were the main source of mechanical power as they had been for thousands of years. But the 30 percent efficient under-shot wheel was being displaced by the 60 percent efficient over-shot and the 70 percent efficient breast wheel. Impulse turbines (1835) made high falls of small streams useful. Fourneyman had a six-horsepower water turbine in 1827, a 50-horsepower one in 1832. And with the formation of the Escher-Wyss company in Switzerland in 1845 the modern science of water power was well on its way. This company was the real developer of the turbine.

POWER TRANSMISSION—Prime movers, indeed, were much farther advanced than the means for transmitting the power they generated. *The Journal of The Franklin Institute* (1837) described fully integrated belt-driven cotton mills in Lowell, Massachusetts, belying the belief that modern belt drives originated in the 1780s. Infinitely variable ratios, within limits, had been created in an opposed-cones belted device of a type still in wide use. In 1786 the Watt and Boulton flour mill (England) had been built with the then unheard-of metal shafts and bearings. A few slow-speed chain drives existed. Babbit metal was invented in 1839.

Gears were the mainstays of power transmission. Most of these were cast, although many were made of metal strips

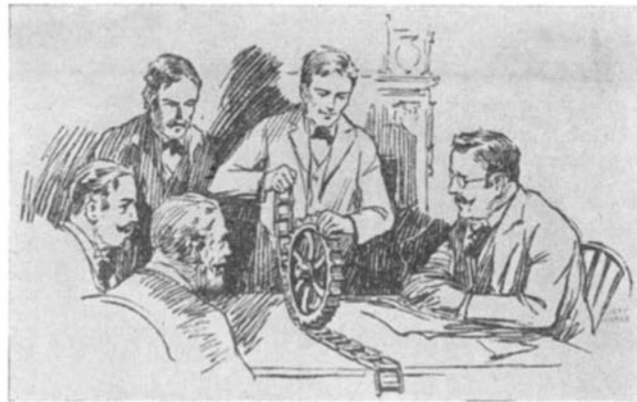


Courtesy Allis-Chalmers Manufacturing Company

In 1878 the Allis Company offered to the waiting public an improved Reynolds-Corliss engine. This type marked a step forward in supplying industry with better power and higher speeds. Within the next 25 years, 6000 of these improved engines were made

fastened across the rims of wooden wheels. They made a horrible racket when they ran, but then the mechanic of that day was as proud of the distance at which his factory could be heard as of the rancid lard or sperm-oil smell which permeated his hair and clothing and advertised his calling to all who passed him on the street.

Any refinements in power transmission were built into individual machines; they seldom were found throughout any shop as a whole. Thus the machine shop of the day had lathes complete with lead screws, sliding rests, and change gears. Bevel gears were known in 1775, the involute form of gear tooth in 1760. Sometime around 1800 Oliver Evans of Philadelphia had a machine to cut involute gear teeth

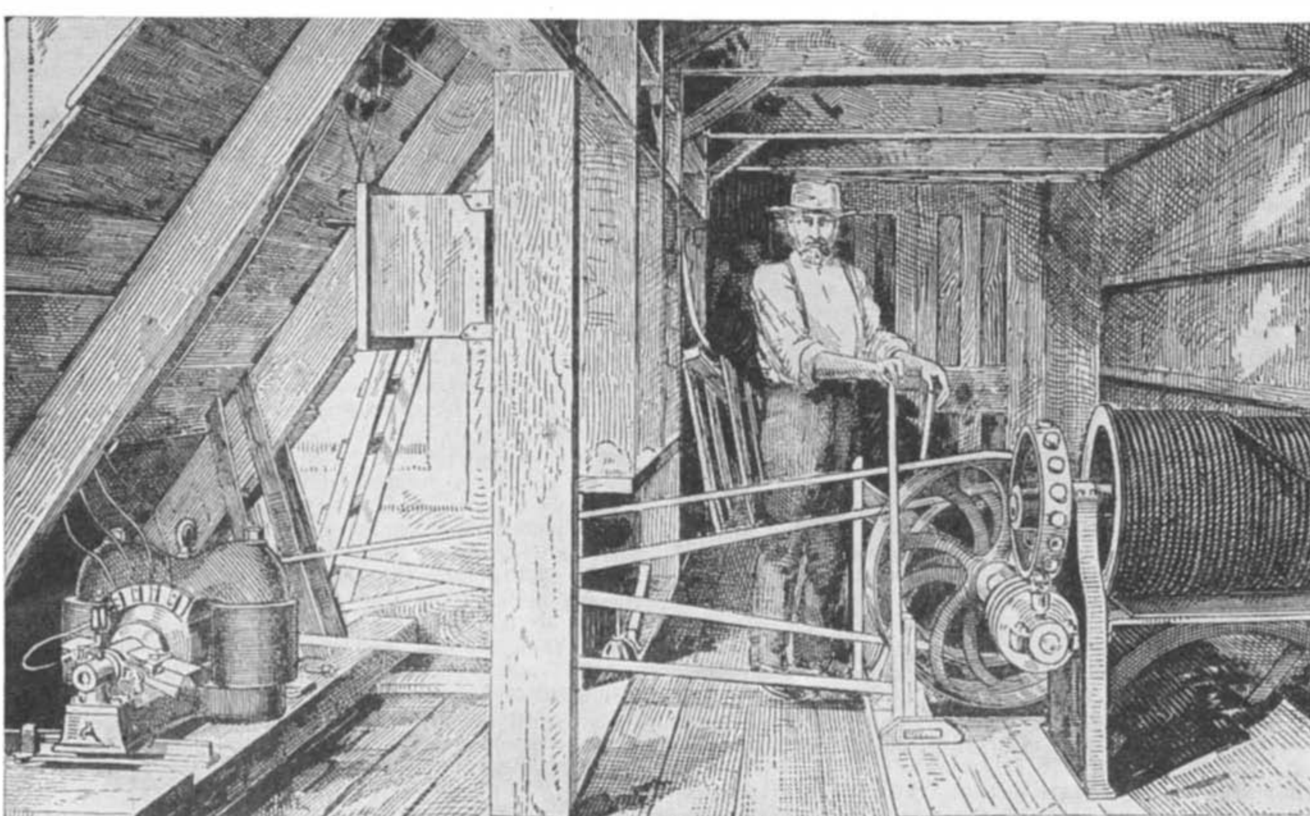


William Dana Ewart demonstrating his invention, the detachable-link chain, preceding the organization of the company that grew into Link-Belt Company

accurate to shape, diameter, and pitch line, but nevertheless the Saxton (Philadelphia, 1837) accurate gear-cutting machine was a wonder of the world. The Putnam lathe (Massachusetts, 1835) had back gearing with worm and rack feeds, and the Baxter D. Whitney lathe (Massachusetts, 1833), had worm wheels and a four-step cone pulley.

Machine tools, as usual, were far more advanced than the machines which were to be made upon them. Shops had engine lathes, planers, shapers, drill presses, and boring mills. The steam hammer was at work. Eli Whitney, making rifles, was using special machines for forging, rolling, boring, grinding, and polishing. Terry had made wooden clock wheels on a mass-production basis, then had switched to brass and was stamping them. Stamping operations to put heads on pins had been known since 1680, and the micrometer principle of measuring since 1637. Eli Whitney had made the first milling cutter in 1818. And milling was to remain a peculiarly American method until well after the Civil War. Failure of the Europeans to adopt it to any great extent gave American industry enormous advantages in the production of twist drills, gears, splines, and all sorts of form-cut parts.

The first Fairbanks platform scale (tap root of Fairbanks-



Courtesy General Electric Company

A Sprague electric motor operating a hoist in the 1880's

Morse) was made in 1830. There was nothing like it in the world. It was a first step in accurate control of production.

THE AMERICAN WAY—Most important in the scene to which Scientific American was born, was that the "American Way" of mass production and integration was already well established.

This way started with the very colonies. By 1650 America had over 2500 saw mills—the lumber industry was integrated. Europeans tried every possible trick to prevent us from learning how to manufacture. Sand castings took the place of loam molds (1708), spinning machinery was developed in 1738, the Jacquard loom—still one of the most amazing automatic machines—was invented in 1801, and the only way we could get any of these machines was literally to sneak the men who knew the secrets into our country. From these experiences we got the habits of learning all we could by any means we could, integrating all the knowledge we obtained, and thinking for ourselves.

Development of interchangeability in musket making (Whitney, 1798) was a natural evolution of integration. Eli Terry's clocks (1803), Colt's revolvers (1836), and the equally great contemporary work of Simeon North followed. In another line, Oliver Evans (1783) fathered materials handling; he had bucket elevators, chain and drag conveyors, screw or helicoid conveyors, cleated belt and bucket belt conveyors. We never have departed from these methods. For over 100 years the Europeans, and principally the English, have called them the "American System."

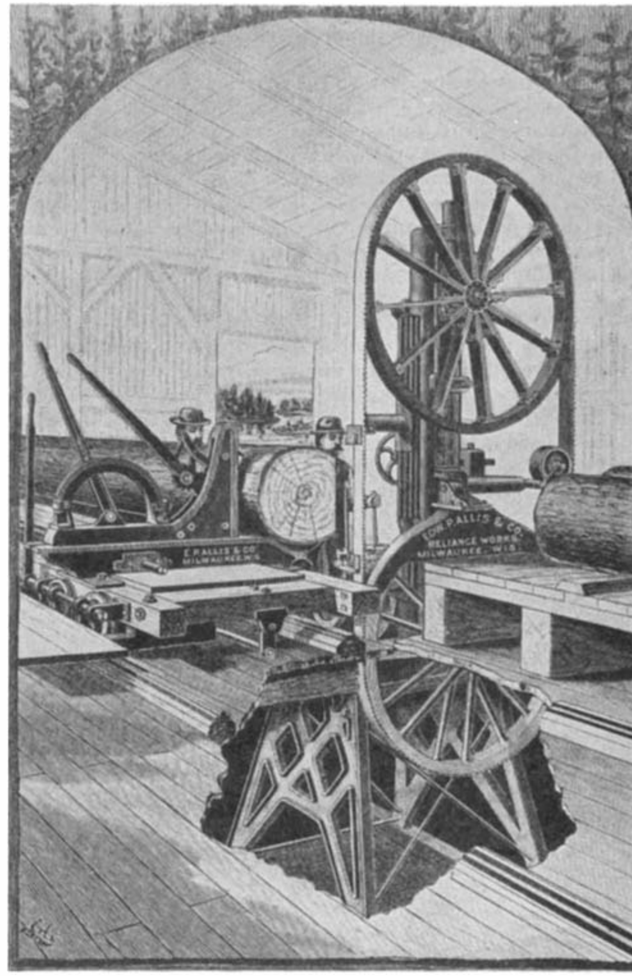
An early Fairbanks platform scale. These weighing units made possible the first steps in providing accurate quantitative control of industrial production

By 1820, Pawtucket, Rhode Island, was a flourishing machinery center. Large machinery enterprises were on their way all over the land. Colonel Stephen Jenks (1820) started the nut and screw company which was to become the William H. Haskell Company. Some forebears of other great companies: 1838, the Eagle Screw Company which became the American Screw Company; 1833, the forerunners of Brown and Sharpe; in 1839 Russell and Erwin were making hardware in New Britain, Connecticut; and in the 1830s the company was started which was to end up as Jones and Lamson.

Paul Revere had rolled copper in 1801; Scovill, at Waterbury, invented the brass and copper utensil spinning process in the 1830s, and Waterbury was a flourishing copper center.

Not everything was in the east. Flour milling started in Wisconsin in 1835. The real beginning of Allis Chalmers was in Milwaukee in 1847. Circular saws, used in Maine in 1824, were to spread quickly to the Great Lakes lumber regions.

Scientific American, then, was born into a nation which badly needed a periodical to integrate its integration-minded industrial men. And the fact that this same integration-mindedness has dominated nearly all the American scientific and industrial magazines, has made them the greatest and most useful the world has ever known.



From the first successful American band-saw mill built in 1869, this type developed to the refined form shown, manufactured by Edw. P. Allis and Company, after George M. Hinkley's design, in 1885

TWENTY FORMATIVE YEARS—Historical periods cannot be defined to the point of strait-jacketing their implications. Descriptive labels of periods must be preceded by an understood "generally speaking." And, generally speaking, the years 1845-1865 were a formative period in mechanical engineering.

Power production made some long jumps. Regnault worked out the principles of superheated steam (1847), and two years later the relation of heat to power was found at 772 foot-pounds per BTU: it now is known to be 778. By 1859 Rankine had developed the theories of steam expansion, condensation, and re-expansion in the steam engine cylinder. Surface and jet condensers both were in use in the 1850s. Richards steam engine indicator (1860s), was the first one good enough for high-speed engines.

Bourdon's pressure gage and the Corliss steam engine both arrived in 1849. And with Henri Giffard's injector feeder (1859), steam was ready for advanced reciprocating engines and for turbines.

Centrifugal pumps (1850) initiated the high RPM age in power, but nobody knew it at the time. Worthington's huge pumps, first made in the 1840s, were to dominate pump rooms for decades to come.

Out in gold-rushed California the spoon-shaped bucket impulse water turbine was dreamed-out by a miner who let his old style wheel wear until the buckets were slightly to one side of the main force of the stream. He found that the wheel worked better that way, and changed the buckets (1854) to take advantage of this.

Another development was made by men who little realized what they were starting. Beau de Rochas, a mathematician, worked out the four-cycle principle of the gas engine, and Otto (1860), made a "silent" four-cycle engine which worked.

Power transmission was to get its real start. In 1845 the Hope Cotton Factory (Pittsburgh) was secretly lubricating its machines with a mud-colored, greasy fluid which came up in Lewis Peterson's salt well, and petroleum lubrication had begun. Mineral oil was found in large quantities in 1859, and by 1855 enough engineers had learned of Hope Mill's use of it so that the world was ready. In the meantime the "oilless" bearings had arrived; Yankees were making bearings of lignum vitae and lubricating them with water.

BIRTH OF THE MODERN FACTORY—Most important to power transmission, James Coombs of Belfast, Ireland, worked out a rope drive (1856) with the endless ropes—a rope is easy to splice endless—working in V-grooved pulleys. The "American Rope Drive" soon followed. Here was the big difference. Coombs used a main shaft but ran a single rope to each machine. The Americans used a single rope from a main drive pulley and ran it to all the machines, thus integrating whole factories so that the machines in sequences could not

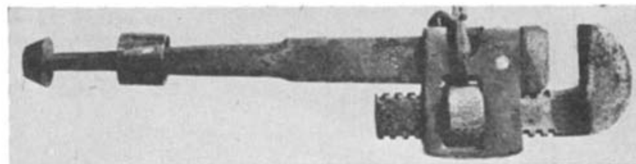
Bustles, coat-tails, and derbies had their place in industry in the 1880's, along with mazes of power-transmission belts, as witness this scene in the wire-insulating department of General Electric

get out of time with each other. With the Coombs selective as well as the American integrated drive ready, power transmission was freed from the short center and limited space problems of gears, but could have the advantages of gears also. The modern factory was here.

The first American machine-made wire rope (1846) presaged modern mining methods, materials handling, and elevators.

Steady flowing power, which did not fluctuate with the heights of streams, was more and more necessary. Mass production was coming along. The Hoe revolving printing press (1845) needed it. The Howe sewing machine (1846) could be cheap enough for public use only if mass made. Aaron L. Dennison of Boston was making machine-made stem-winding watches in 1850. The English confiscated the first lot he shipped them but paid the declared value price; they thought he was dumping his watches, but when he gleefully sent over a much larger lot, and then a third still larger one to this quick cash market, the customs officers called it quits and let them go on to the wholesalers. In 1856 Brown and Sharpe standardized the wire gage. After that, American clock springs and other wire goods were nationally standardized and mass production was nationally integrated on its first item.

PRECISION PRODUCTION—Machine tools and measuring instruments were of mass-production types. Stephen Fitch, of Middlefield, Connecticut, had a horizontal turret lathe with eight tool positions in 1845. J. R. Palmer (1848) had a workable micrometer caliper. Automatic gear cutting ma-



The still famous Stillson wrench has changed but little from this original design patented in 1870

chines (1850s) and a gear cutter with an index plate having 15,690 holes (1852), were followed by the first Brown and Sharpe precision gear cutter in 1855.

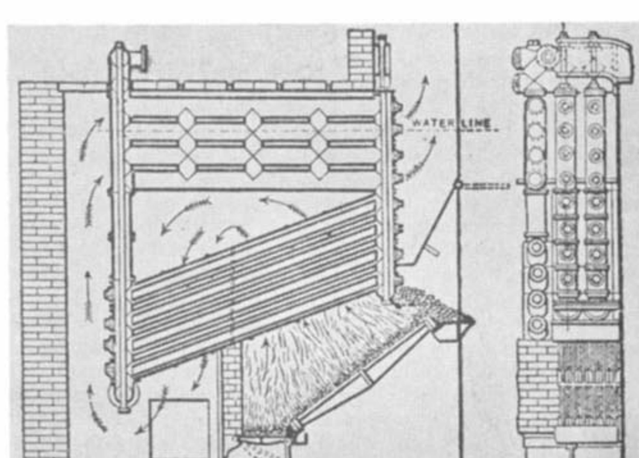
In 1851 Brown and Sharpe brought out a vernier caliper accurate within thousandths of an inch; they followed it with a similarly accurate vernier protractor the next year.

E. K. Root developed a chucking lathe (1855) at Colt's Armory. 1861 saw the start of Pratt and Whitney. In 1861 Brown and Sharpe announced the first universal milling machine and the first automatic screw machine—either would have been a mechanical engineering milestone. The first commercial grinding machine, the Brown and Sharpe cylinder grinder, followed in 1864. In that same year Sellers (American) internationally standardized the micrometer at 60 degree thread angle, and Brown and Sharpe brought out the first spiral miller for cutting grooves in twist drills and the first formed milling cutter which kept its accuracy through several sharpenings. None of these devices had much meaning unless used for mass production—the "American System."

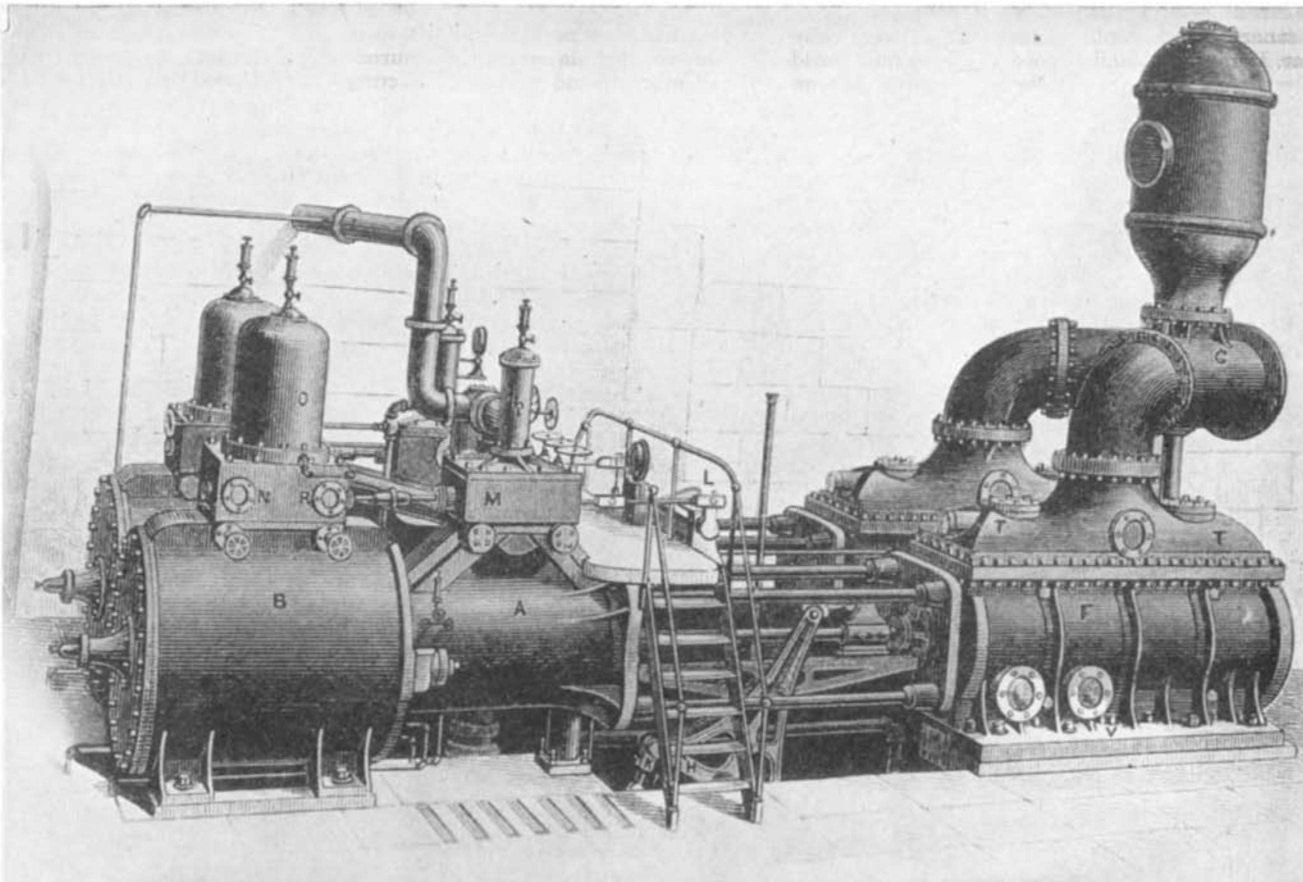
Other events showed how the mechanized age was rapidly growing. Among them were the gimlet pointed wood screw (1846); the first cable car (1858); the birth of refrigerating machinery (1860s); hydraulic presses (1860s); and the first Otis passenger elevator in 1861.

THE EXPLOSIVE SEVENTIES—In the early 1860s, industry seemed fixed in its character. Factories had to work long hours. Their slow acting fire-tube boilers were hard to get up to the production steaming point, and would not stand heavy fluctuations in the load. Water power was available only during the seasons when the streams supplied it, and the plants had to run as long as they could while they had it. Men, in short, were servants of stupid monsters known as power plants, and there was many a social philosopher to remind them of it. Worst of all, this condition threatened to continue until it engulfed all civilized mankind.

About 1865, industry began blasting itself free of these



A drawing of the original Babcock and Wilcox boiler which brought flexibility to steam power plants



This Worthington pumping engine (capacity six million gallons per day) was built in 1876

restrictions. It was the 15-year era of the "explosive seventies."

The first Babcock and Wilcox boiler, with its inclined water tubes, its headers and drums (1867), meant quick steaming. Now power could be had quickly and the load could fluctuate widely. Plants powered by steam could be flexible, adaptable.

Feed-water heating was born in 1870. It was economical; power cost was reduced and therefore more power could be used; it made fluctuating loads much easier to handle—steam can be raised far more easily from hot water than from cold.

The Brotherhood radial steam engine (1870) substituted the unheard-of speed of 225 RPM for the 20 to 60 RPM engines then in common use. It did away with 20 foot diameter fly wheels, the 1800 square feet of floor space devoted to the engine alone, and so on, which were needed by the slow acting engines. It joined the centrifugal pump in using high RPM to get rid of bulk.

In this crude electric furnace, Dr. Edward Goodrich Acheson conducted experiments in the 1890's in the production of the now widely used Carborundum

Most important of all, Moses G. Farmer took out the first American patent on a dynamo in 1875. Thompson, Brush (General Electric), and others were only a year or so behind him. Industry was about to receive the flexibility which only the electric motor could give it.

FLEXIBLE POWER—Power transmission had arrived. The shifted belt, the friction clutch, and the jack shaft (counter shaft) were adding to the flexibility of operations. Rawhide pulleys and paper pulleys as well as leather covered iron ones were permitting more power to be transmitted by smaller equipment. Cotton belts impregnated with rubber were used for wet conditions, but no one then foresaw the modern rubber belt. The disadvantages of lard oil as an all-purpose lubricant were quite apparent. One English manufacturer was distilling 400,000 gallons of lubricating oil a year from coal. Ewart (1874) made the first successful detachable link chain; this was the start of the Link Belt Company and also of modern chain drives.

Westinghouse's development of the air brake (1869), following hard on the heels of 3000-foot pipe lines to take compressed air to rock drills in Italy, got modern compressed-air methods well under way. The adaptability of this method of power transmission still solves thousands of factory problems.

Accurate ball bearings were first announced in 1877. The handicaps of friction in power transmission were on their way out.

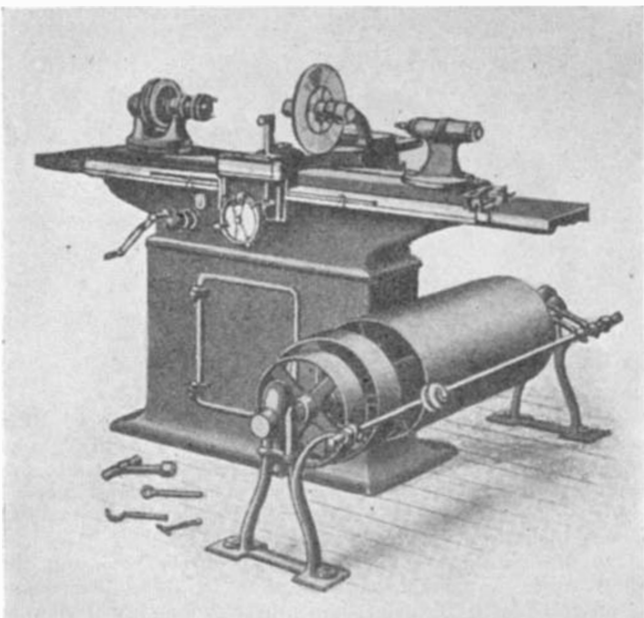
AGE OF ACCURACY—Machine shop equipment came on rapidly. In 1867 Brown and Sharpe had a sheet-metal micrometer accurate to .001 inch, and in 1877 a micrometer caliper good enough to free the tool maker from the need of making his own measuring instruments. Professor Rogers of Pratt and Whitney worked out the Rogers Bond Comparator and found most standard measuring blocks faulty.

He persuaded France, England, and the United States to build standard meters, yards, and inches which were really accurate. International standards good enough to build world trade by integrating all the industry of the world were on their way.

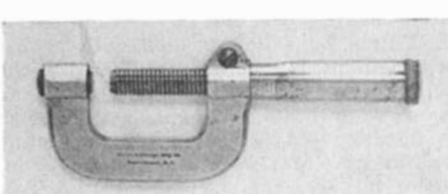
Billings and Spencer (1869), greatest developer of drop forging, was founded in Hartford. Spencer (1870s) worked out the first strap cam controlled automatic screw machine.

The first vitrified grinding wheels were made in the Norton Pottery Plant in Worcester, Massachusetts, in 1873. 1876 saw the first Brown and Sharpe universal grinder. The age of accuracy was developing rapidly.

Band saws appeared in the lumber industry in 1869. Cheap steel (about 1870) removed many of the handicaps from machine builders. Emerson (1875) erected a testing flume at Holyoke, Massachusetts, to test water wheels under standard conditions; hundreds of models were sent to him and standard testing got under way. Cigarette machinery (1876), Remington typewriters (1878), and, most of all, the National Cash Register (1879), were the foundation stones of modern mass marketing. With the first Ingersoll com-



The original universal grinding machine, made by Brown and Sharpe. Such machines as these, developed in the last half of the 1800's, were ideally adapted to pushing forward the "American System"



This Brown and Sharpe micrometer caliper was first listed in an 1877 catalog

pressed air rock drill (1871) Ingersoll Rand was born and with it the modern age of road building. In every direction, industry was finding new fields for itself.

THE INTEGRATION DECADES—At the beginning of the 1880-1900 period, hundreds of mechanical devices had been tried only on a small scale, and hundreds of others had been so localized in their use that their relation to each other was none too apparent. If our modern age of mass production was to grow up, there had to be an age of integration coupled with further development. The "American System" of mass production and marketing had to take form.

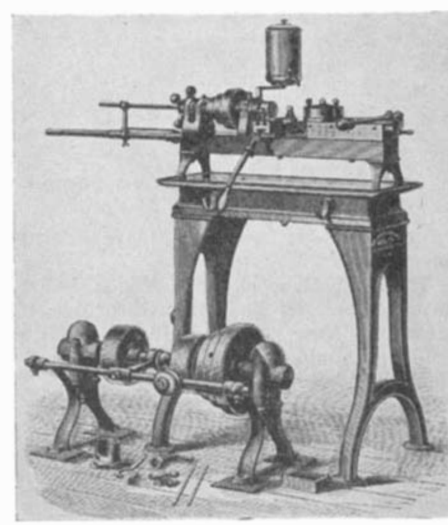
Frederick W. Taylor began his efficiency-engineering work in 1880. First, he worked out his work-rest-work method and proved how much more the human body could do if integrated to a task. Then he directed a heavy stream of water on a cutting tool and found that the speed of the machine tool could be increased 30 to 40 percent when the tool was cooled. Soda and water mixtures to prevent rust, lard oil mixtures, and petroleum-base cutting oils followed rapidly. A better trained man integrated to using more power while working on a higher speed machine could produce more work with less floor space. And when Taylor showed what could be done with high-speed tool steel (1898), the highly flexible yet highly integrated unit system of production was here.

Other engineers worked along similar lines. Among them were Barth with his group drives, Gantt with his production mathematics, Galbraeth with his human engineering, and Emerson the idealist. They integrated men and machines.

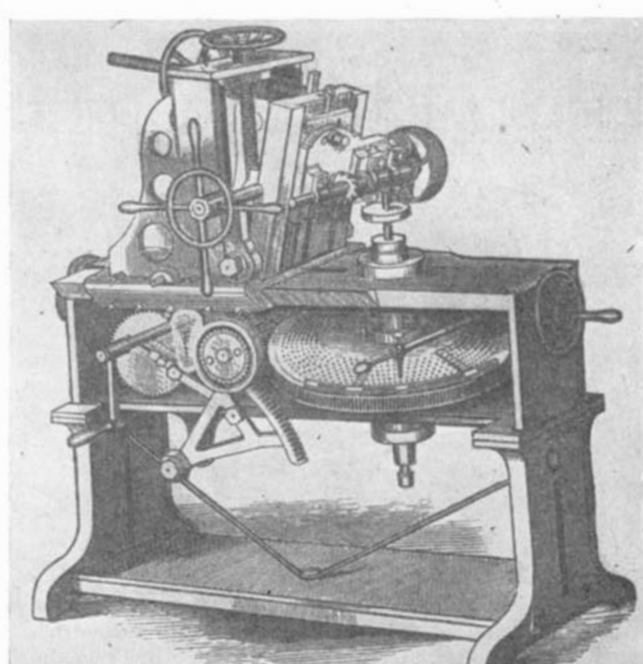
Power was lending itself to the new scene. Sprague (1884) had a constant-speed non-sparking electric motor good enough to be endorsed by Thomas A. Edison. The U. S. Metallic Packing Company (1882) was founded to make a segmented block packing which would solve problems for high-pressure, high-speed steam engines. Steam turbines finally became practical with the Parsons (1881), the De Laval (1885), and the Curtis (1898). With motors and turbines the age of high RPM received an impetus which never has stopped.

Pulverized coal (1890) increased the flexibilities of steam plants. The hot-bulb ignition engine (1883) showed the way to small unit power plants and still greater flexibility in manufacturing. Westinghouse pioneered the multiple-cylinder gas engine to save weight and space. The Daimler

Right: Universal milling machine made by Joseph R. Brown



Below: Type of precision gear cutting machine built by J. R. Brown and Sharpe in 1855



Courtesy Automatic Transportation Company

One of the first contributions to systematic materials handling was the self-loading lift truck

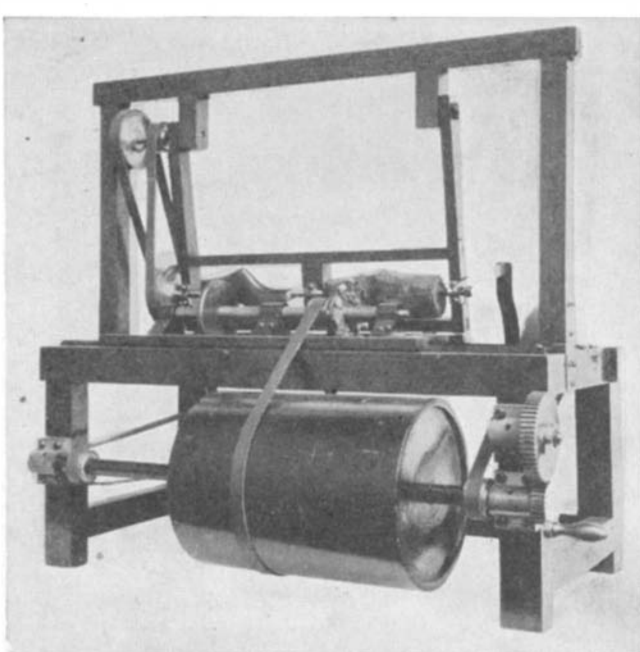
gas engine (1880) ran at 800 PM and weighed only 88 pounds per horsepower; its 200 RPM predecessors had weighed 1000 pounds per horsepower. The Maybach carburetor (1893), with ball float and needle valve, made modern gas engines practical.

BELTS, GEARS, CHAINS—Power transmission had gone definitely to belts, with gears and chains for small, intimate mechanisms. Hans Reynold (1880) made a roller-bushed chain. Forced feed lubrication arrived. Timken (1898) worked out a conical roller bearing to make his sulky run more easily—Timken roller bearings were on their way. Triple valves for Westinghouse air brakes (1887) opened the way to thousands of industrial uses of compressed air.

Ewart and others began applying his link-belt chains to scraper systems, bucket elevators, all sorts of materials handling devices. The Gandy belt was showing what could be done with belt conveyors.

Acetylene gas (1895), Elihu Thomson's first electric welder (1886), and Linde's liquid-air apparatus (1895), presaged the age of welding.

High RPM machinery needed better gears. Gleason's first automatic bevel gear planer (1894) and the Fellows gear shaper (1896), made such gears possible on a mass-production scale. The first Bullard Vertical (1883) and the Hartness Turret Lathe (1889) were integrations of machine building ideas which had been developing for nearly a century. Acheson's Carborundum process (1893), added hundreds of new possibilities to the fine grinding and accurate production



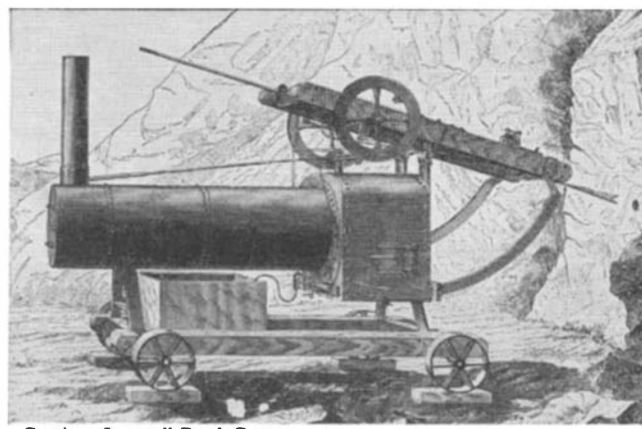
One of the early duplicating lathes, patented by Thomas Blanchard, 1843. U.S. National Museum

fields by providing a man-made abrasive superior to nature's.

Reece's button hole machine (1881) solved the most delaying hand-work problem of clothing factories and complemented the sewing machine in making possible the mass production of textile products. The Mergenthaler Linotype (1884), Edison's Kinetoscope (1893), Eastman's Kodak snapshot camera (1888), and the development of nickel steel (1889), each brought in a brand-new age.

MASS PRODUCTION—In the years 1900-1920, the mass production or "American System" proved itself to be the only one capable of bringing mechanical civilization to its full flower.

The Norton grinder (1900) was heavy enough to make accurate grinding a heavy production rather than a light supplementary operation. Diesel engines added another to the prime-mover types already available. Broaching was born. New Departure (1906) and Gurney (1905) showed that a single ball bearing could take both radial and thrust loads at high speeds—previous practices had called for one radial and one thrust bearing. Accuracies of .001 inch, previously regarded as fine, became coarse ones. Machines working to .00001 inch became common, with .000001 inch tolerances in plain sight. The Federal Products Corporation turned to dial indicators and other high accuracy instru-



Courtesy Ingersoll-Rand Company

Couch's rock-drilling machine, patented in 1849, was the first percussion drill made for this work

ments as an emergency measure to hold their skilled help (1919), and found the market almost unlimited. Spiral gears, bevels, hypoids, and herringbones became common; they could not have been used in an age when high precision was unknown.

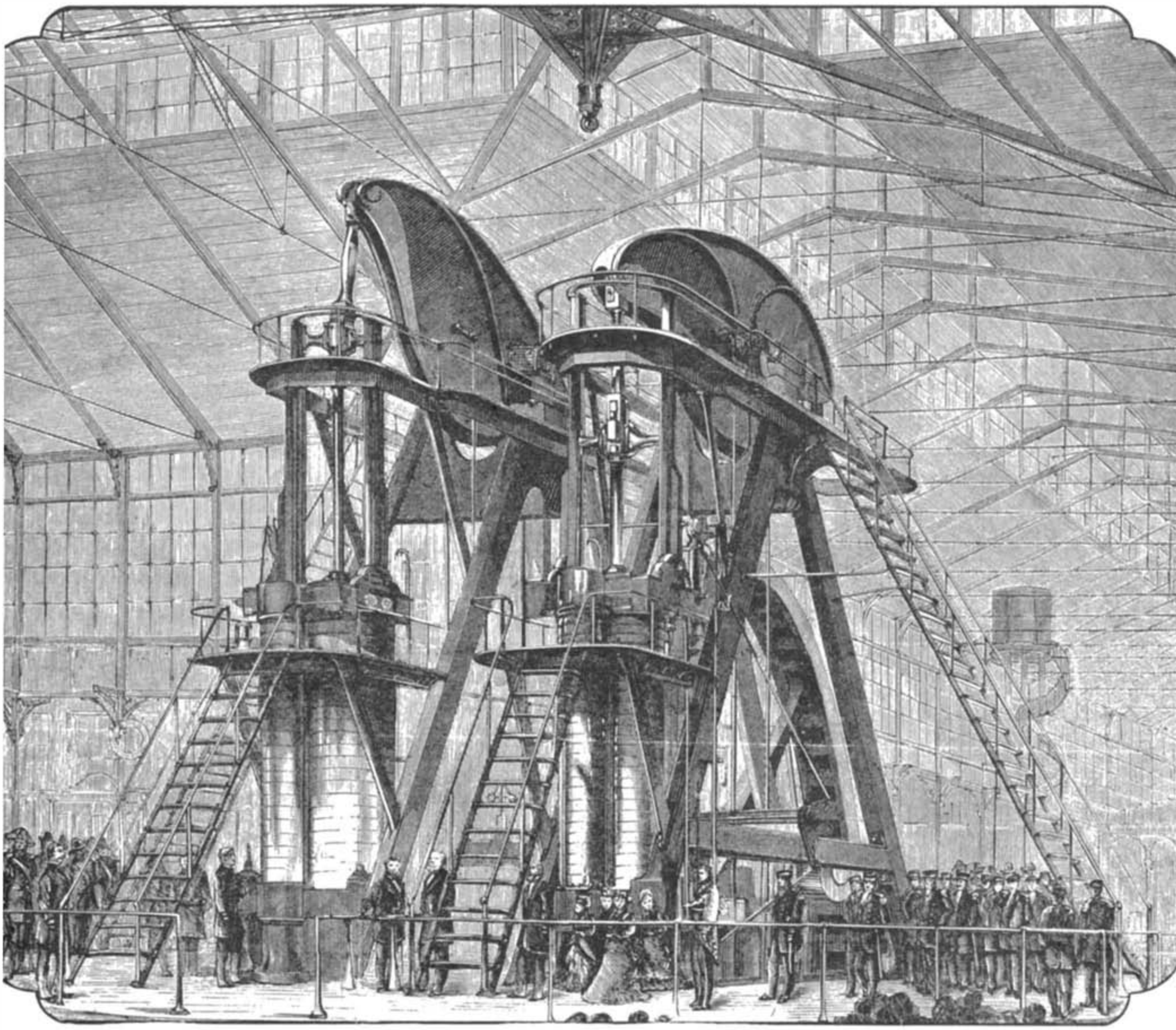
The pooling of the automobile patents and others proved to be a much greater benefit resulting from World War I than could have been received from any grabbing of territory. The automobile assembly line became the merciless proving ground for every mechanical device or idea. Progress went into high gear and has never slowed down.

CHEMISTRY AND METALLURGY—With the 1920s, mechanical engineering was definitely becoming the servant of metallurgy and chemistry. True, the multiple V-belt drive (Dayton Rubber, 1921, and Allis Chalmers, 1923) was joining the silent chain, the greatly improved gears, the new types of electric motors and of variable speed mechanisms to replace long center drives and still further unitize machinery. And materials handling equipment—the lift truck dates from World War I—was turning whole factories into integrated machines.

But higher cutting machine speeds had to wait upon sintered carbides and other metallurgy. Stainless steels and other new alloys were making new machines possible.

Plastics, rubber products, insulations, protective coatings, welding rod coatings for shielded-arc welding, explosives to fasten rivets, concretes for firmer bases, metals cleaning compounds—all these and dozens more were in the chemical fields, and machinery advanced as and when they did.

These years served to demonstrate how completely mechanical engineering—in the United States at least—had become the servant of man. Let anyone mention a type of product he wanted to make or a production operation he



[his Monster Amazed the World

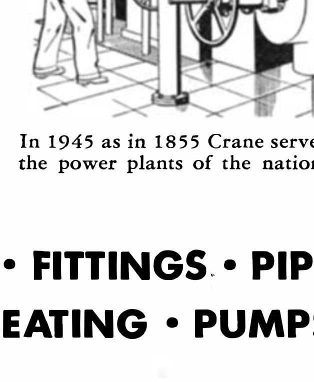
When Crane Co. was founded, inventors were seeking ways to harness the power of steam. One of the earliest successful engines was later exhibited by Corliss, its designer, at the Centennial Exhibit in Philadelphia.

hen R. T. Crane first opened his little ındry 90 years ago, America was at ɜ threshold of an era of economic delopment. A new age of power was at nd—power that would transform the nple economy of hand craftsmanship an amazing age of mass production.

American inventive genius was already work on new engines to harness the ·wer of steam. Thus the founding of ane Co. coincided with the revolution power production and transmission ıt has built America to its dominant sition as an industrial nation.

Through the years Crane Co. has kept step with the demands of power, furnishing pipe, valves and fittings to meet the needs of ever increasing pressure and temperature. Today, as when the monster Corliss steam engine amazed the world, the name Crane is familiar wherever power is produced. For any piping system, whether it handles steam, water or air, gas, oil or processing liquids, Crane can equip it 100%.

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



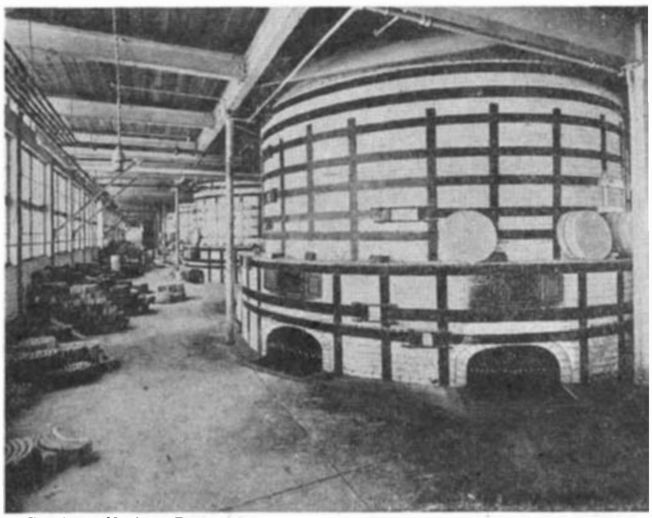
In 1945 as in 1855 Crane serves the power plants of the nation.

CRANE 90 YEARS OF PROGRESS 1855 1945

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

RANCHES AND WHOLESALERS SERVING ALL INDUSTRIAL AREAS desired to perform, and if chemistry and metallurgy were ready with the necessary materials, then mechanical engineering would produce the goods.

Automobiles, for example, did not perform as well as was desired. Designers accordingly worked out the needed improvements without many worries about how the new, highly accurate, and intricate parts could be made. Machine-tool builders turned out special machines to do everything needed, and materials handling men followed through with the assembly lines to keep down the costs. Strip steel cost too much; the answer was the continuous strip mill which was made possible by modern, accurate anti-friction bearings. Airplanes could not be made fast enough; mechanical



Courtesy Norton Company

A row of old-style periodic kilns of the pottery type in which vitrified grinding wheels were fired

engineering devised the mock-up and the modern welding and riveting techniques.

In 1845 the machine age was taking hold. In 1865 the machine was master of the man. In 1945 the man is complete master of the machine. There is the story.

WHAT OF THE FUTURE?—From these facts, a few developments can be foreseen.

Accuracies will stabilize at the order of .000001 inch for a few years to come. Lubrication, warpage, metal creep, and other troubles must be overcome before they become finer.

RPM will go higher. Mechanisms operating at 100,000 RPM are in plain sight. They will make machines smaller, faster, more accurate.

Steam pressures have not stopped advancing. Experiments are being performed at 5000 pounds pressure. High-pressure steam will be stored as in a battery, used as needed.

Electronic instruments will perform the most exquisite inspection operations upon metal-working operations while the machines are in motion. The instruments will correct machine settings, eject partly finished parts if too badly mismachined to be corrected, detect flaws in raw materials, and eject the bad pieces before any work has been done upon them. As a result, high-accuracy operations upon intricate forms will be more practical.

Materials handling systems right now are in relatively the same stage of development as steam engines in 1845. There will be far more accurate and efficient methods with much higher integration of factories.

Machines and mechanical motions will become so controlled and trustworthy that far more of them will be totally enclosed. Accidents, therefore, will be greatly reduced.

Heat will be turned into refrigeration directly at the heat-exuding process, and the refrigeration in turn used to control waste heat or for other purposes. No longer will steel mills raise the temperatures of the rivers near which they are located.

Smokestacks will disappear from factories. The gases, heat units, and solid materials which they throw off are too valuable to waste.

Noise, vibration, and odors will be absent from factories. They are dangerous wastes that never should be tolerated.

The gas turbine will become one of the most important prime movers at all horsepowers but especially at 10,000 horsepower and up.

Power transmission sequences will contain far more governors; they will constantly compensate for changes in the power and speed requirements of processes.

Automatic controls will increase in numbers, efficiencies, record-keeping abilities, and integration.

Mock-ups, born in the aeronautical industry, will be used in every phase of machine design. They will have actual working parts including gears, motors, bearings, and mechanical motions. Often they will be made of glass or clear plastics.

Prestressing to achieve higher strength with lower weight and smaller cross-sections will be the most dramatic development of the next 15 years. It will solve millions of design problems.

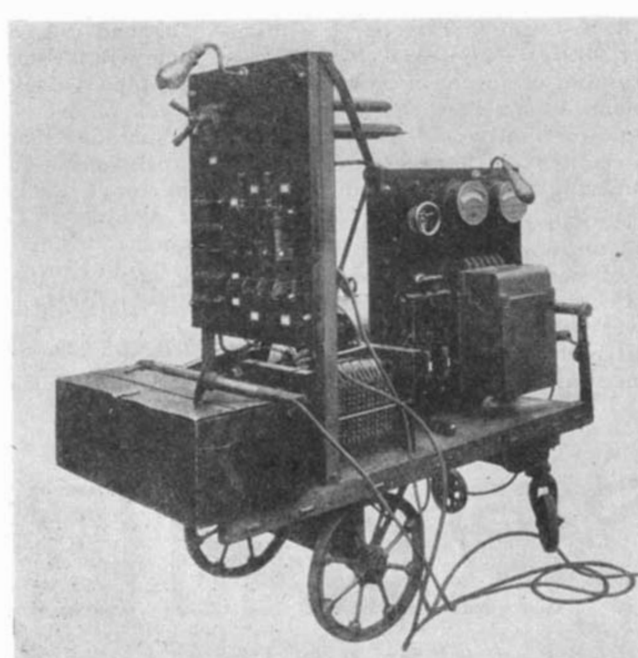
Welding now is about where machining was in 1865. We have a fairly clear idea of how it will develop. But it has not even begun to give us its best.

Upsetting and forging, both hot and cold, will be done with accuracies predictable to the order of .00001 inch. Extruding and stamping will be similarly accurate.

Standards and standardization will be developed to a point which will make our present efforts toward them seem like the drawings of kindergarten children. For standards are the back-bone of mass production. And mass production, the "American System," is the world's only hope that economies of plenty may displace the war-producing economies of scarcity and bring real civilization to all men.

Right: When Federal Products Corporation developed dial indicators to aid unskilled help, they found a hungry market in industry, ready and waiting for precision equipment of this type

Below: In 1915, The Lincoln Electric Company built this 200-ampere welding machine to sell for $1550. By 1941 they were producing equipment of similar capacity, but greatly improved, for a selling price of $200



Plastics' Future

Can the Industry Handle the Huge Volume of Business that Will Certainly be Available When Peace Comes? Some Figures on Machinery, Production Processes, and Materials Indicate that Engineering Design is Providing Equipment and Methods of Outstanding Future Importance

"WHAT is the present capacity of the plastics industry? What new production methods are being employed in it? What are the figures on new equipment ordered but not yet installed, on the monthly consumption of plastics materials, and on plans for plant expansion?"

These questions are being asked both by the plastics industry and by the end-users of its products. Despite their present absorption in the production of armaments, American manufacturers are now laying plans for peace-time manufacture of their own lines.

Since these plans depend, necessarily, upon the ability of the companies to get delivery of component parts, interest is high in the ability of the plastics industry to handle the volume of orders that will accompany resumption of civilian production. This interest extends not only to those who have used plastics in the past but to a large number who expect to use them for the first time in their post-war products. Members of the plastics industry also want to know all about its post-war destiny.

In an effort to answer these various questions, a survey was conducted recently by means of personal interviews plus a questionnaire mailed to 500 molders, extruders, and laminators who constitute the bulk of the industry. On the basis of these reports the plastics industry looked like this when the Japs sneaked in on Pearl Harbor: Some 500 molders were operating approximately 9000 presses of which 8000 were compression and 1000 were injection types. There are no authentic figures on the machines used for plastics extrusion at that date because the process then was just coming into its own. The average monthly consumption of plastics molding compounds of all kinds was approximately 13,000,000 pounds in 1941—of which 82 percent was consumed in compression molding.

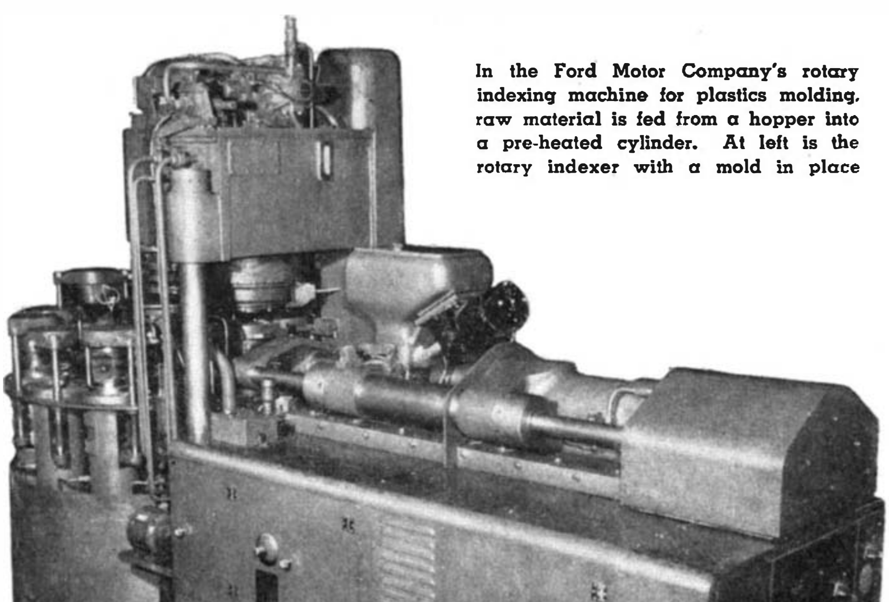
OVERALL INCREASE—Despite drastic restrictions on machine production, the three years between 1941 and 1944 saw an overall increase of 44 percent in compression and 50 percent in injection presses. The extrusion machines in operation in 1944 are separated into those used for coating wire alone and those doing other types of plastics extrusion; no rubber machines are included. It is possible that the time will come when some of the 330 machines that are now working exclusively on wire insulation will be diverted to other types of plastics extrusion.

The increase of 44 percent in the number of compression presses since 1941 has outstripped the 23-percent increase in thermosetting molding compounds that has resulted in a present monthly production of 12,500,000 pounds. This increase would be even more impressive if it were weighted to allow for the larger presses and the automatic presses installed since the beginning of the war.

The same situation exists with respect to injection machines and current production of thermoplastic molding powders, although the uninterpreted figures would seem to indicate that the reverse was true. Statistics gleaned in the survey show that, since 1941, thermoplastic molding powder production has increased 165 percent (to a current monthly consumption of 6,350,000 pounds) while the number of injection machines has climbed but 50 percent.

However, to this latter figure should be added some of the extrusion machines because compounds used for extrusion, with the exception of the vinyls, have been included in the total thermoplastic production. With the existing 350 extrusion machines of the non-wire-coating type added to the injection machines, the total increase is about 85 percent instead of 50 percent.

And still the figures are misleading. Back in 1941 and 1942 almost all the machines were two-, four-, and six-ounce units while at least 400 of the 1500 injection machines which were expected to be in operation by the end of 1944 were listed as eight-ounce or more. Estimates indicate that 400 eight-ounce machines or larger can use up as much or more molding material than the 1000 older and smaller machines listed for 1941. Hence it is obvious that the capacity of processors to handle molding compounds has increased out of all proportion to the actual number of presses.



In the Ford Motor Company's rotary indexing machine for plastics molding, raw material is fed from a hopper into a pre-heated cylinder. At left is the rotary indexer with a mold in place

The number of hours in the present workday must also be taken into consideration. If the plastics industry could handle 2,400,000 pounds of thermoplastic compounds a month in 1941 in a 12-hour day, with 1000 smaller presses, it can handle at least 4,000,000 pounds a month today in a 24-hour day. The new and often larger machines, plus 100 or more extrusion machines, will therefore take care of the

2,350,000 pounds remaining from the current consumption figure of 6,350,000 pounds.

FURTHER EXPANSION—This overall increase in compression and injection presses during the last three years has not satisfied the molding industry. It is planning a 21-percent expansion, according to its answers to the survey question, "Have you definite plans for additions to your plant and, if so, by what percentage will the additions increase your plant size?"

Obsolescence of facilities is, of course, a factor after the last four years of all-out effort to keep our military forces supplied. There have been few replacements of machinery during this period. Operators are eagerly awaiting the day when obsolete or worn-out machines can be melted down for scrap. There is the possibility that if the emergency lasts over an extensive period, the machinery situation would seriously interfere with production. Fortunately, most of the obsolescent equipment falls in the small sizes where its loss would have a lesser effect on output.

For some time the plastics molding and extruding industry has been guessing what the equipment manufacturers have in store for them. Most of the items supplied to the Armed Forces have been made on equipment of a type in existence before Pearl Harbor. Nevertheless, despite the lack of manpower and the diversion of engineering facilities, many important changes in design have taken place since that time. In addition, equipment suppliers to the plastics industry have been storing ideas, some of which have been tried and proved.

According to information gathered during work on this recent survey, the machinery trend is toward larger and larger capacity, hence toward faster production and lowered cost to the consumer. One of the leading press manufacturers planned to produce only 10 four-ounce injection presses during 1944. His six- and eight-ounce schedule was for 60 while his 16- and 22-ounce machine production was set at three each. Even 36-ounce presses and larger are in the talk and blueprint stage.

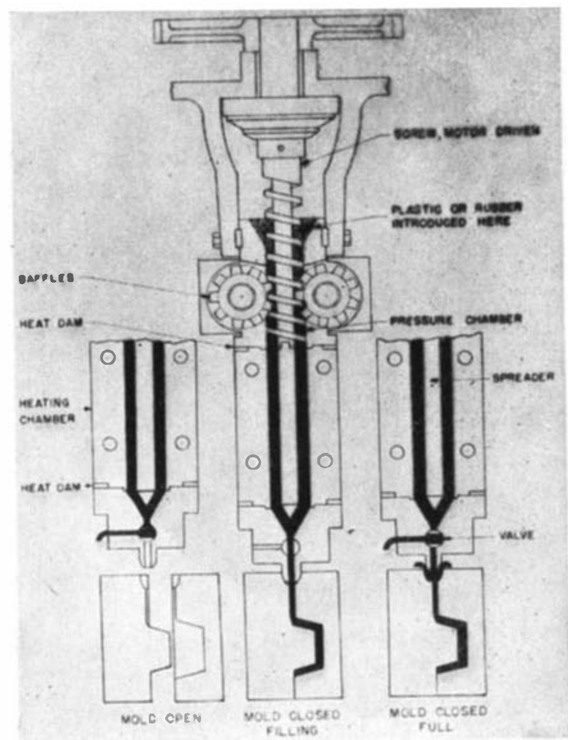
The attitude in some sections seems to be that the plastics industry has thus far been slow to follow the American practice of standardizing and then producing on a mass basis so as to achieve a better product at a lower price. This is attributed partly to the fact that the development of new materials and new processes has been rapid, and partly to the relatively small size of most of the processors of plastics materials. Standardization, however, presupposes extreme flexibility wherein one machine, for example, can handle a variety of materials.

INJECTION AND EXTRUSION—In line with this trend, the Chrysler Corporation has recently developed an unusual injection and extrusion machine. It offers great possibilities in both the thermosetting and thermoplastic fields. In its design, particular emphasis has been given, thus far, to the injection and extrusion of thermosetting compounds. In contrast to standard injection machines which employ a ram or plunger that feeds prescribed amounts of compound into the die cavities, this machine employs a worm screw which makes possible continuous feeding of the plastics materials. (See also page 40, January 1945, Scientific American.)

The original Chrysler machine just mentioned was built by Walter P. Cousino, project engineer in the Engineering Division of the Chrysler Corporation. Utilizing the reciprocating plunger principle, it became known as the single plunger type. In this first model, which processed only thermoplastic materials, the powders were loaded into a circular hopper from which the reciprocating plunger fed the plastics granules into a heating unit where the material became plasticized under electrical heat. The mold was then closed, and the plunger started again to feed the plastic into the cavity of the die. As soon as the mold became filled, the excess material backed up as overflow around the nozzle contacting the sprue of the die. At this point a valve was closed.

The success of this original unit led to the development of a second machine—the design of Mr. Cousino and other Chrysler engineers—which was equipped with two reciprocating plungers instead of one. After preliminary work with thermoplastic materials, the machine was tried out with thermosetting plastics such as phenolics. As experiments progressed, it was noticed that better results were obtained with thermosetting materials than with thermoplastics.

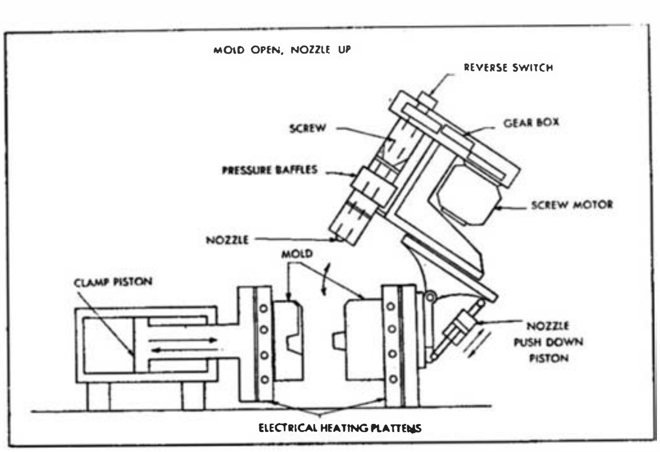
About this time the attention of com-

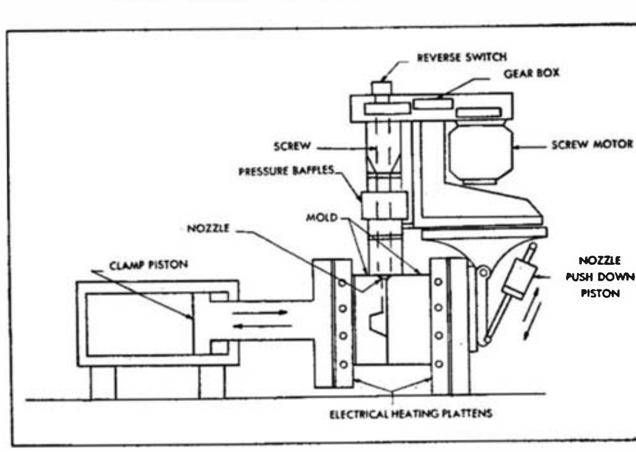


High pressures in the Chrysler screw-injection molding machine are obtained by the aid of baffle gears which prevent the molding powders from backing up on the screw exerting the pressure

Lower left: The Chrysler machine in open position

Lower right: The same unit as at left, but in the molding position. The push-down piston has lowered the extrusion head and the nozzle is in position to extrude the material into the closed mold





pany engineers was directed to a part about 18 inches long and two inches in diameter with a ⅛-inch concentric wall. Injection molding of this part was difficult in view of the fact that a removable mandrel had to be used to make possible the removal of one molded part from the press while another was curing in the die. A suggestion that the tube be extruded led to the latest development of this machine whereby the extrusion of thermosetting plastics on a continuous basis was achieved. To make this possible an extrusion die was mounted against the front end of the injection head.

SCREW INJECTION — Although the double plunger machine had given good results, it was decided to substitute a screw injector driven by an electric motor. This change has the advantage of giving continuous injection of the material, regardless of its bulk, until the mold cavities are completely filled. Thus, instead of having a machine limited to parts weighing up to 12 ounces, company engineers were confident of being able to mold much heavier pieces.

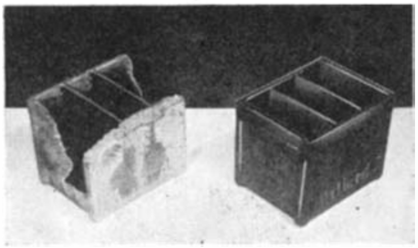
To verify this, a battery box requiring eight pounds of paper-base phenolic was first molded on the screw injector machine and then on the same machine after the screw had been replaced by the double plunger type of injector. One of the photographs shows the results. The battery box molded with the double plunger injector did not fill out completely while the other test piece was perfectly satisfactory.

When thermosetting plastics are molded with this Chrysler machine, a screw first feeds the molding powder from a convenient hopper into the heating chamber. As soon as this chamber is filled, the screw is stopped and the plastic material subjected to heat for 15 to 20 minutes. After this interval the injection head, already heated to the proper molding temperature, is lowered against the clamped die so that the nozzle seats tightly against the concave entrance of the sprue adaptor. The screw is again started, injecting the heated material by pushing it with cold material from the hopper. As soon as the die is filled the screw is stopped.

Finally, after the material is cured, the die is opened and the molded part ejected by a suitable mechanism. Then the die is again closed and the next cycle started by lowering the head against the die. The baffle gears, a unique feature in this design, are responsible for the high injection pressures obtained in this machine (up to 22,000 pounds per square inch) since they prevent the molding powders from backing up into the top of the screw and into the hopper.

Most of the results obtained thus far have been on a pilot plant scale. They would seem to indicate, however, that it is only a matter of time before the Chrysler screw injector machine will be ready for mass production of plastics—a result that has already been achieved with rubber. The machine has been developed primarily to inject large parts because the company feels that there is a definite need for such equipment if plastics are to find increased uses, not only in the automotive but in other fields as well.

Another recent successful development, by Hydraulic Press Manufacturing Company, is a rotary indexing machine—built to Ford Motor Company specifications. This machine has



The battery box at the right, perfectly formed, was molded from plastics with screw injection. The one at the left, molded by double plunger injection method, did not fill out

made possible the continuous, large-scale injection molding of truck oil cases from a variety of thermosetting materials. In operation the continuous injector is similar to an aircraft machine gun synchronized to fire through its revolving propeller blades.

Raw material from the elevated hopper feeds into a small cylinder where a slowly revolving screw pushes the proper quantity of material necessary for a single casting into a large cylinder. In the large cylinder, the temperature of the plastics is gradually raised as it progresses toward the nozzle or point of injection. At this point a hydraulic injection clamp holds the nozzle in place while the plastics material is forced into an electrically heated mold. Once the casting has been made, the mold is released from the injection position, to be replaced by the next mold on the turntable—and so through all the stations on the indexing machine. Meanwhile, the temperature of each mold after it is charged with material is carefully controlled until the die is ready to be opened and the casting removed.

The advances that these and other machines promise for the post-war period are given increased emphasis when it is remembered that less than 15 years ago an injection-molding machine consisted of a letter-press affair into which a teaspoonful of material was placed and electric or gas heat applied to melt the plastics. Then the material was injected by hand into a mold to make a miniature piece having a volume of only a fraction of a cubic inch.

REDDY KILOWATT

Is Molded of Cellulose Acetate

Over 200 power companies in the United States, Alaska, Canada, Cuba, Argentina, Brazil, Hawaii, San Salvador, and Portugal are using in their advertising and public-relations programs a small cellulose-acetate model of the trade character, Reddy Kilowatt,

This lively symbol of electricity is injection molded of cellulose-acetate

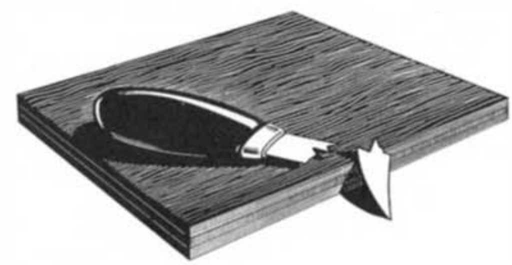
supplied by Ashton B. Collins. The figure is injection molded of Fibestos by the Mack Molding Company in seven separate pieces. The head is painted by hand in a finishing operation in order to attain the exact facial expression indicated in the original model. Ready Kilowatt has proved popular with power companies for display purposes—so popular, in fact, that the figures are being sold as novelty items. Because of the bevelled edge, distinct lightning-like flashes can be observed when a light is moved behind the figure.

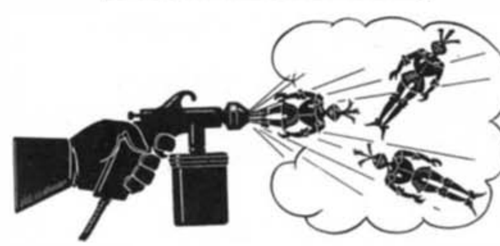
GUN COVERS

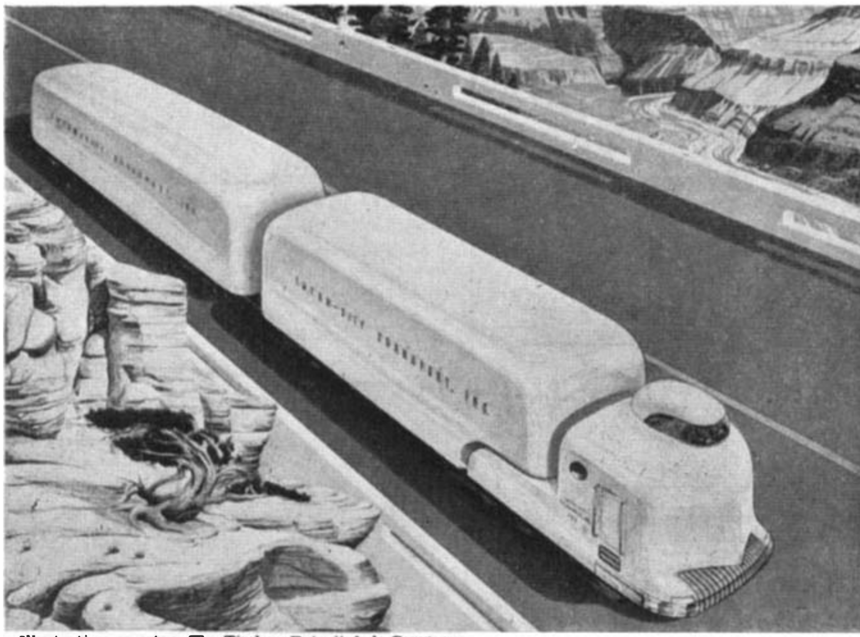
Provide Protection as Well as Flotation

Assault troops must come in fighting. To keep their firearms ready for immediate action regardless of the soaking they receive during the landing operations, the Army has adopted flexible water-proof gun bags which offer complete protection to the equipment enclosed in them.

After a gun is placed in one of these bags, it can be closed tightly by a simple knot. Enough air is trapped inside so that the bag and gun will float for an indefinite period if dropped in the sea. The Lumarith V.N. (vinyl chloride vinyl acetate copolymer) from which these bags are made by Shellmar Products Company is so flexible that men armed with pistols, rifles, or machine guns can manipulate the trigger and begin firing immediately without pausing to remove the protective wrapper.







Illustrations courtesy The Timken-Detroit Axle Company

The inter-city truck-trailer combination visualized here may be one answer to the motor-transportation industry's constant striving toward carrying heavier loads faster and with greater safety. It is designed to utilize all load space to the fullest and would be constructed of light materials for economical operation

HIGHWAY TRANSPORTATION

Conducted by LESLIE PEAT

Tomorrow's Vehicles

Immediate Post-War Output of Trucks and Busses Will be on a Basis of Current Models. But, as Soon as Possible, Manufacturers Will Put Into Commercial Vehicles All the Proved War-Born Advances in New Alloys, Plastics, Synthetic Rubbers, and Improved Engines

WHAT KIND of trucks and busses will roll along the highways of the United States in the years immediately following the war? The answer to this question is of great interest to intensely automotive-minded Americans. The answer is that, to begin with, they can expect no startling changes. Immediate post-war trucks and busses will be basically the same as pre-war vehicles. Because of the hungry market for new vehicles, any and all types will show an increase in the hands of users. Current production types are the basic models for most of the Army and Navy trucks, and have been service-tested through the years as commercial vehicles.

Manufacturers are confident that these current types are the best vehicles that can be produced quickly and in large volume as soon as materials and man power are released from war production. The jeep, of course, is being widely considered as a possible war-born vehicle for tomorrow, and the amphibious "duck" also may find a role in civilian life when peace comes again.

Basically, there have been improvements in alloy steels, considerable development in plastics, and tremendous strides in synthetic rubber during the past few years. Most of the future engines, however, will still be of the gasoline type. Diesel engine builders expect a spurt in sales based chiefly on an increased use of present models rather than on any striking improvement in the Diesel engine itself.

THE NEW CRITERION—A new philosophy in steel specifications has come into being as a result of the shortages of steel alloying materials. This is "hardenability." New steel specifications are based upon the relative ability of steels to harden under given heat-treating processes. The theory behind this is that hardness of steel is an indication of its strength. Thus the chemical specifications are taking a back seat, and data of practical use are being offered to the designers of machinery parts. All the designer wants to know about a material is its physical properties and its machining, welding, finishing, and other manufacturing characteristics. This is one of the legacies of coördinated research work stimulated by the war.

The Diesel engine will probably continue to be used more extensively over long hauls where the economy of fuel in relation to ton-miles hauled will make or break the operator. Diesel engines cannot be throttled down to as slow idling speeds as the gasoline powerplant, and are rougher in operation. Because of their greater operating pressures, they must be built of sturdier alloys and are heavier and more costly than gasoline engines of comparable output. They have been improved, however, during the past five years. The gasoline engine, on the other hand, stands only a little ahead of where it was a decade ago—insofar as overall economy of operation is concerned.

TIRES—Of all post-war automotive prospects, the synthetic rubber tire is the most intriguing subject for engineers and the public alike. Some of the nation's leading chemists expect their test tubes to produce a rubber far superior to natural gums. Others are brave enough to believe that the price of synthetic tires will equal that of those produced from natural rubber before the war. Plantations have been hard hit by Japanese seizure, and the necessary period of re-establishing the natural rubber resources of the world will give the chemists a little more time to do their stuff. The new silicone synthetic rubber appears to have advantages possessed by neither crude nor the petroleum and alcohol-base synthetics. These superior qualities seem to make it better for a number of uses, notably inner tubes.

As manufacturing technicians advance in their pioneering work in handling synthetic rubber materials, the cost of the material itself may become less important. Fleet operators and motorists are interested primarily in the cost per mile of tires, and the laboratories know that this cost is on the way toward—and they hope beyond—competition with natural crude rubber as far as *price per mile* is concerned.

BETTER TRANSMISSIONS—During the past decade, transmissions have been the bane of vehicle designers. Fully automatic power transmission for motor vehicles has long been a dream of inventors and knowing motorists, and some steps in this direction already have been made. Several companies are spending a great deal of development energy on this component for the post-war vehicle.

Jet propulsion has opened a new door to thought about transportation power-plants of the future. The intense research and development now being done under the aegis of the Army Air Forces and Navy Bureau of Aeronautics may be the first step toward obsolescing the gasoline and Diesel engines. The answer will lie in economics. Even if the jet or gasoline turbine engines of tomorrow are foolproof, the factors of first cost, maintenance expenses, and miles per dollar eventually will decide the question of practicability.

Several manufacturers have already placed orders for machine tools designed to make parts for gasoline-injection systems. The number of tools ordered indicates that carburetors will face stiff post-war competition. Experience gained in the aircraft field proves that gasoline injection has a number of important advantages over carburetors—even for highway vehicle use.

Extensive economic and technical studies are being made today on the motor fuels of tomorrow. In general, pending a more complete report on the details in Scientific American at a later date, the bulk of post-war motor fuels will probably be gasolines of about 70 octane and less. This disturbs engine designers who yearn to bring out vehicle engines of higher specific output, but it nevertheless appears to be a fact.

AERODYNAMIC INFLUENCES—Considerable work has already been done to adapt aircraft design structure principles to automotive vehicles. Several experimental cars and buses have been built along airplane structural lines and it is only reasonable to expect others. The aircraft manufacturers have talked some about getting into the motor vehicle business, now that they have had experience in mass production.

Motor vehicle manufacturers, on the other hand, are so certain that strong dealer organizations are necessary to sell and service cars, and to distribute trucks and buses, that they have no fear of important inroads into their business. As far as the public is concerned, the merger of aeronautical design ideas with the design of motor vehicles will bring interesting innovations.

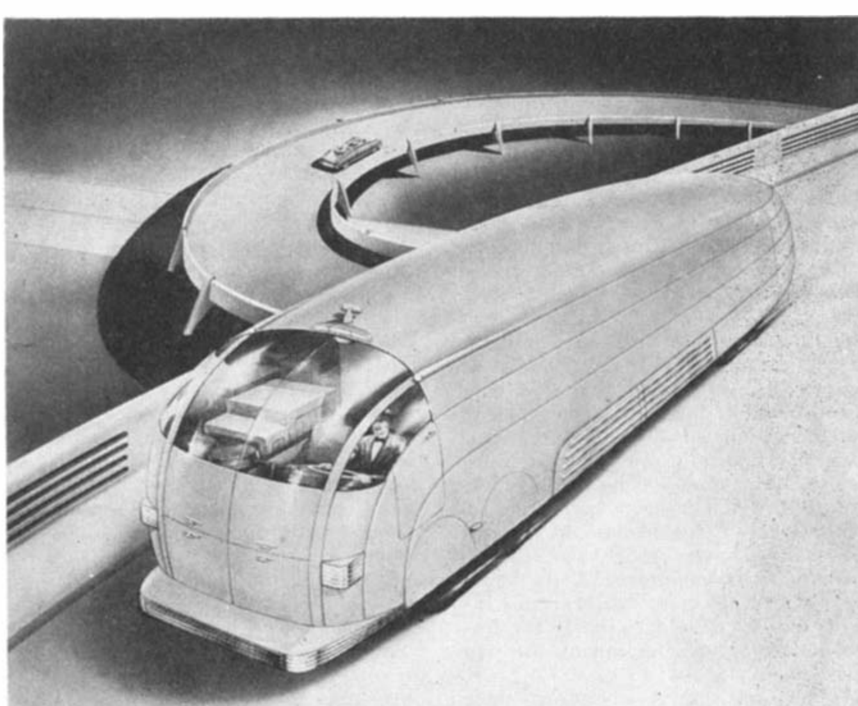
An example of the potential influence of aircraft design on the automotive industry is found in the fact that several decades of normal development work on air conditioning have been telescoped into three or four war years in the aircraft industry. The vehicles of the later post-war period will certainly reflect some of these advances, since the automotive industry was moving in this direction before the war. The final decision as to acceptance of such innovations will depend upon first cost plus maintenance expense in relation to the increased comfort of better ventilation, heating in winter, and cooling in summer. Commercial trucks, too, will benefit from this work, and the post-war refrigerated trucks for perishable foods will be far more economical and effective than their pre-war granddaddies.

Structural engineers in the automotive industry are working on applications of new synthetic materials such as paper and cloth impregnated with plastics, plywood molded sections, and some of the lighter metals which will be more abundant than ever before as a result of increased capacity built for the war effort. As far as production models of cars, trucks, and buses are concerned, the deciding question again will be price. As long as the post-war price of aluminum extrusions, sheets, and forgings are unknown, production engineers are still thinking in terms of pre-war metals for automobiles and trucks. Ingot aluminum prices mean nothing to design engineers.

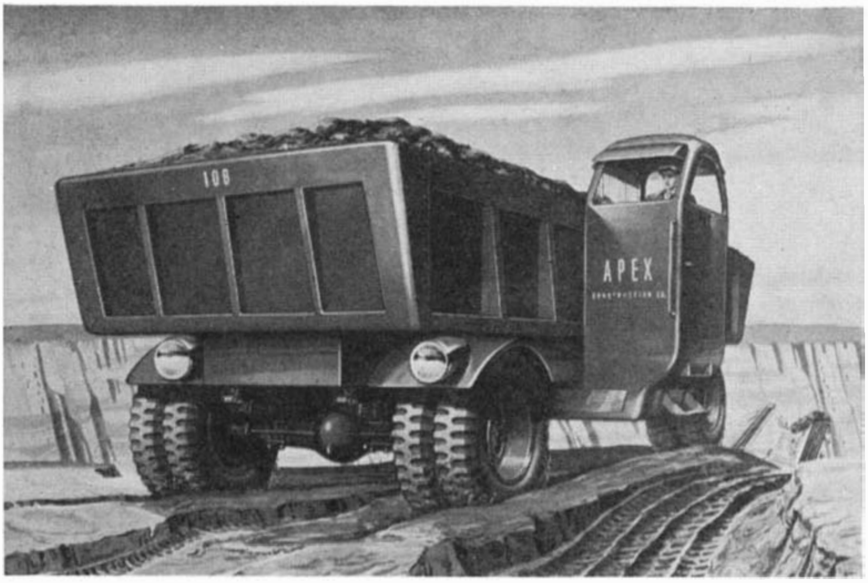
BRIGHT FUTURE EXPECTED—Post-war highway transportation prospects appear bright enough without indulging in fanciful air-brush dreams of streamlined curves and pastel shades, although a number of companies have done some of this rosy day-dreaming in off moments. The basis for solid, feet-on-the-ground optimism in regard to the automotive business can readily be seen when we remember that the industry of keeping commercial and private trucks in operation amounted to a billion dollars yearly in pre-war years. As much or more was spent in the operation and upkeep of bus lines. The huge school-bus outlay reaches astronomical figures in total annual mileage, gasoline consumption, and maintenance costs. In 1943 the chartered bus lines alone took in more than $1,000,000,000, and the 9000 buses in use cost about $90,000,000 when new.

Important as were the economics of the truck, bus, and parts manufacturers in the immediate pre-war era, operators are looking forward to huge expansions of their operations. Here are some of the reasons:

Industry has been decentralized during the war emergency period in the United States. Factory expansion has largely been achieved out-of-town, in small communities where real estate was not prohibitive in cost and where the labor market had not been already tapped. One Michigan armament manufacturer, for example, extended his manufacturing line 125 miles by having parts trucked for various operations to five plants in three towns—all within a fifty-mile radius. Lack of



Advantages of front or rear loading would be offered by trucks of this design



One of the most important transportation lessons learned from the war is that specialized vehicles do a given job faster and more economically. Such lessons may someday lead to the construction of dump trucks of this type. The side-cab gives perfect visibility and, because of the steering-driving axle at each end, the vehicle can be driven in either direction without the necessity of turning around

local foundry, machining, and annealing facilities forced him into this roundabout proceeding which proved economical in the long run and permitted him to meet his shipping dates for finished artillery shells.

Second, home deliveries of retail merchandise and foods have extended further from centers of urban areas during the past two decades. This trend has been accelerated in the past three years. It will continue, but at an increasing rate when the post-war home-building business gets started after V-E Day.

Twenty major cities in the nation receive all their milk by truck, and a substantial majority of all milk received in all American cities and practically every town and hamlet in the country depend upon trucks. The same is true of other farm produce. Most of the retail deliveries of food from coast to coast have been depending upon commercial vehicles of one type or another for more than a decade. Nearly 5,000,000 motor trucks were registered in the United States in 1941. More than a quarter of these were used by farmers. Nearly another quarter were used by entrepreneurs and firms in the grocery, creamery, meat, bakery, and other food businesses.

In the third place, the war has brought far more coördination into the economical and technical details of highway transportation than has ever been known in the past. The Office of Defense Transportation and national engineering societies interested in highway transportation—such as the Society of Automotive Engineers and technical committees of the American Transit Association—have brought together a vast amount of engineering and operating data. They have analyzed this information to develop reports on improved use of vehicles during the war emergency.

As a result, many operators know more about the business than ever before. An important by-product of this work has been a better understanding by vehicle designers of the specific needs of the truck and bus user. Although lacking the showmanship of an automobile salon, this new philosophy may be counted upon to stimulate better design of trucks and make bus travel more comfortable in the years to come.

HIGHWAY EXPANSION FORESEEN — Highway authorities are agreed that huge sums will be spent on roads of all types in the immediate post-war era. State gasoline and vehicle taxes for this purpose are expected to continue ($15,000,000,000 in 1941 and $13,000,000,000 in 1942) and a number of Congressmen have Federal highway aid bills ready for the "hopper" on Capitol Hill. Pressure of local constituents for better roads may be expected to continue. A number of large road building programs halted by the war will fan out from our great centers of population to increase the 1,583,734 miles of hard surfaced roads and streets and the total of more than 3,000,000 miles of surfaced roads and streets in the United States.

World War II may be counted upon as a gigantic stimulus to the increased use of motor transportation of all types, just as World War I cradled the development of the motor truck and bus. Today's modern armies have been almost completely mechanized. The world battlefronts have provided a vast proving ground where innovations of a few years ago have been proved by hard usage over all types of terrain and in all extremes of climate. Reports on performance are made to the manufacturers, both through Army channels and directly by engineers assigned to duty with the Army as automotive, fuels, and lubricants technicians. As a result, design engineers have a wealth of information as a background to many improvements which they eventually will pass on to the public.

It appears probable that post-war truck and bus production will hit new highs as soon as material and manpower is available for civilian production. In 1941, more than one million motor trucks were manufactured in the United States at a total wholesale value of more than one billion dollars. If the market is not flooded by the vast fleet of used Army trucks, vehicle manufacturers will be busy for several years after peace comes, catching up on needed replacements.

This means that the numerous factories of General Motors, Chrysler, and Ford, as well as the major truck, bus, trailer, fire apparatus, and specialty automotive manufacturers, will be busy on heavy backlogs of orders. It means also that thousands of plants supplying parts and accessories will swing into action on parts and supplies for the manufacturers.

In the kaleidoscope of America's prospective expansion of land, air, and sea transportation, the pattern of highway transportation will be the production of current models first and the development of today's dreams later. Accompanying all this there will be a steady progress toward more and more applications of the scientific achievements and engineering knowledge of every field explored by the ingenuity of mankind.

TRANSMISSIONS

Undergoing Intensive Experimental Work

HIGH concentration of engineering effort to improve automobile and truck transmissions is going on in Detroit and other mid-western automotive manufacturing centers. The almost forgotten Owens Magnetic gearshift has at least two counterparts in experimental stage being readied for test, and a number of simpler versions of the Oldsmobile Hydra-Matic transmission are being given the "complete treatment" by several manufacturers. Many engineers agree that motor-vehicle transmission development has been generally neglected.

CUSTOM BUILT

Motor-Cars Offer Extensive Post-War Market

SEVERAL informed motor-car distributors believe there will be an important market in "non-branded" special models of automobiles in the post-war era to satisfy the strong "fringe market." The town-car models, built on Ford chassis, were strikingly successful during the late 20's and early 30's, compared with imported European cars. Before the war the artist Peter Arno designed and had built a number of special bodies for moneyed motorists, using standard Mercury and other chassis. LeBaron, Brewster, and other custom-body builders are in business no longer, but men who know the trade are angling for this market.

Engineered Electronics

Infinitely Variable Motor Drives, Accurate Timers, Safety and Limit Switches, and Other Electronic Devices Can Improve Production Quality and Lower Costs. Application Can Often be Made to Installed Equipment, Lengthening Service Life and Increasing Output and Efficiency

By VIN ZELUFF
Associate Editor, *Electronics*

ELECTRONIC drive for machine tools has several important advantages:

(1) An infinite number of speeds in the speed range are available, instead of just a certain number of steps provided by gear changes.

(2) Changes in speed with a gear-change mechanism necessitate stopping the machine, which requires considerable time and makes a mark on the work. With electronic equipment, speed changes are made without stopping, simply by turning a small knob.

(3) Electronic motor drive is ideally suited for setting up an automatic sequence of operations where it is necessary to change the feed speed frequently, as well as for automatically regulating the feed speed to maintain a given load on the cutter motor.

TIME SAVING—A reduction in finishing time from 13½ hours to five minutes in the machining of aluminum spar beams for plane wings has been accomplished at one Cleveland aircraft plant, with the help of an electronic motor control system installed on a large automatic contour milling machine designed and built by Onsrud Machine Works, Inc.

In aircraft, spar beams are long, one-piece structural channels which run lengthwise through the wing, from fuselage to wing tip. The spar must be machined accurately to permit perfect joining of wing ribs and cap strips, and it must be contoured exactly to conform with the shape of the wing itself.

The carriage of the milling machine houses four cutter motor assemblies that finish the long spar in a single set-up despite the wide variety of cuts required. Flexible speed control of the carriage motor by the electronic drive assures that the cutters at all times are fed to the work in proper relation to the changing contours of the spar beam.

In one pass over the table, the depth of cut may increase and decrease several times, while the number of cutters entering the work may change from one to four. Such varying conditions require a change of feed to avoid overloading of the cutter motors. Moreover, a fast "skip" speed is essential to save time when no cutting at all is necessary.

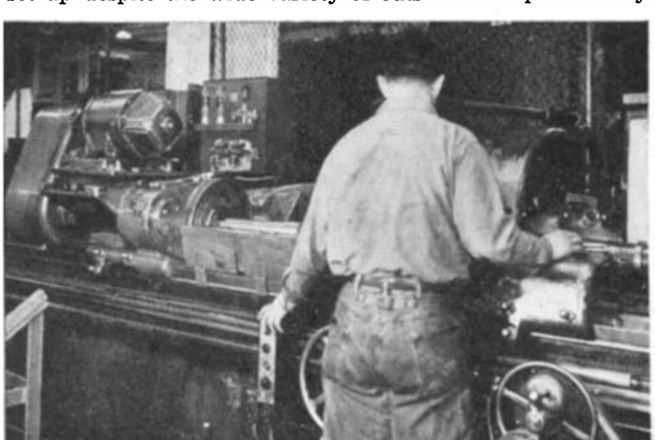
With the General Electric Thy-motrol electronic system, A.C. power is converted to D.C. to obtain a stepless speed range. The resulting infinitely variable speed within the established limits has resulted in top-speed machining of the complex spar beam at all times.

PRECISION GROOVING—A few days after Pearl Harbor, the Sundstrand Machine Tool Company was asked to build a machine for cutting a precision spiral groove in the end plates of a cartridge reel. Up to this time the best output obtainable on a special vertical mill operated by a good toolmaker was 1.5 pieces per hour. By adapting two automatic lathes for this spiral-cutting operation and using electronic control to vary the speed of the drive motor as the cutting tool moved along the spiral, output for the two machines was five pieces each per hour, and both could be handled by a single unskilled operator.

One of the automatic lathes was tooled for the right-hand spiral and the other for the left-hand spiral. On the spindle nose of each was mounted a face plate provided with a centralizing plug and manual clamps for holding the work. On the back of each face plate was a master cam with a spiral track for actuating a roller and lever arrangement for moving the tool slide in as the machine rotates.

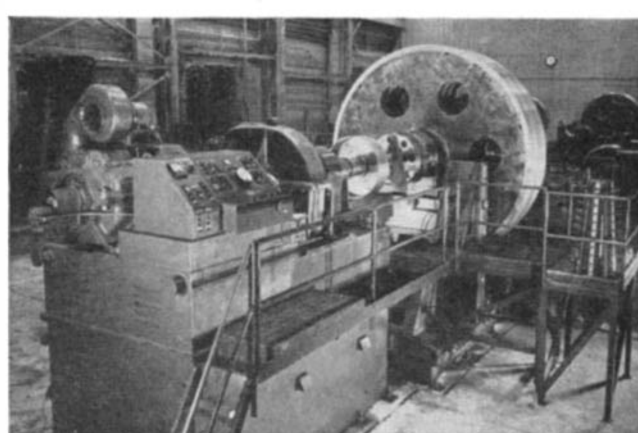
Due to the thinness of the part being machined, it was necessary to take a series of very shallow cuts until the desired groove depth of 0.07 inch had been reached. A ratchet-type in-feed device was devised to advance the cutting tool during each return stroke, and a gadget was placed on this to trip a limit switch and shut off the entire lathe when the correct depth of cut was reached.

After the operator had clamped a



Courtesy Reliance Electric and Engineering Company

Electronic drive and sequence controls reduce operation of this heavy machine-shop lathe to the utmost simplicity



Courtesy General Electric

Gear-balancing machine with 50-ton marine gear set up for test. The drive motor is electronically controlled.

MACHINE SHOP APPLICATIONS OF ELECTRONICS

Grinders	Reversing Table Drives
Metal-Working Lathes	Drill Presses
Milling Machines	Winch Drives
Slotters	Conveyors
Key Seaters	Boring Mills
Gear Cutters	Weld Positioners
Straightening Machines	Super-Finishers
Bending Machines	Balancing Machines
Spinning Machines	Automatic Screw Machines
Flanging Machines	Honing Machines
Cold and Hot Metal Saws	Molding Machines
Thread Mills	Punch Press Safety Stop
Wire-Drawing Machines	Power Shears
Planers	Sheet Grinders
Testing Machines	Automatic Welding Machines

blank end plate in the lathe, all he had to do was push the starting button. The lathe started turning and simultaneously the cutting tool advanced into the work from the outside at exactly the correct speed to produce the desired spiral. When the tool reached the inside of the plate, the lathe stopped, the cutting tool retracted to clear the cut, and the lathe and tool both reversed to return to starting position. The entire cycle then repeated itself automatically until the limit switch stopped the machine at the end of the last return stroke.

Maximum efficiency in this operation required constant surface speed at the cutting tool, with speed in the return direction as high as possible to reduce non-productive time. Reversals had to be smooth, acceleration fast, and speed changes gradual. All these requirements were inherent characteristics of the electronically controlled motor used to drive the lathe.

While waiting for delivery of the electronic equipment, conventional two-speed motors were temporarily installed. The production of the two machines was only six pieces an hour, with the motors running dangerously hot. After the variable-speed electronic drives were installed, combined output increased to 10 pieces an hour and the temperature rise was well within the motor ratings. The machines, complete with electronic control, cost about 10 percent more than with two-speed drives but they increased production by 67 percent. In other words, two machines with electronic drives produced as much as three machines running without benefit of vacuum tubes.

Another adaptation of this same Sundstrand automatic lathe was for turning an internal clearance radius in a propeller barrel. This was formerly a milling operation, but the cutters required resharpening so often that the manufacturer sought another method of machining. The change in the diameter of the work from start to finish was in the ratio of two to one, and best tool life and highest production was obtained by maintaining constant surface speed at the cutting tool. This was achieved with a five-horsepower motor, electronically controlled. A small cam-actuated potentiometer mounted on the carriage controls the electronic tubes in such a way that the motor starts at low speed, gradually accelerates to high speed at the end of the cut, and is then dynamically braked to stop the spindle.

TIME-DELAY RELAYS—Such machine tools as welding machines, honing machines, grinders, and molding machines have been arranged for processing, cycling, and sequencing by means of electronic time-delay relays. This type of equipment is available for timing intervals as short as 0.45 second and as long as several minutes. Nearly all such electronic devices operate over a range between maximum and minimum time settings of 20 to 1 and accuracy of repetition can be held to 1/120 second. Adjustment of the timing period is done with a single knob and the number of settings possible within the range is almost infinite. Millions of operations are possible with but a single setting and, since there are no moving parts, dependability and long life are consequent advantages.

Another use of electronic equipment in mechanical engineering should be of great interest to the safety engineer in industrial plants. Phototubes and their accompanying electronic amplifiers and relays have been applied to machines such as punch presses and molding machines. Here the interruption of a beam of light by the operator actuates the phototubes and causes the machine to become inoperative, thus avoiding accidents.

On thread milling machines, electronic drive is used to obtain a wide feed-speed range. Here, speed of operation is important and the electronic equipment provides a means for running the machine at optimum speed and making it possible for the engineer to eliminate a complicated mechanical system previously used.

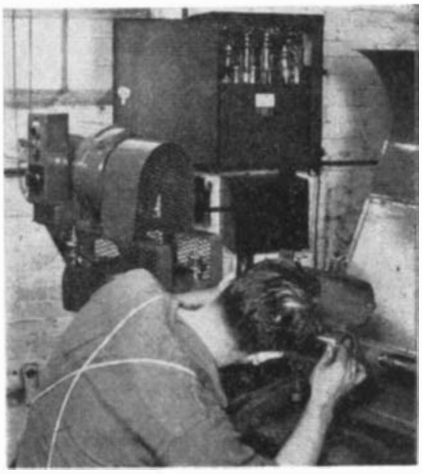
A.C. TO D.C.—The demands of many machine tools require the flexibility of speed and torque control provided only by D.C. motors. Previously this has been supplied by motor generators or rotary converters which have moving parts and require maintenance and supervision. Electronic equipment provides a satisfactory means of obtaining D.C. power at constant voltage from a mercury-arc rectifier, a device having no moving parts and requiring little supervision and maintenance.

These mercury-arc rectifiers are built in two forms—the glass tube type and the tank type with a metal casing. Such rectifiers have a greater overall efficiency than rotating equipment, particularly at light loads where the efficiency of the rectifier unit may be nearly eight times that of the motor-generator set. It has been reported that comparable operation of both systems at 85 percent of rated output permits a saving of $800 in power cost for a 300-kilowatt unit of the rectifier type. This is over and above a reasonable allowance for replacement of tubes.

Electronic drive offers many features that can be used to advantage by the grinding-machine operator. Smoothly adjustable low speeds permit designing of driving units which have a minimum of rotating parts. This reduces the vibration that is a constant source of trouble and a cause of inferior grinding.

Speed control of a grinder by means of a small device is something every mechanical engineer welcomes because the large rheostats otherwise necessary with adjustable-speed D.C. motors are difficult to mount on a machine and require a large amount of space. The electronic control uses only one or two small potentiometers.

In a grinding machine, efficiency is highest when the pressure of the work against the wheel is constant at a value corresponding to the optimum cutting capacity of the wheel. This pressure can be found, and it is possible with the electronic drive to control the in-feed of the grinding wheel so that this rate of cutting will be maintained even though it is necessary to vary the feed speed to obtain it.



Courtesy Westinghouse

Electronic drive makes it possible to mount the motor at the machine, place a small control cabinet on the wall, and give the operator handy speed-change and start-stop controls

Many electronic applications have been made to the headstock drives of cylindrical grinders to turn the work at the required varying speeds during plunge-cut grinding. Without such control, the finished product may show irregularities on the surface.

Surface grinders which have a circular rotating table and a reciprocating wheel head that is separately driven can be controlled to provide practically a constant surface speed. As the wheel approaches the center of the chuck, both the chuck rotation and the wheel head speed should be automatically increased so as to maintain within fairly close limits a constant wheel head feed movement of a specified amount per revolution of the chuck.

The application of electronics to grinding machines generally involves redesign rather than application to present design. The modernized and entirely new design gives a big reduction in the number of rotating parts and in the parts necessary to produce the desired results. This gives the user of grinding machines the advantage of wide speed ranges that will enable him to produce ground parts at the maximum production rate, finest finish, and high accuracies necessary now and in the post-war period.

ELECTRONIC BALANCING—In balancing machines, rapid acceleration and deceleration has been a difficult problem because couplings and other parts must be light in order to avoid distortion of results. Torque must be smoothly applied and limited in amount so that such parts will stand the strain. Also, acceleration and deceleration must be done quickly since the time involved is not useful.

With electronic motor control, machines with drives rated up to 200 horsepower have been provided. With these, a gradual application of torque and torque limit acceleration and deceleration is provided. The torque is not allowed to increase above the safe operating value for the machine and this maximum torque is held closely during the entire accelerating and decelerating periods.

With electronic equipment, balancing machines gain in two ways. First, the motor torque can be held to the maximum permissable value and, second, the speed adjustment is stepless and permits accurate and easy adjustment at exactly the correct speed.

By means of electronics, many old machines can be given greatly improved operating characteristics when it is impractical to obtain new machine tools. For example, use of electronic motor drives on three 30-year old Heald grinders at the Axelson Manufacturing Company resulted in improved precision finishing of hardened pump liners requiring finished tolerance of 0.001 inch. The variation in liner sizes and materials used required grinding speeds over a wide, closely regulated stepless speed range of 20 to 1 in order to secure the desired tolerance and finish.

The electronic drive used in this case consists of an electronic rectifier to change A.C. to D.C., plus a D.C. driving motor whose stepless speed is controlled by a potentiometer in the push-button station.

Physical advantages were also gained by new layouts of the machines. The three grinders were reset on a 35-degree angle with a saving in floor space of about one third. Removal of all overhead pulleys, belts, and shafting resulted in increased safety, improved illumination, and elimination of vibration.

Time study engineers at Axelson report that an appreciable saving in set-up has been effected largely by better illumination of the working area, plus less complicated controls and speed-changing apparatus on the grinders.

Thus far, the full automatic electronic control of machine-shop equipment has been confined to motors of relatively small size. Fundamentally, however, there is no reason why similar controls cannot be applied to motors of any size so long as suitable tube combinations are available for handling them. When the limit of the thyratron tube has been reached, it will undoubtedly be possible to employ the pool-type ignitron tubes in suitable circuits.

For the mechanical engineer, then, the outlook ahead in the direction of electronics is promising. With electronic drives, electronic timers, photo-electric safety and limit switches, and other tube-operated devices available at continually decreasing prices in a widening variety of types and sizes, he will find more and more frequently that he can economically specify control by electronics for improved production quality and, at the same time, lower production cost.

ELECTRONIC TESTER

Ends Guesswork in Repairing Wires

THE GUESSWORK usually involved in locating broken wires under the insulation of extension cords and wires used on electrical appliances is eliminated when an electronic tester developed and constructed by Consolidated Vultee Aircraft Corporation is used.

In the unit, one electronic tube is connected as a self-excited oscillator operating on a frequency of about 400 cycles. The output of this oscillator is applied to the cord.

A small amount of the signal energy is picked off the cord by a metal ring through which the cord is passed. Fed to a high-gain amplifier, the signal amplitude is increased sufficiently to operate the output meter. When a break in the conductor passes through the ring, a sudden change in the meter deflection occurs and the broken spot can be quickly and accurately ascertained. Thus the necessity of cutting the cord in more than one place to locate the break is eliminated.

STABLE CRYSTALS

Produced by Exposure To X-Ray Beam

A NEW production technique for quartz crystals uses x-rays to adjust the delicate plates to final frequency at a rate of 30 to 50 cycles a minute. Quartz plates for the six- to eight-megacycle range can be lowered as much as three kilocycles in frequency simply by exposure to x-ray beams.

Frequency can be checked continually during the treatment, hence the crystal can be removed from the beam at the instant it reaches the correct frequency.

The x-ray equipment, developed for this purpose by North American Philips Company, employs a new high-intensity water-cooled x-ray tube. One crystal is exposed at a time. Experiments made by Dr. Frondel of Reeves Sound Laboratories show that the change in frequency is permanent throughout and beyond any temperature range that the crystal is likely to experience. Factory applications of the technique include: recovery of overshot crystals that have been carried too far in finishing and hence are too high in frequency; precise adjustment of standard crystals for use in calibration and in testing; manufacture of precision crystals for frequency and time standards; precise adjustment to final frequency without the possibility of further aging.

X-ray equipment for lowering frequency of quartz oscillator plates

FLUTTER RECORDER

Is Light, Compact, and Simple to Install

PRESENT knowledge of the flutter of airplane parts has been gathered from experiments on the ground and in flight. For exhaustive study in the air, equipment weighing about 500 pounds has been used. Installation and tests by this method required about two weeks.

A new flight vibration recorder uses electronic tubes and is light enough to be held on the lap of the observer. Installed and put into use in a few hours, it is also useful in the study of vibration in motor mounts, cowling, and small accessories. Velocity or accelerometer type pickups can be placed at many points about the plane and two of these can be operated simultaneously. A selector switch permits other points to be studied during the same flight. The electronic unit contains its own batteries, amplifier, electronic switch, and cathode-ray tube as well as a camera to photograph the oscillograph record.

Engineers and Wings

Co-Operation Between Aeronautical and Mechanical Engineers Has Made Possible Such Strategic Airplanes as the Superfortress and Other Military Marvels. It will Bring to Post-War Civilian Flying a Like Measure of Success in Conquering the Problems of Flight

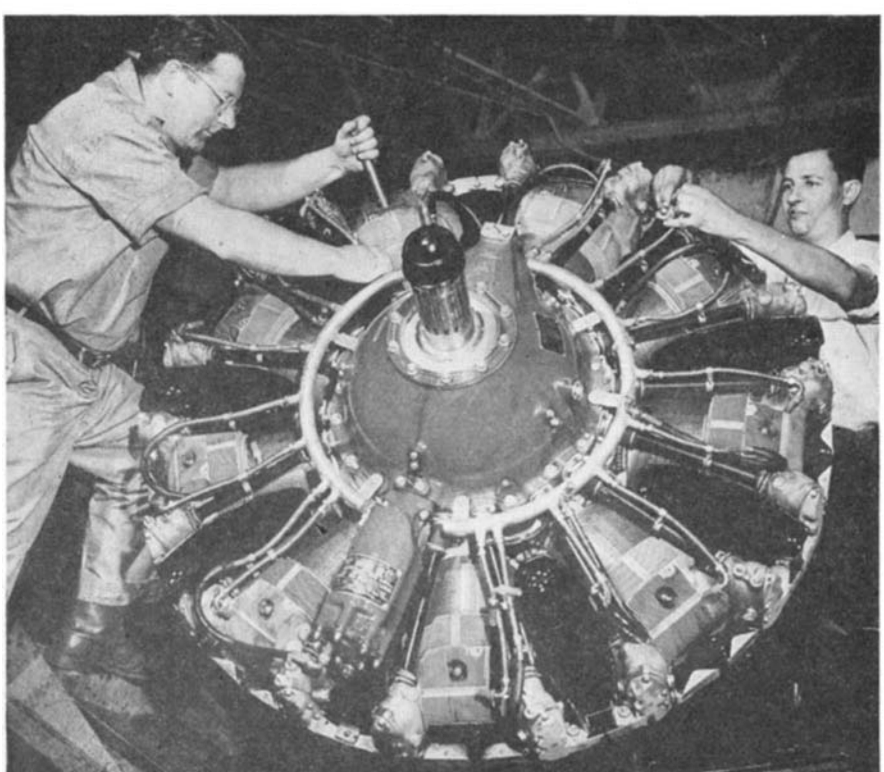
WITHOUT high development of mechanical engineering, and its continuous support, modern aviation would never have been possible. On the other hand, aviation has, by its scientific research, led directly to many refinements and advances in the theory and practice of mechanical engineering.

The airplane power plant is the point where the immense achievements of mechanical engineering attain their highest concentration in the science of aviation. Hence a survey of the relationship between the two fields can best begin with a consideration of the contributions of mechanical engineering to the airplane engine. The prime mover in aviation has grown in power and complexity from the early days of the Wright brothers until it is today a remarkable unit capable of developing 2200 horsepower with its weight running scarcely more than a pound per horsepower. Other aviation engines have an even lower power/weight ratio.

For many years the airplane engine has not departed from the classical principles of the four-cycle internal combustion engine, although it has been improved rapidly in compression ratio, refinement of materials, strength design, and better cooling. There is no comparison as regards specific power and efficiency between the airplane engine and the automobile or motorboat engine.

While in the early days of aviation the internal combustion engines used were designed largely by mechanical engineers with automobile experience, aeronautical designers have now far outstripped the originators. It is probable that in the post-war period motorboat and automobile engines will follow airplane practice. Today, the conventional four-cycle engine is losing ground. A greater knowledge of thermodynamics, coupled with vastly improved materials capable of withstanding high temperatures under stress, all enlivened by a burst of new ideas in both mechanical and aeronautical thought, have changed the whole situation.

It may confidently be expected that the development work of many years in the building of airplane superchargers will be succeeded by the construction of gas turbines running possibly to 5000 horsepower and causing something like a revolution in the aircraft power-plant. The turbo-jet engine, in which a compressor, driven by a gas turbine, compresses fuel and air so that they burn to give a jet of great speed and high power to drive the airplane forward, will supplant the conventional power-plant and propeller in planes with speeds well over 500 miles an hour. At the same time, a return to mechanical industry in the development of the aircraft turbine will be made. Undoubtedly the success of these prime movers will fire with renewed ambition engineers concerned with railroads and surface vessels. Gas turbines may soon be propelling both railroad trains and sea-going vessels.



Lighter and more powerful engines are continually being made as a result of the joint efforts of mechanical engineers and aeronautical experts. This new Wright Cyclone engine weighs only .97 pounds for each of its 1350 horsepower

APPLIED KINEMATICS—There is scarcely a single aspect of kinematics that is not utilized to the full in aviation. A typical application is that of geared combinations of various types and design. In the airplane engine, where as much horsepower per pound must be developed as possible, every effort is made to increase the engine's revolutions per minute. On the other hand, a propeller which revolves too rapidly loses efficiency (because the tip speed then approaches the speed of sound) and also makes far too much noise. Hence it becomes essential to gear the propeller down, and here applied kinematics comes into play.

Gearing down the propeller would seem at first to be quite a simple problem. Why not use a single reduction gear, of the herring-bone type, with a big gear on the propeller shaft meshing with a smaller gear on the engine shaft? If this apparently simple solution is applied, the thrust line of the propeller is placed to one side of the axis of symmetry of the engine so that complex stresses are produced in the crankcase.

The airplane-engine designer therefore borrows the system of planetary reduction gearing from the applied kinematics of the mechanical engineer. An internal-tooth drive gear is splined to the crankshaft and drives four or five planetary gears carried by a pinion cage, itself splined to the propeller shaft and meshing with a fixed gear bolted to the crankcase. This is a typical but not a universal arrangement. Because a number of "planets" revolve around the fixed "sun," the load produced by the tremendous power of an aircraft engine is divided into several parts and thus reduces the strain on the gear teeth. The planetary gear is more complex than the single gear system, but it avoids eccentricity of thrust and is probably more compact and lighter.

If the aeronautical engineer has borrowed from mechanical engineering in using gear trains, he has also given much in return. To provide adequate strength and minimum weight, aircraft engine requirements have speeded the development of heat-treated and hardened alloy steels. Also, the great engine builders such as Wright Aeronautical and Pratt and Whitney have insisted on a degree of accuracy and efficiency in spur and bevel gearing which the gear-making industry had previously thought impossible.

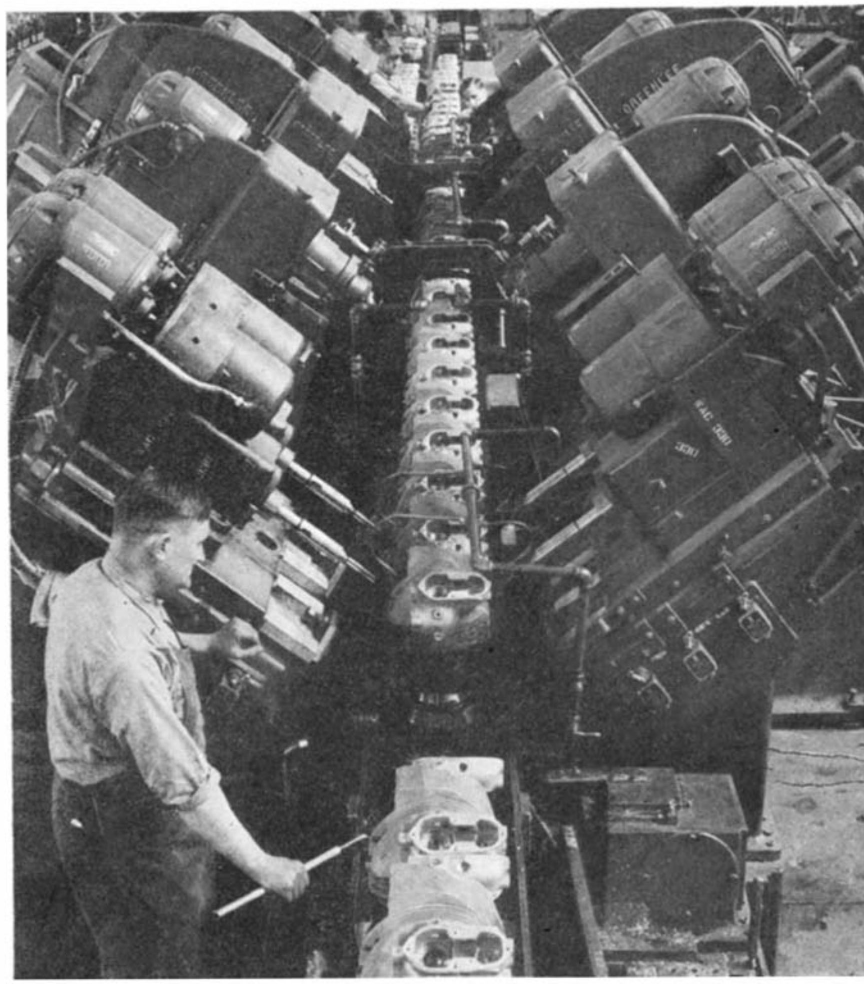
The opening and closing of the intake and exhaust valves at the proper point in the cycle is closely connected with the efficiency of a four-stroke cycle engine. Because the aircraft engine works at high speed, the valves must be opened and closed quickly and held wide open for a large part of the total time. But to keep down acceleration forces and spring tension, the valves should be opened and closed gradually. This contradiction in requirements and the necessity of designing cam contours that are neither difficult nor too expensive to produce, makes cam design difficult and fascinating. Aviation here borrows all it possibly can from the mechanical engineer.

VERTICAL FLIGHT—A new type of aircraft is now in the forefront of public attention. No aerodynamicist, however skilled or learned, could build it unless he had the mechanical engineer to back him. This is the helicopter. The aircraft engine is most efficient when turning over rapidly, but the lifting propeller of a helicopter must revolve rather slowly to give a powerful thrust per horsepower. A 10 to 1 reduction must be achieved in small compass, with little weight and, above all, with the highest possible efficiency of transmission.

In the helicopter, efficiency of transmission may make the difference between hovering ignominiously 20 feet or so above the ground and the ability to climb straight up to a height of several thousand feet. Hence the helicopter constructor has called on the finest art of the mechanical engineer to secure the best possible gears: spur gears cut with greatest accuracy, or the wonderful spiral bevel gears, which are so smooth in operation because of their gradual engagement.

Another necessity of the helicopter is a clutch which will engage automatically yet slowly when the engine has reached certain revolutions per minute. The helicopter engine must idle and warm up before flight. If the clutch were then thrown in suddenly, a violent shock would be imparted to the rotor blades, with possible damage. Therefore the mechanical engineer has been asked to design a clutch with balls subjected to centrifugal force acting against a spring, bringing the clutch into play at a certain predetermined speed, with the clutch allowing a certain amount of slip before full engagement.

Still another mechanical problem of the helicopter is that of the over-running clutch. When the engine fails, the rotor must continue to rotate in the same direction as before; that is, to autorotate. To have autorotation, two things are necessary: the pitch of the rotor blades must decrease quickly (either by manual control or automatically) and the rotor must be disengaged from the remainder of the transmission. It is for automatic disengagement that an over-running clutch is required. Such clutches are being designed on the wedge principle, with rollers between an inner and an outer ring, and a plane cam surface on the inner ring. With the inner ring splined to the transmission drive, the rollers are wedged to the outer ring when power is applied. When the engine fails and the outer ring tries to drive the inner ring, the rollers are un-wedged, engagement between the two rings ceases, and the rotor is free for autorotation.



This Greenlee machine, that drills and reams all the holes in a Wright Cyclone cylinder head, strikingly illustrates how successfully mechanical engineering responded to the demand for machine tools to speed up the output of warplanes

HYDRAULICS AID FLIGHT—Applied hydraulics is yet another branch of mechanical engineering upon which airplane designers have drawn heavily. The advantages of hydraulics in power transmission are light weight, controllability, and low inertia of moving parts.

The airplane hydraulic system is more complex than that in automobile brakes and involves the use of a reservoir and a directional control valve. The reservoir is necessary to take care of change of volume of the fluid with change in temperatures. The directional control valve or "four-way valve" is required in a system that must operate in two directions.

Airplane hydraulic systems have been developed which can be applied to brake actuation, retraction of landing gear, actuation of wing flaps, moving of gun turrets and, in general, to any task where reliable and rapid application of power is desired. It is certain that applied hydraulics is of as much service to aviation as applied kinematics.

And here again reciprocity exists. The special needs of the airplane have introduced into hydraulics an exactness and rapidity of control hardly thought of before. In airplane hydraulic systems, where lightness is sought above all, pressures of as much as 3000 pounds per square inch have been introduced, with the lightness and compactness of the new equipment astonishing hydraulic engineers accustomed to more conventional design.

COMFORT IN FLIGHT—In comfortization of aircraft, aviation has drawn heavily on heating, ventilating, air-conditioning, and air-compressor engineering. From the ventilating engineer, aircraft engineers have obtained data on the quantity of air required by passengers. They have also learned other fundamental requirements of air supply such as humidity control, constant circulation, reduction of carbon dioxide, proper distribution of both humidity and heat, and so on.

The comfortization of aircraft has also applied principles of heating engineering in utilizing exhaust heat of the engine for building adequate heating systems which are not excessively complex and at the same time are free from the danger of introducing exhaust gases into the cockpit. It is probable that in the post-war era airplane design will include heating of wings and tail surfaces to prevent icing-up; electric heating of many accessories such as pitot tubes to give speed indications; and the use of exhaust-gas heating with due precautions for use in the cabin. Finally, on air transports there will be almost universally a system of supercharging the cabin for altitude work.

The mechanical problems involved in pressurizing will deal first of all with the cabin supercharger. This is nothing but the mechanical engineers' air compressor. Automatic controls will be provided for maintaining the pressure inside the cabin at the equivalent of an altitude of about 8000 feet. Safety devices will help to maintain pressure in case the compressor fails, and methods of sealing the cabin will be used even where multiple instrument and control lines pass through the cabin walls.

UNIVERSAL STREAMLINING—Not so very long ago, railroad engineers had queer notions of resistance to motion. The writer has seen formulas in which the ground friction, which is roughly constant and proportional to the weight of the train, was lumped together with the air resistance which varies with the square of the speed. Applied aerodynamics has now penetrated into mechanical railroad engineering and substituted correct conceptions of resistance.

Also not long ago, railroad engineers were likely to neglect completely the question of air resistance. They did not seem to realize that at 70 miles an hour, two thirds of the entire power of the locomotive was expended in working against the air. It is under the stimulus of the constant example of streamlined aircraft that railroad men have gradually accepted the streamlining of locomotives and coaches.

There is still another way in which the airplane has benefited the mechanical engineering of the railroads. In the airplane, almost since its inception, there has been a striving after lightness of construction. This resulted, later on, in the use of light, high-strength aluminum alloys and stainless steel. At all times it demanded careful calculation of stresses and strains. In the construction of railroad equipment there never was striving after lightness. Cheap metals were deemed the best metals, and there was no attempt at structural analysis. Safety was secured by following tradition and strength of construction by brute-force of masses of material. The result was the strong but exceedingly heavy coach of American railroad practice, whose unnecessary weight wastes so much power. In the design of the modern streamliner, on the other hand, whether in aluminum or steel, the most refined methods of aviation stress analysis have been studied and applied.

The automobile has similarly benefited from aviation. America's cars are already far better streamlined than in the early days. In post-war days they will follow aviation practice as regards lightness and the liberal use of aluminum and magnesium. Their engines will imitate aircraft engine practice in being lighter for a given weight, and in having higher compression ratios.

Aviation has also benefited another branch of mechanical engineering far older than the automobile or even the railroad—the production of power from wind energy. For centuries, the windmill remained unchanged. Even the advent of the industrial revolution left windmills of small power, clumsy blades, clattering shifts into the wind, and clumsy gearing. Their use was restricted chiefly to isolated farms. Aviation has changed the whole outlook for the windmill. Windmill theory has been completely changed by analogy with propeller theory: for inefficient blades the best airfoil profiles have been substituted. Ideas borrowed from the variable-pitch propeller have brought into being mechanisms designed to change the pitch of the windmill blades in sudden gusts so as to limit airloads and prevent disaster. The art of building cantilever wings has given engineers the confidence that they can build windmill blades of enormous radius. The war stopped windmill development, but there is every reason to believe that the post-war period will see a number of ambitious undertakings in the building of auxiliary power plants based on the capture of wind energy at selected locations.

All in all, the writer is convinced that mechanical engineering has benefited almost as much from aviation as aviation has benefited from the activities of the mechanical engineer. American engineers, industrialists, and publicists might well keep in mind that excessive specialization is harmful. Let them remember that all branches of American industry and applied science are likely to benefit from cross-fertilization.

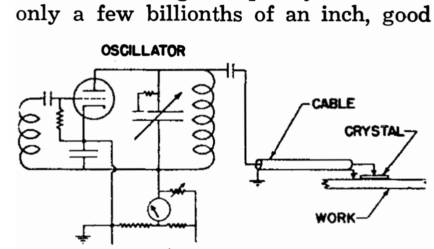
THICKNESS MEASUREMENT

Applied to Airplane Parts Where One Side is Inaccessible

IN THE inspection of highly stressed airplane parts, it is highly important to check the thickness. Sometimes this becomes a difficult task when the inner surface of the wall is inaccessible—as, for example, the wall of a hollow steel airplane propeller. To measure by the echo method of sound reflection, or by the use of short-wave reflection as in "radar," might theoretically be feasible, but would mean intolerable complexity in practice.

Wesley S. Erwin, in a paper presented before the Society of Automotive Engineers, describes a supersonic contact instrument for thickness measurement which has been developed in the research laboratories of General Motors. It is as accurate as it is ingenious and simple. The Sonigage, as it is called, does not measure time intervals but rather the frequency of oscillation at which the metal is set into resonant vibration. This frequency, on appropriate calibration, gives a correct indication of the thickness of the work.

The circuit of the device is shown in the sketch. A small flat piece of quartz crystal is placed against the metal wall whose thickness is to be measured. If a high frequency potential is applied to the quartz plate faces, the crystal will change thickness rapidly at that frequency. This forced mechanical vibration is transmitted to the material by placing one face of the quartz plate in contact with it. Since the amplitude of this high-frequency motion is only a few billionths of an inch, good



Checks thickness by resonance

coupling must be provided between the crystal and the work by an oil film.

A power output meter serves to indicate the resonant frequency of the work. This resonance point is very sharp and if the oscillator is detuned as little as 1 percent, by changes in metal thickness, the indicated power amplitude is greatly reduced. Thus a quick glance at the indicator will tell the inspector whether the particular part is of the right thickness or not.

Backbone Of Engineering

Continuing Development of Metals and Alloys is Giving the Mechanical Engineer New Tools With Which to Work. What Metallurgy is Doing Now Will Have a Direct Effect on the Progress That Will Be Made in the Future. New Materials Mean Better Machines and Prime Movers

IT DOES not take a metallurgist to perceive that machines and engines are largely masses of metal in motion and that there are many different metals in a particular machine. But the job of selecting or developing the best alloy for each part or service—the right material for a bearing, the correct steel for some reciprocating shaft, or the most durable metal for the base—requires not only an intimate knowledge of materials and a thorough understanding of machines but the combined wisdom of Solomon and the patience of Job as well.

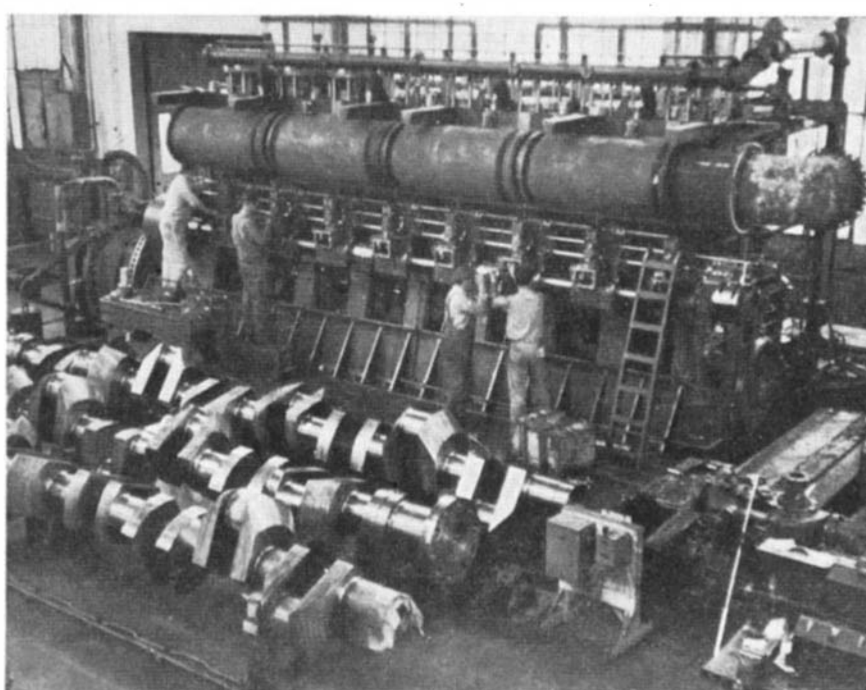
Mechanical engineering has always depended on metals. But to an even more significant extent its recent progress has rested directly on metallurgical progress. Limitations of power, speed, loading, and temperatures of mechanical equipment today are limitations imposed by the existing materials and the maximum performance obtainable from them. This being the case, what does the future hold in new alloys and new metal-working methods that may strike away the bonds of the recent past and permit the design of faster and more powerful machines and engines than those in common use up to now?

Looking at the problem from the engineering rather than the metallurgical point of view, it is observed that the necessary improvements must come from the following directions: (1) Ability to withstand vibration, repeated stressing, or rapidly reversed loading—broadly called fatigue endurance or fatigue strength—required in such parts as Diesel engine crankshafts, airplane propellers, springs, bolts, machine-tool bases, automotive bearings and rocker arms, axles of all types, and so on. (2) Surface smoothness and wear resistance, needed in bearings of all kinds, automotive and aircraft cylinder walls and pistons, machine tool guides and ways, scarifier blades, valve seats, and the like. (3) Toughness and shock resistance—technically known as impact strength—to withstand pounding in service received by things like ball bearings, forging hammer dies and blocks, automotive connecting rods, valve stems, shock absorber links, aircraft landing gear, railway car couplings, rail ends, axles, and thousands of large and small machine parts that strike each other in service.

There is, in addition, another basic property that must be possessed to a greater extent by some new or future materials than it is by any metals now in common use, if mankind is to enjoy the full possibilities of mechanical engineering design. This is resistance to the effects of high temperatures (loss of strength and rapid oxidation). It is the chief requirement for materials used in steam and gas turbines, boilers, furnace and heater parts, oil refining and other process-industries equipment, as well as brake drums, thermostatic and pyrometric elements of various types, internal combustion engine valves, exhaust manifolds, and so on.

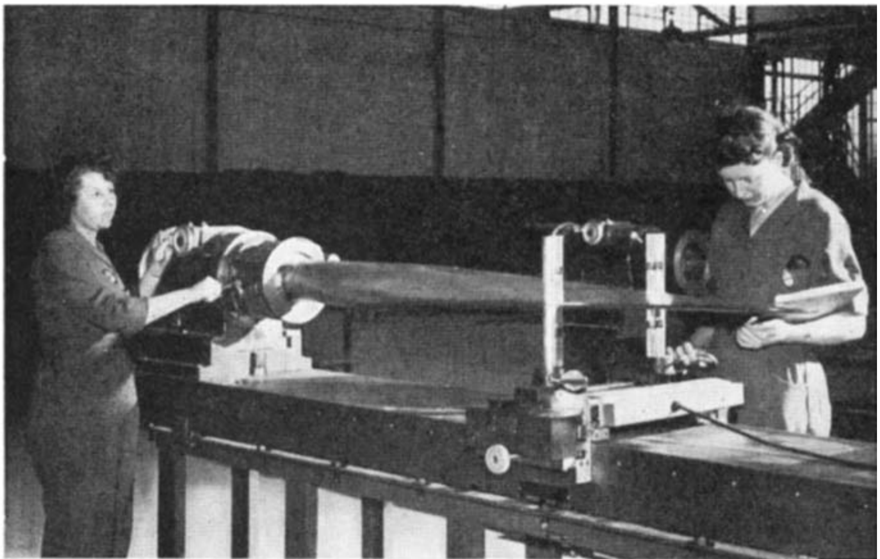
Further, the mechanical equipment of the future will require metals and alloys with even better strength/weight ratios than those now serving in machines, engines, and transportation equipment. Not only must such materials be developed and applied to railway trains, busses, autos, and aircraft, but the lightweight development will also have to be extended to machines and other factory equipment and especially to their load-bearing parts if power increases per unit of equipment weight are to be realized.

FATIGUE FAILURES—How is the battle faring with vibration or repeated-stress failures? Here, indeed, progress has been astonishing! In the first place, a once-obscure property of materials—damping capacity or the ability of a material to absorb and thus "dampen" vibrations rather than to transmit them freely—has been investigated and it has been found that certain metals possess it to a degree that has invited new engineering respect for them. Foremost among these is the once-lowly gray cast iron, whose damping capacity is so much higher than those of other metals that, despite its frequently lower strength and fatigue value, it is virtually our best engineering metal for vibration service. The increased use of gray cast iron—



Courtesy Bush-Sulzer Company

This direct reversible marine engine exemplifies several applications of metals in mechanical engineering. Note especially the crankshafts in foreground, parts of which must be simultaneously resistant to wear, fatigue, and impact



Courtesy American Propeller Corporation

Checking dimensions of an airplane propeller. Such propellers demand metals that are light and strong, fatigue resistant, and which can be precision finished

and especially of the high-strength varieties now available—is one way in which post-war machine designers will reduce vibration and thus cut down the number of fatigue failures that may occur in their equipment.

Materials of high damping capacity like cast iron tend to eliminate the vibration that leads to fatigue failure. The greater attention in the fatigue sphere, however, has been directed to making materials and machine parts more resistant to whatever vibration *does* occur, or to repeated stressing or alternate pulling and pushing of a part. Since this is an obvious and major problem in the operation of guns, it is no wonder that the war period has witnessed enormous strides in improving the fatigue properties of materials.

These strides have not involved the development of new fatigue-resistant alloys. Rather, they have been in the direction of the treatment or protection of metal surfaces in various ways, primarily to aid in preventing the formation of even the tiniest fatigue crack. In the heat treatment of parts intended for fatigue service, controlled atmospheres, salt baths, or quick surface-hardening methods are employed to avoid—in some cases, even to correct for—decarburizing the surface, since a decarburized surface is highly susceptible to the formation of a fatigue crack.

Scratches, tool marks, identification stampings, and the like are scrupulously avoided in airplane wing coverings, propeller blades, overhead power-line cables, machinery shafts, bearings, and so on. From such small beginnings do great fatigue failures grow. Surfaces of parts are highly polished in proportion to the fatigue service they are expected to undergo; occasionally they are electroplated to improve their endurance, but some types of plating seem to be better than others, while certain electroplates are definitely harmful.

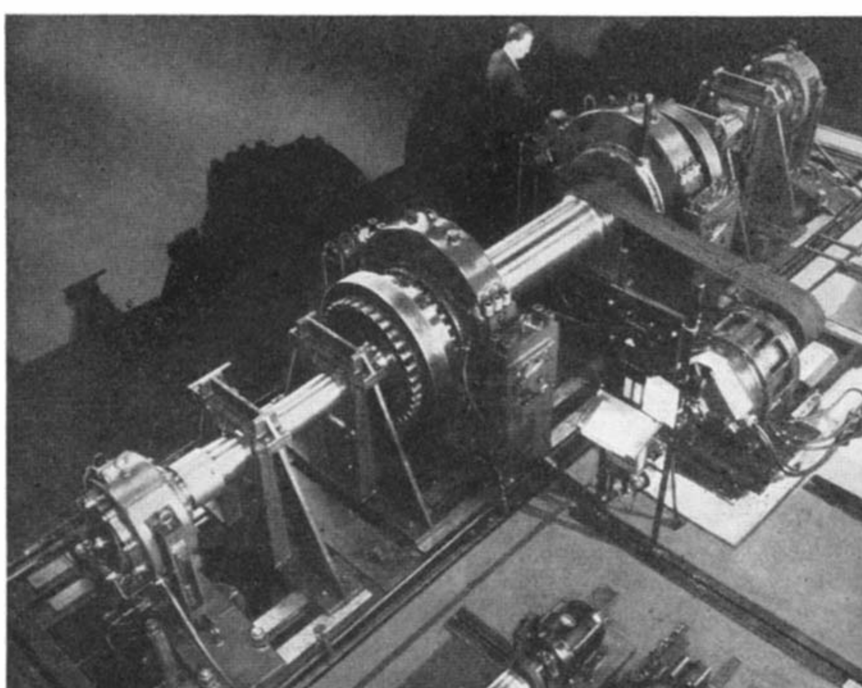
The most spectacular method of improving the fatigue strength of a metal part is shot peening, alluded to in Scientific American, January, 1945, page 14. By this mass-production treatment, castings, forgings, and other parts are enabled to resist from two to ten times the number of stress reversals that the un-peened part could withstand.

Fatigue failures are believed by many engineers to be the most common cause of breakdown of mechanical equipment. Their reduction will obviously mean better and longer service from our machines. In a broader sense, however, our new ability to design parts of thinner sections means that greater power can be built into machines of given weight than has been possible heretofore.

BEARING PROBLEMS—The familiar machinery bearing is a metal product that is required to undergo considerable fatigue stressing in service; it is also a first-class example of the need for metals having high smoothness and resistance to wear in continued metal-sliding-on-metal service. Mechanical engineers, faced with this problem from the first moment a wheel turned, have utilized a variety of materials for so-called plain bearings. The old standbys include lead-base babbitts (lead-antimony-tin alloys), bronzes and leaded bronzes, tin-base babbitts (tin-antimony-copper alloys, widely used in the automotive field in normal times), copper-lead alloys, cadmium-base alloys, cast iron, and "oil-less" or self-lubricating bronze or iron materials.

Bearing service is a combination of many factors, the most important being resistance to galling, conformability, embeddability, fatigue strength, corrosion resistance, and ability to be bonded to a backing if required. The metals listed in the preceding paragraph possess these in varying degrees: there is no perfect bearing metal. Not so long ago, engine and machine designers were actually forced to compromise their speed, power, and lubricating oil relationships. No one of the foregoing bearing metals could measure up simultaneously with respect to (a) resistance to seizing at the temperatures reached with higher loading, (b) fatigue strength, and (c) resistance to corrosion by the modern high-compression-engine oils.

But the war years have evolved and gained acceptance for new bearing metals that remove some of the barriers once considered inevitable by engine designers. Pure silver bearings and silver-lead alloys (either cast or plated and heat-treated) have found an important place in aircraft engines and are certain to be widely used in post-war trucks, motor-cars, and machines in general. They have superior fatigue strength and excellent corrosion resistance. Indium-plated bearings are now widely used and are promising



Courtesy Timken Roller Bearing Company

A locomotive axle-testing machine which simulates conditions that will pertain at operating speeds of up to 150 miles an hour. Few services required of metals are so severe as those demanded by axles for high-speed transportation

post-war prospects for similar reasons.

A special bearing consisting of lead-base babbitt impregnated into the pores and over the surface of a copper-nickel matrix sintered by powder metallurgy methods onto a steel back has been used by at least one automotive company. It has been found that the combination of backing strength, bondability, fatigue strength, and corrosion resistance which this bearing metal provides is a great improvement over those previously used. Finally, self-lubricating powder metallurgy bearings made with tougher, stronger iron-copper materials offer promise of use in heavy-loading service once considered too severe for the conventional sintered bearing.

TOUGHNESS—To most engineers, the outstanding characteristic of metals that leads to their use in machinery and engines is their toughness—their ability to withstand pounding or sudden shock or rapidly applied pressure without breaking. Certain types of wrought steels and copper alloys are among the toughest metals, with cast metals as a group weaker than those that are rolled or forged.

Machines and engines throw metal against metal in many places; thus, wear tests such as those carried out on this machine at Westinghouse are essential to proper choice of materials for such applications

A common design situation in the past was that in which castings were employed for certain machine parts because the shape of the parts precluded production as forgings, or because only the casting method would meet the speed or cost specifications of the job. This was done despite the limitation on the speed or power of the resulting machine necessarily imposed by the relatively lower toughness or general strength of the cast materials with which engineers have traditionally worked. Mechanical engineering of the future will not be so limited, however, by virtue of certain recent developments. Notable among these is the growing availability of high-strength castings on one hand and the perfection of methods and equipment for economically forging large and complicated parts on the other.

Improvement in the properties of castings has been accomplished variously: Gray iron castings are now scientifically processed to give impact and tensile strengths three or four times those available 15 or 20 years ago; centrifugal casting methods yield copper alloy (especially aluminum bronze) and steel castings comparable in toughness to the corresponding wrought materials; modern heat-treating methods have elevated steel castings to the status of a first-class engineering material.

Similarly, war-time developments in the forging field hold much significance for post-war mechanical engineering. Forging machines and presses have been developed to manufacture aluminum and steel forgings of sizes previously considered impossible. The result is that many aircraft engines now are 15 to 20 percent more powerful or faster because their cylinder heads are now strong aluminum forgings instead of the conventional castings. Forged steel cylinder head and barrel units make our PT boats faster and deadlier than if the unit were a casting or an assembly job.

The impact strength of metals decreases rapidly as temperatures are lowered. For this reason, the development of alloys that would not become dangerously brittle at the sub-zero temperatures which supercharger intake parts encounter has been a major war-time problem and achievement. The materials that maintain their toughness best at low temperatures are the austenitic or stainless steels and the copper alloys as a class. Nickel-alloy steels have always been superlative in this respect, and several have been assigned war-time low-temperature uses that are ideal preparation for a bright post-war career in the expanding refrigeration and air-conditioning field.

BRILLIANT ACCOMPLISHMENTS—Bright as are these advances, metallurgy's shiniest contribution to the expansion of mechanical engineering design horizons, in the opinion of many, is its solution to the high-temperature problem that up to now had blocked the development and efficient use of the ultra-compact and light gas turbines and related power equipment. The gas turbine, based on the use of hot combusted fuel gases to operate an air compressor for combustion-air and then to deliver the surplus power for useful work, is an efficient prime mover only when it can run at temperatures above 1300 degrees, Fahrenheit. Up to now there have been no alloys in general use capable of withstanding such temperatures for an economically reasonable period.

Today, however, gas turbines or their derivatives are serving as super-chargers in fast stratosphere-flying aircraft, for jet-propelled planes, and for ships of certain types. Their future for powering such things as locomotives and generators, and developing more power per unit of space or weight than by other means, is bright indeed. And this is all because new alloys and forming methods were developed and used for the impeller buckets and blades and for the drive shafts that reach extremely high temperatures. The alloys—still a military secret—must also be balanced and stable as to thermal expansion characteristics and for some jobs must be resistant to the destructive effects of *cold* at one end of the system as well as of *heat* at the other.

LIGHT WEIGHT—Perhaps the most obvious of today's metals developments which will have a strong influence on tomorrow's mechanical engineering is that of light weight. Aircraft, railway trains, motor vehicles—in fact, anything that moves or must be lifted—are better if lighter. There is now emerging a specific group of either high-strength or low-weight materials (aluminum alloys, magnesium alloys, stainless steels, "low-alloy" steels, plywoods, and so on) that are going to be the foundation for an era of light-weight design whose scope today can merely be guessed. Since this development will be featured in our appraisal next month of metals in the railroad field, we'll do no more than mention it here.

Non-metals are certainly increasing their applications as materials of construction in engineering equipment, especially in the transportation field. But it will be many many years before they will seriously threaten the position of metals as the backbone of mechanical engineering, able to withstand the terrific pounding, twisting, pushing and pulling, abrading, and heating and cooling to which machine and engine parts are characteristically subjected.

FAST HEAT

Made Possible Through New Gas Heating Process

STEEL heat-treatment is being advanced at a rapid pace through the development and increasing application of a new gas-heating technique variously referred to as high-speed heating, patterned combustion, "hell-hole heating," and so on. This process is not only reducing heating time on many jobs but also opening up, for gas heating, applications once reserved for torch and induction-heating equipment.

In high-speed heating, pre-mixed gas and air are fed to radiant ceramic cup burners so designed as to develop and hold extra-high temperatures and concentrated heat in a relatively small space. In a particular installation, large numbers of these burners or chambers are employed, the result being an extra-high-temperature "head" delivering heat to the work at such a rate that the time to heat it is a simple function of its own thermal conductivity.

Using this technique, a six-inch bar of steel can be brought up to 1800 degrees, Fahrenheit, in 15 minutes—three times faster than has been heretofore possible. Stainless steel tubing 1/16-inch thick is fully annealed in five seconds. Large installations are now in production on surface-flowing of electro tin-plate and on heat treatment of steel castings, in addition to many applications to the continuous heating of bars and tubes.

Partners In Production

Mechanical Engineering Looks to Chemistry, Chemistry Looks to Mechanical Engineering, and Between the Two They have Produced an Industry Second to None in the World. Chemical Production Requires Equipment that Can be Provided Only by Close Co-Operation With Fabricators

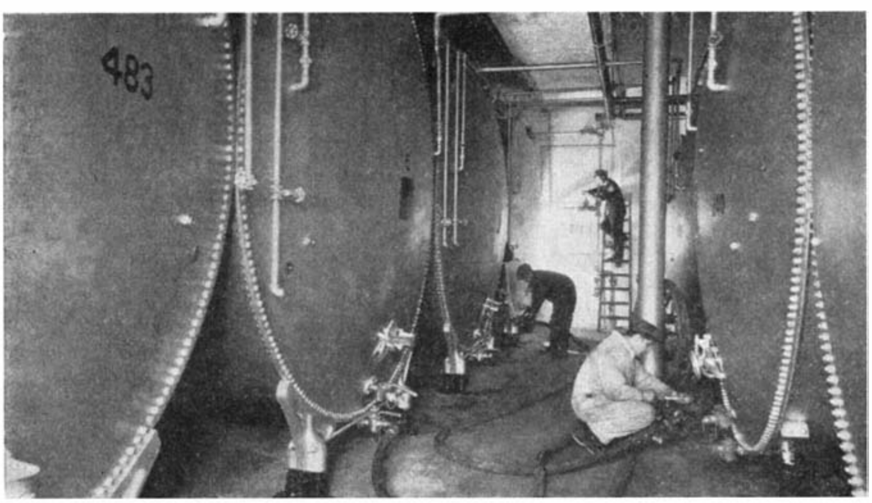
By F. J. VAN ANTWERPEN
Associate Editor, *Industrial and Engineering Chemistry*

MUTUAL dependence is an axiom of American industry. Total war has proved completely that each industrial unit is dependent upon the production and products of another and that the failure of one portion of the production machine means the failure of the whole. Particularly is this true in the case of chemistry and mechanical engineering. Every chemical used in this country is made in apparatus that came out of fabrication shops scattered all over the nation.

Once, in walking through a huge gasoline cracking plant that had been constructed during the period of the most hectic materials- and facilities-shortages of this war, I was surprised to see that the heat exchangers all bore metal tags proclaiming their maker to be one of the large manufacturers of rayon materials. Never to my knowledge had this particular company been in the business of building chemical equipment.

My inquiries were answered promptly by the statement that when it had come time to place orders for equipment necessary for the gasoline plant, all regular channels were so busy with other important war orders that delivery would be delayed many months. The rayon company had a large machine shop well qualified to make any type of equipment and they were given the orders and plans for making the hundreds of heat exchangers that are necessary in producing high-octane gasoline.

This illustrates the important point that no chemical can be made without suitable equipment. It also helps to prove that the science of mechanical engineering is basic and that its principles can be successfully applied once the fundamentals are determined. In this instance, a firm of engineers, designing and building a chemical petroleum plant, could turn over an order for mechanical equipment to a producer of rayons—and because of the close co-operation between the world of theory and engineering, the results are all that had been originally planned.



Glass-lined tanks and easily cleaned rubber hose help keep breweries sanitary

CHEMICAL-MECHANICAL GROWTH—The story of the growth of the American chemical industry cannot be separated from the efforts of the mechanical engineer in creating and building new equipment. The industry that supplies the tanks, pumps, reactors, autoclaves, filters, and hundreds of other specialized and intricate pieces of apparatus is a great American business in itself.

When World War I burst upon us there was a great demand for chemicals made domestically. Not only was American industry forced to expand, because of the necessity of creating an entire organic chemical industry, but the demand for heavy chemicals, such as sulfuric acid, was increased manyfold. To make all these products, new machinery and corrosion-resistant vessels were necessary. Prior to that, much of our chemical industry was carried out in foreign equipment by processes written by foreign chemists. Suddenly the demand was made not only for a home-grown chemical industry but for an industry using home-produced equipment. Designs in many cases at that time were copied from already existing machinery, and the materials of construction were the ones most commonly available—iron, steel, some nonferrous materials, and some alloys. Ceramic materials bore the brunt of construction designed to prevent corrosion. In many cases their fragility caused much delay and loss. But America came through. Upon the fundamentals that were then laid down, a mighty American industry has been organized.

UNIT OPERATIONS—The chemical engineer has been of prime importance in this development. Using his training in the fundamentals of chemistry, and borrowing heavily from the technique of experimentation and the resolution of experimental data into basic laws, he has evolved the science of chemical engineering into a series of functions known as unit operations. These in most cases can be reduced to mathematical expressions.

The basis for equipment design has been removed from the realm of experience alone and the design of a working plant is no longer merely an art. An engineering problem today is reduced to the operations that must be performed, and usually the actual calculations that predict the performance of any piece of equipment can be made from the basic experimental data obtained through laboratory study.

Experience in most cases would be a bad teacher. The mere physical facts involved, such as the location of the plant, would throw off any calculations that were made on the basis of a plant that worked somewhere else. The change in location would involve such fundamental data as the mean temperature of the cooling water, the hardness of the water and its scaling characteristics, the altitude, and the type of fuel available. It has become necessary for the engineer to take the lead of the chemist in this respect, and rely on experimental facts for the design of equipment. If the basic data are available, most of the problems peculiar to a location or new design are easily solved.

Another important point seldom realized in general considerations of the engineering sciences is the interchange of information and techniques. Thus one of the largest manufacturers of process equipment designed and discovered the methods that resulted in the cladding of steel plate with other more chemically resistant materials.

An important contribution to the mechanical engineer is the introduction of an amazing number of new materials of construction. The use of plastics is too well known to require more than passing mention. The chemist has supplied more and better alloying materials—an outstanding example is molybdenum, a metal that has helped in this war to relieve shortages forced upon us by the cessation of imports.

MAKING MAGNESIUM—The production of the light metal, magnesium, is a chemical procedure. Its production, however, demonstrates the interrelated dependence of every industry. The operations that make it possible to extract magnesium from the waters of the sea are predicated upon basic operations that are guaranteed by the mechanical equipment made and designed especially for it. The task of winning magnesium from the sea is one that calls for the concentration of the metal from a solution in which it is present to the extent of 1.2 thousandths of a percent. Thus in a million pounds of sea water there are 1200 pounds of magnesium. Much of the operation rests solely upon the blending of two important skills—the skill of the mechanical engineer in making equipment that will work, and the skill of the chemist and chemical engineer in designing and visualizing the overall operation.

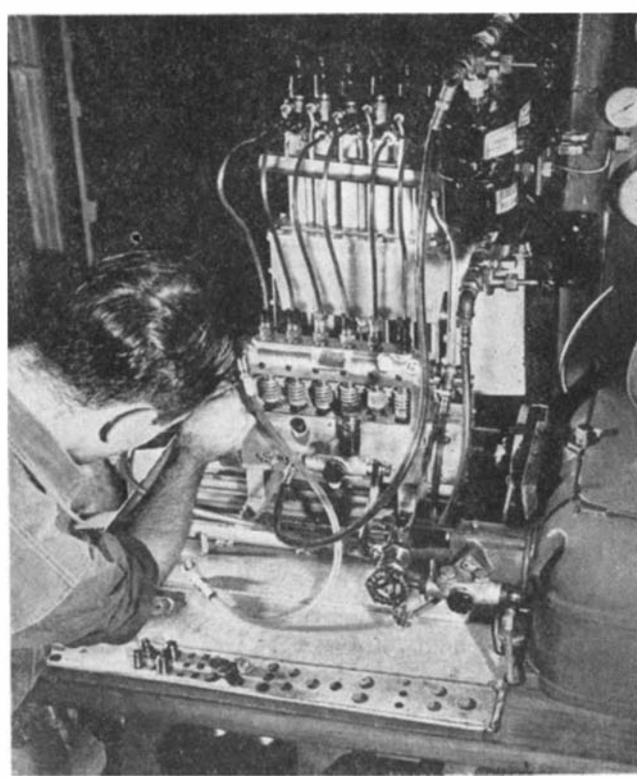
In the very beginning of the magnesium extraction process, there is ample proof that the skills and techniques of the mechanical engineer play an important part. Four pumps, each capable of delivering 70,000 gallons per minute, take in the water from the sea. Each pump, roughly, is doing 170 horsepower of work. The trash in the sea is screened out of the water before it is delivered to the plant—seemingly, a casual procedure, were it not that the successful screening of water calls for the use of special metals to prevent corrosion and short life of the screen. Not only does sea water present a hazard, but galvanic currents require special study and expert correction to prevent loss and shutdown time.

One of the important side processes in making magnesium is the production of lime from oyster shells. These shells are fed to kilns by a special belt arrangement that delivers 16 tons of shells per hour. The shells are fed to huge 3000-foot-long kilns about seven feet in diameter. For insulation, the mechanical engineer has supplied an improvement on the old fire brick which he first used to insulate steam boilers. A half foot of fire brick is used to seal off the tremendous temperature of 1300 degrees, Fahrenheit. The heat makes calcium oxide (lime) from the oyster shells, which are essentially calcium carbonate. Kilns of these sizes are capable of making about 150 tons of lime per day.

TANTALUM STEPS IN—The processing of chemicals today calls upon expert specialization in the mechanical field. Centrifugal pumps have been designed and made of special chemically developed alloys capable of handling acids of any concentration. Once the making of hydrochloric acid was an especially dangerous operation because of high corrosion rates. Complete installations of chemical quartz had to be made, but this was a procedure that was hampered by fragility and expense. Today tantalum, formerly a rare metal, is being fabricated into units that successfully handle hydrochloric acid with a minimum of corrosion. Heaters for acid solutions are constructed from this same metal, and industrial processes move more certainly and for longer periods because of the co-operation between the chemist and the engineer.

Process industries were once handicapped when it came to the filtration of solids from acid or alkaline solutions. Now the mechanical engineer has his choice of materials with which to equip any filter press that is used to filter the corrosive solutions of modern technology. He may use cloth made of glass, rubber, or plastic. Wire cloth made of all the metals and alloys that are susceptible to fabrication are his for the specifying. Asbestos fibers have been used; and for the intricate task of filtering colloidal suspensions he can

Portable mechanical mixers play a large part in the efficient operation of pilot plants and in small-batch work



Testing of Diesel fuel-injection pumps is made a visible operation by the use of transparent compar tubing

use rubber of minute cell structure and, perhaps, glass if the future development of this field continues at the same rapid pace that has characterized it in the past.

The engineering industries avidly adapt the inventions of the chemist and in turn the chemist is the faithful customer of the engineer. Thus, in building one of the new catalytic cracking plants, which is solely a chemical development based on the practical application of chemical principles, over 340,000 pounds of valves and fittings were purchased. In addition, well over 300,000 pounds of tubing for heat exchangers had to be used, while the pump manufacturers were some $56,000 richer because of the project.

Into the same plant went 89,000 feet of piping. Instruments for the control of the process cost $47,000 and electric motors to run the machinery cost $14,000. In any line-up such as that, it is a foregone conclusion that the industries are interdependent.

The synthetic rubber program of the United States is massive and impressive, but no less impressive are the feats of the mechanical engineers in making working equipment out of substitute materials. The boiler installations that

Non-corrosive glass tanks, designed for Westinghouse by Pittsburgh Plate Glass as a war-time substitute for metal and wood tanks, are found better in many ways than old types

produce steam for the rubber plants are intricate but at the same time compact units that represent a high point in efficiency.

At one of the butadiene plants there is a steam unit that can make 50 million pounds of high pressure steam a day. Without this steam not a pound of rubber could be produced. The engineering profession, its members working together, is the keynote of industrial achievement.

WORKING ON STUMPS—One of the most chemical of industries is the production of turpentines, rosins, and other pine derivatives from the stumps left behind in our Southern lands when the logger moves out. From the very inception it was realized that the industry depended upon proper chemical methods for its life. Yet it could not continue to function were it not for the development of mechanical aids. At one time, the stumps were pulled out by mule power or blasted out by dynamite. Today, special tractors with huge cranes efficiently extract the stump from the ground. It took years for this particular method to be perfected, but now after many trials this has been accomplished. The cranes that remove the stumps can travel easily over rough terrain. On the end of the crane boom is a large head, called the "nutcracker," which is lowered over the stump; internal teeth in the head of the nutcracker clasp the stump, and as the upward pulling strain of the crane becomes greater, the teeth sink deeper into the pine stump.

This particular industry, says the largest company in the business, was given a big impetus "by the development of a satisfactory 'hog' for the reduction of the stump wood to properly sized pieces for processing. The hog . . . devours irregularly shaped pieces of wood eight feet long and over a foot thick with no difficulty."

In the plant of this company, great dependence is placed on mechanical equipment. To eliminate metal pieces, a magnetic "eye" is placed over the belt that conveys the wood chips; when metal is detected, the belt is reversed automatically and the contents discharged to the waste pile.

Without the help of the other sciences and engineering techniques, the chemical industry could not function. Industry, more than ever before, is interdependent, and what one develops the other uses.

FLYING RUBBER

Gives Good Account of Itself in Bombers

RUBBER used in airplanes is not limited to tires. Each four-motored bomber, exclusive of tires, requires almost one ton of synthetic rubber. The huge B-29 uses more than that, for it is estimated that one of these giants requires almost two and a half tons of rubber in its construction.

Bullet-sealing gas tanks; rubber sponge in wing voids to sop up spilled gasoline; oil-resistant hose for the hydraulic, fuel, and oil lines; diaphragms; valves; and gaskets help to make up the huge quantities of rubber that go into the sky giants.

PENICILLIN ACTION

Requires that Drug be Administered by Injection

PENICILLIN does not destroy bacteria directly, according to the latest information on this subject, but prevents the fission or subdivision of the bacteria cell. Thus the magic drug, by preventing the rapid growth of harmful bacteria, allows the normal body action to carry off the attacking organisms. This is the job of the blood leucocytes, which apparently are not harmed by the penicillin.

Because the stomach generates acid, all penicillin must be administered either by intramuscular or intravenous injection; the salts of penicillin are destroyed by acid conditions.

PROTEINASE

Useful in Industry Obtained from Waste

ASPARAGUS butts, a waste product of the canning industry in certain areas, may find useful application if the plans of chemists from the United States Department of Agriculture bear fruit. Working in the Government's Western Regional Research Laboratories at Albany, California, three scientists found that juice pressed from these butts can be used as a culture medium to produce bacterial proteinase, an enzyme that digests proteins. Bacterial proteinase is used in the brewing industry for chill-proofing malted beverages, in the leather and textile industries, and in the recovery of silver from used photographic film.

It was also found that the juice could be used as a culture medium for other processes as a replacement for vegetable materials that are now scarce.

TANNIN

Can Now be Obtained From Hemlock Bark

CHESTNUT blight has seriously depleted the nation's source of tannin; from the chestnut tree could be obtained a rich and economical supply of this material. One of the substitutes that has been proposed is western hemlock tannin, and a method of making this tanning material from the bark of this tree has been discovered.

At pulping centers in the western United States there is a large and inexpensive source of bark, and through mechanical pressing and chemical leaching, it is thought that a commerical process can be started that will prove competitive with other sources of tannin.

COLORED SMOKES

Employ Mixtures of Dye and Fuel

COLORED signal smokes are being used extensively in this war as a way of signaling to distant observers. Most of the colors are produced by volatilizing organic dyes by burning a fuel and a dye together. Successful colored smokes are made by using dyes of the anthraquinone type, and the fuel mixture that gives the best service is probably potassium chlorate and a combustible material such as sulfur or sugar. For signaling, colored smokes are necessary in battle as there must be a distinction between the signal and the huge quantities of smoke given off by bursting shells and burning equipment. It is possible through the proper combinations to make smokes of the following colors—yellow, red, orange, violet, green, blue, and deep blue.

Heat Transfer

Some of the Fundamental Science Surrounding the Many Ways in which Heat Transfer is Involved in the Machinery of Modern Industry. Five Different Basic Mechanisms for Transferring Heat. Many Large Companies Maintain Basic Research on These Problems Because of their Importance

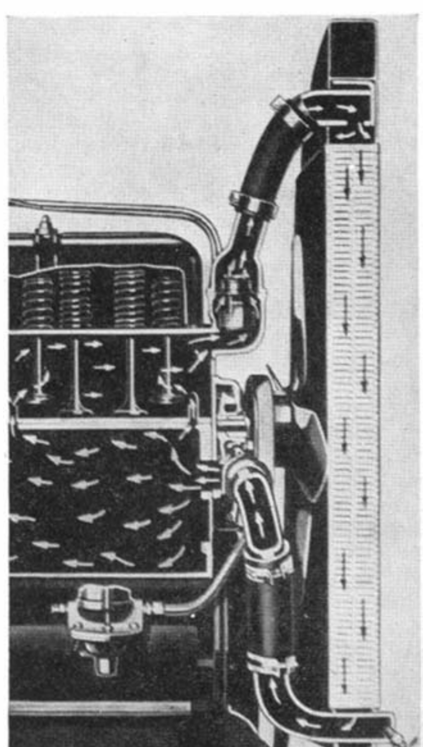
By G. W. PENNEY
Research Laboratories, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania

With the advent of the machine age, one of the major developments has been the provision of means for rapidly transferring heat. Our modern way of living would be almost out of the question were it not for these developments. Most examples of heat transfer are accomplished by one of the following means: conduction, radiation, convection, evaporation, and condensation.

CONDUCTION — Heat conduction is the transfer of heat within a substance when there is no relative motion of the various parts. Heat is a form of molecular energy which may be thought of as a vibration of the molecules. If one part of the substance is hotter than other parts, the increased molecular energy in the hotter portion is gradually communicated from molecule to molecule and we say that heat is conducted from the hotter part of the substance to cooler parts.

We can find materials having a wide range of thermal conductivity, but there is no substance which can be regarded as a non-conductor of heat to the same degree that we are able to provide electrical insulators. Among ordinary materials copper is our best conductor of heat. Low density materials, such as granulated cork, glass wool, eiderdown, and similar materials, are the poorest conductors. These poor conductors or thermal insulators have a thermal resistance approximately 10,000 times that of copper. Compared with this, a good electrical insulator has from a million-billion (10^{15}) to a million-billion-billion (10^{24}) times the electrical resistivity of copper. Such resistivity of electrical insulators is so great that, if we want to equip a handle for an electric switch, a piece of paper can to all practical purposes isolate the handle, so that in touching the handle we do not feel any shock. In the case of an ordinary cooking utensil we want to provide a handle which will stay cool even though the dish is hot. For this purpose we may use a handle of wood, plastics, or some other poor conductor, and so provide a handle which is usable, but we are unable to provide a handle which is a perfect thermal insulator.

In general, metals are the best conductors of heat. Those which conduct electricity best are also the best conductors of heat. The Wiedemann-Franz law states that at a given temperature the ratio of thermal conductivity to electrical conductivity is the same for all metals. Experimental values agree with this theory so closely as to indicate strongly that the mechanism which conducts heat in a metal is closely related to the mechanism giving electrical conductivity, although the exact nature of the relationship has not been completely explained.



Courtesy General Motors

The cooling system in your car is a homely example of heat exchange

Copper, which is one of our best electrical conductors, has a thermal conductivity over 100 times that of common dense non-conductors of electricity such as sandstone, granite, slate, or glass. Metals and alloys range in conductivity from silver and copper down to alloys having a thermal conductivity comparable to the dense non-conductors.

There is no known dense or non-porous material which is a good thermal insulator. However, by subdividing such a material, many small pores filled with air are provided, and air, when it is thus prevented from circulating, is a very poor conductor of heat. Hence all our common thermal insulators merely approach the thermal conductivity of air. You may ask, "Why use insulation if it has no lower thermal conductivity than the air which already surrounds things?" The reason is that air in any space of appreciable size will move about or circulate and so transfer heat by convection and the heat transferred by convection will be many times that transferred by its thermal conductivity.

If we must secure a heat conductivity lower than that of air, one expedient is to exhaust the air, as in the common vacuum or thermos bottle, but this is not practicable in large structures. Filling the pores of a substance with a gas having a lower thermal conductivity than air gives a moderate improvement. It is difficult, however, to seal the gas permanently, hence this is usually not a practical solution.

Another theoretical possibility uses low "accommodation coefficient" — a condition at the boundary between a solid and a gas which results in decreased thermal conduction. However, the effect at any one surface is small, so that to be useful there must be many such surfaces; that is, the gas spaces must be very small and the solid material must be broken up into very thin films or small fibers. Considerable progress is being made in this direction and a gradual improvement in such thermal insulation can be expected.

Even though in most cases we do not have an ideal thermal insulator, we still can reach almost any desired low limit of heat loss merely by making the insulation thicker. We commonly call houses "insulated" if their construction includes insulating board only ¾ inch thick but, by filling the four-inch space between studding with insulation, very much lower heat losses can be obtained. By increasing the thickness of insulation in refrigerators, houses, and so on, the loss through the insulation can be reduced to where it is small compared with the loss through air leakage, windows, metal parts, and the rest. Hence in most applications a better thermal insulator must also be inexpensive or it will not be used.

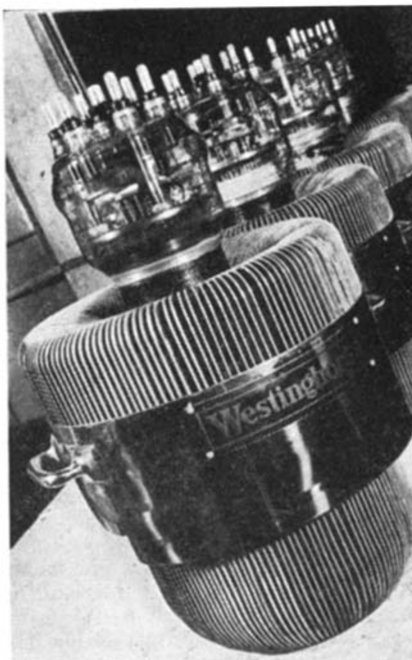
CONVECTION—Convection is often defined as the transfer of heat within a fluid by the relative motion of warmer and cooler parts of the fluid. Using this definition, the transfer of heat from a surface is said to consist of conduction through a relatively stagnant layer of gas followed by the transfer by convection over larger distances. This definition is not very useful because in most cases we cannot measure the separate effects. The quantity which can be measured and is therefore useful is the overall effect, or the transfer of heat from a surface to a moving fluid. For this reason engineers are coming to use the word "convection" to mean the transfer of heat between a solid and a fluid or between various portions of a fluid in which the heat is transferred by a combination of thermal conduction and motion of the fluid. This is the meaning given to "convection" in this discussion.

Almost all modern mechanical developments depend on convection to secure the high rates of heat transfer required for their proper operation. In heating a house the old method was merely to provide a stove or fireplace which heated the adjacent air, and the accompanying change in density caused the air to circulate. This has been called natural convection. However, this did not adequately equalize the temperature in various parts of a room. Now ventilating systems have provided forced convection by means of fans so that air is circulated rapidly throughout the house with only a small change in air temperature.

Many of the improvements in modern machines have been made possible by advances in the art of transferring heat by forced convection. In forced convection, heat is conducted from a surface to the adjacent fluid, and a fan or pump is used to move the fluid so that the heated fluid will be carried away and replaced by cooler fluid. By increasing the velocity, cooler fluid is brought closer to the surface. In this way the heat transfer rate can be increased almost indefinitely. However, the surface heat transfer rate increases only approximately as the ¾ power of the velocity, while the power required to circulate the fluid through a given duct system commonly increases as the cube of the velocity. From this relation it follows that, to double the rate of heat transfer, the power required to drive the fan or pump will increase 16 times. This gives an economical limit beyond which it is impractical to increase the rate of heat transfer by increasing the velocity of a fluid.

Particularly in the case of air cooling, finned surfaces have been used to increase the surface exposed to air and thus increase the heat dissipated from a given object. Many tricks are used to produce turbulent motion of the air to bring cool air over surfaces. Deflectors and guide vanes can be used to bring air to points which would otherwise be poorly cooled. The radial aircraft engine is one of the best examples of air cooling. In this case a large supply of high-velocity air is fortunately available. Such important advances have been made in air-cooled engines that some engineers predict that we will again be using them in automobiles and trucks.

In many pieces of apparatus, heat is generated in such small volume that it becomes impractical to cool the part



25,000-watt broadcasting tubes with cooling fins (heat exchange)

by air, and in this case we usually resort to water cooling—water is usually the most effective coolant available. For example, large radio transmitting tubes have a very high concentration of heat at the anode and on tubes of the highest powers water cooling is used. In one typical modern oscillator tube the losses amount to 20 kilowatts in a cylinder 3 inches in diameter by 6½ inches long. This amounts to 68,000 Btu per hour or enough to heat a typical six-room house in zero weather. To remove the heat from this small area without allowing the surface to exceed 100 degrees, Centigrade, water must be circulated over the surface at high velocity. However, water cooling requires piping and other complications, including the fact that the stream of water used for cooling may conduct electricity where it is not wanted. For these reasons, radio transmitting tubes are sometimes used at somewhat less than full rating in order to permit the use of air cooling. Air cooling is accomplished by the use of long copper fins spaced very close together, over which air is passed at a high velocity.

The modern x-ray tube is another example of a highly developed cooling system. In order that the x-rays may approximate a point source, high energy electrons must strike a small spot on the anode. This anode may be at a potential of 100,000 volts, and therefore, to secure electrical insulation, oil cooling must be used. Oil is ordinarily a poor coolant, compared with water, but by using pressures of 30 to 60 pounds and especially devised passages, a rate of cooling with oil is secured which would ordinarily be accomplished only by water cooling, at the same time providing adequate electrical insulation.

Central station boilers require enormous surfaces to transfer the heat from the burning gases to the water. To reduce the size of the boiler it has been found economical to use large fans to draw the gases of combustion through the boiler tubes and discharge these gases up the chimney. This contrasts with older schemes in which the chimney produced the draft.

Modern rotating electrical machinery is possible only because of highly developed cooling systems. In the electric locomotive space is very limited and fans therefore are used to draw the air over the motors and control apparatus. In most rotating machines many small ducts have been provided through which air is blown at high velocities. However, in locations such as steel mills, dust gradually fills these ducts and leads to overheating. Filters and air washers were used but in many cases were not adequate and therefore closed systems were developed.

In the closed system a fan is used to draw air through the machine and blow it over water cooling coils and back into the machine; assuming that the housing is tight, no dust can get into the ducts. Recently the development of the Precipitron has given a sufficiently high efficiency in air cleaning that many steel mills have eliminated the water cooling coils by taking in outdoor air and cleaning this air with the Precipitron before blowing it through the machine.

Turbo generators in our power plants have used enclosed machines with water cooling coils to cool the air, but here another limit was reached. In order to obtain efficient turbine operation, these machines must run at high speed and, to improve the cooling, air velocities were increased until the power required to move the cooling air was greater than that in the heat removed. This difficulty has been solved by the use of hydrogen cooling. Hydrogen has approximately the same thermal capacity per unit volume as air, but its density is less than 7 percent of that of air. The power required to force gas through common systems of ducts is nearly proportional to the density of the gas, and thus, by substituting hydrogen for air in a totally enclosed machine, the power required to circulate the gas can be reduced to approximately 7 percent. In addition to reducing the power required to drive the fan, the use of hydrogen eliminates oxidation of the insulation and increases the thermal conductivity of most insulation, since hydrogen has about seven times the thermal conductivity of air. Thus, by filling all small pores

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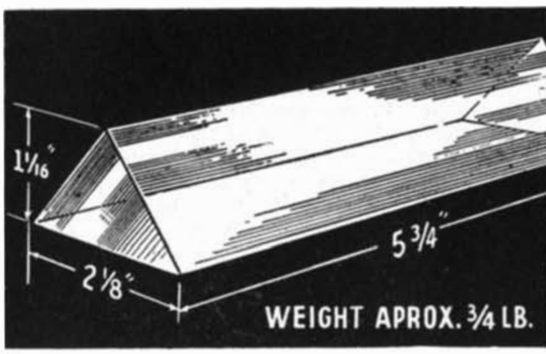

TANK PRISMS

In order that the tank driver shall not get shot in the face, two of these Silvered Prisms are used to make a periscope (without magnification). We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree prisms of huge size — 5¾" long, 2⅛" wide, finely ground and polished.

You can use these Prisms to make Periscopes to see over the heads of crowds, fish under water, high or low gauges, inspection of machinery without climbing, for examination of hot metals without danger to eye or camera, etc. Also excellent for experiments, class-room demonstrations at high schools, colleges, camera clubs, astronomy clubs. Some of our ingenious customers have used these Prisms to make camera stereo attachment, photometer cube, range finder, etc.

Normally, these Prisms would retail from about $24 to $30 each.

Stock #3004-S . . . SILVERED TANK PRISM — Price $2.00 each Postpaid. Free Booklet on Prisms incl.

Stock #3005-S . . . PLAIN TANK PRISM — Price $2.00 each Postpaid. This one is excellent for projecting all the colors of the spectrum — a beautiful sight. Free Booklet on Prisms incl. FOUR TANK PRISMS — Special $7.00 Postpaid . . . This is the most sensational bargain we have ever been able to offer.

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Stock No.	Diameter in MMs.	Focal Length in MMs.	Comments	Price
6016-S	12	80	Uncemented	30¢
6017-S	12	80	Cemented	50¢
6018-S	15	41	Uncemented	40¢
6019-S	15	41	Cemented	60¢
6020-S	18	49	Uncemented	50¢
6021-S	18	49	Cemented	60¢
6022-S	25	95	Uncemented	50¢
6023-S	25	95	Cemented	75¢
6033-S	37	51	Uncemented	70¢
6074-S	37	130	Uncemented	70¢

FREE Cement and Directions included with all uncemented Sets.

USES: — Use these lenses for making projecting lenses, low power microscope objectives, corrected magnifiers, substitute enlarging lenses, eye-piece lenses, macrophotography, gadgets, optical instruments, etc., etc., etc.

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Stock #6002-S . . . Educational Set for Individuals . . . consisting of 1 Porro Binocular Prism Blank and 1 finished Porro Prism (3rd grade) — Price 25¢ Postpaid.

REDUCING LENS SET #1004-S .... $1.20 Postpaid
Contains a 2½" diameter and 1¾" diameter reducing lens of different powers.

LENS SET 120-S "The Experimenter's Dream" 60 lenses with 50-page illustrated booklet "FUN WITH CHIPPED EDGE LENSES" — $10.00 Postpaid.

The variety of lenses in this set will enable you to conduct countless experiments and build many optical gadgets.

50-PAGE ILLUSTRATED IDEA BOOKLET .... $1.00 Postpaid
Describes wide variety of uses for our lenses and contains much information especially designed for beginners in optics.

WAR BARGAINS IN LENSES USED IN NAVY'S 7 POWER BINOCULARS

KELLNER EYE-PIECE LENSES with F.L. of 27.5 mms. Comes uncemented with free cement and easy directions. Edged Field Lens has diameter of 26 mms. and edged Eye Achromat a diameter of 17 mms. These are excellent for all sorts of telescopes.
Stock #6061-S — Uncemented but Edged — $1.25 Postpaid
ACHROMATIC OBJECTIVE LENSES with F.L. of 193 mms. Have wider diameter than those used in Army's 7 power binocular. Excellent for telescopes. Diameter of edged lenses are about 52 mms.
Stock #6064-S — Edged and Uncemented — Price $1.75
COMPLETE SET OF LENSES AS ABOVE AND THE PRISMS TO MAKE A MONOCULAR (TELESCOPE)
Stock #5100-S . . . Monocular Set . . . $5.00 Postpaid

LOW POWER MICROSCOPE LENS SET — (May also be used to make Telescope Eye-Piece) Perfect Lenses, one with diameter of 9 mms., F.L. of 20 mms., and one with diameter of 14 mms. and F.L. of 39 mms.
Stock #1003-S — Price 70¢ — includes free copy of our Microscope Booklet.

PORRO ABBE PRISMS—Stock #3006-S..25¢ each Postpaid
Size 9 mm x 17 mm. . . . another war bargain. Normal prices would be 20 to 40 times above quotation. At this exceptionally low price, you should purchase a few of these, even though you have no immediate need for them. Such a bargain will not be available long.

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in insulating materials with hydrogen, the conductivity of these insulating materials is increased.

It might be thought that the surface heat transfer rate would also be increased by seven times, but this is not the case since the heat transfer also depends on the viscosity of the gas. Because of this, the heat transfer secured by the use of hydrogen is, in many cases, only 25 percent greater than that obtained by air. A mixture of air and hydrogen is, of course, highly explosive, and so several years of research and development were required to perfect a means for making machines gas-tight and developing control devices to insure that an explosive mixture will never be present in the machine.

RADIATION—Heat is radiated by electromagnetic radiation. Its wavelength is frequently measured in microns. A micron is one millionth of a meter or 39.37 millionths of an inch. The eye is sensitive to wavelengths from about .38 to .76 microns. Radiation in this range is called light although it also transfers heat. All ordinary objects constantly emit and receive radiant energy. The amount of energy radiated from a given object is proportional to the fourth power of its absolute temperature. As the temperature of an object increases, the intensity of all wavelengths increases, but shorter wavelengths increase more than the longer wavelengths. Thus the average wavelength becomes shorter as the emitting object becomes hotter. At body temperature the maximum intensity of radiation occurs at about 10 microns. At 500 degrees, Centigrade, the maximum intensity is at 3.74 microns and the shorter wavelengths have increased so that an object commences to be visible in a dark room.

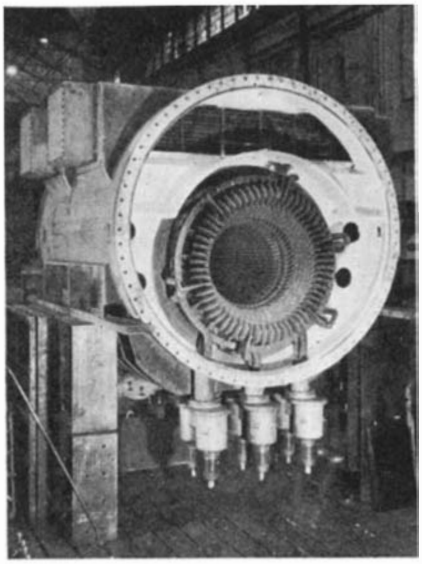
A typical 100-watt tungsten lamp filament operating at 2470 degrees, Centigrade, has the maximum intensity of radiation at 1.05 microns, which is outside the visible range. Thus the tungsten lamp is not the most efficient means of transforming energy into light. If the filament could be operated at a higher temperature, a larger fraction of the energy would be transformed into light. But higher temperatures result in too short life of the lamp.

The maximum intensity of sunlight is in the middle of the visible spectrum at about the maximum sensitivity of the eye. About one half of the radiant energy of the sun is in the visible range. Most of the remaining energy is in the infra-red, that is, wavelengths longer than the visible.

The transmission of infra-red radiation is similar to that of visible light, except that materials which transmit one wavelength do not necessarily transmit another wavelength and, likewise, materials which reflect one wavelength do not necessarily reflect another wavelength. Copper may be cited as an example. It is not a good reflector of light but is usually used as a reflector in radiant heaters because among common materials it is one of the best reflectors of wavelengths longer than one micron.

A material which is a good reflector for a given wavelength is necessarily a poor emitter of that same wavelength. That is, a material which would reflect a wavelength of two microns, if heated, would not be able to cool itself by giving off heat having a wavelength of two microns. The variation of reflectivity with wavelength provides a scientific explanation for the desirability of white clothing in the sunlight in hot weather. Ordinary white surfaces are good diffuse reflectors of visible light, usually reflecting over 75 percent of the solar energy. However, most white surfaces are poor reflectors—that is, good emitters—of wavelengths around 10 microns which predominate at body temperature.

A person, therefore, receives much less heat from the sun when he is wearing white clothing than when wearing black clothing. However, we must be able to dissipate or lose some heat and, since our normal body temperature is a relatively low one, white clothing is equally effective with black clothing for radiating these long wavelengths. If we desire to prevent the emission or absorption of longer wavelengths, bright, metallic surfaces are our only good materials.



Stator of a 25,000 kilowatt Westinghouse hydrogen-cooled turbine generator, its finned tube coolers visible near the top of the housing

Reasonably good thermal insulation can be provided by parallel spaced sheets of a bright metal such as aluminum. This tends to break up movement of the air, thus restricting heat transferred by convection. It also provides a series of reflecting surfaces which interfere with the radiation of heat.

Recent developments in glass provide interesting possibilities in the construction of houses. Ordinary window glass is transparent to wavelengths from about .3 to 4.7 microns and thus it absorbs less than 5 percent of the sun's energy. In summer when we want to air condition our homes, our windows admit light but also let in a large amount of additional heat radiated from the sun.

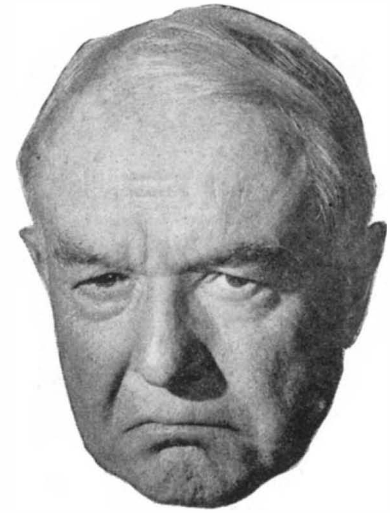
A glass has been developed which has reasonably good transmission in the visible range but absorbs most of the radiation longer than .8 micron. Thus with a given amount of light only about half of the heat is admitted that would be admitted if ordinary glass were used. However, to accomplish this requires a double window. The new glass, in absorbing the longer wavelengths, becomes appreciably warm; if it were used in the ordinary single glass window, a considerable portion of this heat of the sun would still find its way into the house from the warm glass. By providing a double window and using this heat-absorbing glass in the outer pane, and particularly if the air space between the two surfaces of glass is ventilated, very little of this heat that is absorbed by the glass finds its way into the house. In this way we can have a maximum of visibility with a minimum of heat from the sun transmitted into our rooms.

EVAPORATION AND CONDENSATION—We are all familiar with the fact that our bodies perspire in order that we may remain at a reasonable temperature even though the surrounding air is quite hot. But man made relatively little additional use of this phenomenon until the coming of the machine age. In the steam engine we use hot gases to evaporate water in a boiler, forming steam to operate the engine, and in more modern engines we also provide a condenser which permits the engine to abstract more power from the steam and also serves to return water to the boiler.

Refrigeration for preserving food and and air conditioning buildings depends on evaporation and condensation. For example, in air conditioning a building we use a liquid such as Freon which boils readily at relatively low temperatures. Boiling of the refrigerant removes heat from the walls of the vessel. Air may then be cooled by being blown over the Freon container. The vapor which has absorbed heat in cooling the air is then compressed to a higher pressure so that it will condense at a higher temperature. One of the major problems in modern air conditioning is the improvement of this heat transfer, first from the air to the boiling refrigerant, and then from the compressed refrigerant vapor to cooling water or air, in order to condense the refrigerant and return it as a liquid to the boiler. If this rate of heat transfer could be greatly improved, the difference in pressure between the boiler and condenser could be reduced. A reduction in the temperature difference between a boiling and condensing refrigerant would make possible the same amount of cooling with the expenditure of much less power, thus giving us more economical refrigeration.

In modern machinery for the factory and home the transfer of heat is highly important. A number of industries have large research and development programs aimed toward improvement of the cooling of apparatus. Many of the discoveries regarding the mechanism of heat transfer are making important forward strides in increasing the efficiency of machines and apparatus.

"I'll tell you GOOD TIMES ARE COMING!"



"I'll tell you BAD TIMES AHEAD!"

What's it to you?—PLENTY!

OKAY! Maybe the optimists are right. There'll be good times after the war.

OKAY! Maybe the pessimists are right. We'll have another depression.

What's it to you? PLENTY! It's largely in *your* hands as to which we'll have.

The one way to make it *good times* is to do your share to help keep prices down now!

That means *buying only what you really need*. It means *paying off your debts, saving your money*.

And here's where you're lucky. The same program that helps insure prosperity is also the best possible way to get yourself in shape to take another depression if one does come. So what? *You're right both ways*—if you save your money. *You lose both ways*—if you splurge right now.

Think it over, fella. Then get in there and fight. Read—and observe—the four rules to head off inflation. The war isn't over yet. And the war against *inflation* isn't over yet—by a long shot. Remember World War I? The cost of living rose twice as fast *after* the war as it did during the war itself.

4 THINGS TO DO to keep prices down and help avoid another depression

1. Buy only what you really need.
2. When you buy, pay no more than ceiling prices. Pay your ration points in full.
3. Keep your *own* prices down. Don't take advantage of war conditions to ask more for your labor, your services, or the goods you sell.
4. *Save*. Buy and hold all the War Bonds you can afford—to help pay for the war and insure your future. Keep up your insurance.

HELP US KEEP PRICES DOWN

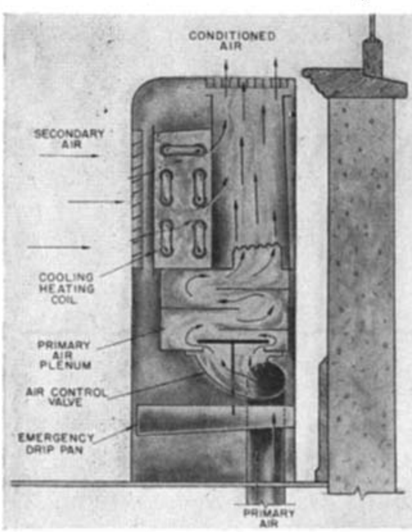
A United States War message prepared by the War Advertising Council, approved by the Office of War Information, and contributed by this magazine in cooperation with the Magazine Publishers of America.

Multi-Room Air Conditioning

Temperature and Humidity Control in Large Buildings with Many Small Rooms Has Been The Great Problem in Air Conditioning. Now a System Has Been Developed Based on High Pressure Flow of Conditioned Air Through Small Pipes, Eliminating the Space-Consuming Air Ducts of Earlier Methods

By JEROME CAMPBELL

SPECIALISTS in air conditioning have long been preoccupied with the difficult problem of cooling and heating the air, as the seasons require, in large buildings divided into many small rooms, and at the same time providing the desired degree of humidity. Now an air conditioning system has been developed for the specific purpose of controlling individually the "climate" inside each unit of multi-roomed structures. Said to be more economical and space-saving than any system before used, the new method has been successfully test-operated for some time. It



A cross-section of the Weathermaster room conditioning unit, showing the details of its design and functioning

is a product of the Carrier Corporation and has been named the Conduit Weathermaster System.

One superiority of the new system over older ways of conditioning the air in the many small rooms of hotels, hospitals, office buildings, and apartment houses lies in the fact that its pipes and conditioning units take up far less space. It also eliminates return air ducts completely and reduces the air supply ducts to conduits no larger than a plumber's waste pipe. In addition, the new system allows each room to be heated or cooled according to the desire of its occupant, although all the rooms receive their conditioned air from a central apparatus.

MAN-MADE WEATHER — Essentially a contemporary development, air conditioning has emerged only in the last 30 years as an important factor contributing to human comfort and the more economical output of manufactured articles. In industry it found its first useful applications. There it showed that more uniform, and hence better, products could be turned out if the temperature and moisture content of the air in factories were controlled.

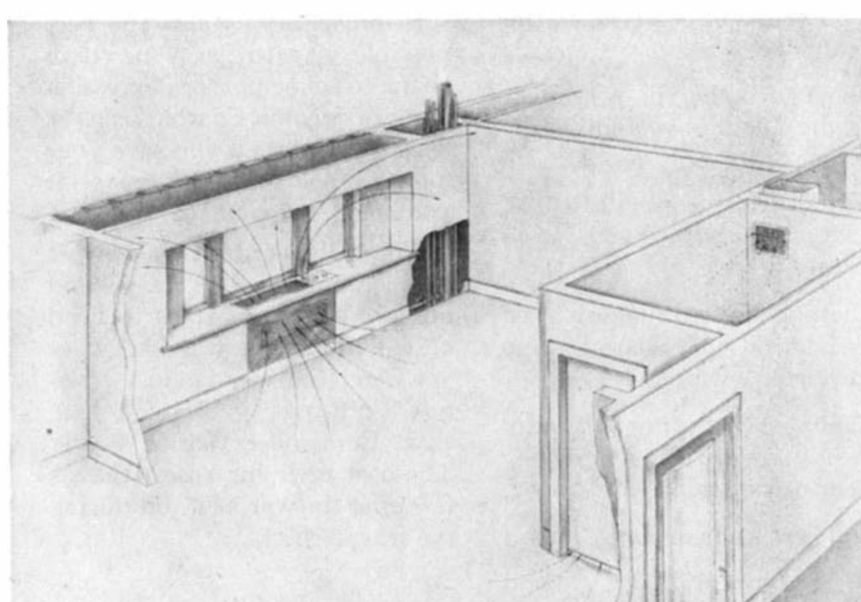
Later, air conditioning was applied to theaters, department stores, and other buildings having large open areas. Americans soon learned to turn to the big movies houses as oases of coolness in the sweltering days of July and August.

Little progress was made, however, at that time in working out a practicable system of air conditioning for structures having a great number of small rooms. The reason was the unwieldiness of existing air conditioning systems. The installations employed huge air washers designed to handle vast quantities of air. They required giant fans and a system of space-consuming air supply and return ducts. In many cases, these huge ducts were large enough for a person easily to crawl through them.

Such systems could not be used without great difficulty and expense in heating and cooling the air in buildings of the multi-cellular type. The small divisions in hotels, office buildings and apartment houses, hospitals and schools, could not economically be fitted with a complex network of heavy, ugly, space-consuming sheet metal ducts.

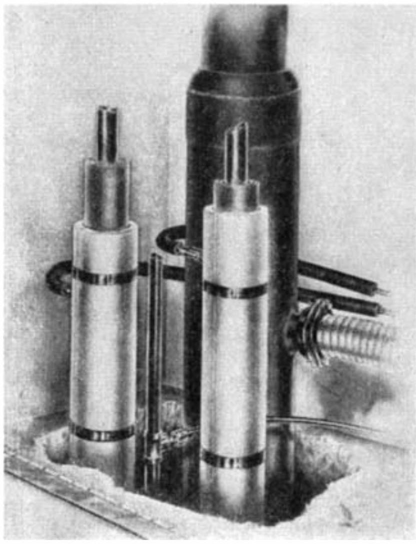
CONTROLLING INTERIOR CLIMATE—To obviate these weaknesses of the older systems of air conditioning, the Carrier Corporation conducted intensive research on this one phase. Now, after extended practical tests, the new system is ready for wide-scale use. Its essential characteristics are as follows:

1. It provides a central air conditioning apparatus about one third the size required by other systems.
2. The air, which is heated and humidified, or cooled and dehumidified, in the central apparatus, is exclusively outside or fresh air. It amounts to 20 percent, more or less, of the total air required for proper circulation in the conditioned rooms.
3. Small high-pressure fans discharge this conditioned air at static pressures



How the new Carrier system functions when installed in a hotel room and velocities much higher than heretofore considered practical. Air velocities as high as 4000 feet per minute are usually employed or about 2½ times the duct velocity allowable in conventional systems.

4. Because of the small volume of conditioned fresh air and the high velocities employed, the new system is able to use air conduits instead of



A typical group of risers in the new system, showing air and water piping

ducts. The areas of these conduits are about one half of those employed in conventional duct systems. Replacing riser ducts, the conduits are, for the average installation, about 6½ inches in diameter for the largest size and are reduced in diameter for most part to about four inches.

5. Each room is equipped with a unit which replaces the conventional radiator, but which serves the room throughout the year—not merely in winter. The high velocity air enters this unit and is discharged through a series of small nozzles so designed that, despite air velocities of 4000 feet a minute, no noticeable noise results. The discharge of this primary air through the unit induces secondary air from the room to enter the unit in volume about four times as great as the conditioned fresh air. The induced air mixes with the fresh air and the mixture of 20 percent conditioned outside air and 80 percent induced room air leaves the unit at a relatively small velocity but in sufficient volume to provide gentle but adequate air movement throughout the room. The volume circulated is always constant. This is a great advantage.

6. Each room unit is provided with a supplementary conditioning device for heating or cooling the air as may be desired. In fact, the greater part of air treatment, whether heating or cooling, may take place in the room. This is controlled by a valve which automatically regulates the admission of heating or cooling fluids to the unit. Hence, an occupant may set the valve to get exactly the room temperature wanted. For example, one room may have its unit produce a temperature of 80 degrees while an adjacent room may have 70 degrees, to suit a particular occupant. The control is equally effective winter and summer and may be regulated so that it will give a desired low temperature at night, and a temperature of, say, 10 degrees higher during the day.

7. No recirculated air is employed at all. This completely eliminates return ducts. Thus, since only fresh air is sent from the central conditioner, there is no danger of contamination as may occur where the air from one room is returned to another. This is obviously of importance in hospital air conditioning.

Since the small fresh-air conduits and water lines may readily be housed in neat base-board enclosures and in small shafts such as are used for plumbing and other building services, the system may be installed without marring the interior effect of a room. The room units are pleasing in appearance, can harmonize with any decoration scheme, or may be concealed without jeopardizing their efficiency in any way.

From the housekeeping standpoint, the system assures freedom from odors, because no air is recirculated and no condensation takes place in the units. An effective filtering system substantially eliminates all dust.

EASILY INSTALLED—One of the outstanding practical features of the new Carrier system is the ease with which it can be installed in existing buildings. The cutting and patching necessary is relatively small. This is another advantage of its elimination of return ducts and the use of air supply conduits with diameters of six inches or less. These features of the new system were purposely designed so as to be small enough to be installed in existing building pilasters.

Another attribute of the new system is the fact that its installation in new or already existing buildings may enable the owners to add considerable rental space. In buildings completely air-conditioned by the Weathermaster System, this gain has been estimated to be as much as one additional room for each ten rooms housed in a given space. In terms of a hotel or office building of 1000 rooms, this could mean 100 additional full-sized rooms in the same space.

All in all, the new air conditioning system holds out a great promise for more comfortable and healthful living in the future for millions of Americans. In the post-war years it may make inexpensive and efficient air conditioning as widespread in multi-room buildings as electric light and steam heat are today.

ALUMINUM STRETCHING

Now Used to Harden and Form in One Operation

The old-fashioned taffy pull now has an industrial counterpart at Ford's Willow Run bomber plant where millions of feet of aluminum material are being stretched and formed by unusual machines into structural parts for the B-24 bomber.

As you watch one of these stretching machines in operation, a 28-foot rib-like stringer actually grows more than a foot. The stretching of the aluminum is necessary to straighten, strain-harden, strengthen, and form parts that cannot be shaped efficiently by any other process.

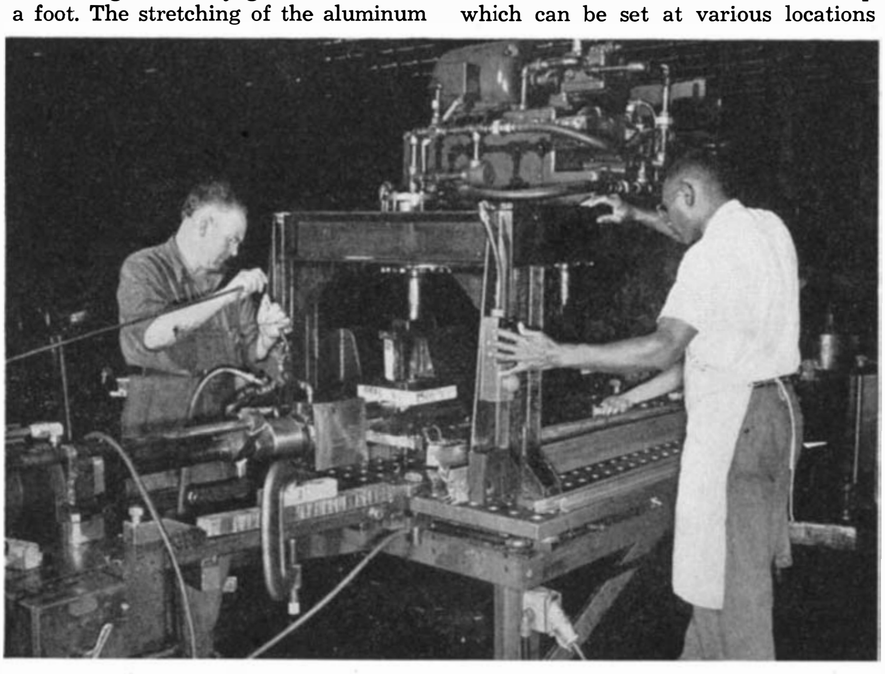
It has been found that the physical properties of aluminum are such that many bomber parts could not be formed efficiently by re-strike dies in presses, the "spring-back" of the material indicating that it must be drawn or form-stretched under pressure into the desired shape.

In order to provide means whereby parts could be formed adequately on a production basis, Ford tool design men combined the hardening and forming operations into one process called stretch-forming, using a stretcher die (similar to a press die) in a hydraulic stretching machine.

Stock is rolled in annealed condition or in heat-treated condition, preformed, and then sent to be heat-treated. After heat-treatment, this preformed channel, extrusion, or Y-section is gripped by specially fitted jaws, and stretched by hydraulic pressure over or around the stretcher die.

The explanation for the remarkable strengthening effects of this stretching process seems to be that each circular molecular body in the aluminum is drawn out into an egg-shaped elliptical particle, making the metal hard and strong. The stretch-forming process results in better parts and is easier to handle than re-striking. Furthermore, stretcher dies cost only 50 or 60 percent as much to build.

A 75-ton hydraulic pressure stretcher, believed to the most powerful stretching machine in the aircraft industry, is used at Willow Run to stretch the heavy-gage stringers used in the center wing section of the B-24 bomber. The stretching machine is made of three tubular tie rods about 35 feet long with cast iron supports at each end. The hydraulic unit is attached to the jaw at one end, and develops a pressure of 75 tons. The jaw at the other end is attached to a movable tail stop which can be set at various locations along the tie rods by clamping an interlocking washer into notches in the tie rods. The jaws are air operated. It is estimated that the machine will stretch 20,000 linear feet of the heavy stringer sections in nine hours.



An angle fairing, used to join wing and fuselage of a B-24 bomber, being stretched and formed as the stock is pulled horizontally through the stretcher die

COLOR DYNAMICS

Scientific Utilization of the Energy of Color

According to recent studies on the subject of color dynamics, it is a simple matter to achieve three important industrial objectives: reduced absenteeism; improved efficiency, and higher worker morale.

Generally speaking, color dynamics is based on principles directly opposed to camouflage practices. To camouflage an object, color is used to hide and obscure; in color dynamics, as developed by the Pittsburgh Plate Glass Company, color is used to highlight, reveal, and emphasize.

There are three major parts to the industrial application of the principles of color dynamics—correct paint treatment of focal working areas, of walls and ceilings, and of floors and aisles. By applying the science of color dynamics to each of these, absenteeism is reduced, fewer injuries result, better morale and a higher level of quality are maintained.

STEAM GENERATION

Gains Economy Through Automatic Combustion Control

The fundamental theories behind automatic combustion control for steam power generation in industry were recently put forth by M. J. Boho, of the Hagan Corporation.

According to Mr. Boho, "the modern boiler plant contains many different pieces of machinery, some necessary and others desirable in varying degrees. An engineer need not look too far back into the past to remember when a boiler plant consisted only of a feed pump, chimney, boiler, and a scoop shovel. These plants delivered the goods and, on this basis, it might be argued that all other equipment was unnecessary. Boiler plants are quite different today, however, and much of the equipment in general use, other than the bare essentials, now comes under the heading of necessities. Automatic combustion control is one of these.

"There probably is no engineering problem that has received more intensive study over the past several decades than that of reducing the cost of steam. The result of all this study has been the development of many different types of equipment. Some have achieved temporary popularity, only to be displaced by others as the art further developed. The fact that boiler combustion control has steadily gained in popularity is evidence of the fact that it has made a real contribution to economy of steam production.

"Where previously a combustion control system would have been classed as a luxury, today scarcely a single boiler of any consequence is installed without a complete complement of combustion controls," continued Mr. Boho. To understand why, it is necessary only to consider the operating problems involved. In order to generate the maximum quantity of steam from a given quantity of fuel the ingredients entering into the combustion process must bear the proper relation to each other. In order that the steam produced have maximum value it must be supplied to turbine or process at uniform temperature and pressure. This requires that fuel and air be supplied the boiler furnace in proportion to the demand for steam.

"To obtain these results," Mr. Boho concluded, "a number of related variables must be maintained continuously at their proper relative values, and this becomes a difficult task if an operator has to take care of more than one steam generating unit. In order to change the steaming rate on a boiler, it is necessary to alter the draft at the boiler exit. This involves the adjustment of induced draft fan speed or damper, or a combination of both; also, to alter the forced draft which involves a change in damper position, fan speed, or both; and, finally, to alter the fuel feed so that it bears the proper relation to air flow."

BROADER EDUCATION

Not Hindered by War-Time Technology

THE American public is being unduly alarmed by liberal arts spokesmen who cry out against the possible ill-effects of war-time emphasis on technical training, declares Dr. Edwin Sharp Burdell, director of Cooper Union.

These alarmists warn that an undue burden of technical studies will exclude after the war the studies of man and human experience, says Dr. Burdell, who points out that studies sponsored by the Society for the Promotion of Engineering Education show that there exists in the nation's engineering schools "both a philosophy of engineering education and a plan for achieving practical objectives."

"It should be reassuring to the uninformed," Dr. Burdell explains, "to learn that engineering educators have set up two coördinate 'stems' of educational growth extending through the engineering curriculum—the scientific-technological and the humanistic-social stems—with the aim of developing informed, thinking citizens as well as efficient engineers. The very existence of these two 'stems' in the curriculum requires the closest possible integration in the academic development of the student."

There is current in learned circles today a specious notion that truth is to be sought and found only through and by the scientific method, commonly associated with the natural sciences, according to Dr. Burdell.

"This method of quantification and measurement when applied to inert or even living matter has yielded amazing results," he continues. "The scientist appears to have found the keys that unlock the secrets of nature. But that is not to say that he has necessarily found the keys that unlock the secrets of human nature or that he ever will achieve in the field of human values the sharp, clear-cut findings of mathematical physics. The storehouse of human knowledge and experience to be found in the great writings of history, literature, and philosophy will not be unlocked by chemical analysis, x-rays, or the calculus.

"The difficulty seems to have been that instruction and discussion in the realm of human and spiritual values has been largely confined to the level of higher education and to the so-called liberal arts field.

"There can be no greater crime against American education than the continuance of this isolation of the humanities from the great mass of our youth unless they enroll in a liberal arts college. The humanities and their 'scientific' counterparts, the social sciences, should be brought into the curricula of the high school, vocational school, junior college, technical institute, and engineering school.

"However, the mere exposure of students to the hundred great books is not sufficient. The purpose of introducing these subjects must be understood and endorsed by faculties and students. Some leaders in the field of engineering education have gone on record as saying that as much as one fifth to one fourth of the engineering curricula should be devoted to the socio-humanistic stem.

"If these clear-thinking, broad-minded executives, in close touch with the needs of industry, can see the value of this branch of learning in coördination with science and technology, then other educators should be prepared to add it to other fields of vocational training. Thus there may be opened for the mechanic, tradesman, and housewife, in their youth, those long vistas of beauty and wisdom which are to be found in the humanistic-social studies."

SPECIALIZED HAULING

Accomplished by Unusual Types of Trucks

GIANT 30- to 50-ton super trucks have been developed by the automotive industry for specialized operations on the home front.

Weighing, when fully loaded, from two to three times as much as a General Sherman tank, these huge vehicles are taking an important part in the nation's war production program by transporting basic raw materials from open-pit metallic mines to refining plants, steamship docks, and railroad freight terminals. The trucks cover from three to 160 miles daily.

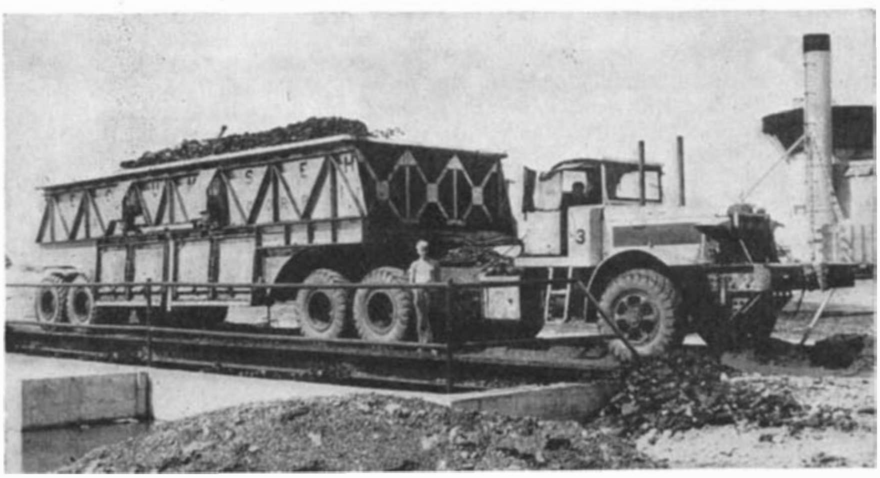
During 1943, for example, the trucks were credited with transporting an estimated 60 percent of all the nickel ore produced in the United States.

Among other unique war-time motor truck developments to date is a fleet of 73-foot tractor-trailer combinations designed especially to transport aircraft sub-assemblies between two war plants 1300 miles apart. Similarly, large truck-trailer units are being used to haul deck houses for Navy sub-chasers from fabricating plant to ship-building yard. Over-sized trailers which carry prefabricated house sections from factory to workers' housing areas in busy war centers, and mobile clothing stores which serve war-worker residents of rural communities are additional adaptions.

The ore-mining trucks are powered by Diesel engines and are built to carry loads which equal their weight. Many of them have been on continuous operation for more than 20,000 hours and have hauled millions of tons of raw ore.

In 1943, similar special motor trucks built for coal field operations were reported to have hauled more than 300 million tons of covering earth and coal from open-pit mines. Fuel-production goals for 1944 indicate that mine-operation trucks will establish a new record by transporting a total of over 400 million tons of coal.

Under actual operating conditions, a single 30-ton truck is able to transport 3000 tons of ore or coal on a short-haul basis every 24 hours, a volume equal to that carried in 60 average railroad gondola cars. At one coal mine, for example, records show that six of the largest type motor trucks consistently transport 9000 tons of coal in a seven-hour day over a three-mile route, a haul equal to that carried in 180 average rail car loads.—*Automotive War Production.*



One of the specialized trucks designed for hauling ore

DIAMETER MEASUREMENTS

Made by Imbedding Fine Wires in Plastics

A NEW method is now being used for measuring to a millionth of an inch the diameters of fine wires used in suspending galvanometer mirrors. The mirrors are attached to a small coil which rotates in response to minute currents flowing through a larger fixed coil around it. The suspension wire is twisted, and its diameter must be maintained with great accuracy if the instrument is to operate with the desired precision. Measurements made to a ten-thousandth of an inch with a good micrometer are not accurate enough.

Developed by E. D. Reilly, of the General Electric Works laboratory, the new method consists in molding, under heat and pressure, a plastics block with a series of V-shaped grooves in its upper surface. By limiting the amount of heat, the block is only partly "cured," otherwise the additional plastics which is later applied to it would not stick. Short pieces of the wires are placed in the grooves. Then the block is returned to the molding press, a very fine molding powder is poured over the wires, and a somewhat coarser powder is put on top. Again pressure and heat are applied, until the whole block is hard.

The fine powder works around the wires and grips them firmly, so that the block can be sawed across the wires without distorting them. If they were sawed or cut without being imbedded in the plastics they would be badly mashed.

The face of the block, which exposes the cross-section of the wire, is then carefully polished and examined under a microscope with a micrometer eyepiece. In this two threads are visible, and by moving them until they seem to touch diametrically opposite parts of the cross-section of the wire, the diameter is determined with a precision as great as a millionth of an inch.

ACID RESISTANCE

Offered by New Glass Made Without Sand

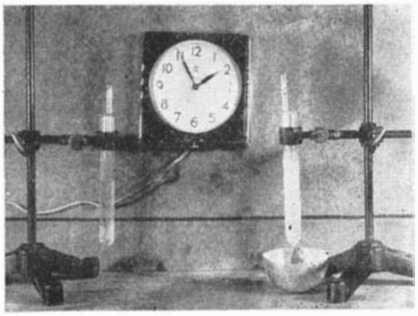
IN ADDITION to corroding most metals and causing dangerous burns, hydroflouric acid disintegrates ordinary glass. Now a new kind of glass, which resists the corrosive effect of hydrofluoric acid, has been developed by the American Optical Company according to its research director, Dr. E. D. Tillyer.

The new glass, says Dr. Tillyer, was especially made to aid in the war effort, and is the first known glass to offer major resistance to the vicious attack of hydrofluoric acid. It was developed by Dr. Alexis G. Pincus, member of the concern's research laboratory.

The discovery, according to Dr. Pincus, is expected to simplify the handling of the important acid which now is extensively used in scientific experimentation, as well as in such industrial operations as pickling metals, etching glass, processing textiles, manufacturing fluorides and ceramics, and as a catalyst in oil refining and synthetic rubber manufacture.

"Previously," he explains, "the use of hydrofluoric acid presented difficulties because it could be shipped only in lead or wax containers while in the laboratory it had to be processed in platinum or gold retorts which prevented visual observance of chemical reactions."

In a test made to demonstrate the acid-resisting property of the new glass, which resembles ordinary glass, a piece



In less than two hours, hydrofluoric acid has eaten through ordinary glass tube (right), but the tube of resistant glass (left) remains unaffected

was immersed in a bath of hydrofluoric acid for 500 hours. At the end of that time the glass was substantially transparent and to the naked eye showed no obvious attack.

"At the same time," Dr. Pincus says, "a piece of ordinary glass made of sand, lime, and soda was immersed in the acid and in a few hours was converted into a chalky mass. Even the tough and seemingly indestructible glass used in the manufacture of laboratory and kitchen ware was rapidly attacked."

The new glass does not contain sand, unlike practically all commercial glass —a phenomenon akin to making steel without iron ore as the base. To obtain the hydrofluoric acid-resisting property, it was necessary to eliminate sand as a major ingredient because the acid instantaneously attacks sand, producing a disintegrating effect.

Major ingredient of the new glass is phosphorus pentoxide which by itself

One of the lenses in this worker's hood is of ordinary glass; the other is resistant to hydrofluoric acid. Note how acid has etched lens on left

instantly reacts with water with almost explosive violence. However, despite this remarkable affinity, the new glass is less soluble in water than ordinary glass, indicating the profound chemical change that takes place when the glass is made.

Since its melting and working properties are about the same as those of ordinary glass, it can be manufactured in a regular glass factory and be cast or drawn into sheets, or blown into bottles and other shapes. It can also be ground and polished, tempered, and subjected to other processes involved in glass technology without requiring special equipment or technique.

Potential uses of the new glass are in the fabrication of test tubes, beakers, bottles, evaporating dishes, and other containers; window panes for laboratories and factories where acids are employed; lenses for safety goggles and helmets; and glass gages to observe and check the action of acids in metal cylinders and reaction vessels.

TINNED WIRE

Now Produced by Electro-Tinning Process

HIGH-SPEED electro-tinning of copper wire, which requires only half as much scarce tin as do older methods, has been developed to a point where it is commercially practical.

Electrical wire ranging in sizes from those about as fine as a human hair on up to heavy gages can be coated in the new apparatus. Wire only five one-thousandths of an inch thick can be given its tin coat at the rate of 800 feet per minute, without breakage, and heavier strands may be put through at even higher speeds.

The wire-plating machine was designed and constructed by the National-Standard Company to utilize the Du Pont Halogen tin plating solution, which already has been extensively employed in the electroplating of strip steel for food cans. In the latter application the process has saved important tonnages of tin by replacing the hot-dip method.

Copper wire which is to be insulated with natural or synthetic rubber—and miles of it are used in the electrical industry—must be coated with tin for protection and other reasons before application of the insulation. Heretofore, when tin has been used for this purpose it has been applied in the molten form, in the so-called hot-dip process. This method picks up more tin than is necessary and the heat forms a copper-tin alloy on the wire, which increases its electrical resistivity and reduces its elongation properties.

The electrolytic process deposits the tin without producing an alloy and therefore does not affect the resistivity or elongation. Unlike the hot molten bath which must be periodically purified, at the expense of time and tin, the electrolytic bath does not become contaminated with copper.

The plating apparatus is ingeniously arranged so that there is a minimum of tension and drag on the wire. In fact, the wire zips in and out of as many as seven baths of cleaning and plating solutions without touching the rim of any of the tubs. It emerges from the baths with its smooth new coat of tin untouched by any metal or other solid material and therefore unscratched.

This "dainty dip" is achieved by keeping the baths "heaping full" and running over—re-circulation saves the fluid. They are so placed that the wire passes through the heaped-up part, the so-called inverted meniscus, just missing the rim of the vessels in each case. Instead of having a wiping mechanism to remove excess fluid between the baths, this is done by compressed air blasts. These arrangements not only subject the wires to a minimum of handling but facilitate stringing them up for the start of a plating run. They are simply laid over the top of the baths, and attached to let-off and take-up spools at the two ends of the apparatus.

AMMONIA

Important in War, Faces Increased Post-War Demands

HUGE post-war expansion in the consumption of ammonia is predicted in *Chemical and Engineering News*, a publication of the American Chemical Society, in a survey of chemical markets.

"Quick-freezing of foods and refrigeration are certain to require more ammonia than before the war," it is pointed out. "In frozen foods alone, production has grown tremendously—from 169 million pounds in 1938 to more than 960 million pounds in 1943—and food authorities believe it was boosted an additional 25 to 30 percent in 1944.

"Refrigeration commonly means the manufacture of ice and the cooling of cold storage plants, but ammonia also provides refrigeration for some important industrial processes such as petroleum refining, production of certain synthetic elastomers, and the nitriding of steel. Under the necessity of providing enormous war production, figured in terms of the finished materials, we have lost sight of these and other essential jobs performed for industry by ammonia.

"It is an irreplaceable chemical in the manufacture of other industrial chemicals, notably sulfuric acid, alcohol, soda ash, caustic soda, and it is the 'controlled atmosphere' for annealing electronic tubes, heating coils, electric heaters, and electric irons.

"Anhydrous ammonia has become so dominant in the fertilizer picture that we face a nitrogen shortage in 1945 because the Government is diverting ammonia and nitric acid to ordnance production, making crops dependent chiefly upon Chilean nitrate of soda, sulfate of ammonia from the coke-oven, and whatever natural organic materials may be available.

"When military needs have been met, ammonia undoubtedly will be freed again for agricultural nitrogen in the form of synthetic nitrate of soda, nitrogen solutions, and ammonium nitrate.

"If the wartime Federal ammonia plants can be taken out of farm politics and the issue of 'cheap fertilizers' left to the fertilizer industry, it is very likely that the post-war era will witness the development of new, highly efficient nitrogen fertilizer materials based on ammonia and urea. Nitrogen solutions have by no means reached a stage of full development. At least one large ammonia manufacturer is planning new developments along this line."

X-RAY TIMER

Speeds Examinations in Tuberculosis Checks

AN ELECTRIC eye "exposure meter" which enables a single crew of x-ray technicians to examine the chests of a thousand people a day for signs of tuberculosis—twice the number previously possible—is called the "phototimer." It is already in use in tuberculosis survey clinics, measuring the precise amount of x-radiation passing through a human chest, and shutting off the x-ray tube when a sufficient quantity has passed through to make a film exposure of the proper density and contrast.

"Miniature photofluorography—taking small-film photographs of full-scale images created on a fluoroscopic screen by the action of x-rays—is the only practical and economically-possible way to conduct the mass chest surveys necessary to detect the presence and prevalence of tuberculosis in the whole population," says A. P. Craig, manager of the X-Ray Division of Westinghouse.

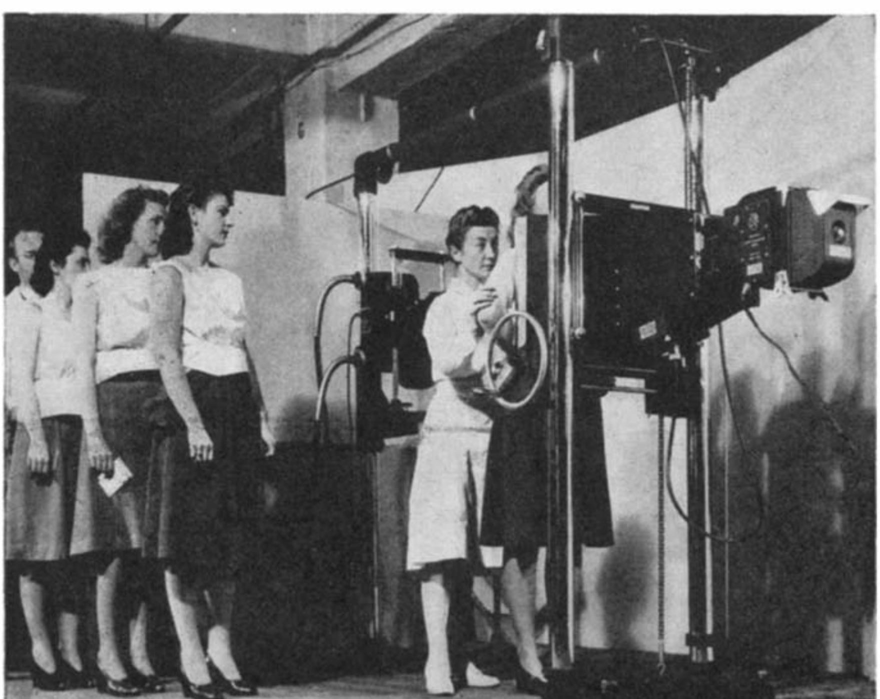
"Its use makes possible the examination of sixty persons for the same film cost as a single examination using direct exposure of film by action of the x-rays," Mr. Craig adds. Such a survey is a fast "screening" process which spots unsuspected tuberculosis cases, and brings them to light so that further and detailed diagnosis and treatment is possible.

Until now, a major difficulty barring full utilization of the diagnostic capabilities of x-rays has been the lack of automatic exposure controls. This meant that every person brought before the x-ray camera for examination had to be individually measured by the technician handling the machine, and then a whole series of adjustments were necessary before his "picture" could be taken, to insure the uniform film negatives on which reliable examination results depend. The use of the new Westinghouse phototimer automatically assures a correct x-ray exposure, enabling the operating technician not only to x-ray twice as many persons a day as he formerly could, but to achieve better and more useful results as well.

Photocell in the x-ray timer measures light on fluorescent screen and controls length of exposure

The timer consists essentially of a photoelectric cell to "see" the light emanating from the fluorescent screen, a capacitor to store the electric current which flows in the tube as a result of this light, and an electronic "trigger tube" to shut off the x-ray tube when sufficient x-rays have penetrated.

The phototube "looks" at the screen simultaneously with the miniature camera mounted in the equipment; but, being mounted below the plane of light



New x-ray timer permits making 1000 examinations a day

beams entering the camera lens, it doesn't interfere with the action of the camera. It "sees" the same light, however, and thus can control the source of the light in a manner that will also control the exposure of the film.

CROWN GALL

Controlled by New Chemical Combinations

CHEMICAL research has found a new and effective way to control crown-gall, those rough, woody disease growths that weaken and often kill almond, walnut, peach, plum, apricot, and other trees and vines.

Pure synthetic methanol, the same chemical compound used as the base for anti-freeze for motors, is an important ingredient in two new chemical solutions now recommended for this purpose. These solutions are being applied with considerable success to "doctor" these harmful knotty growths which are caused by micro-organisms so tiny that it takes 25,000 of them, end to end, to reach only one inch.

The current issue of the Du Pont *Agricultural News Letter* reports that the latest recommendation, made by Dr. P. A. Ark, of the California Agricultural Experiment Station at Berkeley, following several years of testing under actual orchard conditions in his state, simply calls for exposing the gall, cleaning with a brush, and painting the entire surface with one of two mixtures. The first contains one part sodium dinitrocresol and four parts of methanol; the second, 100 parts by volume of methanol, 15 parts glacial acetic acid, and 12 parts by weight of crystal iodine.

Dr. Ark urges growers to experiment with the materials on a small scale and to seek the advice of agricultural authorities before undertaking large-scale operations.

TURBINE LOCOMOTIVE

Designed for High-Speed Passenger and Freight Service

A FUNDAMENTALLY new type of coal-burning steam locomotive, powered by a steam turbine in place of the cylinders, pistons, and driving rods of the conventional design, has been completed for the Pennsylvania Railroad. It is the first direct-drive steam-turbine locomotive ever built in the United States, and is now undergoing tests to determine the adaptability of this type of engine to long-distance high-speed passenger and freight service.

In the new locomotive, the turbine shaft is rotated by the pressure of jets of steam against the vanes of the turbine wheel. A continuous flow of power is thus transmitted to the driving wheels through speed-reducing gears. A product of continuous research and development, the engine was designed and constructed by the Baldwin Locomotive Works and the Westinghouse Electric and Manufacturing Company, in collaboration with the Pennsylvania Railroad.

The purpose of developing the new steam turbine locomotive is to eliminate the reciprocating parts of the conventional steam locomotive; to provide a uniform flow of power to the driving wheels; and to obtain the economies inherent in a turbine. The turbine is designed to develop 6900 shaft horsepower, and provides power at the tender coupler sufficient to pull a full-length passenger train at 100 miles an hour and high-class freight trains at high speeds.

The new engine is one of the simplest to operate that has ever been constructed. Both forward and reverse movements, at all speeds, are controlled by a single lever, actuating specially designed pneumatic control apparatus. Automatically functioning devices make incorrect handling of the mechanism impossible.

Smaller than a living-room easy chair, and accounting for less than 1 percent of the locomotive's total weight, the main or forward drive turbine is mounted at the right-hand side of the locomotive. It is approximately 45 inches in diameter. A smaller turbine designed to move the locomotive backward at speeds up to 22 miles an hour is mounted on the left side, and is brought into operation by engaging a clutch.

There are more than 1000 chromium steel vanes in the forward turbine, some of which are less than one inch long. Steam travels through the entire battery of turbine blades, expending all but 15 pounds of its energy. These produce a non-pulsating draft through the firebox and boiler. The boiler is of the conventional type, carrying 310 pounds of steam pressure and fired by a mechanical stoker.

The heat-treated alloy-steel reducing gears, into which the turbine shaft feeds its power, operate continuously in an oil bath and mesh with so little friction that 97 percent of the turbine's power reaches the driving wheels. Power is applied directly to two center pairs of driving wheels and is also transmitted to two additional pairs of drivers by connecting rods. The engine is equipped with roller bearings throughout.

BETTER PAPER

Obtained Through Use of Synthetic Salt Cake

IT HAS been discovered that synthetic salt cake used in the kraft pulping process does not need to be treated in the smelting furnace, according to Vernon Woodside of the Mathieson Alkali Works. Instead, it may be added directly to the green liquor in the dissolving tank.

The method of addition may vary as required by the plant system. The synthetic salt cake may be fed continuously into the green liquor, at a predetermined rate or, where a batch system is used, a measured quantity of salt cake per batch may be added to the dissolver tank.

The most important advantages claimed for the new process are greater control and flexibility of operations, potential chemical and fuel savings, and better average pulp quality.

STEAM ON RAILS

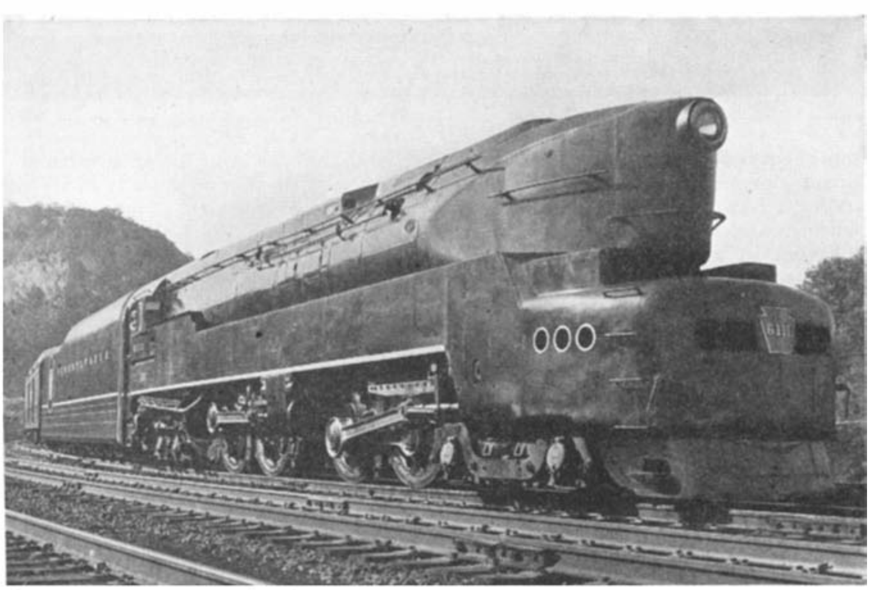
Is Advancing With the Times

THE steam locomotive, streamlined and perfected to meet post-war requirements, will hold its own, despite development of other power sources, in the opinion of Ralph P. Johnson, chief engineer of The Baldwin Locomotive Works.

"Those who point with scorn to steam locomotives as being 'obsolete' and 'backward' and believe the iron horse will give way entirely to other forms of motive power, need only to observe the tremendous advances in steam power since Pearl Harbor to be convinced of the brilliant future for steam locomotives," Mr. Johnson points out.

"One highly advanced type of steam locomotive which has definitely proved itself in regular service is the Baldwin-designed four-cylinder type as exemplified by the Pennsylvania Railroad's streamlined 'T-1' class, two of which have been in continuous passenger service between Chicago and Harrisburg for two years," says Mr. Johnson. "This locomotive is capable of 100-mile-an-hour speed with a load of 880 tons, thereby avoiding the use of two engines on heavy passenger trains.

"The Diesel locomotive seems at the moment to be tied up to electric propulsion and this means that designing ingenuity will be confined to the Diesel engine itself. The Diesel will acquire an added appeal if future engines can be designed to burn lower grades of oil. Work is being done along these lines and post-war Diesel design will not be static," he concludes.



One of the "T-1" class of Baldwin locomotives built for the Pennsylvania Railroad

SILICONE RUBBER

Retains Properties at High And Low Temperatures

RETAINING its elastic properties at temperatures as low as 60 degrees below zero, Fahrenheit, or as high as 575 degrees, silicone rubber has been developed in the General Electric Research Laboratory for many important war uses. One is in aircraft turbo-superchargers, another is in searchlights for the Navy.

For a number of years chemists have been studying the curious chemical compounds known as "silicones," of which an important constituent is the element silicon, present in such common things as sand and glass. Chemically, silicon is a close relative of carbon, upon which the vast family of organic compounds is based. Both elements can form long, chain-like molecules called polymers.

Organic polymers, such as rubber (either natural or synthetic) have as a backbone a string of carbon atoms which are joined directly to each other by primary valence forces. Silicone rubber is also a polymer. Its backbone consists of a series of units, each consisting of a silicon and an oxygen atom linked together. On the side, attached to the atoms of silicon, are groups of hydrogen and carbon, called hydrocarbons. In these silicone polymers, where the carbon atoms in the backbone are replaced by the silicon-oxygen

How gaskets of the new silicone rubber, developed by General Electric research laboratory, are applied to the casing of a turbosupercharger

linkages, the thermal stability is greatly improved in most cases.

Developed entirely apart from the vast governmental synthetic rubber program, silicone rubber is now being manufactured in a pilot plant in the General Electric Company's Resin and Insulation Materials division. While government synthetic rubber is being made by tons, present silcone rubber output is measured in pounds, all of it going into high-priority war jobs.

One of the most important of these is a gasket for the turbo-superchargers in B-29 bombers. Gases from the exhaust, at a temperature well above a thousand degrees, are used to drive the turbine, which is thus subjected to high temperatures even though the air outside may be very cold when the plane is flying through the sub-stratosphere.

The compressor casing of the turbo-supercharger is stamped from sheet steel and a gasket is needed to seal the cover plate over an opening about a foot in diameter. Natural rubber will not continue to provide the required resiliency over the temperature range encountered in this application. One synthetic rubber was tried but became hard and brittle after a hundred hours of operation. In contrast, a gasket of silicone rubber, even after operating continuously for 150 hours, is still soft and can be used over again satisfactorily. This is due to its lack of "compression set" at high temperatures. Silicone rubber can be compressed between metal plates to two thirds its original thickness, held that way for several hours at 300 degrees and, when released, it returns to 90 percent of its former dimensions.

The raw materials from which silicone rubber is made are easily available, and it can be prepared in a wide variety of physical properties. Some types are rather soft, while others are hard. In its present state of development it is not suitable for tires and other uses where high tensile strength is required.

A by-product of the research in silicone rubber is a curious material referred to as "bouncing putty." It looks and feels like putty and can be pulled and kneaded in the same way. Yet when rolled into a ball and dropped on a hard surface it bounces like rubber. A putty ball would just flatten out without bouncing at all.

Scientifically, bouncing putty exhibits paradoxical properties, for it is both elastic and plastic. Which of these properties it exhibits depends upon the rate at which stress is applied. When rolled into a ball or pulled like taffy the deforming forces are applied slowly. Then it is plastic, the material flowing from one part of the mass to another. But when the ball is dropped and it hits the floor, the stress comes suddenly and then it behaves as an elastic material. Though this combination of properties is shown to a slight degree by other materials, silicone putty is the first in which it is so marked and thus it offers the opportunity for useful applications of these unusual properties.

BOILER WATER

Important to Shipping And Industry Alike

FRESH light on how chemical water control is keeping the ships of America's merchant fleet out of trouble was shed recently by a paper read before the Society of Naval Architects and Marine Engineers by Dr. A. C. Purdy, of Bull and Roberts.

Dr. Purdy, a consulting chemical engineer, presented his paper under the technical title, "Water Conditioning and Related Problems of Marine Boiler Operations." It was a sequel to a previous paper read by the water expert before the same body in 1933 and summarized new knowledge gained in the intervening years through research by Hall Laboratories and Bull and Roberts on the prevention of scale and corrosion in steam boilers.

Behind his seemingly prosaic discussion was as dramatic a story as any that have emerged from the war theaters. For in nearly three years of war, with America's merchant vessels fully engaged in cargo carrying all over the world, seldom has a ship using proved methods of chemical boiler-water control been laid up for even a day because of burned-out tubes or corroded boilers.

More than 1200 of the present fleet of merchant ships, Dr. Purdy says, use modern chemical control of their boiler water, and of the high-pressure boilers the figure is 80 percent.

The fact that these ships have not been compelled to wallow idly in the Indian Ocean, the Pacific, or the Atlantic at the mercy of submarines while their boilers were re-tubed or the old tubes turbined, Dr. Purdy says, has saved many a cargo from the enemy and given continued help to the Allied supply lines extending to all quarters of the world.

In his paper Dr. Purdy stressed the fact that post-war design of ships almost certainly will take into account higher steam temperatures, pressures, and ratings; that this will require closer chemical control to keep the boilers on the line; and that much that has been learned in solving the same problems for industrial power plants will be of value to the marine field.

Suggesting a new approach to water conditioning at higher operating pressures, he said that the solution "appears to lie in a closer study of what actually happens as the dilute over-all boiler water traverses those surfaces where steam is generated." Dr. Purdy added:

"Here the water must absorb the heat from the boiler tubes which receive it by radiation and convection from temperatures of 2000 to 2500 degrees, Fahrenheit, and must pass it on with sufficient rapidity so that the external surface temperatures will not exceed 800 to 900 degrees, Fahrenheit."

In conclusion, Dr. Purdy pointed out that the chemistry of boiler water is a constantly developing science in which many able research men are cooperating with boiler designers and operators to give the latter the greatest possible latitude in design. These developments should be followed with interest by naval architects and marine engineers.

POST-WAR CONSTRUCTION

Held to be Key to Vast Employment Problem

IN THE first three to five post-war years the United States will experience the greatest volume of industrial building and greatest employment of construction workers of any similar peacetime period, according to S. M. Rust, Jr., vice president of The Rust Engineering Company. This building will start in large volume immediately after war restrictions are relaxed, as industries rush preparations to skim the cream from huge pent-up post-war markets, Mr. Rust says.

Thousands of inquiries and orders for designs of new plants and alterations of existing plants have been and are being received by engineering firms throughout the country, Mr. Rust states, providing a solid, factual basis for his assertions.

The types of designs most usually sought, he further comments, are "master plans"—not for single structures—but covering all the building and development contemplated by the firms concerned for five or more years.

"Contrary to popular belief, our tremendous construction of war plants will not halt or make unnecessary extensive post-war industrial building," Mr. Rust continues.

"The effect will be just the opposite. The huge competitive potentialities of these plants will force industrial management to modernize to the limit and to build many entirely new plants in order to stay in the running.

"The combination of this biggest production capacity ever known, the biggest consumer market (as verified by research polls), and most extensive launching of new materials and products, represents the key to post-war industrial construction."

PHOTOGRAPHING THE UNSEEN

Achieved by New High-Speed Method

A PHOTOGRAPHIC technique has been worked out that is so sensitive it could presumably take a picture of a ghost, if there were such things. This new process, utilizing flashlight with an exposure of less than one millionth of a second, photographs things which are invisible, such as the finest details of air disturbances even to the extent of making an image of a heat wave rising from the palm of one's hand.

At present the development is being used for many important war projects which cannot be revealed for security reasons. It is expected, however, to have unlimited peace-time applications where air and gas flow problems are encountered.

When photographs of very rapidly changing conditions are made, an extremely short exposure is necessary to show detail. In this technique such a limitation is overcome by use of a new electronic device which not only supplies the illuminating flash at the right instant, but also gives an exposure duration so short that light from the flash has time to travel only a thousand feet.

According to the General Electric engineers who developed the ultra-high-speed equipment, two approaches may be used—the Schlieren method and the shadowgraph method.

Shadowgraphs are made by using nothing more than a film holder and a spark light source with extremely sensitive controls. In the Schlieren method, photographs are made with a highly specialized type of optical system which requires infinitely fine adjustment and manipulation.

Shadowgraphic pictures show only the boundary conditions between regions of sharp variations in density or pressure, such as the difference existing between the air encased in a toy balloon and the air when it is escaping. In the Schlieren technique, however, where the sensitivity is many times greater, gradual variations can be better recorded as they occur throughout the region being investigated. Thus, if disturbances of a minor nature are to be recorded, such as that of breath coming from the nostrils, Schlieren apparatus is used.

Either system may be employed to photograph sound waves or shock waves, provided a sufficiently short photographic exposure can be obtained. If strong disturbances, such as shock conditions in a high-velocity air jet, are to be studied, then the shadowgraphic technique is generally adequate.

UNIVERSITY RESEARCH

Holds Many Advantages For Industrial Organizations

"INDUSTRY has begun to appreciate the service that university laboratories can provide," Dr. Harvey A. Neville, head of the Lehigh University department of chemistry said recently when referring to a 500 percent increase in chemical research contracts since 1940 at that university.

"There is an increasing realization," Dr. Neville continued, "that certain types of research can be conducted more effectively in these laboratories where the academic atmosphere, isolated from production, allows a fresh perspective."

Explaining that 17 new co-operative contracts had been received in his department since the war began, the Lehigh scientist also pointed to values gained by colleges which undertake such researches.

"Professors engaged in co-operative research transmit to their students personal enthusiasm for development," he added. "The advanced undergraduate likewise may share the experience of research by working with his professor on these projects."

New projects in Lehigh's department of chemistry and chemical engineering include those for the Armstrong Cork Company in analytical and leather technology research, the Bethlehem Steel Company in physical chemistry and chemical engineering, and the Catalin Corporation of America in synthetic resin studies.

Among other recent projects are those assigned by the Koppers Company for study of applications of coal tar derivatives and by the William S. Merrell Company, manufacturer of pharmaceuticals, which is supporting research in organic chemistry.

The Raybestos-Manhattan Company's continuing research project is devoted to plastics materials and the National Oil Products Company has also maintained a contract for studies in its field since the pre-war period.

New Products

ALUMINUM DRUMS

DEVELOPMENT of a light-weight aluminum drum to expedite transportation of aviation gasoline over the "hump" to Allied fliers on the China front was announced recently by officials of the Aluminum Company of America.

An allotment of drums, accepted by the Army following exhaustive research

"Flying drum" is light in weight

and tests, has been flown by the Air Transport Command direct to India in order to step up the supply of gasoline needed by the 14th and 20th Air Forces.

With Japan in control of the Burma road, ingenious military men had to take to the air to fly supplies to the Allied fighting front in Asia, and the aluminum gasoline tank—which weighs 21 pounds compared with the 52-pound weight of the old-style regulation drum—was the answer.

The saving in weight will increase the supply of gasoline to the Chinese front many hundreds of thousands of gallons each month, engineers estimate.

VERSATILE SYNTHETICS

THE story of the synthetic resin that out-performed rubber is the story of the compar washers, seals, gaskets, diaphragms, and similar flexible moldings that are being turned out for a wide variety of industries by Resistoflex

They wear better than rubber

Corporation, developers of compar. Though the first moldings of this vinyl resin derivative were not compounded to take the place of rubber, it has now been demonstrated that compar outperforms rubber in many applications where its use has now become standard.

Molded compar is capable of many variations which give the exact degree of flexibility, elasticity, and abrasion resistance required for each particular application and is widely used in such fields of manufacture as machine tool, radio, automobile, aviation, Diesel engine, x-ray, road-building machinery, air-conditioning, and refrigeration.

The compar parts have a service life from 5 to 250 times that of rubber and exhibit the same outstanding characteristics of inertness to organic solvents, abrasion, and flexing as do Resistoflex oil- and solvent-proof hose assemblies which have as their core an extruded tube of compar.

Especially compounded and engineered for each application, compar washers, seals, diaphragms, and gaskets have proved suitable on instruments, oil and chemical pumps, hydrocarbon and rubber cement bottles and cans, ball mills, spray guns, fire extinguishers, and oil cups on hydraulic presses.

PORTABLE ELECTROPLATER

A NEW and improved electrolytic brush, used in conjunction with electroplating compounds, has now become available

Worn parts and shafts may be renewed with this electrolytic brush

for peacetime production. With the co-operation of Du Pont, it was developed by the Warner Electric Company to solve specific electroplating problems.

The new brush and process are now

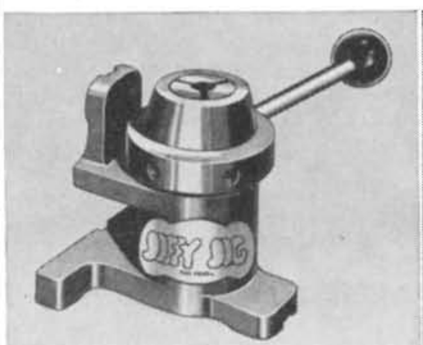
being employed in an increasing number of industrial applications. This method has proved practical and demonstrated its usefulness in decorative work, maintenance, and in salvaging tank-plated rejects.

Immovable objects may be electroplated without being dismantled. A company's name or trade mark may be electroplated on the article being manufactured. The conductivity of electric switch contacts, blades, and jacks may be improved or renewed without disassembly. Dies and shafts may also be plated and renewed when worn.

COLLET CHUCK

A LEVER-OPERATED chuck with a capacity for stock ranging from 1/16 to 1 inch in cross-section, and known as "Jiffy Jig" model J-10, is announced by the Monarch Governor Company. Readily adapted to various machine tools for drilling, milling, boring, grinding, and so on, this chuck can be set up in either horizontal or vertical position.

It has been designed to provide ample chip clearance and when the chuck is either open or closed, the collet is



Horizontal or vertical operation by lever makes this collet chuck handy

stated to have absolute zero axial movement and positive axial dimension control. The "Jiffy Jig" consists essentially of three parts—cap, base, and operating lever, the taper on the cap conforming to that of the collet. With the proper sized collet in place, the cap is screwed down on the base until the collet opens and closes as desired. The operating lever is then screwed into place and the chuck is ready to use.

TIMER

MANUALLY preset, an interval timer having wide application has just been announced by the Paragon Electric Company. The new model, #2500, can be preset to allow a given operation to continue for almost any pre-determined time limit; and to close or open a circuit at the end of the preset time.

This unit is adapted for use in plastics molding, rubber curving, batch mixing, heat treating, enamel baking, liquid agitation, light exposure, blower, pump, and conveyor operations, watchman signals, food cooking, power and light disconnect, machinery operation, control of ventilating fans on a preset schedule, and night heating shut-down.

Engineered features include: (1) Single-pole, double-throw, 1000-watt capacity switch, fully enclosed, underwriters approved. (2) Only two exposed gears—motor pinion and wheel, precision hobbed. (3) Self starting motor, slow speed synchronous, completely sealed. (4) No energy is required of clock motor to trip switch at end of preset time. (5) Ten time ranges from 0 to 15 seconds through 0 to 20 hours. (6) All parts rust proofed and protected against corrosion.

The #2500 series can be mounted on the surface of any panel or directly on the surface of the equipment the timer is to control. It is also designed to be mounted directly over and to any standard single-gang switch box or handy box. Available for flush mounting or wall mounting with conduit connector.

WELDING CLAMP

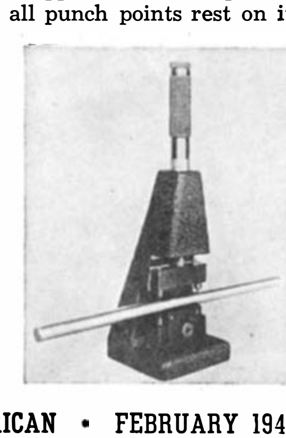
A NEW low-cost ground clamp for welders has been announced by The Lincoln Electric Company. Besides its low cost, the clamp has the advantage that each jaw connects independently to the ground cable. Thus, if one jaw is prevented from making a good electrical contact, due to heavy scale, paint, and so on, the other jaw will carry the current.

The ground clamp has a heavy-duty processed steel frame with durable copper conductors and contacts. The unit weighs only 1½ pounds, has a maximum jaw spread of 2½ inches, and a rating of 300 amperes.

CENTER PUNCH

A GAGE point punch which is double-acting and on which impact force is adjustable for different materials has been made available by the Baldwin Locomotive Works. It is offered to the metals field for four reasons: (1) it marks four uniform centers on specimen with one push of the handle; (2) it automatically centers either round or flat specimens; (3) the impact force is applied manually by an adjustable detent which eliminates the use of a hammer; (4) impact and size of punch marks are adjustable to suit soft and hard specimens.

The upper punch holder, guided in a heavy frame, is attached to the impact-adjustable handle. The entire upper point assembly is spring supported to keep the gap between punch points open for the largest specimen. When the specimen is placed on the support, the upper handle is pushed down until all punch points rest on it.



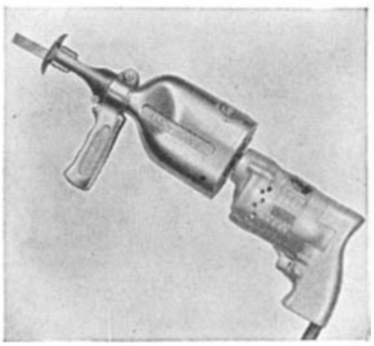
The impact force is adjustable on this gage point punch

A continued push downward on the handle brings to a preadjusted compression a second spring within the tubular knurled handle, releasing potential energy to produce impact on the specimen.

SAW AND FILE ATTACHMENT

An attachment for electric drills that provides a portable power saw and file is sold under the trade name of Saw-Chief.

According to the manufacturer, the



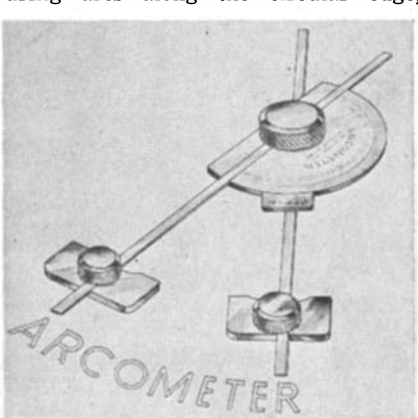
Utilizes electric drill for sawing

Chicago Precision Equipment Company, the new device will rapidly saw every kind of metal, wood, plastics, and other material, by placing an ordinary hacksaw blade in the holder with the teeth toward the operator. It may also be converted into an automatic file by inserting a file in the same chuck or holder.

The inner mechanism of the Saw-Chief is of balanced ball bearing construction, built for heavy-duty cutting and to withstand hard use. The pistol-grip handle permits the operator to guide and hold the device with ease.

MEASURING ARCS

Tool shops and machinery builders of all kinds will be interested in a new device called the Arcometer for measuring arcs along the circular edge,



Saves time in machine measuring

either internal or external, of a surface. With this instrument, shown in the accompanying illustration, it is possible to save time and increase accuracy in the layout of bolt holes on flanges, spacing ribs on cylindrical bodies, and spacing blades in impellers and the like.

In operating the instrument, the corners of the heads are brought against the edge of the work, and the arms are rotated to the proper angle where they are locked with a single thumb-screw. The reference edges of the arms are then used as scribing edges, or for alining parts, as required.

LIGHT WORK GOGGLES

Full protection from impact, dust, flying sparks, and chips is offered by a new work goggle having wide view plastics lenses yet weighing less than one ounce. These goggles fit closely over the nose, brow, and cheeks. They are large enough to be worn over prescription glasses and have ample air space to prevent fogging.

SOFT METAL FASTENING

The motor shown in the illustration, designed for actuating cowl flaps and air cooler flaps on the PV-2, required a rigidly secure mounting in the plane. Since the metal of the mounting boss was too soft to assure permanent fastening, Rosán standard locked-in inserts were installed to give this soft metal the fastening strength of steel.

According to The Dumore Company, who manufacture these motors, Rosán inserts simplified production of the motor and made installation more durable.

These inserts consist of two pieces: A threaded insert with a serrated collar

Locked in securely, these inserts permit mountings on soft metals

and a locking ring which is serrated inside and out. The insert is screwed into a counterbored tap-hole flush with the surface of the parent material. The ring is then pressed or driven into the counterbore. The inner teeth of the ring engage the serrations on the insert collar, while the outer teeth broach the wall of the counterbore and lock the insert in place.

COIL INSULATION

Vacuum impregnation of coils, armatures, transformers, and so on, under pressure, is demonstrating many advantages over ordinary dipping, and costs no more, according to Vacuum Impregnating Works.

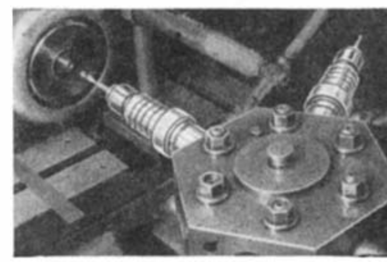
Among the results claimed, in addition to more efficient insulation, are: higher sustained voltages without overload; elimination of wear due to creep-ing of coils; prevention of insulation charring; protection of wires from vibration; permanent filling of spaces; maintenance of coil coolness; coils rendered positively moisture-proof; protection of windings from electrolysis.

Insulation material is suited to each individual type of work. Under the process employed, insulation is guaranteed to the very center of the unit impregnated.

PNEUMATIC SCREW MACHINE

A NEW line of air drills, designed for use on hand and automatic screw machines, is announced by Keller Tool Company.

These drills may be mounted in the regular tool holders of automatic or hand screw machines. Compressed air is fed to the drill through a valve arrangement which opens as the turret moves forward and closes immediately when the turret is backed away from the work.



For increasing drilling speed

Drilling speed may be increased with Keller pneumatic screw machine drills by 1200 to 3500 revolutions per minute. The entire time cycle of parts manufacture that was formerly held up by the drilling operation is thereby improved. This is of advantage when drilling small, deep holes on the larger type of screw machines, where the spindle speed of the machine is too slow to produce a satisfactory cutting speed.

Holes drilled by this method will not "run out," since the air drill spindle revolves in a direction opposite to the direction of the work in the screw machine spindle. This results in a true hole and reduces drill breakage.

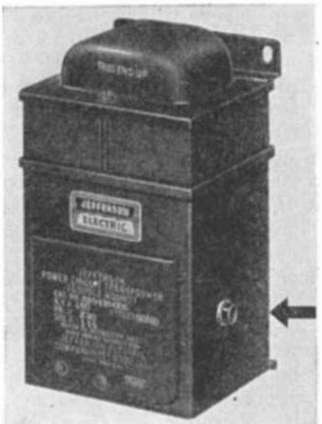
The new Keller screw machine drills are available in three sizes and eight models, having speeds of 1200, 2800, and 3500 revolutions per minute. Drill capacities range from 1/32- to 3/8-inch diameter twist drills.

TRANSFORMERS

POWER-CIRCUIT transformers, made by Jefferson Electric Company, in capacities from 100 to 750 watts, are now available with simple, effective circuit breakers for overload and short-circuit protection. Transformers of these capacities are used extensively, mounted directly on machines to step down the 550, 440, or 220 volts to 110 volts for various electrical appliances and lights.

This type of transformer, in connection with remote control stations, meets electrical safety standards of the National Machine Tool Builders Association. Flexible cable or conduit may be run from the wiring compartment to motor or appliance. Transformers can be furnished with "on" and "off" switch and receptacle in the wiring compartment, a feature that is desirable when serving small wattage appliances or individual lamps.

The circuit breaker is tamper-proof,



Completely protected

being completely housed in the transformer case with the reset button extending as shown in the illustration. For 25- to 75-watt transformers, with their light loads, fuses are provided in place of circuit breakers.

LUBRICANT

An improved line of industrial and automotive lubricants, processed with Bonoleum, holds promise of significant advances in the oil industry.

Bonoleum is an oil ingredient which acts as a film strengthening agent impervious to chemicals, heat, or acid. It is compounded with a castor-oil essence from which the gum-forming ingredients have been removed by secret processes. Bonoleum is reported to eliminate surface tension and assure a transparent, free-flowing lubricant.

Certain medicinal qualities in Bonoleum are claimed that make it actually beneficial to the skin, preventing infection, and decreasing industrial absenteeism due to occupational dermatitis.

DIP TANKS

Processing tanks and kettles, designed around the two basic principles of direct and indirect heating methods, with a choice of either gas or electricity as the heating medium, are announced by the Castaloy Corporation for the purpose of melting, blending, and compounding plastics and chemical formulations. They are especially adapted to "hot dip" plastics packaging, a process used extensively during this war for shipping spare parts and for similar applications.

The indirect heating method is accomplished by enclosing the plastics container within a considerably larger vessel which contains Dowtherm E. The two tanks form an integral welded, leak-proof, hermetically sealed construction. Dowtherm E boils at 350 degrees, Fahrenheit, and at 390 degrees the vapor pressure is approximately 10 pounds (24.6 pounds absolute). By controlling the vapor pressure, the temperature range is maintained within very close limits.

Direct-heated equipment is controlled by means of thermostats mounted on each electric heater to maintain the sheath temperature within predetermined range plus or minus 10 degrees, Fahrenheit. This method provides the correct combination of ambient and sheath temperature that is required to maintain the tank wall at the maximum safe temperature. A relay "cuts-off" all heaters when the desired temperature is reached.

A thermostat bulb is located within a special wall, mounted within the bottom of the tank, where the correct batch temperature is constantly controlled. A green light comes on when the batch reaches the dipping temperature, and a red light indicates the "idling" or below dipping point.

BEARING

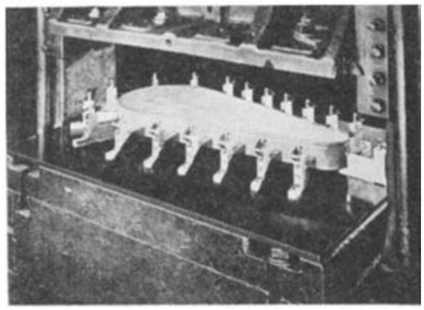
The largest bearing — weighing 96 pounds — ever produced by powder metallurgy exemplifies progress in this

Bigger and better

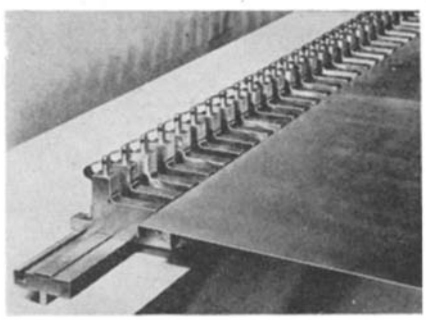
relatively new art. Oilite bearings of this size, produced by Chrysler Corporation's Amplex Division, can be machined from the latest and largest Oilite cored bars now being produced. A striking contrast to the huge bearing shown in the accompanying photograph may be had by recalling that the maximum size of bearings produced by powder metallurgy only a few years ago was less than five pounds.

HORIZONTAL HOLE PUNCHING

ANNOUNCEMENT of a new hole-punching technique with Wales horizontal type "H" hole punching units has been made by George F. Wales, president of the Wales-Strippit Corporation. These units are designed for punching



Above: Hole punching units with work nested in position. Below: Another type of set-up showing the punches laid out on a rail



holes in flanges, angles, container sides, and similar shaped and formed work. Each unit is independent and self-contained, which permits the same group of units to be used and reused, placed and replaced on press brake rails and on templates in stamping presses to punch unlimited straight-line patterns. The minimum center-to-center distance is ⅞ inch. Punch, die, guide, and stripper spring are held as an independent, self-contained unit by the holder.

This holder keeps the punch and die in perfect alinement, eliminating hours, and sometimes days, customarily required to aline conventional dies. This feature also reduces press "down time" to an absolute minimum. Nothing is attached to the press ram. All that is required to make a set-up is to place the units in position according to a master pattern and start punching at the first stroke of the press ram without any further adjustments.

STEAM-SET INKS

DEVELOPMENT of a new synthetic resin binder for the ink maker, which gives a carefully balanced water tolerance and excellent stability on the press rolls to the steam-set inks now widely used on paper bottles, folding box cartons, and food wrappers, is announced by the Resinous Products and Chemical Company. Known as Amberol 820, this synthetic binder is a hard, high-melting resin which demonstrates infinite solubility in diethylene glycol, excellent humidity tolerance, and high resistance to petroleum and hydrocarbons.

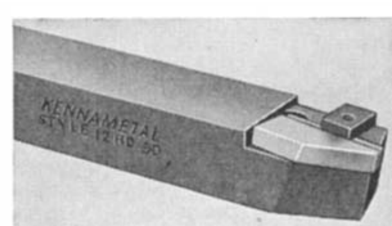
Steam-set inks are a fundamentally different type in that they do not oxidize nor do they utilize a solvent which must be driven off. Their lack of odor, extreme cleanliness, brilliance of color, non-rub characteristics, sealing properties, and elimination of offset have led to their widespread use. Since many foods—butter, lard, bread, and milk—show tendencies to pick up residual odors in printing inks, the lack of odor in steam-set ink is particularly important.

These inks consist of pigment, a resin binder, and an odorless, high-boiling-point organic solvent. In order to function properly, the resin binder must be soluble in the solvent and in a mixture of the solvent and a limited quantity of water, but insoluble in a mixture of the solvent and an unlimited quantity of water. When a film of the varnish formed from this resin and solvent is subjected to an unlimited quantity of water, a thin, hard film is formed over the underlying portion which is plastic and adheres to the paper. The formation of this hard surface prevents any offset or transfer of ink from the printed surface.

The resin is prepared by dissolving it in diethylene glycol with heat to give a clear solution. The method of preparation has little or no effect on the final vehicle and the heating schedule can be selected on the basis of convenience. A typical formula utilizes 100 pounds of Amberol 820 and diethylene glycol and requires heating for approximately ten minutes at 300 degrees, Fahrenheit, to obtain a clear solution. The resin shows no tendency to separate after even several months' storage.

CLAMPED-ON TOOLS

HEAVY-DUTY machining on steel castings and forgings, and cast iron, can be accomplished with minimum tool stocks



Cutting edge clamps on

by the use of new Kennametal Clamped-on Tools. This design has been made possible by the development of heavy-duty tips which, while overhanging the tool shank by about 1/16 inch, have ample strength for heavy feeds and deep cuts.

These new tips have a clamping shelf along the top of the side opposite the cutting edge. When dull, the tip is advanced and resharpened. Only the cutting edge is ground and no steel is removed from the shank.

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.)

How to Run a Lathe is a 128-page, thoroughly illustrated manual on the care and operation of a screw-cutting lathe. Now in its 42nd edition, this book has been proved in practice and is widely accepted for its accuracy and clarity of detail. All phases of the work are considered, including special types of operation. Shop "kinks" and "don'ts" are featured. *South Bend Lathe Works, South Bend, Indiana.—25 cents, paper covers; 75 cents, leatherette covers.*

V-Belt Handbook for Industrial Applications is a 74-page booklet containing data on the whole subject of V-belts including their advantages, installation and care, varieties obtainable, and the qualities to seek when selecting various models. *The B. F. Goodrich Company, Akron, Ohio.—Gratis.*

Pantograph Engraving Machines is a 20-page booklet based on the specifications and applications of standard models as well as seven other machines for special purposes. Request Bulletin 1580-B. *George Gorton Machine Company, Racine, Wisconsin.—Gratis.*

Ditching With Dynamite is a 32-page illustrated booklet, the product of years of experience in the field and in the laboratory, giving a complete explanation of a technique being widely used in agriculture, pipeline and highway construction, and mosquito and flood control. *E. I. du Pont de Nemours and Company, Inc., Explosives Department, Wilmington 98, Delaware.—Gratis.*

Rotary Files War Supplement is a 10-page folder describing more than 72 rotary files of various shapes, both hand-cut and ground from the solid. Diameter, length of cut, and price of each is listed. *Grobet File Company of America, 421 Canal Street, New York 13, New York.—Gratis.*

The Second Mile, a Re-survey, 1944, by W. E. Wickenden, is a 16-page pamphlet written to present the engineering profession to the young engineer and also contains information pertinent to all engineers. *Engineers' Council for Professional Development, 29 West 39th Street, New York 18, New York.—Single copies ten cents.*

Shot Peening and the Fatigue of Metals, by H. F. Moore, is an illustrated booklet based on the findings of laboratory research. Some of the subjects covered are: Types of structural

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

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 practical information on the characteristics and non-communication applications of electron tubes. The text describes experiments and presents results. For students, radio engineers, communications experts, and the serious general reader. **$4.75**

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, repair, 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 SCIENCE OF WATCHES AND CLOCKS — *By A. L. Rawlings.* Not a book on watch and clock repairing, but one for horologists interested in the science underlying fine timekeepers. **$3.60**

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

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

ELECTRONIC PHYSICS — *By Hector, Lein, and Scouton.* 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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damage of metals; the origin of fatigue cracks; effects of cold working; measurement of shot peening intensity. *American Foundry Equipment Company, 555 South Byrkit Street, Mishawaka, Indiana.—Gratis.*

General Catalog is a 28-page publication of particular interest to research men and development engineers. Laboratory instruments, such as resistors, inductors, capacitors, galvanometers, dynamometers, and potentiometers are described and illustrated and their characteristics shown by means of tables and charts. Request Folder ENT (7). *Leeds and Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pennsylvania.—Gratis.*

Jiffy Jig for Drilling, Milling, Boring, and Grinding is a four-page circular describing and illustrating the four standard set-ups of this new type of lever-operated chuck. Stock size capacities and other pertinent information is given. *Monarch Governor Company, 1832 West Bethune Avenue, Detroit 6, Michigan.—Gratis.*

Pull-Up Broaching Machines by Colonial is a 16-page bulletin describing the standard pull-up machines, tools, and attachments. A section is devoted to the basic tooling of the machines and specification tables with drawings of machines, tools, and attachments are presented. *Colonial Broach Company, P. O. Box 37, Harper Station, Detroit 13, Michigan.—Gratis.*

Seamless Steel Tube Data is a 320-page loose-leaf binder divided into four sections, with guide index, covering general data, mechanical tubing, pressure tubing, and reference tables. Supplementary sheets with new data will be supplied from time to time. *Seamless Steel Tube Institute, Pittsburgh 19, Pennsylvania.—$2.50.*

How to Plan Your Post-War Air Conditioning Today is a 16-page illustrated booklet which outlines the three general types of air conditioning, how air conditioning works, the principal factors to be considered when planning for a specific application, and describes the equipment including compressors, condensers, units, and coils. *Westinghouse Electric and Manufacturing Company, 150 Pacific Avenue, Jersey City 4, New Jersey.—Gratis.*

Aeroil Hot Liquid Dip Tanks (Gas Fired and Electrically Heated) are two 16-page catalogs giving complete specifications on insulated hot dip tanks that are fueled by city gas, natural gas, or electrically heated with thermostatic controls. *Aeroil Burner Company, Inc., Box BG, West New York, New Jersey.—Gratis.*

Arriving Safely Protected by Mystik Self-Stik is an illustrated booklet designed to give plant executives specific ideas on how they can use self-sticking industrial tapes in a wide range of applications. *Chicago Show Printing Company, 2635 North Kildare Avenue, Chicago 39, Illinois.—Gratis.*

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By Orrin E. Dunlap, Jr.

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By Jerome S. Meyer

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By John Alden Knight

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By Harry H. Judson and James M. Brown

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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"

READERS of this department will recall a discussion of air currents in reflector tubes, by F. N. Hibbard, of Richmond, Virginia, in the January 1944 number. The following discussion of this subject is by E. K. White, Chapman Camp, British Columbia, and is reprinted from *The Journal of the Royal Society of Canada,* Toronto, Ontario.

"PRESENTED in this article are the results obtained from experiments made with an electric fan forcing a current of air into the metal tube of a Newtonian reflector.

"The telescope is of 9" aperture, and 100" focal length, and is used chiefly for the study of lunar and planetary detail. The tube is of iron, 10" in diameter and 104" long. There are no ventilation holes in the tube, save for a narrow space between the wall of the lower end of the tube and the mirror cell. When not in use the instrument is housed in a roll-off wooden shelter.

"It is well known that many observers are of the opinion that closed metal, and even closed wooden, tubes have a detrimental effect on the seeing, the reason being assigned to the presence of air currents within the tube of a different temperature from that of the outside surrounding air. Possibly the best remedy is an open skeleton-type tube, similar to those of the large reflectors. However, one living in a damp climate, as prevails in most of southern British Columbia, will have severe dewing and frosting conditions to contend with unless the mirror is removed to the house when not in use; and this method is bad for the silver film. The closed tube insures freedom from dewing of the mirror and prevents trouble from stray light; also, it aids in keeping the mirror free of frost crystals in winter.

"The late W. H. Pickering, ('Amateur Telescope Making—Advanced,' pages 610-612), well known lunar and planetary observer, claimed greatly improved seeing with closed tube reflectors by forcing a stream of air through the tube, introducing it by means of a small fan near the mirror's surface, and expelling it out of the open end. Here is movement of air within the tube, but of the same temperature as that outside. In other words, the troublesome warmer or colder air in the tube is displaced by outside air. Of course, the fan must be kept running as long as observations are made.

"By way of experiment, a round hole 5" in diameter was cut in the lower wall of the tube, just above the surface of the mirror. This is covered by a metal hinged door, having a close-fitting felt gasket. A 5" electric fan was obtained and experiments started.

"At the beginning of observations the extra-focal rings of a bright star, usually Polaris, were noted. Immediately the tube door was opened these rings became much distorted and unsteady. When the fan was started the rings became circular again and steadier, but they always showed a rapid rotation in the direction of the fan blades. With the fan running, the rings were definitely steadier than when the fan was off but the door open.

"The definition of detail on the moon and the planets Saturn and Jupiter was studied, with and without the fan, in all conditions of seeing the skies afforded. It was impossible to note any improvement with the fan on these objects, when the seeing was between 0-4 (scale of seeing objects devised by W. H. Pickering—0 very poor, 10 excellent). However, on a few occasions when seeing was estimated to be from 5-7, a very slight improvement in definition seemed certain when using the fan. The floor of the lunar crater Plato under oblique lighting was used as a test, and on good nights from two to four craterlets could be seen as such. With the fan running, these marks were steadier although no more fine details could be seen than before. No further detail could be seen on the planets mentioned, simply a steadying of the difficult marks seen without the fan. No improvement could be noted in the resolving of close double stars in any condition of seeing, but little time was spent with this particular investigation.

"The fan must be mounted on an adjustable stand, and not attached to the tube, so as not to set up any vibrations in the instrument. The blades should be kept close to the tube opening, in order to have a maximum current of air flowing through it. These requirements introduced some inconvenience in any careful observing program by necessitating rather frequent adjustments of the fan as the drive carries the long tube forward.

"From results so far obtained, with the exception of rare nights when seeing is quite good, the use of a fan is not considered worth while as a measure to improve definition. While it is known that other observers than W. H. Pickering have claimed that the use of a fan gives marked improvement in definition, I have unfortunately been able to find little published of their findings, or methods. Further experiments with a fan are being continued at this station."

THE FOLLOWING is the remaining part of an article begun last month by Daniel E. McGuire, on the use and technique of scotch-tape spacers for speeding up the previously tedious task of testing optical surfaces by means of interference fringes:

The collimating lens system can be computed by graphic ray tracing. This is done for a zone about 90 percent of the way from center to edge of the test plate surface. This zone focuses to the center of the smallest circle of confusion in the image formed at the viewing distance. The single surface collimator is easiest to compute by graphic ray tracing (Figure 3). It is much more difficult to determine the amount of curvature required for the two lens collimating system, especially when both curved surfaces are required to have equal radii in order to simplify tool making.

The designing may be simplified by selecting a curvature for the back of the test plate which deviates the ray through approximately one third of the angle required to focus to the eye position. The flat surface of the auxiliary lens further deviates this ray. The last step is that of finding the radius required in the third surface to deviate the ray still farther, so that it crosses the optical axis at the required viewing distance. In the first and third steps, an unknown curvature is determined by means of a known index of glass and a known deviation. In the second step, an unknown deviation is determined by means of a known index and curvature (or flatness) of the glass. Only the first step is used with the simpler system.

The two diagrams in Figure 3 show how to determine the radius of the single surface collimator. The test plate curvature is indicated by R_1. The clear aperture falls within the dotted line, and the 90 percent zone is used in the calculation. The radial line passing through the 90 percent zone locates point P laterally, but its longitudinal position is judged according to the required thickness of the glass at this zone. *PE* crosses the axis at the eye position *E*. Points *A* and *B* are distant from *P* in the same ratio as the refractive index of glass and of air. The index in this case is 1.52, so *PA* equals 1.52 times *PB*. Line *CD* is made parallel to *AB*, passing through point *P*. The center of curvature of the collimating surface, R_2, is found where line *CD* crosses the optical axis.

The concave test plate (Figure 3, left) nearly exceeds the limit of curvature for a single surface collimating system. Spherical aberration is much reduced by using an auxiliary lens.

The convex auxiliary lens must be made larger in diameter in order to include the marginal rays. In Figure 4, the auxiliary lens is too small to illuminate the margin of the test plate; but it is advisable to make the test plate oversized, with illumination over the needed area. In this way, a turned-down edge on the test plate can do no harm; it is masked off, invisible.

The convex test plate is well within the limit of practical design. When it is necessary to add an auxiliary lens, it is made still smaller in clear aperture at its back surface to keep its edge thickness to a minimum. Its plane surface rests upon the flat area surrounding the first collimating surface, with the concave side toward the eye. The same rule can be applied, regarding the use of an oversized test plate, to exclude from vision an imperfect margin of the surface.

The 100 percent zone is at the edge

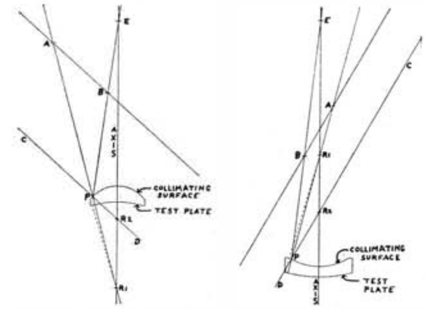

Figure 3: Graphic ray tracing

of the required diameter of test plate surface. An additional 5 percent can be added to the diameter of the polished surface to simplify the making of a perfect surface within the used area. Ray tracing the 100 percent zone shows the required boundaries of collimating lens surfaces.

For a further study of graphic ray tracing through a number of surfaces, see Martin's "Applied Optics," Vol. I, Figure 7.

When designing collimating test plates, it is not desirable to have normal incidence for the marginal rays on any of the collimating surfaces. An optical flat, having a plane-parallel back surface, needs an auxiliary lens to collimate the light; but the light reflected from the back surface is focused at the eye position the same as the light used

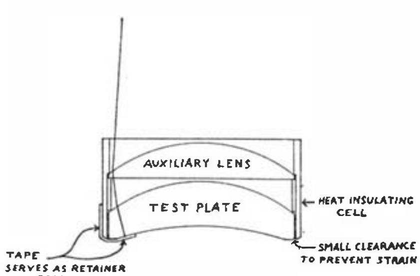

Figure 4: The test-plate cell

in testing. This fogging of the fringe pattern can be reduced by a non-reflective coating on the back surface of the test plate. Non-reflective coatings on all collimating surfaces improve the test when extraneous light from the room is reflected in the surfaces. Reflection of the light source in the center of uncoated collimating lenses is not objectionable.

There are two methods of using the test plates. Figure 1 shows how finished work, or single surface work in process of polishing, may be tested. It is practical only where the work is easily handled by the edges, or by an attachment. The work is viewed in the mirror below. Nothing is reversed in the mirror, since the work is interpreted as though looking down from above. Top, bottom, left, and right are in their respective places. This method eliminates handling the test plate for each test. Only the work is touched, and for a very short period per piece, and thus thermal effects are negligible. Some 300 to 400 surfaces an hour may be tested.

The test, as shown in Figure 2, requires handling of the test plates, but cells of heat-insulating material are used to guard against thermal effects. Thin edged, convex lenses are difficult to test with the arrangement in Figure 1. In Figure 2 they are placed on a padded ring, with the test plate on top, while looking down through the beam splitter.

With sufficient clearance between beam splitter and table, multiple blocks of lenses are tested, as shown in Figure 5. The lenses in the outer row are viewed in turn by rotating the block upon a fixed axis that is set at the proper angle. The block is set with axis coincident with that of the light for testing the center lens, or at a slight angle for an inner row of lenses.

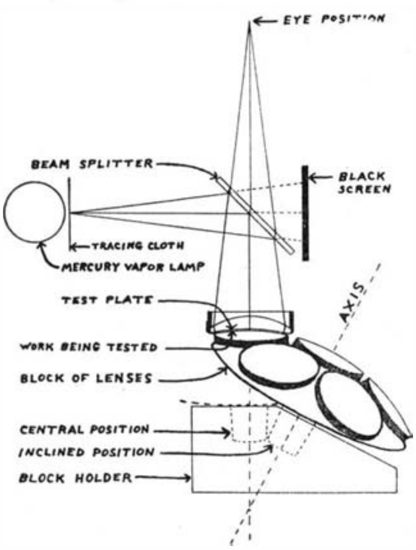

Figure 5: Testing on the block

In order to simplify the drawing, Figure 5, the tool shank is made longer than it ordinarily is. A shorter shank requires a convex block holder to fit roughly into the hollow, curved back of the blocking tool. Tapered holes are bored at the proper places, similar to those shown in the flat sided block holder.

A concave block of lenses requires a concave block holder, or simply a hollow arch, with holes bored at the proper places to line up the various rows of lenses with the axis of the light source. Blocks of flat work are held in place by any one of a number of adapters, all of which are mounted on a flat plate. Small, light-weight work is easily supported in one hand while making the test.

Air-spaced test plates are not entirely new, although the writer may have some original ideas. These, or similar, methods are being used in some optical shops—just how many and in what circumstances is not known.

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