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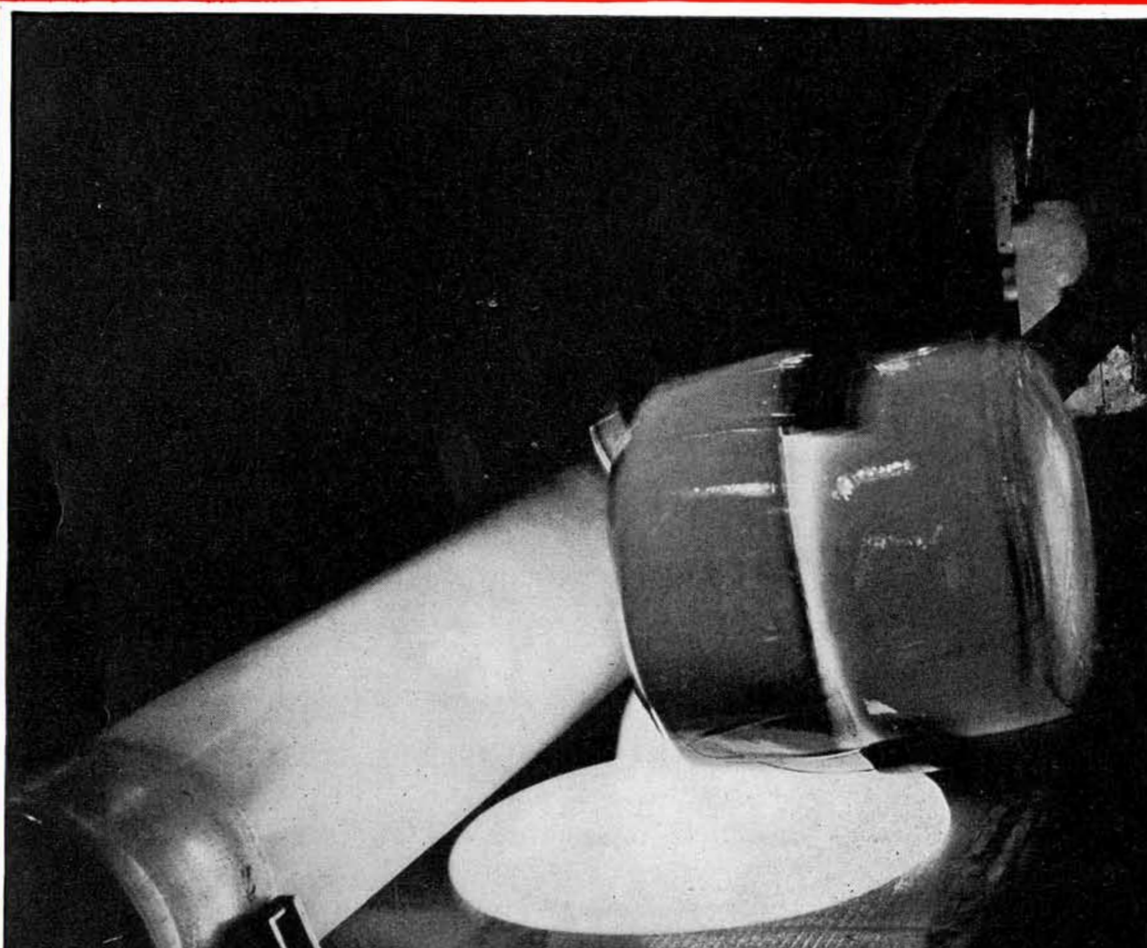
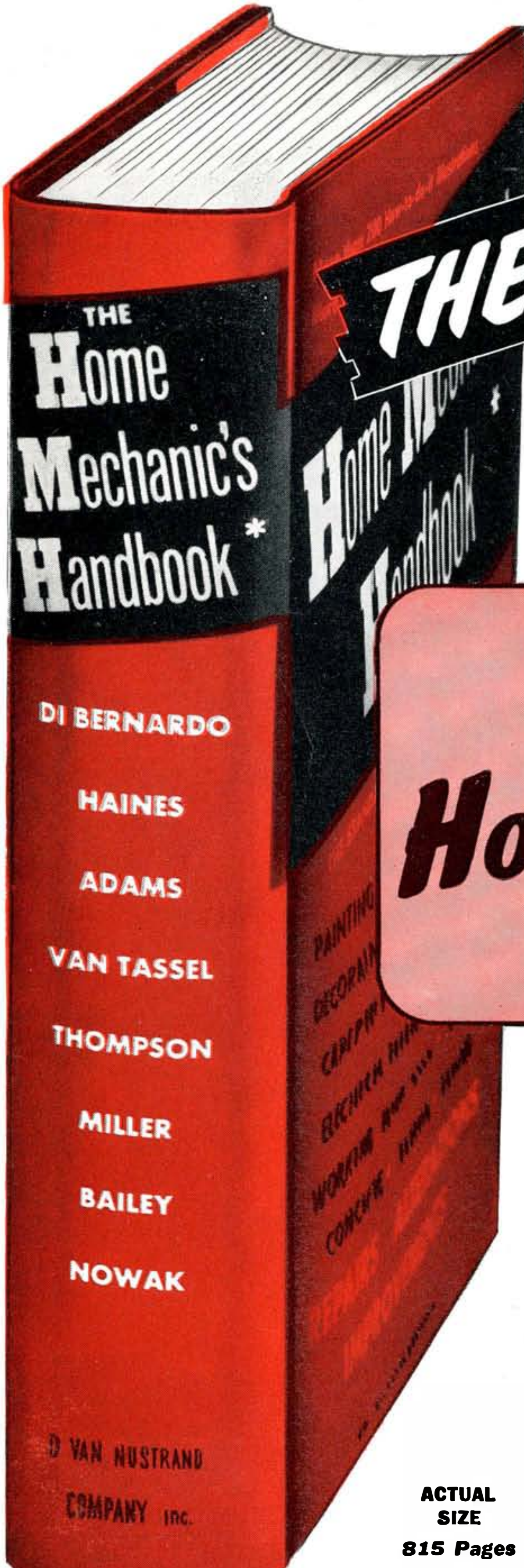


Optical Glass at 2200 Degrees, Fahrenheit . . . See page 130

The Story of THE GLASS INDUSTRY

Anniversary Issue No. 9



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Fix a window, door, or drawer that sticks
Fit screens, storm windows, doors
Build a chicken house, cupboard, workbench, cold-bed frame, storage cabinet
Cut, drill, grind, solder, temper, and forge metal
Measure, cut, thread, join, and assemble pipe
Fix leaks in faucets and valves
Thaw frozen pipes
Install a hot-water heater
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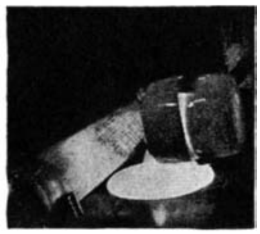

Our Cover: After being heated to 2700 degrees, Fahrenheit, optical glass is maintained at this level for about 14 hours. The temperature is then gradually lowered to 2200 degrees and the molten glass is poured on a rolling table and rolled to a sheet of uniform thickness, prior to annealing. See article starting on page 137 for historical details on glass.

Cover photo was taken with a Bausch and Lomb anti-reflection surfaced photographic lens to eliminate flare caused by reflection due to intense brilliance of the molten glass. Photo used by courtesy of Bausch and Lomb Optical Company.

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Previews of the Industrial Horizon

By A. P. Peck

RESEARCH TOMORROW

Much in the news these days is the subject of scientific research and its application to industry in the future. In November of 1944, President Roosevelt asked Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, to make recommendations regarding ways in which scientific knowledge can best be made available to the world, ways in which the Government can aid research activities of public and private organizations, and ways in which scientific talent of American youth can best be promoted to assure the future of scientific research.

In July of this year Dr. Bush transmitted his thoughts, and those of a number of distinguished committees who collaborated with him, to President Truman. The complete report, presented under the title "Science, the Endless Frontier," should be read by every business man in the country. It is thorough-going and pains-taking in detail, and the general tenor of the whole report can be sounded by quoting the following paragraph from it:

"The most important ways in which the Government can promote industrial research are to increase the flow of new scientific knowledge through support of basic research, and to aid in the development of scientific talent. In addition, the Government should provide suitable incentives to industry to conduct research, (*a*) by clarification of present uncertainties in the Internal Revenue Code in regard to the deductibility of research and development expenditures as current charges against net income, and (*b*) by strengthening the patent system so as to eliminate uncertainties which now bear heavily on small industries and so as to prevent abuses which reflect discredit upon a basically sound system. In addition, ways should be found to cause the benefits of basic research to reach industries which do not now utilize new scientific knowledge."

In other parts of the report, some may find implications of proposed socialization of research activities. If this be true, then industry must beware. Governmental red tape, the lack of incentive bred of bureaucratic sinecures, and the tendency toward playing politics on the part of governmental employees are not at all conducive to progressive and aggressive research of the type that has placed American industry in its present enviable position.

Whatever implications may be read into the report rendered by Dr. Bush, it should be encouraging to note an increasing realization in all quarters that industrial research is *necessary* and that it must be pressed forward at all cost if the nation as a whole is to prosper. But it must not be forgotten that a vast proportion of the research which has made our nation what it is today has stemmed directly from industry itself, fostered by what some people still sneeringly refer to as the profit motive.

The profit motive has its faults, it is true, but it has built in the United States the most powerful industrial nation in the world. It has reduced mass-production — with its attendant material benefits — to almost an exact science. At the same time it has made possible, directly and indirectly, much of the pure or fundamental research which has contributed so largely to cultural progress — and which, in turn, has completed the cycle by contributing in large measure to the furtherance of private industry and of the same profit motive that gave it birth.

We think that a brighter side of the whole subject of the future of research lies in the recent announcement by General Motors of its Technical Center where post-war research in all its aspects will have the objective of providing more and better things for more people. Here is a promising view of a not too distant horizon where one segment of one industry will work toward providing an economy of plenty that will benefit not only its own selfish profit motives but will spread these benefits over the whole face of the nation and of the world.

What this one segment of one industry can do, under the American profit system, every other segment of every other industry can do, each in proportion to its size and potential productivity. If each segment does its own share, the total aggregate will eventually equal and surpass even the enormous possibilities of Government-sired and Government-sustained research. And the incentive that goes with private industry will be there, ever spurring onward toward greater accomplishments.

BELTS CAN CARRY IT

Forward-looking engineers see on the horizon a time when conveyor belts will do a far greater number of jobs than they are doing today. In coal and copper mining, belts large and small have proved themselves; in coal mining, belts are making serious inroads on the electric locomotive method of handling coal. It is estimated that today more than a million and a half feet of belting is used for this work but even this vast footage handles only a small fraction of the coal production of the nation. So satisfactory are the belts, however, that it is predicted that, within a few years, 80 percent of the coal mined underground will be removed from the mines on belts.

But the surface of the conveyor-belt business has just been scratched. Belts are being used increasingly to transport raw materials in factories, and this phase will increase in importance as possibilities are explored more thoroughly. In the meantime, engineers are again toying with the idea of moving people from point to point on belts. If the bugs can be worked out, and the people can be adequately protected against accident, this transportation method should have great appeal, particularly for moving passengers from waiting rooms to planes and trains, workmen from parking lots to their benches, and the like.

FACSIMILE

One of the oldest forms of communication by electricity is facsimile, in which an exact copy of a message, picture, complicated sketch, or what-ever is reproduced at a point distant from the transmitter. However, technical difficulties have beset the paths of facsimile engineers, with the result that, despite earnest effort, success was slow in coming. Facsimile, offering advantages of highly accurate transmission, extreme speed, and a permanent record of the communication, has received great impetus during the war. It has been used to send maps, orders, photographs, and other military information by wire and radio.

Facsimile differs from wire-photo methods of communication in that facsimile builds up a copy at the receiver by direct electrical action on paper; in wire-photo the receiving action is photographic and a darkroom and attendant equipment are required.

Present plans for the future of facsimile include units for inter-office communication and for attachment to home radios. The latter, of course, presupposes a transmitting set-up that would make ownership of a home facsimile unit desirable.

FOR FUTURE REFERENCE

A home dishwasher, to sell for about $75, is reported to be ready for near-future manufacture . . . Complete, assembly-line-built houses of three rooms and bath, that will sell for $2000 or less, are being made in a Goodyear pilot plant . . . Link these houses with "prefabricated" dinners, on plates that are designed to be used and thrown away; meat and vegetables, tastefully arranged, are partially cooked, then frozen; just heat and eat.

With the new RCA lifeboat radio, shipwrecks need no longer take a terrible toll of lives.

ı two-way radiophone—for lifeboats!

re's when a telephone comes in rather ndy . . . when you can "get your party" d hear "We'll be there to get you in a ɹple of hours!"

With the new RCA compact lifeboat lio, that's exactly what happens. A kite, a balloon, takes the antenna up 300 feet.

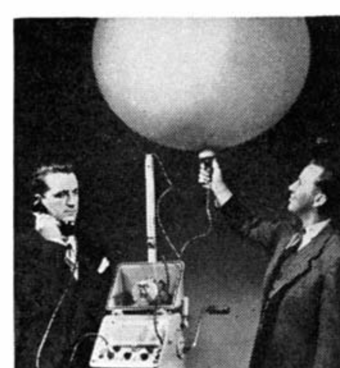
Turn the power-generating cranks and t goes an SOS—along with a direction-der beam so shore stations can figure ɹr exact location.

But even more amazing, shipwrecked ɹriners can talk with the men on their ɹy to the rescue. They can "pick up" ships, airplanes, and that wonderful place called "land"—even if it's 1000 miles away!

Endless research, such as went into developing this lifeboat radio, goes into all RCA products.

And when you buy an RCA Victor radio, or television set or Victrola, you enjoy a unique pride of ownership in knowing that you possess one of the finest instruments of its kind that science has achieved.

Radio Corporation of America, RCA Building, Radio City, New York 20. • *Listen to The RCA Show, Sundays, 4:30 P.M., E.W.T., over the NBC Network.*



Joseph McDonald and Donald Kolb (holding balloon) are the Radiomarine engineers who developed this lifeboat radio. Here is the balloon that is inflated with helium and carries the antenna as high as 300 feet into the air.

RADIO CORPORATION of AMERICA

50 Years Ago in . . .

SCIENTIFIC AMERICAN

(Condensed from Issues of September, 1895)

NIAGARA POWER—"After almost five years of work and the expenditure of over $3,000,000, Niagara Falls are now being utilized for power. The monster 4,000 horse power dynamos of the Cataract Construction Company are now sending out electricity for commercial use. The first power was delivered to the works of the Pittsburgh Reduction Company at 7:30 o'clock, August 26, when dynamo No. 2 in the construction company's power house was set in motion. At the reduction company's works there were about a dozen men at work and the pots used in the making of aluminum are being tested by them."

FORESTRY—"Farmers throughout the United States are making a mistake when they fail to plant trees on all their land not suited to crops, and along their lanes, fences, and highways. Without any other expense than that of planting the young trees they could provide for fine rows of maple, oak, pine, birch, hickory, walnut, and other trees on their farms, all of which would be increasing in value every year."

FREIGHTER—"The twin screw White Star steamship Georgic, Captain Smith, finished her maiden trip to this port, August 26. She is the biggest freighter in the world, and probably the swiftest, being able to make thirteen and a half knots. She was built at Belfast by Harland & Wolff, and measures 10,077 tons. She is 538 feet long, of 60 foot beam, and 40 feet deep."

TRANSPORTATION—"The whole of the tonnage on the oceans of the world last year was about 140,000,000 tons, while the tonnage of the railways of the world, carried 100 miles, was about 1,400,000,000 tons. There are 400,000 miles of railroad in the world, of which 180,000 are in the United States. Of the 1,400,000,000 tons carried 100 miles last year on the railways of the world, 800,000,000 tons were carried on the railways of the United States."

SOUND STUDY—"Voice analysis is recorded by making a resonator for the fundamental and overtones so as to sound in sympathy, and to cause tiny gas jets to flicker. These variations have hitherto been drawn by hand, but now they are photographed by a swiftly moving camera, so as to make a perfectly accurate record. Practically this invention is very useful in analyzing the voices of singers or speakers, and determining at once where they need improvement."

INVENTION—"No better examples of the importance of small things can be found than among the records at the United States Patent Office, in Washington. There are to be seen certain small objects which, by a lucky turn of affairs or, perhaps, by the ingenuity of the inventors, have become known throughout the world, and have been the means of filling the pockets of both the inventors and their representatives. In fact, it would seem as if inventors of small objects have sometimes been far better paid than skilled mechanics and engineers who have spent months and years in perfecting elaborate mechanisms."

WOOD PULP PINIONS—"The great development of electrical mechanism during the past few years has caused engineers and mechanics to give special attention to anything connected therewith. It has been found that an objection to nearly all electrical power apparatus is the extensive vibration of the gear wheels, which in almost every instance revolve at a higher rate of speed than in ordinary machinery. . . . Compressed rawhide pinions and cogs made from same material have been adopted with some success. Even this material, however, has its drawbacks, all of which are claimed to be done away with by combining wood pulp with the same."

FRUIT IN GLASS—"A new vacuum process of canning fruits in glass has lately been introduced from Europe among the packers of the Pacific coast. . . All the deleterious gases generated in cooking the fruit, and even the air, are extracted under this new process, so that fermentation is reduced to a minimum."

BELLS—"Church bells are, with but little variation, made of copper and tin, in the proportion of copper 78 parts, tin 22 parts. Bell founders claim that all additions of gold and silver, etc., are of no practical value. . . The flasks whereon and wherein the mould is made consist of two parts, constructed of boiler iron, of a general bell form, and plentifully perforated with holes for escaping gas while casting, one being so much less in size than its fellow as to give space for the loam forming the mould between the two. No 'pattern,' as the term is generally used, is provided. The two parts of the mould are 'swept' by 'formers,' accurately finished from thin iron to the form intended for the inner and outer surfaces of the bell. . . The melted bell metal being ready, the furnace is tapped, the bright stream caught in a huge ladle swung over the mould by a crane and poured into

the open mouth of the mould till it is filled. . . After cooling and removal from the mould, the bell is usually polished with sand and water in special revolving grinding machines."

FIRE-CYCLE—"The New York Fire Department has under consideration the construction of a bicycle chemical engine for use in the up-town and suburban districts. The plan proposed contemplates a light chemical engine of from 30 to 40 gallons capacity, which will be propelled by four men, which would make much better time than the horses do. Out of 1,100 men in the fire department, 300 now ride bicycles."

ROADS—"The total length of the common roads in this country, good, bad, and indifferent, is estimated by Gen. Stone, of the Road Bureau of the Department of Agriculture, at something over 1,300,000 miles. The majority of these roads have been opened by common laborers hired by county supervisors, and no engineering principles have been observed in their construction. As a result, it costs more to keep them in repair than if they were so many finely macadamized roads."

THE BIRD WITH THE 16-MILE TAIL

ıe wire you see with the parachute on e end of it is a telephone wire, being :yed out from a C-47 cargo plane.

Bell Telephone Laboratories, work- g with the Air Technical Service ommand of the Army Air Forces, de- loped this idea. It will save precious ʼes and time on the battlefield.

A soldier throws out a parachute th the wire and a weight attached. ıe weight drops the line to the target ea. From then on, through a tube thrust out the doorway of the plane, the wire thrums out steadily — sixteen miles of it can be laid in 6 2/3 minutes. Isolated patrols can be linked quickly with headquarters. Jungles and mountain ranges no longer need be obstacles to communication.

This is in sharp contrast to the old, dangerous way. The laying of wire through swamps and over mountains often meant the transporting of coils on the backs of men crawling through jungle vegetation, and in the line of sniper fire. It is reported that in one sector of the Asiatic theater alone, 41 men were killed or wounded in a single wire-laying mission.

Bell Telephone Laboratories is handling more than 1200 development projects for the Army and the Navy. When the war is over, the Laboratories goes back to its regular job — helping the Bell System bring you the finest telephone service in the world.

BELL TELEPHONE LABORATORIES

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

The Research Laboratory of the Libb
Owens•Ford Glass Company in Tole

THIS IS WHERE WE TEACH GLASS TO DO NEW THING

If visibility were the sole purpose of glass, achievements of past decades in producing glass that is flatter, clearer and freer from imperfections would be enough—and scientists in the glass laboratories could rest on their laurels.

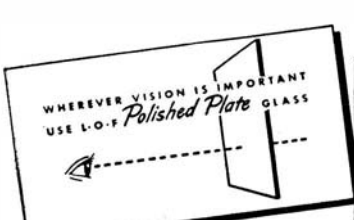
But engineers saw in glass far greater potentialities, far more benefits than those resulting from its ordinary uses. And so they found ways to make glass do new jobs—and do old jobs better. Their efforts have made glass more versatile than is commonly realized.

Could glass be made to withstand great thermal shock, impact and heavy loads? It could . . . and out of the laboratories came Tuf-flex, the L·O·F tempered glass of amazing strength.

Would it be possible to have window walls to "open" rooms to sunshine and view without excessive heat loss? It was . . . and L·O·F developed Thermopane, the hermetically-sealed, multiple-pane, glass insulating unit, suitable for all building types.

Could glass be made to let in daylight, yet block out most of the infrared rays of the sun? Now it's an actuality—L·O·F Heat Absorbing Plate Glass. *A glass to reduce fading?* Yes, L·O·F Golden Plate. *Glass in special shapes?* L·O·F has moulded thousands of bends. *Glass in transparent and opaque colors?* Yes, a wide variety of colors for unusual decorative effects. *Even laminated glass?* L·O·F has laminated millions of square feet of glass with plastic, producing Safety Glass for motorcars, planes, trains and ships. These and many other modern glasses typify the industry's progress.

Research has improved glass through the years, broadened its services and pointed to better things ahead. Glass technology has never stood still . . . and never will. Libbey·Owens·Ford Glass Company, 3095 Nicholas Building, Toledo 3, Ohio.



LIBBEY·OWENS·FORD
a Great Name in **GLASS**

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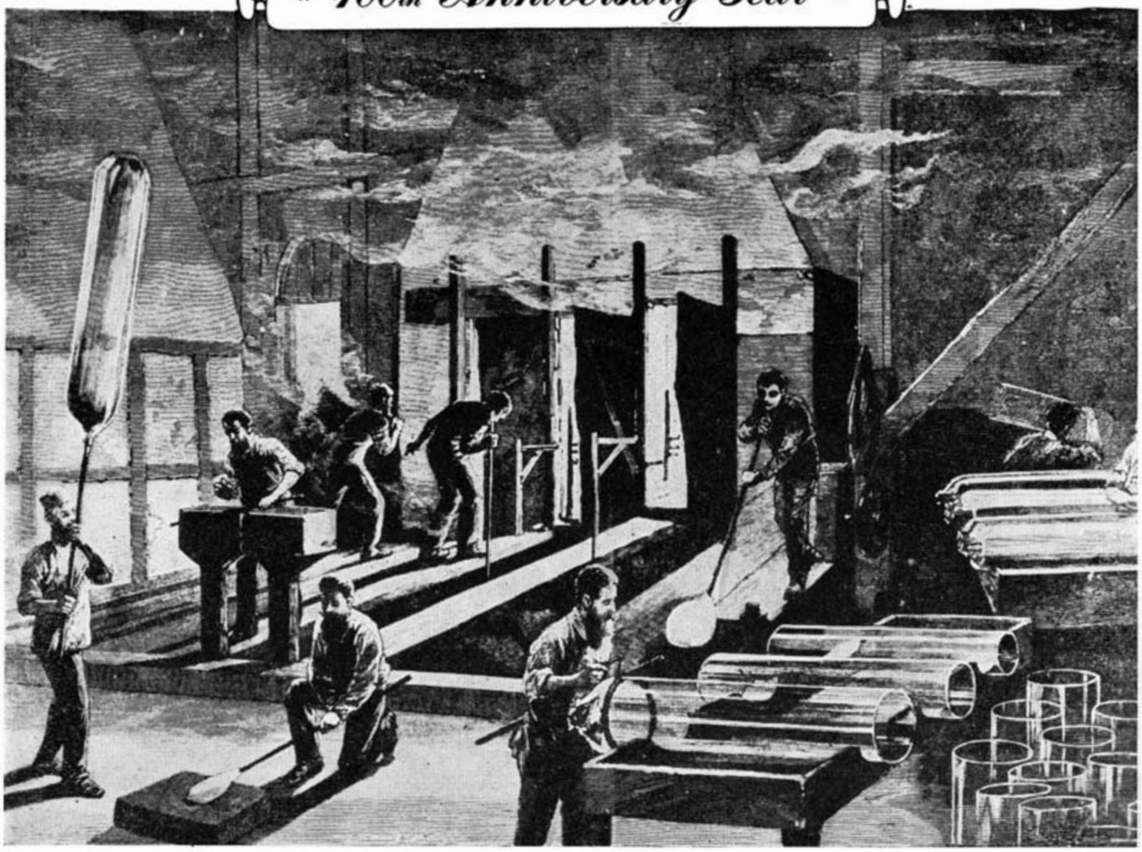


Steps in making sheet glass in an early American plant

Light and Progress

By JEROME CAMPBELL and A. P. PECK

Glass, Material of Many Uses, Has Extended Man's Sight Into the Far-Off Universe and Into Microscopic Worlds. At the Same Time it Has Served Utilitarian Purposes in the Home and in Industry. Strangely Enough, it Was One of the Last of Present-Day Materials to be Adapted to Mass-Production Methods and Hence Put to Wide Use

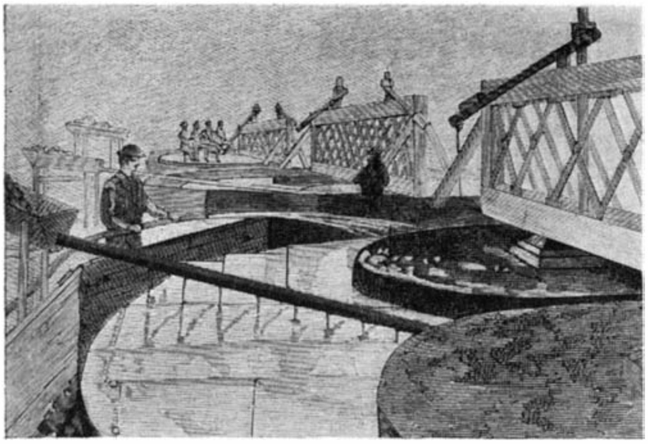
TO SHELTER his body from the rigors of climate, man has had to erect walls around him and build a roof over his head. And glass, man's creation, allows him to admit light into his dwellings, while maintaining the protection of his shelter.

But glass does far more than this. To impaired eyesight glass brings vision so that the printed word is made clear. Glass made into telescope lenses and mirrors opens to man the enormous vistas of the heavens and makes known to him the complexities of outer space.

In an opposite direction glass also enriches man's understanding. Cunningly made into microscope lenses it reveals the swarming life too small by far to be seen by his unaided eyes. Bacteria and other micro-organisms, causes of death-bringing ailments and also sources of strength and health, are observed by him. By means of glass he learns how to check the harmful power of these organisms, invisible to the naked eye, and how to make use of their power to do him good.

When man began to make glass no one knows. Pliny offered the plausible explanation that it was discovered accidentally by the fusion of sand and soda in cooking fires. Whether this is true or not, it was during the great civilization of ancient Egypt that the making of glass, first as a glaze on pottery and later as a translucent and transparent material, emerged among human activities as an art and an industry.

The invention of the blow pipe sometime near the



Grinding plate glass in the 1880's. The rough plates, trimmed to best advantage, were mounted in plaster of Paris on the revolving table of the grinding machine

beginning of the Christian era, probably by Phoenician glass workers, enlarged the scope of glass-making greatly. It stimulated the development of clear transparent glass, and glass blowing became a great industry in the leading cities of the Roman world during the first four centuries of the Christian era.

Skipping over the development of stained glass windows, the famous Venetian glasses, and so on, it is found that during the 17th Century important progress was made in the manufacture of glass. In 1612, Neri published in Florence his work on glass technology, *L'Arte Vetraria,* translated into English in 1662. It was the first work on the chemistry of glass and has since come to be one of the classics of glass technology. It served as a source of information that contributed to the progress in glass making during the next hundred years.

The craft of glass cutting was greatly improved in the early years of the 17th Century by Caspar Lehman and his follower, Schwanhardt. An Englishman, George Ravenscroft, made an important contribution to glass technology by inventing flint glass in 1675. He used lead oxide to give this glass its features of great brilliancy and relative softness that make it adaptable to forming and decoration. An additional important step forward in glass manufacturing was taken in 1688, this time in France, when Louis Lucas invented the process of casting glass.

The 18th Century, the great "age of enlightenment," was marked by intense intellectual activity that bore fruit in advances in thought and in politics, culminating in the New World in the establishment of a free United States, and in Europe in the French Revolution; it was also marked by the development of optical glass. This the world owes to Pierre-Louis Guinand, a Swiss (1748-1824), who in 1790 worked out a method of producing it. He and his descendants found that by stirring the molten ingredients, and by annealing the glass, they could produce an optical glass substantially free from the imperfections that impair refracting qualities.

Guinand and his sons established a dynasty of optical glass makers whose activities spread from Switzerland into Germany and France. One of Guinand's great-grandsons, Edmond Feil, in 1893, set up an optical glass plant in America at Lenox, Massachusetts, and attempted to build up a business, but without great success.

AMERICAN GLASS—Although the production of optical glass in the United States did not get started in a large way until World War I abruptly cut off imports from Europe, the manufacture of glass for utensils, ornaments, and windows was actually the first industry set up by the English settlers in the new world. Among the first 70 passengers brought to the settlement of James Towne in 1608 by Captain Christopher Newport, at the instigation of the London Company, were eight Dutch and Polish glassmakers. A glass manufactory was established and some of its products were among the first exports from America in 1609.

The main job of the glasshouse in James Towne was to manufacture window lights for the colonists' houses. The venture seems to have failed shortly afterwards. Nothing more is heard about glass manufacturing in Virginia until 1621, when the London Company again tried to establish the manufacture of glass in its colony. In that year six Italian artisans were shipped across the Atlantic to make colored beads and similar gewgaws for trading with the Indians. Thus the second glasshouse established in America was also its first mint, for the glass manufactured for trading with the Indians was, in effect, currency. This glass-making attempt lasted until 1623 and then collapsed. It passes at this point in time from the pages of history into oblivion.

The next attempt at glass making in America was made in 1641 when Obadiah Holmes and Lawrence Southwick constructed a plant in Salem, Massachusetts, where it is believed they made window panes, bottles, pitchers, and lamps for a few years.

Some years later the Dutch in Nieuw Amsterdam set up a glass factory and turned out glass for more than one hundred years until 1767. The earliest furnaces were built on Glass Makers Street, now William Street, center of the insurance business. Later, several furnaces were built farther uptown at the Glasshouse Farm on the banks of the Hudson River. The Jansen and Melyn families were active in these glass-blowing enterprises. Other Dutch artisans who made glass in Nieuw Amsterdam were Johanes Smedes, Cornelia Dirksen, and Everit Duycking, who with his son, Gerrit, made America's first colored art glass for the windows of the Dutch Reformed and other churches in the colony.

In 1739, Caspar Wistar, a German immigrant, sent to Belgium for four glass makers. He set up a small furnace in southern New Jersey and manufactured panes for windows, as well as bottles and glass chemical apparatus. After Caspar's death in 1752, his son Richard enlarged the plant and carried on the work until 1781. Many fine examples of this south Jersey glass survive

Courtesy Corning Glass Works

In 1879, in a glass "shop" like this, Corning blew a bubble for a man named Edison and thus began production of incandescent lamp bulbs, now a mechanized process producing up to 700 bulbs a minute

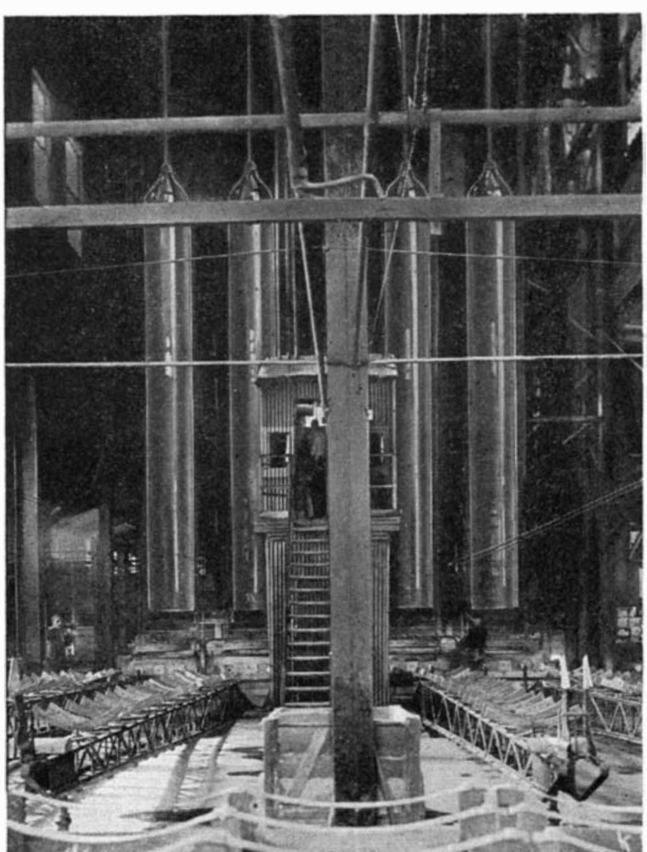
today in museums and private collections. These authentic examples of early Wistar glass are mostly what is known as "off-hand" blown glass. These are pieces that the workmen fashioned for their friends or families apart from their regular production. To the last run of glass in a pot, they often added a bit of coloring matter and then exerted their greatest skill, out of love for their craft, in blowing useful and ornamental objects.

During these years glass furnaces were also established elsewhere in New Jersey and New York. They turned out glassware largely similar to the products of the Wistar manufactory. It was sturdy and substantial, yet graceful and well-balanced.

The most beautiful glass in America was made by William Henry Steigel at Mannheim in Pennsylvania. Steigel, a German, came to America in 1750, and is frequently referred to as "Baron" Steigel, although he was not a nobleman. He was something more important —an energetic and courageous American who made a great artistic and technical contribution to his adopted country.

Believing that there was a need for fine glass in America, he constructed a large glass plant at Mannheim and then went to Europe where he selected and brought back to America from many countries experienced glass workers including cutters, engravers, gilders, and etchers as well as blowers. The first run of glass was made in 1765, and, though everything seemed to point to success, the general depression preceding the Revolution, coupled with Steigel's personal extravagances, caused the enterprise to fail.

In 1784, the struggling glass industry in America received a stimulus to new life when 82 experienced glass workers left Bremen, Germany, and came to America.



Courtesy Pittsburgh Plate Glass Company

Cylinder process of sheet-glass making, ultimate refinement of the old blow-pipe method. The cylinders, here about 30 feet long, are blown by compressed air

They set up a glass works at Frederick, Maryland, but the business soon collapsed. The failure of this venture and of Steigel's ambitious glass-making enterprise testifies to the great difficulties that faced the infant glass industry in the newly established United States.

Many of the German glass workers who had lost their jobs when the Maryland attempt ended, found work in glass plants that were springing up in the coastal cities or they crossed the Alleghanies to obtain employment in the glass furnaces being erected in Ohio, western Virginia, and Pennsylvania. On a hillside along the Monongahela River near Pittsburgh, Major Isaac Craig in 1797 came upon an outcropping of coal. This discovery was of great importance to the future of the glass industry because it meant that coal would gradually supplant wood as fuel for the glass furnaces. Craig and James O'Hara constructed an eight-pot window and bottle glasshouse near the coal bank, and thus started the great Pittsburgh glass industry.

THE 19TH CENTURY—The opening of the 19th Century in the United States, then, found the glass industry small and weak, struggling against great difficulties for survival. There were many reasons for this lack of success. Most important was a dearth of sufficient trained workmen. Another reason was the lack of roads in good enough repair to permit the safe distribution of glass products. There were no railroads in those days and the highways were far from smooth. Strong competition from Europe and heavy domestic taxation on glass articles were additional factors working against the industry.

The 19th Century was characterized in America and Europe by the mechanization of productive techniques, and the glass industry was caught up in the general tide. Throughout the eastern states, glasshouses multiplied, turning out household glass and window panes. Deming Jarves, founder of the Boston and Sandwich Glass Company, set out to solve the secret, hitherto baffling to American glass makers, of compounding red lead or litharge which was necessary in order to manufacture crystal glass or lead flint capable of being cut in the English manner. In 1827, Enoch Robinson invented the first crude pressing machine which was at once improved by Jarves. The invention was perfected by 1838 and pressed glass became popular throughout the country, although it did not become a familiar household commodity until about 1845. By that time America was exporting these machines to all the glass centers of the world. The circle was closing. America, which only recently had been compelled to import its glass craftsmen from Europe, was now returning to the old world an improvement that was to become characteristic of its development—a machine to speed production and reduce costs.

SHEET GLASS—From the earliest days the major use of sheet glass has been in windows, and from the time of the Roman empire down to the beginning of the 19th Century the method of its manufacture remained essentially unchanged. Known as the crown method, it consisted of first blowing a hollow glass sphere with a blowpipe. To this a punty—an iron rod used to manipulate hot glass—was attached opposite the blowpipe which was then removed, leaving an opening in the globular mass. After being heated until it was very soft, the ball was rotated rapidly until centrifugal force caused it to flatten out into a disk. It was then removed from the punty, annealed, and cut into small sheets. At the center of every sheet was the "crown" or "bull's eye." Only small sheets of glass could be fabricated by this strenuous process.

The crown method was entirely replaced in the early

He's planting seed for a new kind of Glass...

ONE day the man in charge of research at Corning called in the man who writes these advertisements.

"I think we're making a mistake in our ads," he said. "In these critical times, we should remind people that glass is a basic raw material and that Corning makes many, many different *glasses* for many different kinds of jobs."

It sounds almost unbelievable, but Corning has developed more than 25,000 glass formulae. Every day chemists pour widely varying raw materials into rough clay crucibles to obtain more types of glass. The results are to the glassmaker what seedlings are to nurserymen. Some are discarded. Some are used. Some are combined to achieve the sought-after formula.

This patient labor has led to such remarkable discoveries as the Pyrex brand heat resisting glasses. It has produced glasses of a hardness that compares with steel. It has produced crystal as clear as dew.

Corning is able to help in the war because its hundreds of research people are backed by over three-quarters of a century of experience in the hands of glassworkers who understand the possibilities of this wonderfully versatile material. Maybe you can turn some of this knowledge and skill to a profit when your peacetime plans reach the blueprint stage. Corning Glass Works, Dept. 59-S, Corning, New York.

CORNING
means
Research in Glass

years of the 19th Century by the hand cylinder technique. This consisted of gathering from the tank enough molten glass on the end of a blowpipe to make a cylinder from 15 to 20 inches in diameter and from 50 to 70 inches long. When the blower had formed a cylinder of fairly uniform surface thickness, the ends were removed and the cylinder split and placed in a heating oven where it was softened and flattened with a wooden tool or hoe. After passing through a lehr (annealing oven), the glass was cooled and cut into required sizes. Great labor and considerable skill was required in making window glass by this slow process.

Up to the end of the 19th Century nearly all window glass was made by the hand cylinder method. Mechanization began when J. H. Lubbers introduced a machine-blowing process. In his machine, molten glass was poured from a ladle into a drawing pot. A circular metal bait about ten inches in diameter, on the end of a blowpipe, was dipped into the surface of the melt. By withdrawing it slowly by means of an electrical hoist and applying carefully controlled compressed air, a continuous cylinder was formed to a height of about 40 feet and approximately 30 inches in diameter. The subsequent work of splitting, flattening, annealing, and cutting were the same as in the hand cylinder method. The production rate, however, was higher because the cylinders were far larger and could be blown with greater speed.

But the great need in the production of window glass was a continuous method of manufacture. The undulations and waves in window glass, the principal causes of distorted vision, could not be eliminated as long as the manufacturing process involved the flattening of glass cylinders. The problem was solved in the United States and abroad almost simultaneously.

Emile Fourcault invented in Belgium a practicable machine for the continuous production of sheet glass, relatively free from waves. In America, Irving W. Colburn invented a similar machine that was put into use in 1917 in Charleston, West Virginia, by the Toledo Glass Company, later merged with the Libbey-Owens Sheet Glass Company. The Fourcault process was introduced in America in 1923 by the Blackford Window Glass Company. About that time a third continuous process was developed by the Pittsburgh Plate Glass Company.

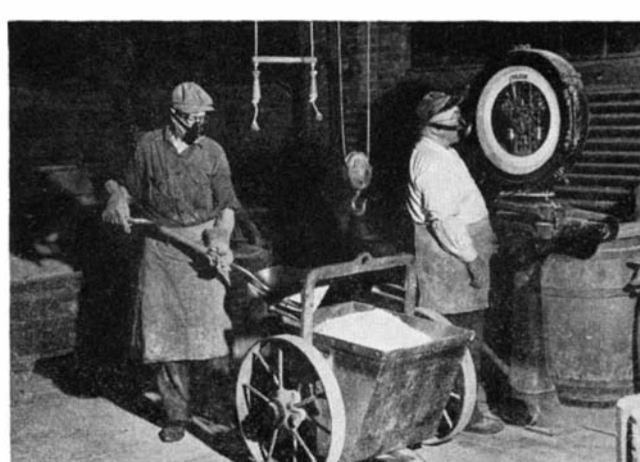
A GREAT INDUSTRY—The fact that these automatic and continuous methods of manufacturing sheet glass had been developed at the cost of much laborious experiment and the investment of millions of dollars meant that glass manufacturing had grown in the early decades of the 20th Century to be a great American industry. Its emergence as one of the giants of American industrial development was the result of the rapid growth of a number of American glass-making companies lead by energetic and intelligent men. Some account will be given later of the start and growth of the organization that is now the Pittsburgh Plate Glass Company. There were others of equal importance in the rise of American flat glass manufacturing. Outstanding among these is the Libbey-Owens-Ford Company of Toledo, Ohio. The three men whose names are perpetuated in the company name were leaders, each in a different way, in the development of the American glass industry. Edward Drummond Libbey was a New Englander who moved his small glassworks from East Cambridge, Massachusetts, to Toledo in 1888. He was one of the most skilful and artistic producers of cut glass and his work was extremely popular during the nineties when cut glass was greatly in demand.

Son of a West Virginia miner, Michael J. Owens was a glass blower and labor representative in the Libbey factory. He later became superintendent and invented the Owens bottle machine in 1899. The third man who contributed greatly to the development of the present company was Edward Ford, son of Captain John B. Ford, America's pioneer plate-glass manufacturer. Edward Ford retired as president of an eastern glass works in 1896 and resolved to establish a glass works of his own. He saw in Toledo an ideal location for a glass factory, and he purchased 173 acres on the Maumee River where he established the model town of Rossford for his employees and constructed what was then the largest plate-glass plant under one roof in America. It had a capacity of six million square feet a year. This output was later doubled and is now many times greater. These three pioneering leaders of the glass industry died between 1920 and 1925 and their companies were merged in 1930.

PLATE GLASS—The same difficulties that made the beginnings of the sheet and household glass industry in America hesitant and precarious also attended early ventures in the manufacture of plate glass. In 1850, an attempt was made to establish American manufacture of plate glass on a stable and successful basis. A company was formed, certain European patents obtained, and a factory was built at Cheshire, Massachusetts. The business was later moved to Brooklyn where it faltered and died in 1856.

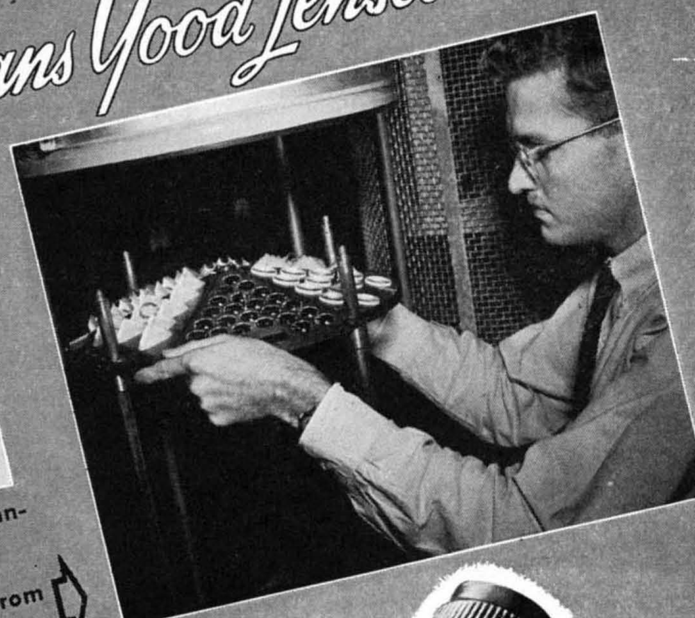
Another group founded a plate-glass factory at Lenox, Massachusetts, importing for the purpose the best foreign equipment and utilizing the most advanced European techniques. Excellent plate glass was produced, equal to the best imported from Europe. Nevertheless, this company failed in 1871. Failure was also the lot of a plate-glass enterprise started in New Albany,

Left: Mixing a batch of glass ingredients in an old-time glasshouse. Right: In a modern Bausch and Lomb optical glass plant, the batch is accurately weighed



Wollensak means Good Lenses

Lenses and prisms in the process of cleaning prior to being coated.



Prisms and lenses being removed from machine after being hard coated.

LENS COATING means EVEN FINER Wollensak Lenses . . .

A major wartime achievement in the field of optical glass, *lens coating* will increase the light-transmission quality of many postwar Wollensak lenses.

When you see the guarantee, "This instrument has COATED OPTICS," on your new Wollensak Photo Lens Prism Binocular, Rambler Field Glass, or Vari-Power Scope, you'll know your lens will give sharper, more brilliant images . . . help you get more fun from sporting events, hunting trips, vacation travels.

After the war Wollensak instruments will again be available for sports lovers . . . offering many new, improved features achieved by Wollensak skill and experience in precision manufacture.

Wollensak ROCHESTER 5, N. Y., U. S. A.

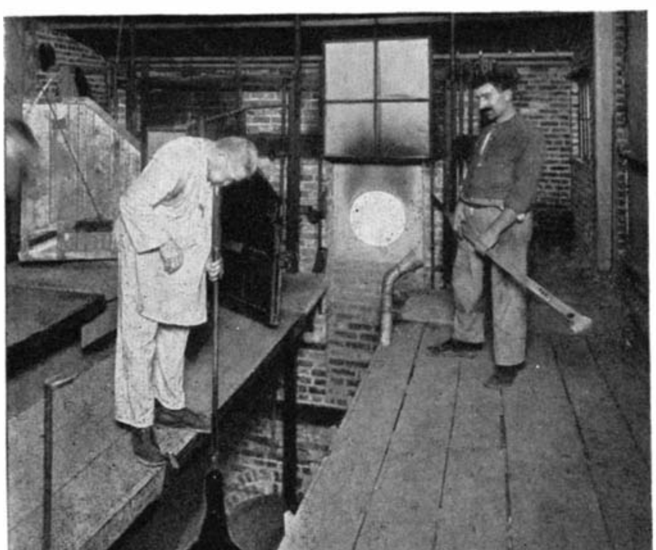
ARMY E NAVY

★ BUY WAR BONDS TO PROTECT YOUR FUTURE ★

Indiana, by Captain Ford. But Ford, who had made an intensive study of glass making in America and abroad, was convinced that plate-glass making in America had a future. With others, he formed the New York City Plate Glass Company, and in 1880 constructed a factory in Creighton, Pennsylvania. This enterprise later became the Pittsburgh Plate Glass Company and the factory at Creighton is now known as Works Number One of that corporation.

Realizing that the success of the company depended upon attaining economy of operations through mass production, its directors energetically commenced the development of machinery for large-scale manufacture. This development in turn led to a tendency to reconstruct the entire glass-making method itself. Until this time, American plate-glass makers had followed European processes and had used European machinery either ready built or made from foreign specifications.

One of the first problems tackled by the Pittsburgh company soon after 1895 was the development of a continuous process for the manufacture of plate glass. The method then in use consisted of melting the raw materials in pot furnaces, pouring the molten glass on water cooled tables made of cast iron, and hand rolling it flat. After these operations, the sheets of glass were manually transferred to fixed lehrs and later transferred again by hand to the fixed grinding and polishing lathes. This



Courtesy Pittsburgh Plate Glass Company

Forming a glass cylinder by lung power, the only method used up to the end of the 19th Century. The helper at the right assisted in handling the cylinder

method was time-consuming. Much labor and time was expended in the work of moving the glass from pot to rolling table, then to lehr, and later to grinding table.

The first step in improving this lengthy process was the invention of a rod lehr to replace the fixed annealing lehr, and in a short time this in turn was superseded by a continuous roller lehr which cut annealing time from a matter of days to hours.

There still remained, however, the laborious and time-consuming job of carrying the sheets of glass from the lehr to the grinding table and later to the polishing table. The solution was found in the installation of conveyor lines. A moving belt of metal table tops was arranged to convey the glass under rotating, grinding, and polishing disks, thus making it possible to grind and polish the glass in a continuous manner. During the years between 1900 and 1920, the continuous conveyor system for both lehrs and finishing processes was constantly improved. This was achieved by further mechanization of the intermediate transfer steps, increases in the size of pots, enlargement of the capacities of lehrs, as well as improvements in grinding and polishing abrasives and in the manner of pouring the melt from the pots.

One gap remained, however, to prevent a continuous mechanical production line from raw material to finished product. This occurred at the point where the molten glass was poured from the pots to the iron tables to be rolled into sheets. In 1921, this gap was bridged. Now plate glass is melted in large continuous tanks and flows from the refining end through a gate over a wide spout in a continuous stream, passing downward along an inclined plane between two water-cooled rollers. It

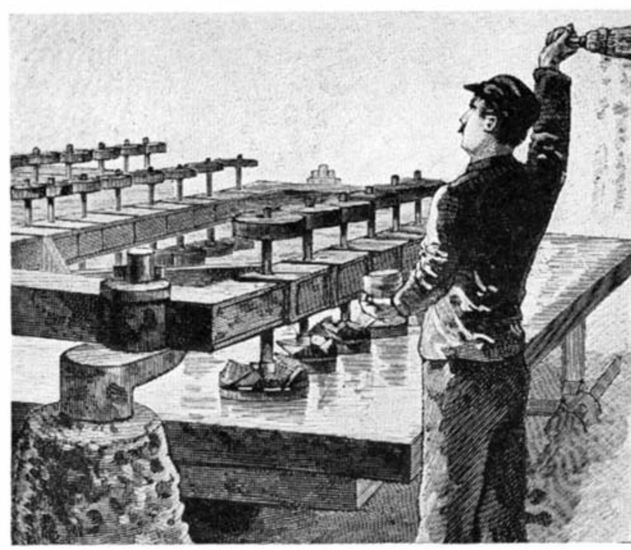


Plate glass polishing in the 1800's. Weighted felt buffers were used and the whole surface of the glass was covered with rouge and water. The table reciprocated

emerges as a flat ribbon of uniform thickness and width and is pulled by multiple rollers through the lehr. It is then cut and inspected before passing into continuous grinding and polishing machines.

Continuous mass-production methods of manufacturing plate glass permit an enormous output to meet the demands of the modern world for clear, strong, transparent glass. Plate glass, once a rarity, is now used everywhere. Prior to 1889, about ten days were required to make a piece of plate glass from raw materials. The time has now been reduced to 22 hours after the raw materials enter the glass-making plant. The greatest size of the sheets is about 127 inches by 286 inches, while the range of thickness runs from 1/8 inch for automobile glass to 1 1/4 inches for the heaviest plate glass.

CONTAINER GLASS—During the years of growth of the sheet- and plate-glass industry in the United States, the manufacture of glass containers was also growing by leaps and bounds. The power behind this growth was the mechanization of the glass blowing process. In 1838 a four-ounce cologne bottle made in a glass factory for the Reeves Drug Store in Boston was first blown in a clay mold and then stuck up on a punty, the shoulder, neck, and finish being shaped by the blower with a pair of shears, the bottle being reheated several times at the furnace while this was being done. A day's work for the blower was 216 bottles and his working day lasted 12 or 14 hours. Today glass blowers turn out as many

bottles in about three minutes, using modern methods.

Mechanization of bottle making received great impetus in 1882 when Philip Arboblast of Pittsburgh invented the first press and blow machine. His conception was later improved in the Teeple-Johnson machine which employed two turrets each carrying three molds. Still later developments lead to fully automatic press and blow machines of all kinds. A typical machine now in use has 12 blank and 12 blow molds all on one table which is operated mechanically. Compressed air actuates a plunger and a vertical camshaft operates timing valves.

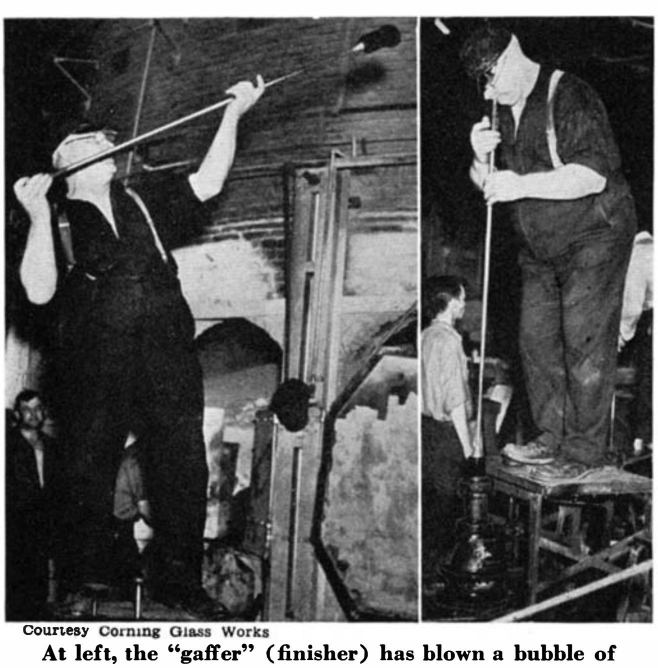
Another of the early steps toward complete mechanization of bottle making was the suction or vacuum gathering device invented in 1899 by Owens. This was first installed on a machine having six arms, each equipped with a mold which, when placed over the rim of a revolving pot of glass, obtained its charge by suction. The gather was cut off by a shear sliding across the lower end of the mold. Individual dip machines with ten sections were later developed. In these, instead of having the whole machine raise and lower itself each time a mold was dipped into the pot, the individual blank mold was lowered as it passed over the pot, much as a horse dips its nose into a watering trough. Although many improved models of the Owens machine have been brought out in recent years, the fundamental principle remains unchanged: a fixed amount of molten glass is gathered by suction. This kind of machine is used to produce about 30 percent of the glass containers made in this country and it has been adapted to manufacturing bulbs and tumblers. A later development was the "gob" feeding device of Peiler, an improvement on the Brooke flowing device invented in 1903. It delivers a large charge of molten glass of predetermined weight, size, and temperature.

In the manufacture of glass specialties, such as tumblers, bowls, and tableware, mechanization, starting with the old side-lever press, proceeded rapidly until today fully automatic machines are used in conjunction with a continuous melting tank, a mechanical feeding device, and an automatic "take-out" for removing the ware.

Another contribution to the increased productivity of glass manufacturing was the development of the paste-mold blowing machine which can turn out as many as 120 40-watt bulbs or 40 tumblers a minute. But the last word in automatic glass working machinery is achieved by the remarkable ribbon machine developed by the Corning Glass Works, primarily for the manufacture of electric light bulbs. Speeds of 400 to 600 bulbs per minute are common and production has been raised at times to 700 per minute.

Courtesy Bausch and Lomb Optical Company

Making pots for optical glass by the old hand method. A newer method involves casting pot material in mold



Courtesy Corning Glass Works

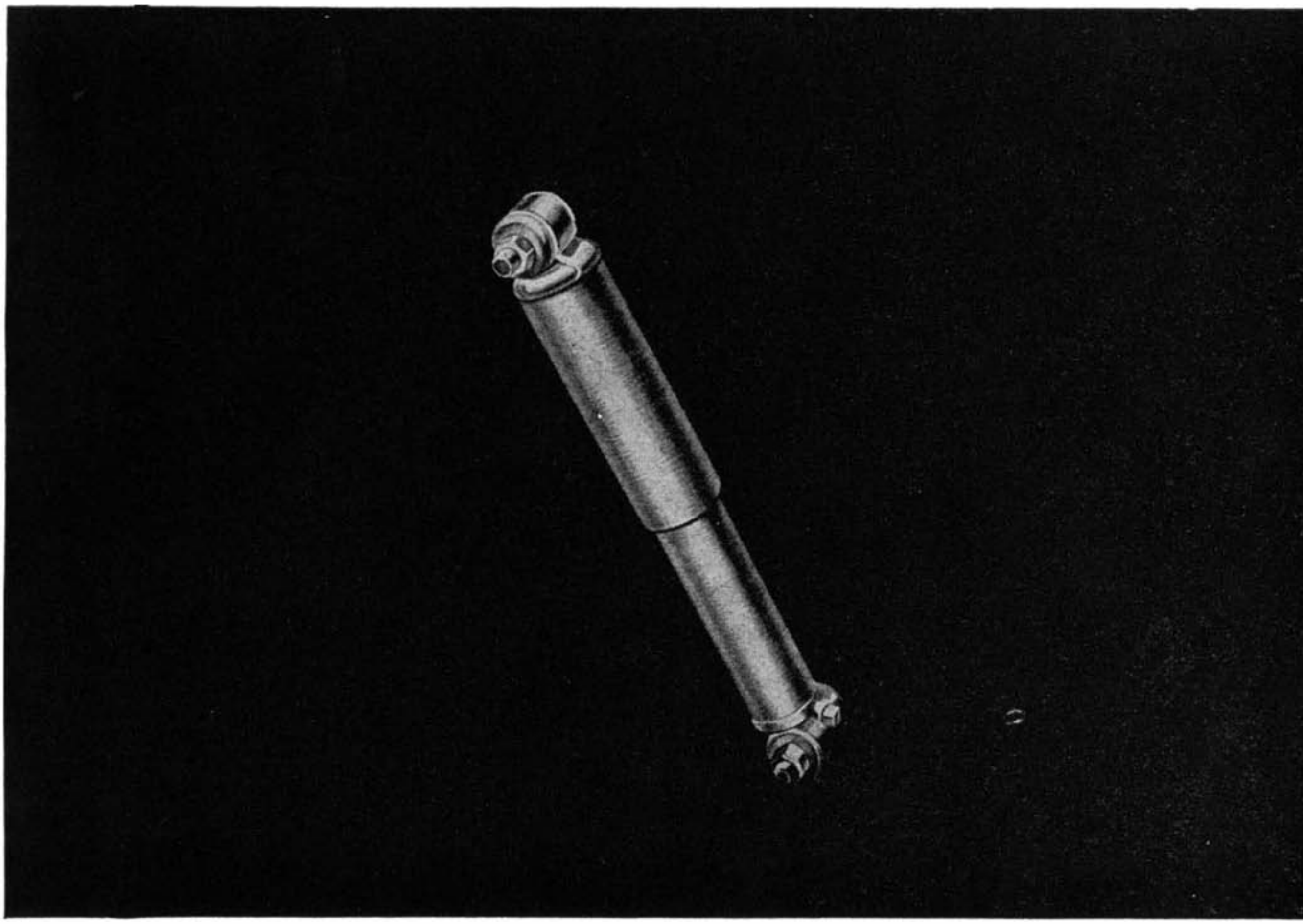
At left, the "gaffer" (finisher) has blown a bubble of molten glass and is shaping it preparatory to the final blowing operation in the mold, as in picture at right

The Corning Glass Works had its beginning in Summerfield, Massachusetts, in 1851, operated in Brooklyn, New York, for a few years in the early 1860's, and moved to Corning, New York, in 1868. One of its earliest advertising signboards modestly proclaimed that it manufactured "plain pressed and moulded glass-ware of every description." By 1879 the Corning plant was producing thermometer tubing, laboratory supplies, and railroad signal glass. That it had an important hand in early research and experimental work is evidenced by the fact that in 1879 a glass bubble was blown for Thomas A. Edison, starting the production of incandescent lamp bulbs which culminated in the automatic machinery described above.

From Corning has also issued much of the heat-resisting glassware so important in industrial and laboratory processes, and equally valuable to the modern housewife in the form of glass cooking utensils. Their research facilities have contributed largely to the production of other glass specialties such as toughened glass, glass fiber, and so on. In 1934 Corning successfully tackled the largest single job in the history of glass-making—the casting of the 200-inch refractor for the giant telescope which, post-war, will make Mt. Palomar the Mecca of astronomers.

OPTICAL GLASS—While the sheet-, plate-, and container-glass industries were growing into maturity in the latter part of the 19th and early part of the 20th Centuries, another important branch of glass technology was struggling to get started in America. This was the manufacture of optical glass.

Eight years before the thunder of the cannon at Fort Sumter announced the beginning of the bloodiest war in young America's history, two German lads who had left their native land to find greater freedom and prosperity in the new world, decided to go into the business of manufacturing eyeglasses in Rochester, New York. They



were John J. Bausch, a trained optical worker, and Henry Lomb, an ambitious young cabinet maker. The business grew rapidly even though Henry Lomb took time off to fight in the Civil War where his bravery and intelligence caused him to rise from the rank of private to captain. By 1875, the demands of the business required the construction of a three-story factory building, and in the same year Bausch's three sons, Edward, William, and Henry, entered the firm. Of these, Edward was most active in developing the manufacturing of optical instruments, and at his death in 1944, after 69 years of service to his company, was regarded as one of the foremost authorities on microscopes in America. One of his outstanding achievements was the pioneering in the application of mass-production techniques in the manufacture of precision optical instruments.

In this he had great success, and his success meant a healthier, more prosperous, and more enlightened America. A measure of his contribution can be found in the fact that six years before Bausch and Lomb began the manufacture of microscopes, in 1870, there were only 50 in the United States; sixty-five years later Edward Bausch presented to the University of Michigan the 250,000th microscope made by Bausch and Lomb. When this company made its first microscopes, a good one cost about $1000. Within a few years, Bausch and Lomb were making a superior instrument that sold for less than $200.

The outstanding achievement of William Bausch was his work in teaching America how to manufacture optical glass. Until the outbreak of World War I, virtually all the optical glass used in America was imported from Europe where the exacting techniques of its manufacture were closely guarded secrets. The attempt of Charles Feil, great-grandson of Pierre-Louis Guinand, to manufacture optical glass in America had fizzled out at the turn of the century and had not been tried by others.

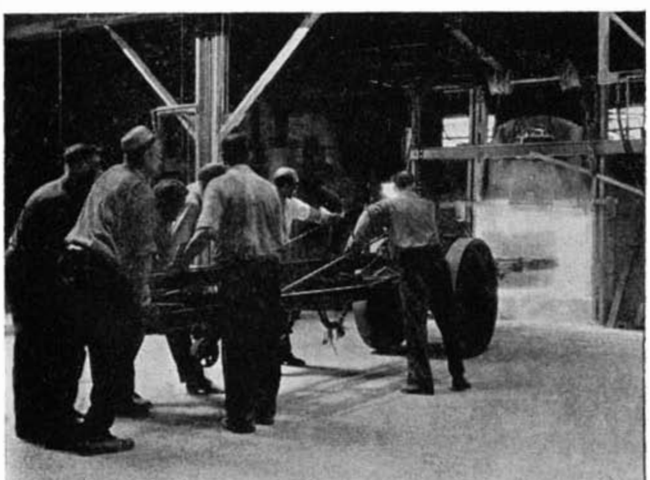
As early as 1912, William Bausch realized how important it was to make optical glass in America in the event that a European war cut off importations, which by that time had swelled to considerable volume. He devoted nearly all his time to the problem of manufacturing high quality optical glass. Laboring with a few enthusiastic assistants William Bausch pushed the work forward despite difficulties and discouragements. Great progress was achieved, however, and by the end of 1916 he and his co-workers produced the first large quantity of optical glass made in America. It was used in several hundred high-priced anastigmatic photographic lenses of a type previously made only from the best imported glass.

The United States Bureau of Standards, the Pittsburgh Plate Glass Company, as well as a number of other glass makers, had produced small experimental quantities of optical glass prior to World War I. When that event occurred, American production of large quantities of optical glass became imperative. It was needed for artillery range finders and many other military purposes. The government mobilized the best glass-making brains in the country, as well as authorities on the properties of light, and sent them to Rochester where, in collaboration with Bausch and Lomb, production of optical glass was enormously increased. By the end of the war, Bausch and Lomb had produced 450,000 of the total of 650,000 pounds of optical glass made for military purposes.

SPECTACLES, PLUS—Back in 1831, William Beecher, a jeweler decided to go into the business of manufacturing spectacles in the little town of Southbridge, Massachusetts. From this modest beginning grew an industry that was to make this small town into one of the great optical centers of the world. For 30 years Beecher's business grew slowly, reaching an important milestone in progress when, in 1864, George W. Wells joined with him as an apprentice. By 1869, through the initiative and vision of Wells, the business was incorporated under the name of American Optical Company. To the work of the company Wells applied modern production methods and changed the manufacture of spectacles from a slow hand operation to what is today a speedy machine process.

In 1891, three sons of George W. Wells—Channing, Albert, and Cheney—entered the service of American Optical Company and ably forwarded its activities until they now span the entire nation and its products include not only eyeglasses but innumerable types of precision optical instruments. It may seem odd that this important company in the optical field makes no glass on a commercial scale. Yet its influence on optical glass practice has been enormous. From its research laboratories have come a broad range of improvements and developments in glass technology and applications. Today all the glass used by American Optical Company is made to its specifications by Pittsburgh Plate Glass Company.

Side by side with American Optical, in point of time, grew the Spencer Lens Company, which had its genesis in the work of Charles A. Spencer who, about 1838,



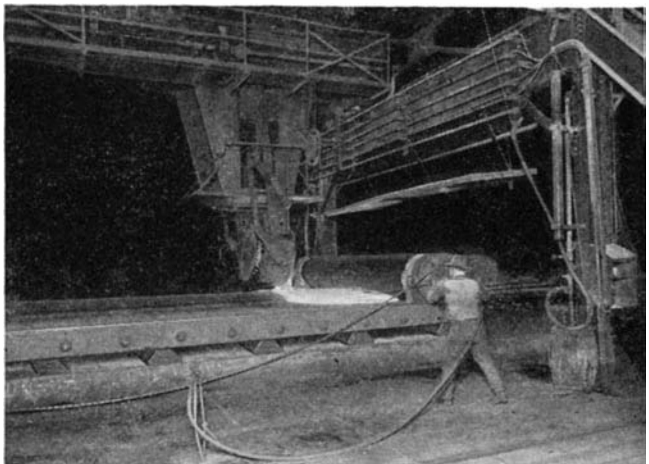
Courtesy Bausch and Lomb Optical Company

A hand truck of the vintage of 1917, used for handling optical glass pots, required services of seven men

A modern pot-handling truck rolls on pneumatic tires, is completely mechanized, and is operated by one man

set out as a manufacturer of telescopes and microscopes. For many years, with the assistance of Robert B. Tolles and later of his son, Herbert R. Spencer, he pioneered in the design and manufacture of fine microscopes and microscope objectives, bringing to America a leadership in this branch of science in which glass plays so great a part.

Spencer Lens is linked here with American Optical Company because, in 1935, the Spencer organization was



Courtesy Pittsburgh Plate Glass Company

Casting plate glass by the old pot method. The molten glass was conveyed by a crane from the furnace, dumped on the metal table top, and flattened. Modern plate is manufactured in one continuous operation

added to American Optical in order to round out the line of ophthalmic and optical products, and, in 1945, became known as the Scientific Instrument Division of the American Optical Company.

GLASS TODAY—The years immediately preceding World War II saw the uses of glass proliferating at an astonishing rate, spreading into every phase of American life. Factory and office buildings, homes, schools, theaters, and stores were erected in which glass in some form or another took the place of opaque walls of masonry. Glass block was used in walls and partitions and colored glass in facades, windows were of double glass and plate glass, while tempered glass doors and skylights and partitions of fire-resistant wire glass all came to be more and more widely employed. The use of great expanses of plate glass in shops and other retail outlets revolutionized the art of merchandise display and store design during the decade of the 1930's. Shatter-proof glass came into wide use in modern automotive vehicles, reducing the danger of serious injuries from flying glass in accidents. In the home, heat-proof glass cooking utensils added a new dimension to comfortable living.

In electricity, also, glass has found many uses. Because it is a homogeneous, non-porous material, smooth, hard, and highly resistant to weathering and other kinds of chemical attack, and at the same time possessing high electrical resistivity, it has found wide application in high-tension insulators. Then there is that staple of modern civilization, the incandescent lamp. Millions upon millions of them are in use, all made of glass. One company alone, the Corning Glass Works, manufactures at least 880 different sizes and shapes of bulbs. The growing popularity of fluorescent lamps and neon tube lighting has caused an increase in the manufacture of glass tubing, specially designed for this kind of illumination. In medicine and industrial research the uses of glass apparatus are virtually limitless. Much of this glass equipment is individually designed and manufactured for specific tasks.

Fiberglas, as manufactured by the Owens-Corning Fiberglas Corporation, is a form of glass that can be bent like rubber, twisted like thread, squeezed like a sponge. It has high temperature resistance and also resists the corrosive effects of acids. It is finding wide use in industry as an insulating material while in medicine it is speeding the treatment of dangerous burns and other injuries.

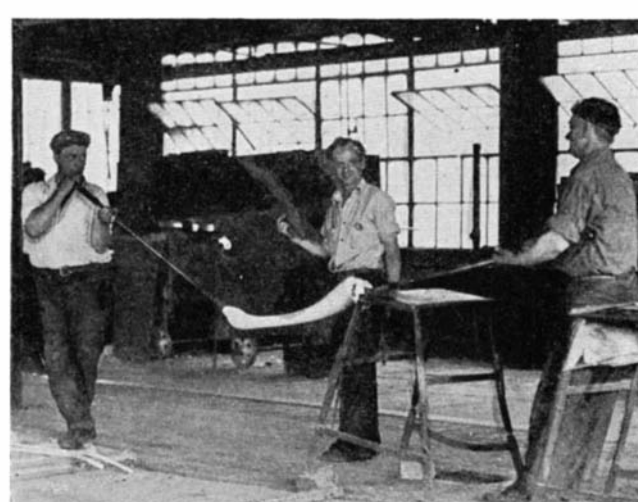
Another development of recent years, Polaroid glass, a product of the Polaroid Corporation, has found application in many forms to protect human eyes from the harmful effects of glare.

THE WAR AND AFTER—America's entry into World War II expanded enormously the demand for optical glass and glass for scientific and medical purposes. Shortage of metals for food containers caused food packers to turn to glass for packaging their greatly increased output of prepared foods. A nation hell-bent on victory gardening and home canning demanded glass containers. The industry met the test.

War-time production of optical glass at the Bausch and Lomb plant shot up to 1200 percent of the pre-war level. Since Pearl Harbor, five million pounds of optical glass has been made there, consuming upwards of 31 million pounds of sand and other raw materials. From this glass has been produced over 100 million pressings for optical elements. They have gone into an immense variety of instruments used in the armed forces of the United States and her allies.

The flat-glass section of the industry has been turning out bullet-resisting glass for tanks and planes. The manufacturers of all kinds of glass containers produced far more bottles and jars than they ever had thought possible. Glass containers were put to an increasing variety of new uses, and many of these uses will stick even when materials now scarce are available once again.

When the war finally ends, the glass industry will stand at the beginning of a period of unlimited expansion. In the 20th Century the difficult problem of glass production on a large scale has been overcome, and in the future, glass, in many new and more durable forms, will come into its own. America is on the threshold of an age of brightness, an age of cleanliness, an age of glass.



Courtesy Corning Glass Works

Drawing glass tubing by hand, a method still in use for certain drawing jobs. The man in the center "fans" the glass to cool and prevent it from sagging

Cutting Oil Comes Back

Plain Water, Water-and-Oil Mixtures, and Straight Oils All Have Helped to Speed Machining Processes and Make Them More Accurate. Every Time Tool Materials Changes Seemed to Point to the Possibility of Eliminating Cutting Oils from the Machine, It Was Found that Better Work Could be Accomplished by Keeping Them on the Job

ONE OF the fondest hopes of many machine-tool designers and tool-materials metallurgists has been to get rid of any need for cutting oil, or at least to reduce it to the ranks as a mere "coolant."

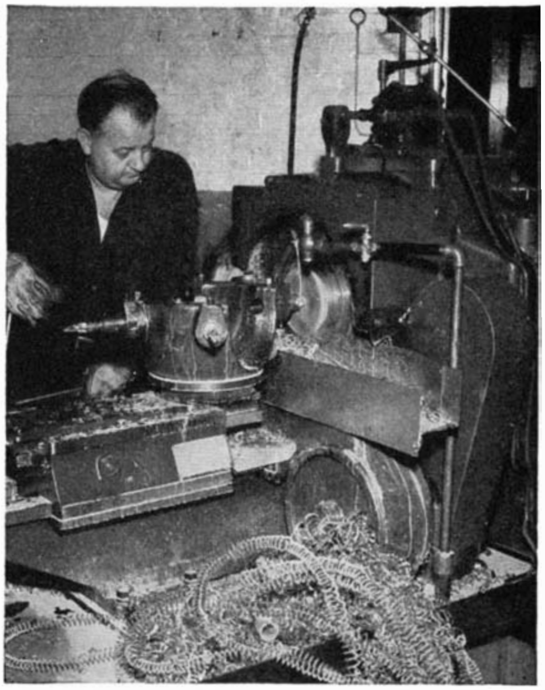
No machinist ever has genuinely wanted the stuff on his machine. Back in 1880 when Taylor (the father of methods engineering) cooled the carbon-steel tools on a lathe by flowing a stream of cold water on them, his idea was called a "stunt" and a "threat to the ancient art of machining." The trouble with the objections was that Taylor managed to increase machining speeds by 80 percent when he cooled his tools. And, of course, no manufacturer could run machines at any slower speeds than Taylor did and remain in competition.

High-speed tool steels came along in the early 1900's. Here were tools that would stand much higher cutting temperatures than the old carbon steels. In fact, the high-speed alloys were inferior to carbon steels unless the cutting speeds and stresses were high enough to generate working temperatures above those which carbon steels would stand.

Quite a few tool engineers read coolants out of the picture right then and there, but their hopes were short lived. High-speed steels would do plenty without coolants, but would do ten times more with them.

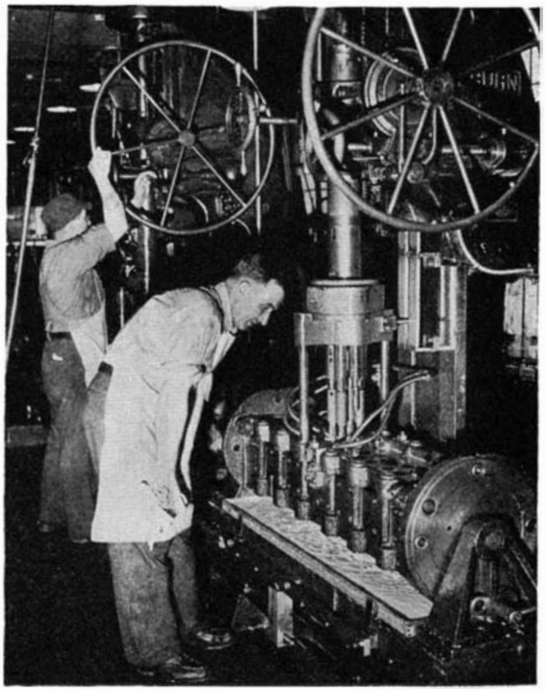
In the meantime, tool engineers had been experimenting with coolants. They mixed soda with the original plain water and cut down the rust problem which the water had brought to the machines and the finished work. They tried lard oil and found that any oil which contains fat, whether made from animals, vegetables, or synthetically from coal or petroleum, would do wonders in helping the tools to cut sharper threads, more intricate forms, and smoother surfaces in general. Nobody knew why the fatty oils had this quality for making machining more accurate, and, strange to say, nobody yet knows. But the fatty oils enabled machines to do better work at higher speeds, and they stayed in the machines.

During World War I the cobalt alloys for cutting tools came into common use. Here were tools which did their best work when red hot. In fact, their one fault was that they were too brittle until they reached red-hot temperatures. And when, in the 1920's, the tungsten and the



Cutting oils of all-around types work with nearly any tool and increase the versatility of the versatile turret lathe

A flood of emulsion forces out chips, improves finish, holds accuracy high, and increases the work speed



tantalum carbides (which would work when either cold or red hot) came in, cutting oils seemed to be on their way down if not out.

CHATTER-FREE — Machine-tool makers again got ready for a brand new era. They made their machines stiffer because the carbide tools will break if heavy cutting loads cause the vibration known as chatter. They sought out the causes of chatter, found that it always vibrates in the sonic frequency of some part of the tool mounting or of the machine. They used stiffer metals here, higher accuracies there, ribs and reinforcements in other places. But strengthen as they would they still found that machine tools could be chatter-free at higher speeds and on tougher jobs only if they used cutting oils. So thoroughly was this learned that the Carboloy Company (makers of tungsten carbide tool tips) has issued some of the most informative and intelligent data on how to feed cutting oils to the points of work.

Cutting oil was still proving its case, all right. But the users of carbide tools seemed to need only water mixtures of it, with the mixture often containing only one part of oil to 20 or even 80 parts of water; 100 to one mixtures were not unknown. As had been the case with Taylor away back in 1880, it was the water which did nearly all of the cooling. Oil and a few chemicals were in the mixture mostly as rust preventives; a thin film of the oil would cling to the finished work pieces and prevent them from corroding while in storage waiting for the next operations on them, and this same oil would protect the machine.

Grinding increased in use as a secondary operation also. A high proportion of finished steel pieces had to be heat treated to increase their hardness and toughness. It seemed easiest to machine them to quite accurate and fairly rough surfaces, then harden them, and later grind them to remove not only the roughness left by the machining but also to correct any roughness and distortion imparted by the heat treatment. Grinding machines seemed to get along very well with coolant mixtures which started at 40 parts of water to one of oil for the heaviest work and were made thinner as the grinding cuts became lighter.

NEW FACTOR—All of this seemed to mean that cutting oils were becoming mere coolants which could be bought on price and dismissed with a wave of a splash guard as serious factors in the world of machine-tool operations. But a new factor was coming into the picture. Machine-tool users wanted to machine harder and harder metals, at higher and higher speeds, and with greater and greater accuracies.

They soon were taxing the new found strengths and power capacities of their machines to the utmost limits. And then the cutting oils began to repeat their oft told story. Far tougher alloys could be machined with them than without them, and at far higher speeds.

Machinists found that they could cut steels so hard and tough that for many purposes no further hardening was needed. But they still had to have their high accuracies. They began using more of "straight" cutting oils (straight cutting oils are not mixed with water) and getting their accuracies. By 1940 many a finished piece was being made more accurate in dimensions and with smoother surfaces on a lathe or an automatic screw machine than had been produced by hardening and grinding only a few years ago.

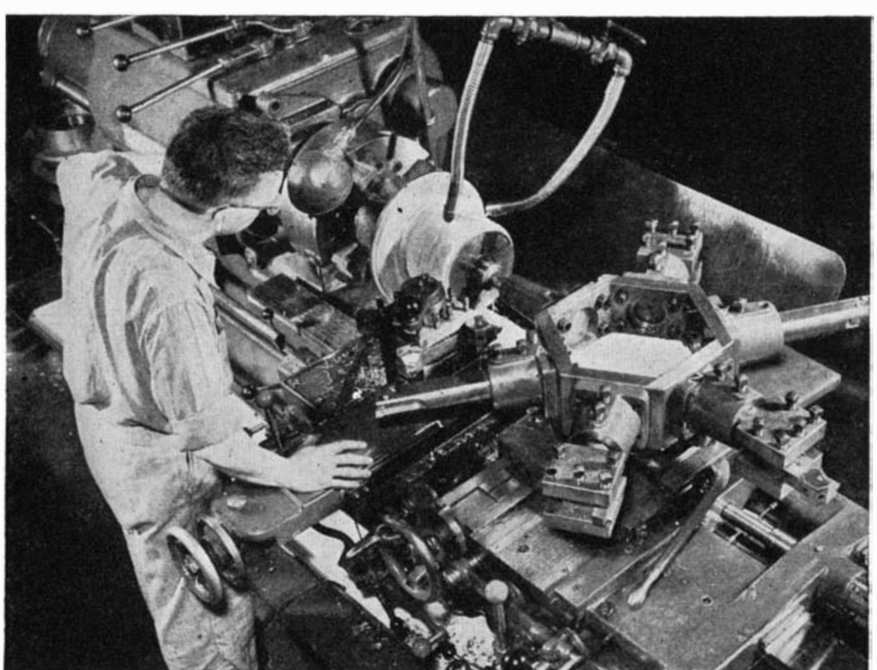
This did not put the hardening furnaces and the grinding machines out of work. The steel heat-treaters quickly pointed out that the distortion in hardening, and many another hardening trouble, could be reduced if the original machining was more accurate. They began the modern methods of "predicted distortion" by which a piece that is machined very accurately to one set of dimensions can be so hardened and toughened that it will come out of the quenching tanks just as accurate but to slightly changed dimensions.

The grinders in turn showed that with more accurate original machining and more accurate hardening of extremely hard and tough steels the grinding operations could be made to produce accuracies which were undreamed-of a few years ago. After all, no outright metal cutting operation ever can attain the accuracies of grinding, lapping, and honing. And, in addition, the grinders could grind more intricate shapes than had been previously considered practical, and could grind them at very high speeds.

It was this combination of extremely hard and tough metals, machined to high accuracies, hardened to just as accurate dimensions and then ground to exquisite accuracies, which brought the modern airplane, automobile, television transmitter, and machine tool into being. Strength comes from toughness and hardness of material, but it is greatly promoted by accuracies of dimensions and finishes. Increase the accuracies and the sizes and weights can be reduced. Light weight, so badly needed by some devices, comes largely from increasing the strengths and thereby decreasing the necessary sizes of their parts.

In studying ways and means for making their processes more useful the grinders found that they, too, needed better cutting oils.

CONSTANT TEMPERATURE—The original water mixes of cutting oils for grinding had been based upon the belief that water, having more heat conductivity than oil, would keep the work cooler, and cooling is

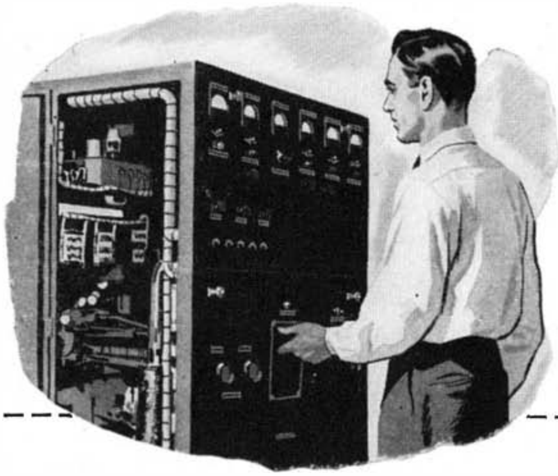


Courtesy Gisholt Machine Company

Cutting oil keeps work cool for accuracy, tool cool and lubricated for long life

In a test cell an ENGINEER studies the performance of a jet-propulsion engine that is expected to produce greater thrust—*for its weight*—than any made in America.

... the name on the J-P ENGINE is Westinghouse.

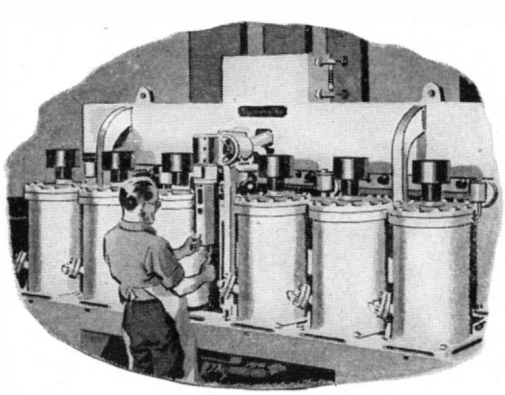


In a synthetic rubber plant a CHEMIST uses a mass spectrometer to analyze a complex gas mixture by sorting its molecules—reducing analyzing time from *days* to a matter of *minutes.*

... the name on the MASS SPECTROMETER is Westinghouse.

High in the air a SCIENTIST adjusts a fulchronograph which accurately records the *intensity* and *duration* of thunderbolts—in the never ending study of improved protection against lightning.

the name on the FULCHRONOGRAPH is Westinghouse.



In a refining plant a METALLURGIST uses an Ignitron* rectifier for the more efficient conversion of alternating to direct current—in producing vast quantities of aluminum for our war effort.

... the name on the IGNITRON RECTIFIER is Westinghouse.

*Reg. U. S. Pat. Off.

Westinghouse
PLANTS IN 25 CITIES — OFFICES EVERYWHERE

TODAY — Westinghouse war products are making vital contributions to final Victory over our enemies in the Far East.

TOMORROW — Peacetime products . . . backed by Westinghouse research, engineering and precision manufacture . . . will contribute to greater efficiency in industry and better living in our homes.

Tune in: JOHN CHARLES THOMAS — Sunday 2:30 pm, EWT, NBC • TED MALONE — Monday through Friday, 11:45 am, EWT, Blue Network important. If the work gradually increases its temperature as it is ground, then it also will increase its dimensions, with the result that when it cools again some parts will have had more metal removed from them than others and the work will be inaccurate. Grinding machines have means to compensate for this, but in spite of the best devices the most accurate grinding at the highest production speeds can be done only when the coolant is effective enough to keep the work close to constant temperature.

Superior as the water mixes might be as coolants, the straight oils also had an advantage. Their superior lubricities (abilities to lubricate) cut down the friction between the grinding grits and the chips and the metal right at the points of work. And it is more important to prevent heat than to remove it, since some of the generated heat is sure to go into the work pieces and change their dimensions.

Straight cutting oils soon took over much of the thread grinding and extremely accurate form grinding, and their use on less intricate shape grinding is being increased because fewer "grinding cracks" are produced with them. Grinding cracks are fine fractures on the surfaces of finished work. They are so tiny that a magnifying glass may fail to pick them out, but the magnaflux test will find them, and they result in rejections of parts since they can cause those parts to fail in service.

While extra tough, extra accurate materials-machining was bringing back the cutting oils, plenty was happening in other and closely allied fields.

It has long been known that at highest cutting speeds steel chips will actually weld themselves to tool steels. There is plenty of reason why they should. The temperatures at the heavy pressure areas of the chips on the tools can go well over 1000 degrees, Fahrenheit, with the pressures at those points in excess of 400,000 pounds per square inch.

ANTI-WELDANTS — Nobody can prove that any oil does any actual lubricating at those pressures and temperatures. But the cutting-oil makers put such anti-weldants as sulfur and chlorine products into their oils and stopped the welding. They found out that much of the welding had been invisible and undetected, that tiny bits of the chips had welded themselves to tiny areas of the tools and then under the pressures of the moving chips had broken off those tool areas and carried them away. The results had been rapid tool wear.

With that chip welding stopped, cutting became more rapid and accurate. Studies which still are going on will make it even better.

It was found that under extremely heavy cutting pressures bits of some kinds of metal actually built themselves up on the cutting edges or "noses" of the tools. These "built-up" noses do not do the cutting—the tool alloy still does that—but they cushion and protect the tool. They also reweld themselves to the moving chips and are carried away, thus having to be replaced by more build up.

Modern studies are showing how to apply cutting oils so that the build up always will be constant, always the exact amount which will best protect the tool, while maintaining the highest cutting speeds and accuracies. What the results of this research will lead to, nobody knows. How soon the machinists and the cutting oil makers will make soluble oils do everything that straight oils are doing today, and drive straight oils on to new fields, nobody knows. But cutting oils, once seemingly on their way out, are still in the picture and here to stay.

FIRE ALARM

Can Warn of Incipient Danger

Coming over the industrial horizon is a fire alarm which will detect a fire by the heat rays given off. The alarm, as announced by the National Board of Fire Underwriters, can have its sensitive or detecting element as much as 100 feet away from the fire. Once actuated by the heat rays it can sound an alarm bell, actuate a circuit which will warn the factory or the municipal fire department, or turn on a sprinkler head or shut off a machine to stop the danger.

Better still, such an alarm can be arranged to warn of incipient fires long before the blaze actually begins.

Radiant heat, especially if emanating from a black body, can sun-burn a man even though the emanating object is cold enough so he can easily bear his hand on it. And, from a great many objects, radiant heat may be detected long before they reach the combustion stage.

Burning is a type of chemical change which can take place slowly at temperatures far below those of actual combustion. The rate at which this change takes place in ordinary combustible materials doubles for just about every 18 degrees, Fahrenheit, of temperature. The approximate increase in this rate is shown in the table.

Rate of chemical change involved in the burning of ordinary combustible materials, with ordinary room temperature of 68 degrees, Fahrenheit, taken as unity

Degrees Fahrenheit	Rate Of Increase
68	1
86	2
104	4
122	8
140	16
158	32
176	64
194	128
392	262,144

A chemical change of this type tends to generate heat as well as be promoted by heat—a phenomenon aptly illustrated by the well known spontaneous combustion of oil soaked rags.

As the temperature rises, the tendency of the material to be damaged by the chemical change also will rise. Therefore temperature alarms which are actuated by heat radiations or by any other means such as thermometer bulbs are highly valuable in protecting materials in storage, process materials in vats, and the like. Moreover, the value of air conditioning in holding down damage to some stored materials is emphasized.

OIL QUENCHING

Made More Controllable With Additives

In the past, any engineer who had an exacting heat-treating operation to perform had his choice of two quenching mediums. He could quench in water and get such rapid cooling that he wrecked the steel, or he could quench in oil and get too slow quenching for the results he wanted.

Additives mixed with the quenching oils are ending this problem. With them the oil can be given any cooling ability (quenching speed) between that of ordinary oil and that of water, or can be made even slower than ordinary oil. Moreover, the oil blended with additives is far more uniform in performance and lasts much longer without changing its characteristics.

Plastics Sandwiches

Laminated Structures, Made of Glass Cloth Combined With Synthetic Resins, Have Proved Practical for Aircraft Sections. New Production Techniques Have Been Evolved Which Presage Wide Use of these Glass-Plastics Sandwiches in Many Industrial and Domestic Applications

A COMBINATION of plastics and glass broke into the news as a successful structural material a little over a year ago when engineers of the Air Technical Service Command at Wright Field announced the development of an experimental laminated resin-impregnated glass cloth sandwich fuselage for a BT-15 airplane. But from the point of view of the Army Air Forces there was one outstanding objection—the part employed a balsa wood core.

In contrast to the British, who used a completely wooden sandwich—a 7/16-inch balsa core faced with 3/32-inch birch plywood—for the DeHaviland Mosquito, the United States Army Air Forces have always considered wood a marginal material for combat aircraft which must operate under extreme weather conditions. Thus, with the wooden skin of the sandwich replaced with impregnated glass cloth, there remained the problem of finding some material to substitute for the wooden core.

The primary function of a core material is to stabilize the thin high-strength faces of a sandwich structure so that they develop a substantial portion of their ultimate compressive strength without buckling. What was needed was a low-density synthetic core with adequate strength, low moisture absorption, and dimensional stability—a material whose density and properties were uniform and controllable in manufacture.

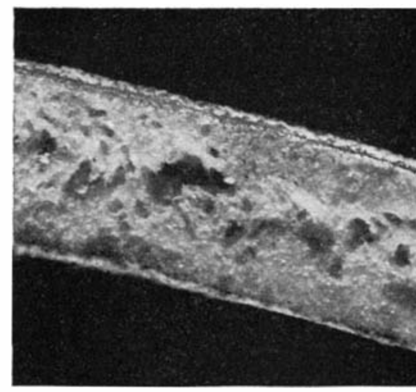
In the search for a core material which would meet these requirements, the Air Technical Service Command at Wright Field carried out a series of tests on a variety of cores which fell under the following eight general classes:

1. Foamed thermosetting (phenolics, ureas, or copolymer) resins.
2. Foamed thermoplastic (cellular cellulose acetate, polystyrene) resins.
3. Foamed rubbers.
4. Foamed glass.
5. Foamed calcium alginate.
6. Gridded cores (honeycomb or square filled grid).
7. Impregnated fibrous cores.
8. Natural (balsa wood or cork).

The core they sought had to be strong enough in tension, normal to the surface, so there was no buckling of the glass fabric faces through tension failure in the core itself. Further, compression strength of the core material normal to the faces had to be sufficient to resist local loads usually encountered in service due to rough handling, such as a blow resulting from a falling wrench. Compressive strength needed to be such that the core would not fail before the faces of the laminate developed their maximum strength. Finally, the shear rigidity of the core had to be enough to hold the entire sandwich combination stable before the faces developed their full strength. At the same time, the core could not be brittle or granular since such materials possess poor impact and vibration characteristics.

Construction material	Weight	Effect of 100 percent of design loads	Design load at failure (tail wheel side load)	Strength-weight ratio
	pounds		percent	
Aluminum alloy	70	No failure—visible buckling in some cases	105	1.00
Wood and plywood	86	No failure—visible buckling in some cases	110	0.82
Glass cloth laminate with wooden core sandwich construction	78	No failure	180	1.50
All resin-glass cloth laminate sandwich construction	75	No failure	180	1.55

Tabulation of results of static tests on airplane fuselages



Highly magnified view of section of a sandwich structure made with a foamed core. The high percentage of voids in the foamed resin is clearly evidenced

TEST RESULTS—Compressive tests, tension tests, tests to determine relative flexural rigidity and ultimate strengths, and bending tests were carried out on specimens made up with cores falling into all eight classes listed above. The compressive stress developed in the glass-cloth facing material ranged from 8000 to 36,000 pounds per square inch, depending upon the core material and the thickness of the faces. Certain brittle cores such as alginate, which had reasonably high tensile strength, failed prematurely before developing maximum strength in the faces. Bending tests indicate that with cores of comparable properties, the strength and stiffness of the sandwich combination are more dependent upon the physical properties of the core itself. All bending failures occurred in the compression face either by compressive failure of the face or by delamination (tension failure of the core).

Tests seemed to show that certain types of cores such as the Hycar cores, honeycomb glass cores, and cores of cellular cellulose acetate containing 3 percent chopped glass fiber had sufficient physical properties to develop a substantial portion of the compressive strength in Fiberglas cloth faces.

One of the results of this investigation was the construction by the Plaskon Division of Libbey-Owens-Ford Company, at the request of Wright Field, of an all-laminate rear section of a fuselage. Tests carried out on this structure and on aluminum alloy, wood, glass-laminate, and wood fuselages are compared in the accompanying table on the preceding page.

Four types of laminate construction were employed in this experimental fuselage, which was constructed in halves and then assembled. This two-part construction was followed, not because it was considered the most desirable procedure, but because a full fuselage mold was not available.

STRUCTURAL ADVANTAGES—The outstanding strength-weight ratio of this all-laminate construction, its smooth exterior surface, and extreme stiffness suggest that it will someday find extended use in the aircraft field. Aircraft designers have long recognized that substantially increased performance can be obtained if the exterior surfaces of aircraft can be made smoother and more stable. And when a structure is developed which not only offers these advantages but is adaptable to mass production as well, the possibilities are endless. Among the construction advantages which an all-laminate structure would seem to offer on the basis of the experimental fuselages built to date are:

1. Prefabrication — Component parts may be readily produced in widely separated plants and assembled as a complete structure in yet another factory.

2. Mass production — Sandwich core material may be readily corrugated and assembled, and cheaply produced with semi-automatic machinery in any desired weight and thickness.

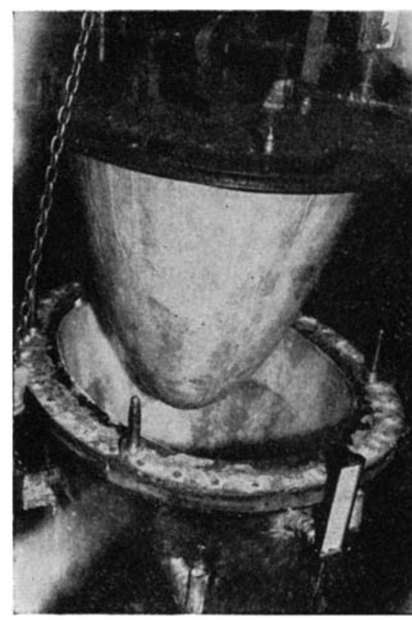
3. Uniform results—Easy cure of the resin coupled with its tackiness makes it possible for the core, skins, and sub-assemblies to be easily placed and held in position. This also guarantees consistent production results.

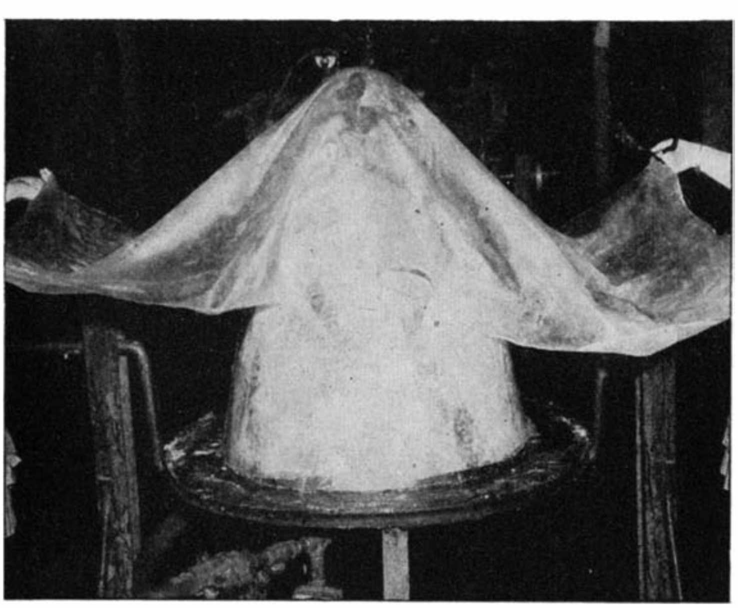
4. Easily repaired—Damage by gunfire, for example was less for all-laminate construction than for either wood or metal. Another advantage is that repairs may be quickly carried out with no more equipment than is available in the field.

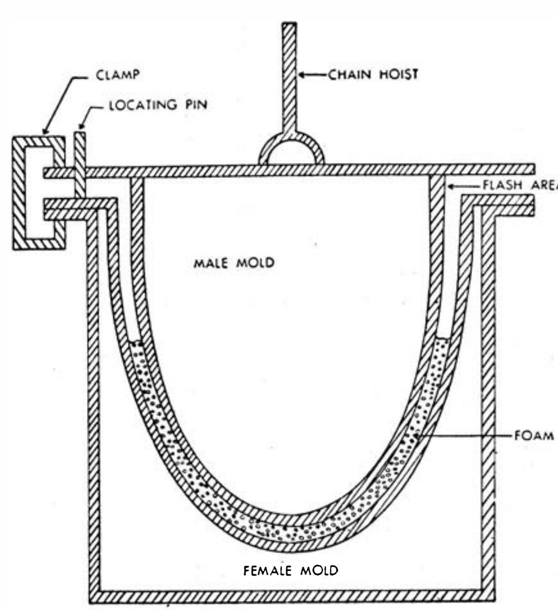
5. Material availability—The production of both the resin and the glass cloth, which is the basis for the all-laminate construction, can be readily expanded to meet all conceivable demands.

FOAMED CORES—All the tests which have been made on these sandwich structures with synthetic cores have not been confined to the laboratory. The Virginia-Lincoln Corporation, for example, is even now producing noses for fast fighter planes made up of plastic foam enclosed between inner and outer laminated glass cloth skins. For this application it was particularly important that the core have a specific gravity of 0.30, excellent weathering and electrical characteristics, and resistance to destruction caused by gun blast concussion. To date, the structures, which are made of Valenite using Laminac as the core resin, have met all the requirements very satisfactorily.

Following the step by step construction of one of these fast fighter







Lower left: Applying resin impregnated cloth and paper upon surface of mold to form inner skin of nose

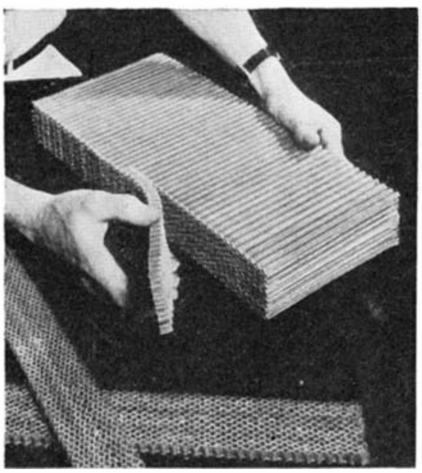
Right: With outer skin in position in lower mold, upper mold with the inner skin attached is lowered into place ready to receive foamed resin

Lower right: Section drawing showing mold in a closed position with foam filling the space between the skins

Illustrations courtesy of the Virginia Lincoln Corporation

noses suggests how adaptable this type of structure is to mass production. It is easy to imagine how this construction can be used after the war in the manufacture of low-weight furniture, refrigerator boxes, stoves, household insulation and, of course, aircraft..

For the manufacture of the fighter noses the equipment consists of cast-iron male and female molds, the contours of the male form exactly duplicating those of the female minus the thickness of the wall of the completed nose. A spacing mechanism is provided to facilitate the locating of the male form in the female form. As can be seen in the drawing, there is a flash area between the two molds at the top. This is provided so that pressure generated during the foaming operation can be relieved. In addition there are clamps which hold the molds together, a resin mixing unit, a trimming jig, and a thin laminated canvas male plug used in making the outer skin.



A honeycomb core material such as is used in many sandwich-type structures. Made in blocks, cores can be sliced to suit requirements of any type of job

The manufacturer of the nose begins with the skins. The male form and the wrapping plug are inverted (nose-up) and covered with cellophane, which facilitates parting. The necessary lamination of impregnated paper and glass cloth for the inner skin are wrapped on the male form which is then covered with another layer of cellophane. To insure more uniform evacuation during the curing operation, a thin canvas bag, or "breather," is placed over the entire assembly. This construction is then covered with a rubber bag, properly sealed to permit evacuation. Upon the application of heat, through the mold, the inner skin is cured. Removal of the rubber bag, the canvas breather, and the top cellophane layer follows, exposing the cured inner skin laminate.

At the same time that the inner skin is being molded, the outer skin of impregnated paper and cloth laminations—is wrapped upon the cellophane-covered wrapping plug. Another layer of cellophane follows as with the inner skin. This done, the plug and the uncured skin are inserted in the female mold. The plug is removed, leaving behind the outer skin in proper place in the female mold. A rubber bag is inserted in the mold and the sealing lid put in place. With the application of heat, vacuum, and pressure the skin is then cured. Finally, the rubber bag and cellophane layer are removed, exposing the inner surface of the outer skin.

At this stage, the portions of the mold are readied for foaming. The male form is elevated with a chain hoist and placed in the "nose-down" position above the female form where, by rapid lowering, it can properly locate itself in the female form for the foaming operation.

The various components of the foam resin mixture are weighed out and cooled to a safe operating temperature. Next, they are carefully combined in a Hobart-type mixer. Within five minutes' time, a homogeneous mixture results.

With the molds ready, the foam mixture is poured into the female portion. Guided by the spacing mechanism, the male mold is lowered into position and the molds locked together. Within three minutes of the application of heat, the excess foam material starts escaping via the flash areas. Fifteen minutes later the curing is complete and the molds are cooled.

After the male mold has been raised, the foamed nose, which is securely bonded to its skins, is lifted from the female form and sent to the finishing area for trimming and painting. Due to the fact that this particular part requires a reinforced area for attachment to the airplane fuselage, portions of the foam and inner skin must be trimmed away and the inner surface of the outer skin exposed. "Beef-up," or reinforcing material, which consists of uncured impregnated glass fabric, is bonded so as to cover the section of foam which has been exposed. Curing of this material follows. Rough edges are then sanded away and the nose is sent to the paint department to be prepared for shipment.

The principles outlined in the manufacture of this nose are applicable to other items. The same general procedures were found to prevail in parts where specific gravities ranging from 0.20 to 0.80 were desired, where bearing and flexural strengths were stressed, where surface areas of 50 square feet and more were required. The desired properties were obtained primarily by foam formula variations; secondly by changes in equipment.

While all the work that has been carried on in developing suitable synthetic core material for use in glass-cloth sandwich structures has been for war, all indications point to the use of this type of structure in endless post-war application. Among these are such household items as stoves, refrigerators, and unit bathrooms and kitchens. The aircraft industry will undoubtedly find extended use for the construction. At the moment it is hard to say just what are the limits for these synthetic core materials for sandwich structures, or for the sandwich structures themselves.

EAR PLUGS

Reduce Annoying Noises, Permit Conversation

INDUSTRIAL workers stand in constant fear of becoming deaf as a result of the constant loud noise that fills their working hours. To combat this hazard, John L. Brill and Associates has developed "Noise Masters" ear plugs, molded of Lucite. These plugs, which are fitted to the individual ear, are said to reduce the loudness of surrounding noises as much as 45 percent when the sound is in the low frequencies and as much as 65 percent when in the high frequencies. At the same time, it is reported, ordinary conversation at close range can be heard without difficulty.

BATTERY SEPARATORS

Now Made in the Form of Fiberglas Mats

FELTED Fiberglas is now being used in low-cost batteries of various types manufactured for Goodyear Tire and Rubber Company by the National Battery Company. In one model the felted glass fiber mats are placed on each side of every positive plate; in another model similar mats are wrapped entirely around each of the positive plates. The mats are made of finely spun glass fibers held together with a binding agent. Pores of the mats provide minute indirect openings, so small they permit passage of only very small spent articles of active material. Because active material is locked in the plates, the life of the battery is reported to be greatly extended.

Gas Turbine Possibilities

Will Airplanes of Tomorrow be Powered by Reciprocating Engines, by Turbo-Jets, by Turbines Driving Propellers, or by Some Combination of these Systems? Analysis of Present Technology Indicates that Each System Will Find its Place in Meeting the Varied Requirements of Flight

If the Germans had had six months more to put into production their V-1 and V-2 bombs, their airplanes equipped with rockets, and the turbo-jet, the whole course of the war might have been changed; the victory of the United Nations might have been indefinitely delayed. In the peace to come, it is probable that the turbo-jet (and, therefore, the gas turbine which is an indispensable element of the turbo-jet) will have, of these novelties, the greatest influence on modern aviation.

Within the last few months, there have been at least three fine papers on the gas turbine and its use in the airplane. S. R. Puffer and J. S. Alford, of General Electric Company, spoke of "The Gas Turbine in Aviation" before the American Society of Mechanical Engineers; Charles D. Flagle and Frank W. Godsey, Jr., of Westinghouse Electric Corporation, discussed "The Place of the Gas Turbine in Aviation," at a technical press luncheon; and C. F. Bachle gave to the Society of Automotive Engineers his thoughtful study of "Turbine Compounding with the Piston Engine." A forthcoming book by B. Hennlip, of Bell Aircraft, on "Modern Flight Testing" will also add greatly to knowledge.

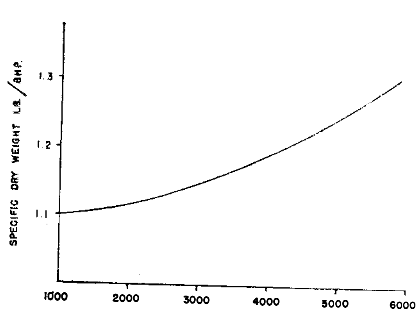


Figure 1. In reciprocating engines, the specific weight increases rapidly with size beyond a certain point

From these sources, it is possible to understand and to evaluate the various embodiments of the gas turbine and jet reaction in the wholly modern aviation power plant.

The phrase "various embodiments" is used because it is now possible to offer quite a classification of aviation prime movers:

1. The conventional reciprocating engine and propeller—still the heart of aviation, still efficient, and improved when equipped with supercharger and water injection and utilizing the thrust of the exhaust to some extent by special design of exhaust outlets.

2. The turbo-jet in which air is compressed and forced to burn fuel in a combustion chamber. The exhaust gases drive a turbine that operates the compressor, and then rush out through a nozzle to provide a powerful reaction thrust. It is the turbo-jet with which Captain Whittle's name will be forever associated, and which has most impressed itself on the public's mind.

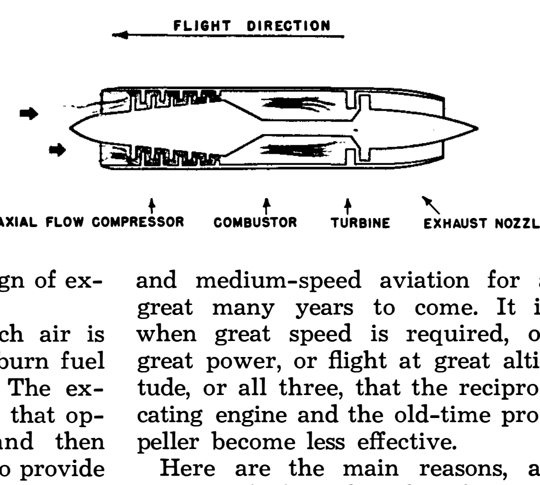
3. The gas turbine driving a geared-down propeller and utilizing the thrust of the exhaust to a marked degree; not yet flown, but certain of employment in the near future.

4. The compound reciprocating and turbine engine which Mr. Bachle has proposed.

There may be other combinations such as a conventional reciprocating engine acting together with a turbo-jet, with each functioning at the time appropriate to its best efficiency: reciprocating engine at take-off, and turbo-jet at great speed and altitude. But an evaluation of the four systems as above should give a basis of comparison for all possible combinations.

PROPELLER LIMITATIONS — Will the conventional reciprocating engine with propeller disappear like the horse and buggy? Not at all. In the history of technology, it is very rare that a new invention or improvement utterly displaces older appliances or vehicles. Thus, the Diesel locomotive has not and will not drive out the steam locomotive. The conventional reciprocating engine and propeller will continue to render excellent service in low- and medium-speed aviation for a great many years to come. It is when great speed is required, or great power, or flight at great altitude, or all three, that the reciprocating engine and the old-time propeller become less effective.

Figure 2: Simplified diagram showing the basic principle of an axial-flow turbo-jet



Here are the main reasons, as Messrs. Flagle and Godsey have so well put them: The reciprocating engine reaches its best weight figures at around 1000 horsepower, when the specific weight per horsepower is only one pound. In larger sizes, as Figure 1 illustrates, the specific weight will increase rapidly unless either more cylinders or better fuels are brought into action. The reciprocating engine functions most efficiently at 60 percent of its rated power, and that is a limitation on its use at full speed when full rated power is needed. Again, the very large reciprocating engine needs complicated controls so that not only does the specific weight of the engine itself go up with the size, but the complete installed weight becomes excessive. Again, even the best air-cooled engine, with fine cowling, offers large frontal area and nacelle drag so that the net thrust per horsepower becomes disappointing. And, finally, at very high speeds, particularly at altitude, the propeller itself begins to lose efficiency because its fast

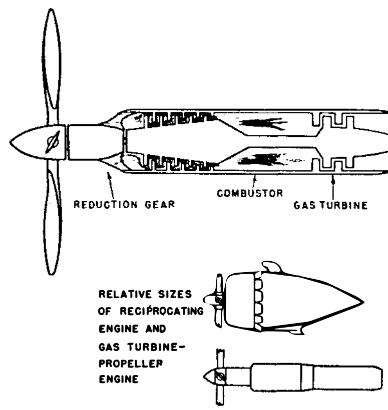


Figure 3: Diagram of a geared-down gas turbine driving a propeller, in combination with a turbo-jet unit

whirling tips approach the speed of sound. For all these reasons, it is possible to say that, unless and until many improvements are made, very high speed operation of aircraft would be limited by the deficiencies in the reciprocating power plant no matter how well resigned the airplane itself might be.

General Electric has been a pioneer in the development of the supercharger, and Messrs. Puffer and Alford, distinguished members of the General Electric family, rightly point out that when the exhaust gas supercharger, water injection, and exhaust thrust are employed, the reciprocating engine has, by far, the greatest overall efficiency where long-range flying is involved. But these refinements serve up to a point only. When super-aviation or flight at very great speeds is involved, the turbojet has to be considered.

Figure 2 illustrates, diagrammatically but clearly, the basic simple principle of the turbo-jet, in which an axial flow compressor is driven by a gas turbine. The axial flow compressor inducts the air, compresses it, and delivers it to the combustion chamber. There the fuel is burned at high temperature and constant high pressure. The compressed air and exhaust gases expand and drive the turbine and then leave the nozzle at the speed of sound, producing enormous reaction thrust.

When turbo-jets had to be built quickly, the AAF sought the aid of General Electric; the Navy called on Westinghouse. Both giant companies responded magnificently, and succeeded splendidly. If Westinghouse used the axial flow compressor, claiming to secure thereby the most direct flow, the lowest frontal area, and least aerodynamic drag, General Electric did equally well with a centrifugal compressor. To discuss the relative merits of axial and centrifugal compressors would need far more space than available here.

NET POWER—It can be seen from the above brief description that in jet propulsion, the whole net power (which is the difference between the power generated and the power used up in the compressor) is used to impart backward acceleration to the compressed air and exhaust gases. The question then arises: Why is the gas turbine so well adapted to jet propulsion?

The answer is readily found. As can be shown by simple applied mechanics, *jet propulsion is most efficient when the speed of the jet is not so far above the speed of the vehicle from which it issues.* This is a cardinal principle always to be remembered when thinking of jet propulsion. The gas turbine handles a great mass of air (four to eight times greater than the reciprocating engine) for each pound of fuel consumed. This is because the gas turbine swallows its own cooling air and subjects it to the same thermodynamic cycle as the air needed just to burn the fuel, while in the reciprocating engine the cooling air is used externally to the combustion space.

Because of this great mass of air handled, the exiting jet is cool and slow, and propulsive efficiency is far better than were the hot exhaust gases released from a reciprocating engine used for reaction thrust.

But when it is said that the exiting jet is cool and slow, relative terms are being used. To anyone who looks at a Bell Aircraft turbojet plane, or a Lockheed Shooting Star, the jet will appear to have tremendous speed and temperature. Accordingly, below 500 miles per hour, jet efficiency is very low and fuel consumption is very high. The thermodynamic or internal efficiency of the turbo-jet equipped with a good compressor may be 31 percent at 15,000 feet, which is of the same order as that of the modern reciprocating engine, but its propulsive or external efficiency is very low at take-off or climb and only becomes reasonable at the enormous speed of the fastest fighters.

JET ADVANTAGES — Does this mean that the turbo-jet will always be restricted to a special type of interceptor combat airplane where enormous thrust is required for only a short time and fuel consumption is unimportant? Not at all, because airplane speeds tend to go up all the time (unless compressibility effects bar further progress) and because the turbo-jet has so many other advantages to commend it. It is extraordinarily simple, there is no carburetor to ice up, no ignition trouble, no valve system to go out of order, no intermittent cylinder action, no overheating of the cylinder head or bearings. With a minimum of parts, the pilot can be completely assured at all times of a powerful, steady, continuous thrust. The turbo-jet is very light in weight, needs little lubricating oil, and is remarkably easy to maintain. This ease of maintenance has brought enthusiastic praise from all AAF personnel who have had experience with the engines. There are no radiators and no cooling surfaces. Frontal area of the engine nacelle is reduced to a minimum, so that the power-plant drag is reduced to a

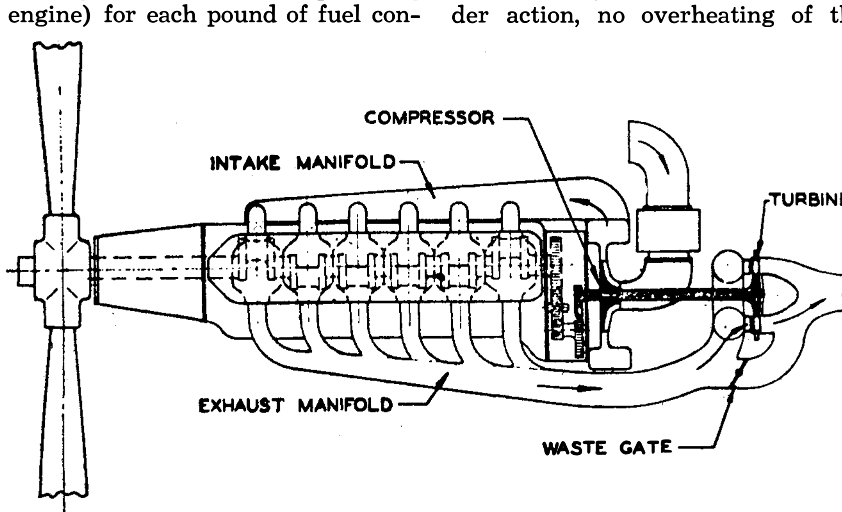


Figure 4: Bachle's compound reciprocating engine and gas turbine

minimum and the net thrust is a greater percentage of gross thrust than in the reciprocating engine. Since the jet is at the back of the airplane, noise in cabin or cockpit is reduced. There are immense potentialities of power, far beyond those of the conventional motor.

For these and other reasons, it may be expected that the turbo-jet will come into wide use reasonably soon—for planes of great speed or planes requiring immense power.

Messrs. Puffer and Alford bring up economic reasons to show that

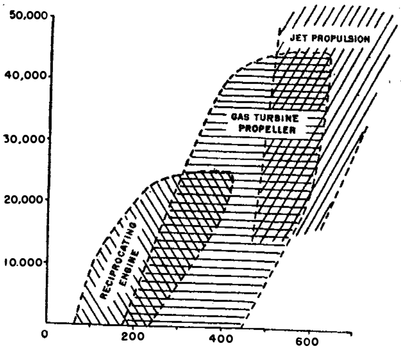


Figure 5: Estimate by Flagle and Godsey of probable spheres of action of various aircraft power plants

jet propulsion is *not* purely a military device. This is true because of the greater reliability of the turbo-jet unit, because of its higher rate of speed and consequently greater potential number of trips, because speed cuts down many items of airplane operating cost, and finally because the fuel required is not high octane gas but any one of a number of cheap fuels such as kerosine. *The cost of jet-propulsion transport is claimed to be only slightly higher than the cost of present-day transport for ranges of over 500 miles.* [See article by D. H. Killeffer immediately following this one for a discussion of jet-engine fuels.—*Editor.*]

A COMPROMISE—There is good reason to be optimistic as to the future of the turbo-jet engine—but wonderfully suited as it is to high speeds, it is *not* efficient at take-off, in climb, or even in long-range cruising. Is the combination of a gas turbine geared down to drive a propeller, in combination with jet reaction, a compromise more suitable to present needs? The combination is diagrammatically indicated in Figure 3. The geared-down turbine will constitute a beautifully symmetrical power plant, of small frontal area and low nacelle drag as compared with the reciprocating engine. Because of its small diameter the gas turbine will be easily buried within a wing. The geared-down turbine shares these and other advantages with the turbo-jet. But there is one advantage which the geared-down turbine possesses to a unique degree—versatility to suit a particular flight condition by varying the proportion of power developed in the propeller and in the reaction nozzle. Towards the lower end of the scale the propeller drive will be favored, with the exhaust jet thrust merely compensating for nacelle and cooling drag loss, and with high net thrust as the result. For high speed operation, 50 percent of the power would be developed in thrust, since jet reaction would then become efficient. Of course, the geared-down turbine loses some of the desirable features of the turbo-jet. It can no longer have the low slung body of the turbo-jet because of the propeller. Yet this intermediate type may have a broader field of usefulness than the reciprocating engine at one end of the scale and the turbo-jet at the other.

In Figure 4 is shown Bachle's scheme of compounding a gas turbine with a reciprocating engine, both working on the same shaft and driving a propeller. The combination is not intended for high speed, but because the gas turbine can take such excellent advantage of the exhaust gases, Mr. Bachle believes that the system would give excellent fuel-consumption economy and offer the minimum weight of power-plant plus fuel for long-range cruising at 300 miles per hour.

A tentative conclusion, illustrated by Figure 5, seems to be that the reciprocating engine will remain supreme for low power and moderate speed; jet propulsion will be superior at great altitudes and speed; and the geared gas-turbine with propeller will occupy an intermediate position.

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POST-WAR FLYING

Jobs Raise an Important Question

WILL there be post-war jobs for wartime pilots? Phillips J. Peck discusses this question in *Flying,* basing his discussion on an appraisal of the situation by Paul E. Young of the Civil Aeronautics Administration.

At the conclusion of the war, the Army alone will have 100,000 "top-grade" combat pilots and 50,000 Air Transport Command instruction and service pilots. Of this number, 75,000 may be discharged at the end of the war. The Navy, Marine Corps, and Coast Guard discharges will raise this total above the 100,000 mark. To this number must be added men in the Civil Air Patrol, and those already employed on the airlines. The Army does not intend to stay in the air-transport business, and thus eventually the Air Transport Command will dump its entire personnel back to the airlines.

But in the war effort the airlines —TWA, United, American, Eastern, Pan American, and others—have utilized their Air Transport Command units to build up a gigantic reserve of well-trained pilot personnel. It is, according to Mr. Young, a physical and economic impossibility for these thousands of pilots to be absorbed in post-war civil aviation, no matter how great may be its growth.

It is Mr. Young's opinion that some 39,000 men will find civil aviation employment: 4000 on the airlines within two years after the war; 15,000 in the flying schools; 20,000 in miscellaneous services. Miscellaneous services will cover feeder-pickup, charter services, crop dusting, forest patrol, aerial survey work, air advertising, lake stocking, and so on. This is a very reasonable view of the situation and it is far better that many of our Army and Navy pilots should regard their flight training as a delightful accomplishment and avocation, rather than a postwar professional activity.

SCRAP RECOVERY

May be Speeded by Chemical Process

IMMENSE quantities of aluminum in airplanes that must be scrapped at war's end for one reason or another pose a tremendous salvage problem because of the complexity of the parts. Separation of pure aluminum from alloying elements and from parts composed of other metals is impracticable by ordinary methods. However, a chemical recovery process promises to solve the problem economically and efficiently by dissolving the aluminum away from other materials present by the use of a solution of caustic soda. This solution readily dissolves aluminum but not the elements with which it may be alloyed and it leaves steel, copper, and other metallic parts unaffected. Furthermore, the solution of aluminum as sodium aluminate readily yields the metal in the form of its oxide in exceptionally pure form for introduction into the electrolytic cell for recovery. Naturally, only composite parts left after large pieces of pure metal have been cut away will need to be subjected to this treatment.

Photo by Air Technical Service Command

A B-25 using rockets for assisted take-off

CHEMISTRY IN INDUSTRY — Conducted by D. H. KILLEFFER

Fuels For Jets

Reaction Engines for Aircraft Seem Capable of Operating Efficiently on Simple Fuels. But it May be that this Simplicity is as Yet Due to a Lack of Knowledge of the Means for Obtaining Highest Efficiency from the Power Plants that Will Operate the Aircraft of Tomorrow

Now that production of huge volumes of aviation fuels for conventional internal-combustion engines is an accomplished fact, industry faces new problems in providing fuel for tomorrow's rocket-powered aviation. Experience so far gained with the toys of 1930's dreamers shows that jet and rocket power will ignore the criteria vital to today's flight and will impose new requirements on the producers of fuels for tomorrow's planes. It is all quite confusing. No sooner have high compression, octane numbers, and super fuels taken their industrial places than the new needs of advancing aviation suddenly discard these and promulgate new specifications for new types of planes operating without propellers. It is worth looking into, for these new needs will profoundly influence trends in the fuel-producing industries for the future.

At first blush the fuel needed for jet propulsion appears much less limited by essential requirements than that powering today's conventional engines. Obviously the basic differences between the two types of engines are reflected in basically different specifications for their fuels. Whereas volatility (except with the new "safety gasoline"), octane number, and high compression characteristics are paramount requisites of internal-combustion reciprocating engines, none of these is of any particular consequence in either jets or rockets of the present day. The specific requirements of today's aviation fuels are inherent in the design and operation of the internal combustion engine itself. Secondary restrictions imposed by the operation of the engine in an airplane are minor as compared with the necessities of the engine's fuels.

Quite the reverse is true of rocket fuels. The rocket or jet imposes no particular restrictions on the fuel that are not easily met by existing petroleum products. But, on the other hand, the extraordinary characteristics of jet-propelled planes, with their possible use at otherwise unattainable altitudes, emphasize the importance of the plane's requirements in the selection of a suitable fuel. Instead of volatility, high octane number, and high compression characteristics, jet-populsion engines emphasize the need for high energy content, low freezing point, and high flash point as the most important qualities in their fuel. That change completely alters the problems of production and refining of fuel, but in spite of the apparently wide latitude thus allowed, vexing problems still remain for industry to solve.

REACTION ENGINE TYPES—To make the matter clear it will be well to examine broadly the characteristics of jet-propulsion engines to learn how they function and what are the controlling factors in their operations. Much of the current development of engines of these types is of such military importance that many details cannot yet be revealed for security reasons. But, nevertheless, enough of a picture can be drawn to indicate the trend, if not the detail, of future developments.

First, two broad types of reaction engines must be distinguished. One is typified by the old-fashioned sky-rocket and is properly designated as a rocket. Rockets carry with them both fuel and oxidizing agent with which the fuel is burned, and may be powered by either solid or liquid fuels (smokeless powder and gasoline are typical). Numerous types of rocket projectiles have proved valuable weapons in the present World War. A second type of reaction engine carries its own fuel but depends on oxygen from the air to burn it and on the air stream to provide the required forward thrust by its thermal expansion. The buzz bomb loosed on England by the Germans and the several types of jet-propelled planes typify this second class of reaction engines. These have been designated as air-stream engines or jets to distinguish them from the true rockets of the class previously mentioned.

Developments thus far in rockets, as defined above, indicate severe limitations on their value as the principal motive power of cargo carrying planes. Extreme temperatures and simultaneous high pressures are encountered in their operation and for practicable efficiency these mount beyond the ability of any known materials of construction to withstand them. This has been shown by both practical tests and theoretical calculations. Hence, for the purposes of this discussion, these interesting engines may be passed over as impractical for any but special uses. Their fuel requirements are best met by liquid atomic hydrogen, so far unattainable, and liquid oxygen. Other fuels consist of smokeless or black powder, various hydrocarbons and alcohols (including gasoline, kerosine, ethyl alcohol, and so on) with liquid oxygen, hydrogen peroxide, or nitric acid as the oxidizing agent.

These rocket engines are useful for throwing explosive charges over short distances as demonstrated by the bazooka and other types of rocket projectiles used in the present war. Perhaps their utility may be tremendously extended in the future, but the extension will have to be very great indeed to bring them within range of practicability as a means of transport of human beings or cargo. The case is presented with absorbing interest by G. Edward Pendray in his book, "The Coming Age of Rocket Power," lately reviewed in "Our Book Corner." To it the reader is referred for more information on the subject.

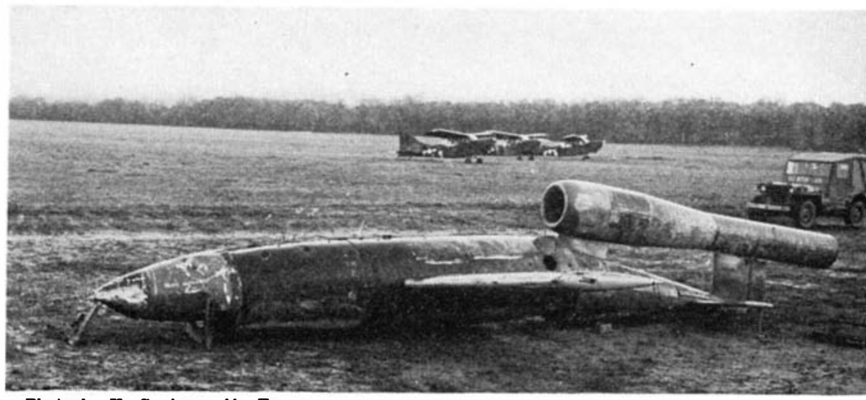


Photo by U. S. Army Air Forces

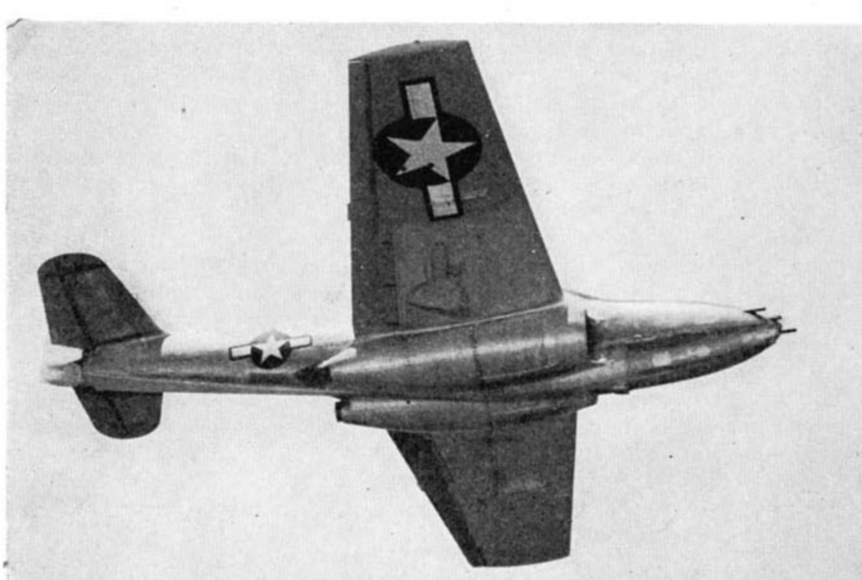
A complete German robot bomb found intact in France

PRACTICAL JETS—The air-stream motors present a different picture. Already they have been utilized both for human flight and for transporting substantial cargoes of high-explosive bombs. Both applications seem already to have come so far within the range of practicality as to suggest here an analysis of their fuel requirements as a problem in production in the near future.

Pendray divides air-stream motors into three sub-classes: thermal or turbo-jet, intermittent duct (buzz bomb), and continuous duct (also called the athodyd). The first draws in air through a turbo-compressor driven by a turbine powered by the flaming jet itself, and ejects the air expanded by the heat of the flame from a rear orifice. The continuous duct engine depends upon the ram effect of its speed to supply air to its flame which continuously heats and ejects the expanded air. The intermittent duct engine operates on the same principle except that the fuel is exploded within its body intermittently, a number of check valves in its forward end admitting air but preventing the combustion products from escaping except toward the rear.

Each of these has both advantages and disadvantages. Although the turbo-jet involves the complication of a turbine and a turbine compressor driven by it, this form seems at present to enjoy greatest favor, temporarily at least. An alloy capable of withstanding temperatures up to 1000 degrees, Fahrenheit, more or less continuously and without undue warping, oxidation, or erosion made possible the turbo supercharger employed on high flying planes. This alloy is also essential in the construction of the turbo-jet air stream engine employing several parts virtually the same mechanically for very nearly the same purpose as in the supercharger. The extreme temperatures of the true rocket are avoided by dilution of the flaming mixture with an excess of air.

Both the intermittent and continuous duct engines are simpler, involving no moving parts, but while simplicity is advantageous, lack of compression requires that

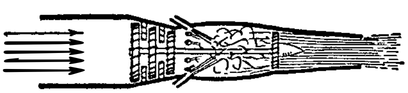


Courtesy Bell Aircraft Corporation

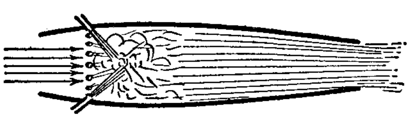
The P-59, AAF jet-propelled fighter, in flight

both of these engines reach relatively high speeds before they will operate satisfactorily. Speed is necessary to force air into the combustion chamber and without this the engine will not function effectively.

FUEL REQUIREMENTS—From a fuel point of view, these three types of air-stream engines are alike. It is only necessary that the fuel possess high heating value and that it be capable of being fed continuously to the combustion zone. Practically, this means that the fuel must be liquid under the conditions of use. The feeding of solid fuel, even in finely powdered form, involves complicating mechanism, and gaseous fuels occupy unduly large volumes per pound or per heat unit. Fuels which are gases at ordinary temperatures and pressures can be used in liquefied form provided the weight of the container necessary to hold them is not too great for practical purposes.


THE THERMAL JET ENGINE (TURBO-JET)


THE INTERMITTENT DUCT ENGINE (BUZZ BOMB ENGINE)


THE CONTINUOUS DUCT ENGINE (ATHODYD)

Reproduced by permission of Harper and Brothers from Pendray's "The Coming Age of Rocket Power"

Three types of airstream engines

These are the only ruling criteria involved in fueling jet planes. Clearly a great number of present commercial fuels meet them well. There are, of course, other specifications so desirable from a practical standpoint as to be virtual necessities. The fuel must be free from solid abrasive particles that would erode the mechanism, a requisite both of the raw fuel and of the products of combustion. The presence, for example, of silica or of combined silicon that would burn in the flame to silica is a serious drawback to any fuel. Soot at high velocity is also harmful. Other elements yielding similarly abrasive oxides must be excluded. The fuel must remain liquid at the low temperatures encountered in flight at high altitudes. This requirement is readily met by many, but by no means all, of the commercial hydrocarbon fuels. Easy flow at temperatures down to the required point of —80 degrees, Fahrenheit, is characteristic of gasolines and naphthas, but even some kerosines become sluggish or actually congeal in this low temperature range.

Also desirable to a point approaching necessity is a high flash point for the fuel. The flash point is defined as the temperature at which the fuel is sufficiently volatile to form a combustible mixture with still air. The higher the flash point of a fuel, the safer it is to carry in a plane. The flash point of ordinary gasoline is below normal atmospheric temperatures and thus its use involves at best a certain hazard of explosion which is particularly great in military planes in combat. Consequently the specifications for fuel used in any military plane call for as high a flash point as practicable. In jet fuel, this can be 105 degrees, Fahrenheit. If the flash point is made too high the fuel is likely to freeze under operating conditions and conversely too low a required freezing point leads to the inclusion in the fuel of hydrocarbons which unduly lower its flash point. Flash point is connected with volatility and a low flash point is necessary for the proper vaporization of a fuel in a carburetor, which is not required by jet engines.

SPECIAL FUELS—The criterion of a clean fuel which burns without considerable residue is easily met, but the combination of low volatility, and consequently high flash point. with an excessively low freezing point, is sometimes considerably more difficult to meet with practicable fuels. Either requirement alone would permit the use of immense volumes of petroleum products already available, but the combination of the two in a single fuel practically requires that it be especially refined for the purpose and thus places it among the special fuels.

Also essential to the efficiency of a fuel in jet engines of present design is the ability of the fuel to burn in dilute mixtures with the large volumes of air now used. Every combustible substance requires a definite proportion of air for its complete burning and it will burn in mixtures both more concentrated and more dilute than the ideal. However, outside a definite characteristic range of concentrations, it will not burn at all. The requirement of high dilution to keep temperatures down in jet engines limits usable fuels to those capable of burning at dilutions necessary to meet temperature restrictions. While this adds to the complexity of the fuel problem it still leaves a wide selection available to the engineer to power his future aircraft.

Perhaps the reason the jet fuel problem still seems relatively simple is that we do not yet know enough about it. The first automobiles were powered by the waste naphthas of kerosine refiners and it was only after decades of operation of millions of cars that efficiency and the factors affecting it became important. This may also be true of jet engines and future developments may show the need for special qualities in their fuel now unsuspected in our present knowledge of the subject. Research in the field proceeds at a swift pace because of its bearing on the military situation. When need comes, chemical industry's petroleum refining division will be ready to meet it. Meanwhile it looks simple, simpler probably than it is.

PEPPER

Alkaloid Used In Insecticides

RECENT tests indicate high insect-killing efficiency for insecticides containing piperine, alkaloid of black pepper. Combinations of piperine with the pyrethrins extracted from certain flowers showed unusually high killing efficiency when used against house flies. The purified piperine alkaloid is relatively non-toxic and non-irritating to persons.

MERCURY FUNGICIDE

Is Soluble in Paint And Varnish Vehicles

DESTRUCTION of materials by mildew, mold, and rot has been emphasized by the Pacific war and this has developed new and urgent demands for fungicides having various properties. Latest additions to those available are the pyridyl mercury compounds containing mercury in a particularly effective form and available as several different salts having different desired solubility characteristics. Pyridyl mercuric stearate, for instance, is soluble in paint and varnish vehicles to an extent that affords excellent protection against tropical destruction. The chloride and the acetate possess advantages for treatment of textile and fibrous materials. Studies conducted both in the laboratory and in the field indicate great effectiveness for compounds of this group.

Glass and Electronics

Glass Has Played a Vital Role in the Development of Electronics. Now Electronics is Reciprocating by Providing a Flexible Tool for the Glass-Working Industry Whereby Welded Glass Products Can be Produced With High Precision and Sharply Localized Melting Areas

By VIN ZELUFF
Associate Editor, *Electronics*

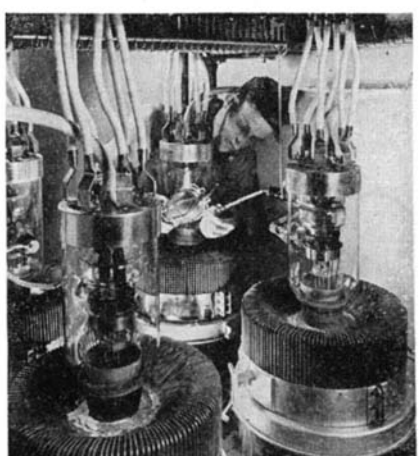
GLASS enabled Edison to produce his first incandescent lamp, in which the "Edison effect" was observed. From this beginning, Fleming, Wehnelt, Reisz, von Lieben, and De Forest all used glass as the containers for their first electronic tubes. By 1934, 55 million glass tubes were being manufactured annually.

A skeptical industry and public first saw metal vacuum tubes, made of steel, in 1935 and this seemed to herald the last days of the use of glass in electronic units. This was not so, however, for each one of the metal tubes contained glass. Less glass, to be sure, than formerly, but still highly essential glass.

In any vacuum or gas-filled tube, there must be wire leads or conductors connected to the electrodes. These must extend through the shell, metal or glass, to permit the tube to become a part of an electrical circuit. In the glass tube, the glass itself is an insulator and no problem exists in making proper connections. In the metal tube, however, the conductivity of steel does not permit bringing the leads through directly. Instead, an insulating bead or sleeve around the wire is necessary. For this purpose, glass is the best material. Thus, even in the metal tube, glass still is necessary.

Metal vacuum tubes contain a "header," which is the stamped and perforated foundation of the tube. Metal eyelets, of Fernico, are inserted in the perforations and welded to the header. Glass-beaded wires are then inserted in the header eyelets and the assembly carried through gas flames which melt the glass beads and form a permanent air-tight seal between the glass and the metal. After assembly of the element structure (the grids, plate, and cathode), the outer metal shell is fitted over the complete element structure and welded to the header. The tube is then ready for the evacuation pumps.

STRESSES—Sealing of glass to the wire leads was solved in the early days of vacuum-tube research by W. G. Housekeeper, of Bell Telephone Laboratories. When glass and metal are heated together and allowed to cool, if the glass contracts differently from the metal a stress is set up which may cause fracture. If the seal is to be made air-tight, the glass must match the metal very closely in its thermal expansion coefficient. The Housekeeper seal lent itself to quantity production and was quickly adopted. In this technique, the copper wall at the joint is made very thin so that the copper can deform enough to compensate for the differential in expansions. The thin wall is formed of a scale of cuprous oxide on the copper wire which fuses together with the glass sufficiently to give a vacuum-tight seal.



Glass envelope and stem assembly of 50,000-watt Westinghouse radio transmitting tubes. In this air-cooled type, the anode is the flanged base through which air is forced by blower

Tubes are not the only radio and electronic components that have benefitted from the use of glass. Condensers, too, in the early wireless equipment, contained sheets of glass between metal plates—an industrial version of the Leyden jar. Radio coil forms are now produced of glass that have a plus or minus constancy of diameter and pitch of one thousandth of an inch. Today a new glass-molding technique, the multiform process, allows glass to be molded into shapes that would not otherwise be possible.

A valuable development brought about by war research is a glass jewel bearing used in meters and instruments of electronic equipment. Sapphires, which were used for such bearings, were manufactured by hand abroad. Now a glass has been developed which can be used for instrument bearings. This glass substitute may replace the jewels because it is better in certain applications.

GLASS HEATING—In conventional heating of glass by glass-working fires, the material is heated through the surface. The surface boiling and destructive loss of volatile constituents in this method limit the heating speed and the size and thickness of the parts that can be heated. Recently conducted experiments made with electronic heating equipment have shown that, given the proper conditions, glass can be heated electronically in three different ways; by dielectric heating, by induction heating, and by electrical conduction through the heated glass with gas-flame electrodes. The best method for a given application is determined by the nature of the particular operation to be performed, the properties of the glass to be heated, and the temperature range required in the processing treatment.

Although glass has high dielectric value, and is, therefore, a good insulator, induction heating has been used in an indirect method of perforating the glass envelopes of cathode-ray tubes used in radar equipment, and as the picture tube in television receivers. In these, a connection must be made from an internal element to a metal cap at the side of the tube. The perforation for the cap is made by placing a metal slug inside the glass envelope at the spot where the hole is to be made. The cathode-ray tube is then positioned at an electronic induction heating outfit so that the metal plug is heated sufficiently to melt the glass wall of the tube and it drops through the glass, leaving a perfectly round clean hole. The metal connection cap is then placed in position and its periphery sealed into the glass wall.

A method of welding glass by the passage of high-frequency current through a restricted area where it is to be softened and flowed was recently described by E. M. Guyer of the Research Laboratories of Corning Glass Works. In this technique, advantage is taken of the fact that glass, although normally a non-conductor of electricity, will permit the passage of electric current when heated.

Flames from small oxyhydrogen burners are used to preheat the glass parts to be welded. The flames are very small and sharp and restriction of the preheated area can be closely regulated. The preheater flames are too small to melt and work the glass, but they can and do raise the temperature of the glass to the point where it ceases to be an insulator and becomes a high-resistance conductor. This happens at temperatures below the melting point and thus avoids destructive surface boiling.

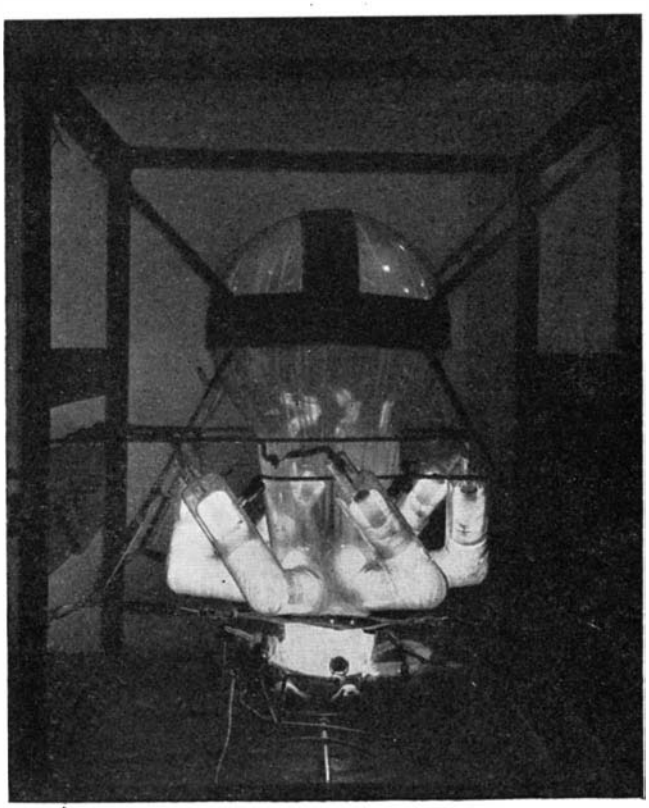
The flames next serve as gaseous conductors to direct high-frequency currents from the metal burner tips to the conducting paths already established in the glass by the localized preheating operation. Since the pin points are velocity directed, they impart controlled direction to the high-frequency discharge passing through them to the glass, thus serving as flexible, non-sticking, electrical brushes.

The combination flame-electrodes also serve as variable resistances in series with the glass load, and exert a certain degree of control over the flow of the high-frequency heating current as they are moved closer to or farther away from the glass.

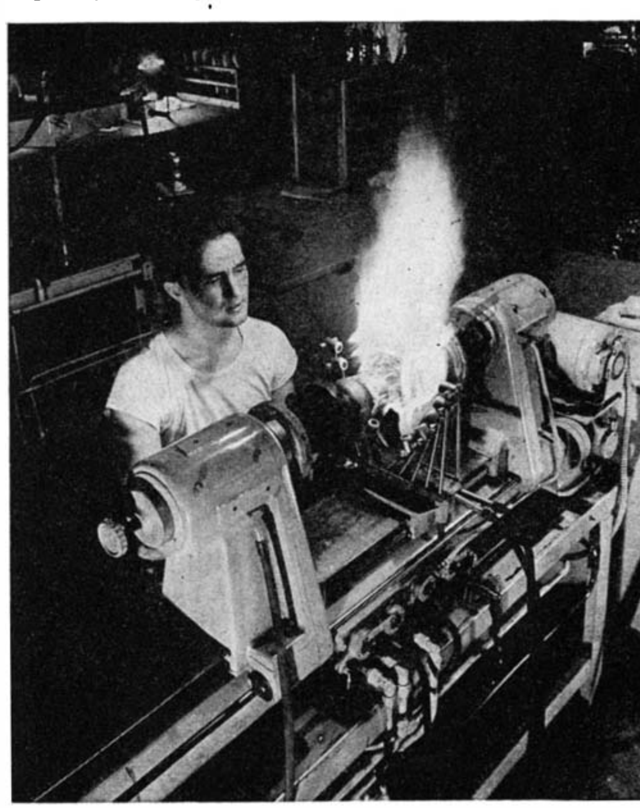
The high-frequency current passing through the preheated paths in the glass produces a much greater heating effect inside the material than the small preheat flames which started the process, and variation of the welding current provides exact regulation of glass temperature. Similar electrical high-frequency cross-fire systems have been applied with success not only to hand-welding operations and to rotating electrical sealing lathes but also to automatic machines.

WELDED GLASS PIPES—Glass pipe lines have been developed that use a cleverly designed and carefully engineered flanged-joint system. This permits convenient lengths to be coupled and clamped together in the process of assembly. In certain types of service, however, an all-glass, one-piece pipe line system has very definite advantages.

Because of the high melting temperature of thick-walled borosilicate glass pipes, the process of sealing together lengths of pipe with no other tool than a conventional glass-fire is a tedious, time-consuming job requiring great skill on the part of the glass worker and resulting in a costly installation. The high-frequency cross-fire method was recently used successfully to weld all-glass pipe lines. The simple portable equipment developed for this purpose makes possible for the first time



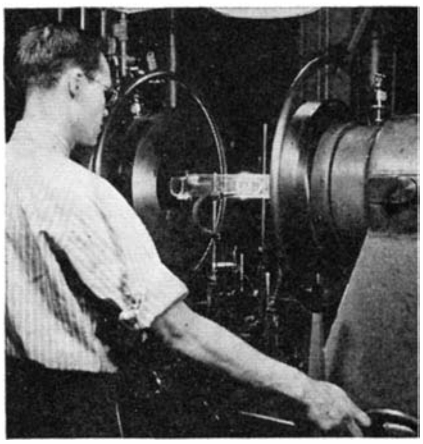
Photographed during operation, this mercury-arc rectifier in Allis-Chalmers equipment supplies 100 kilowatts of power



A glass-working lathe in operation during one step in assembly of a high-power Federal transmitting vacuum tube the rapid installation, repair, and servicing of all-glass lines of any length in the field.

The ends of glass pipe are prepared for welding by removal of irregular edges with a conventional hot-wire crack-off tool. The same instrument permits removal of a damaged section from a service line, preparatory to rapid repair by welding in a new section cut to length at the site of the installation.

Pipe sections to be welded together are mounted in accurate axial alignment on a clamping jig with the ends slightly separated. A small toggle lever permits free, easily con-



Glass-sealing lathe with electronic cross-fire gun developed by Corning

trolled manipulation without loss of axial alignment and provides the necessary means for the smooth application of welding pressures, or for the application of stretching forces to remove excessive upset.

The two glass faces that are to be welded are pre-heated by the pin-fires at the tips of the welding guns until the glass becomes conducting. Two skilled operators are located opposite each other so that both sides of the weld can be critically inspected at all stages of the operation. When they move the hand guns to and fro in slow rotary oscillation, the pipe ends reach a uniform, barely visible dull red.

Next, high-frequency electric heating is started and rapidly melts the two pipe sections together, while pressure is applied with the toggle lever and followed, immediately after the high-frequency power is shut off, by blowing and stretching to reduce the upset. Annealing then eliminates strains.

High-frequency sealing on rotating machines demands less skill on the part of the operator since uniform heat distribution to the work is provided by the mechanically synchronized, regular, and continuous motion of the glass parts as they rotate in the cross-fire.

Experience in the systematic performance of a sequence of properly timed steps and judgment of glass temperature are necessary in the operation of high-frequency glass sealing lathes. Mounting and centering irregular pieces on the rotating heads accurately enough to avoid wobbling and fast enough to keep up with modern production schedules likewise require practice.

AUTOMATIC OPERATION—Fully automatic machines into which glass parts are loaded and from which completely finished, electronically welded glass products are unloaded are now in operation. Electronic high-frequency sealing can be applied to many different glasses and many different kinds of glassware with important advantages over conventional methods. High-frequency generators are more expensive than gas burners, however, and there are many operations where electronic heating does not show sufficient improvement over gas to warrant the extra expense. For example, when close heat restriction and control are unimportant, there is little to be gained from the new methods.

In operations where melting time is a significant factor in total production time, and where accurately controlled and sharply localized melting can produce a superior article or perform a desirable operation which otherwise would be impossible, the electronic techniques have no equal.

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PIPE FINDER

Can be Used to Locate or Measure Magnetic Fields

CALLED the Gradientometer, a new indicating unit quickly locates magnetic fields and hence is useful in aircraft inspection, in locating lost tools and underground piping, in searching for conduits, and so on. It cancels out uniform magnetic fields, such as the earth's field, and is designed primarily to locate magnetic gradients. It is easily converted into a Magnetometer that may be used to measure the strength of magnetic fields.

MOLTEN METAL

Pouring Controlled by Phototube

IN ONE foundry, a single operator working from a remote station governs the pouring of several ladles simultaneously with the aid of a photoelectric control that automatically tips the pouring ladle back when the mold is filled. The heat, splashes of molten iron, and other hazards encountered in hand pouring are completely eliminated and several molds are now poured in less time than was needed to pour one by the former method.

As each group of empty molds moves into position before a ladle, a photoelectric control mounted directly above watches the riser opening through a viewing tube. When the molds are in place, the operator, through pushbutton control of the hydraulic actuating mechanism, tips the ladles of molten iron and the white-hot metal flows into the molds. As it reaches the riser of each mold, the brilliant light thrown off by the molten metal signals the phototube that the mold is full. The electronic unit causes the ladle to drop back and the pouring automatically stops.

These photoelectric control units were made by Photoswitch, Inc., and installed in a foundry of the American Brake Shoe Company.

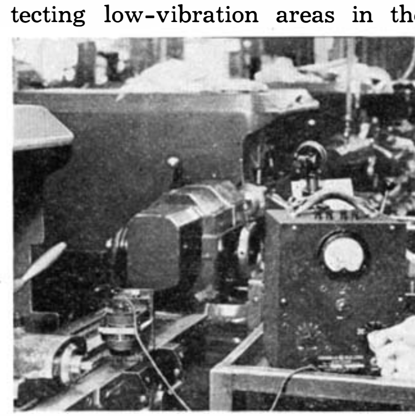
VIBRATION

Located by Use of Electronic Pick-Up

CAUSE of vibration in grinding machines at the plant of a manufacturer of high-precision taps has been located by an electronic instrument. The vibration in one machine in particular was causing a large number of rejects.

A G-E electronic vibration velocity meter revealed that a set of gears in this machine, apparently in good condition, caused the vibrations. Replacing the gears eliminated the difficulty.

The meter was also used for detecting low-vibration areas in the



Electronic vibration detector at work

plant as a guide in placing new equipment.

The meter consists of a vibration pick-up and electronic amplifier which measures vibration velocity and, together with an integrating unit, vibration displacement.

Glass-Metal Collaboration

From Mirrors to Industrial Pumps, Various Combinations of Metals and Glass Have been Developed to Serve Specific Purposes and to Solve Difficult Problems. The Electrical and Chemical Industries Find Many Uses for Such Partnerships, Retaining the Best Features of Each

By KENNETH ROSE
Engineering Editor, *Metals and Alloys*

At first thought glass and metals might seem as incompatible as oil and water. Most common metals are strong, opaque, tough, and capable of a degree of cold-working, while glass shatters at a blow, is ordinarily transparent, and cannot be cold-worked at all. Yet in the unending search for new materials, industry has joined these unlikes in literally hundreds of uses, not merely in association with each other, but actually blended into unit materials.

In 1835 a German chemist, von Liebig, heating acetaldehyde with ammoniacal silver nitrate in a glass vessel, noticed that a deposit of metallic silver formed on the glass. Five years later the process came out of the laboratory as one of the most familiar articles in which glass and metal form a unit—the mirror. Since von Liebig discovered the method for silvering glass, dozens of variations of his process have been invented.

In the usual industrial process for making mirrors today, the glass surface is properly cleaned, then primed or sensitized, usually with stannous chloride. Taking care to avoid touching the prepared surface with the hands, it is then treated with a silver solution and a reducing agent, such as sugar, tartaric acid, glucose, rock candy, pyrogallic acid, Rochelle salt, and so on. After the silver is deposited the mirror is rinsed and dried at room temperature.

Modern mirrors are not merely articles for milady's boudoir. Mirrors for industrial and scientific purposes range from tiny reflectors for use in electrical instruments such as the galvanometer to huge mirrors for telescopes. Nor do mirrors use silver exclusively. Gold mirrors are occasionally used in optical reflectors, and for decorative and advertising purposes. Once they were supposed to possess magical powers. Small mirrors backed with ruthenium, the rare platinum-like metal, are used for medical and dental work despite their high cost. They have the great advantage of being unaffected by acids and alkalies. Platinum itself is occasionally used for backing mirrors.

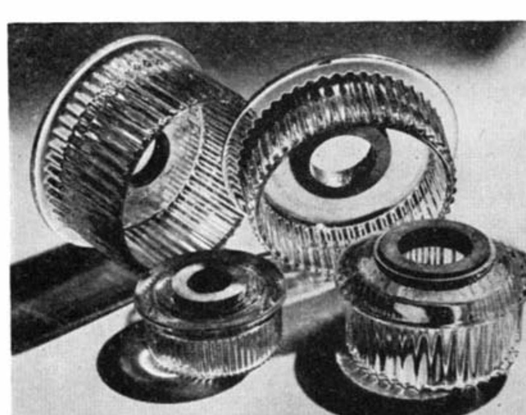
Use is made of the mirror-forming reaction in the preparation of the parabolic reflectors used for motion picture projection in theaters. An accurate mold of the reflector is first made in glass, and silver is precipitated on its surface. The thickness of the metal film is then built up by electroplating a sufficient amount of copper onto the silver. To free the metal reflector from the glass mold, the whole is immersed in hot water, then in cold, alternating several times until the metal slips off. The silver surface is then plated with rhodium to make it non-tarnishing.

ELECTROPLATING — Glass, like other electrical non-conductors, may be electroplated by first applying a conducting film to the surface. Finely divided carbon is frequently used for this purpose. In this way a film of any metal that can be electrodeposited can be applied to a non-conductor. Vaporized metals may be deposited on the surface of a glass article also, forming a mirror-like composite. These metallic films find use in telescope and other reflectors as well as articles other than mirrors, as witness the familiar Dewar flask, the basis of the Thermos bottle, in which metallized surfaces serve for heat reflection; the vacuum tube of our radio sets, shielded by a conducting film; and gold-lettered windows and doors.

Metallized glass bottles and bottle closures are used as novelty containers, especially in the perfumery

Left: A metal drive quill is bonded into glass impeller for a centrifugal pump

Photos courtesy Corning Glass Works



Right: Lead bushings in godet wheels are used to secure perfect fit on spindles in rayon mills and cosmetic industries. Gold lettering, when applied to glazing in place, is accomplished by the use of metallic gold leaf and an adhesive. Recently, vaporization of magnesium has been tried for the production of Dewar flasks. Nickel mirrors have also been prepared from nickel carbonyl compounds.

The incandescent lamp and the vacuum tube have presented their own problems in glass-metal collaboration. Early incandescent lamps were evacuated instead of being nitrogen-filled, and considerable difficulty arose in carrying the conductors through the glass envelope. The greater expansion of the metal wire caused gradual leakage at this point. It was solved by sealing tiny bits of platinum wire into the glass, joining to baser metal inside and outside the envelope. Platinum was selected because its coefficient of expansion is very nearly that of glass. Cheaper alloys of low expansion have since replaced the noble metal.

Courtesy Corning Glass Works

Left: After glass is metallized, metal parts can be attached with a soldering iron

SOLDERING—For certain types of vacuum tubes, the heart of the modern science of electronics, metal diaphragms must be placed in the walls of the glass envelopes. Metal must be fastened to glass so solidly that a hermetic seal is maintained even under the changing temperatures of the tube in operation, and with an extremely high vacuum in the tube. In those tubes intended for war use, as well as in many types for industry, vibration and shock are added service hazards. Metallizing techniques have been developed that permit soldering metal parts to the prepared area, the resulting bond being so secure that the glass itself will break before the bond fails.

The ability to deposit metal films on glass is valuable in other electrical applications also. Glass tubes with metallized bands serve as resistors in electrical applications for which such special requirements as corrosion resistance must be met. Similar glass tubes with metal deposited as a coil may be used in transformers, obviating the use of wire coils. Wherever needed, this method makes it possible to plate conducting channels into one of electricity's best insulators, glass, conductor and insulator becoming one unit material. Silver films on glass form radio condensers of special types.

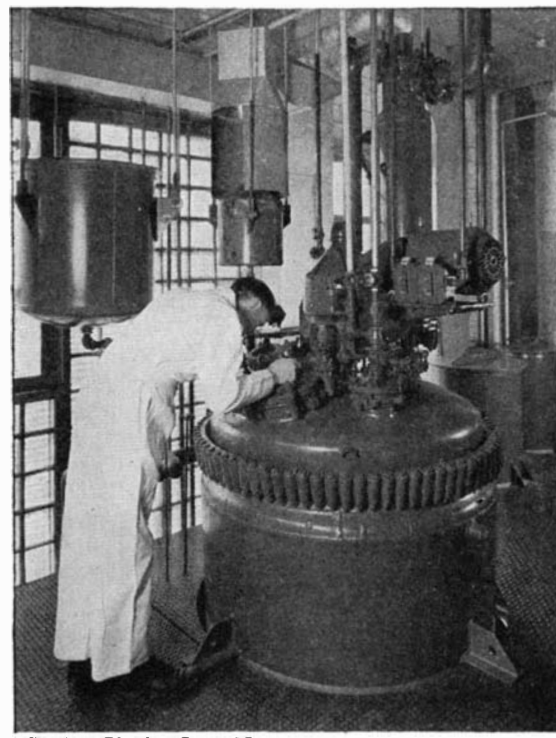
Electrodeposition of metals on glass is sometimes used in the chemical industry, where thermometers must withstand hard service. When temperature readings are required in a time interval so short as to preclude armoring the thermometer bulb, deposition of a heavy coat of corrosion-resistant metal over the bulb has proved effective in reducing breakage.

Metal ornamentation of glass is a procedure of long standing. Gold and platinum bands are applied to glass tumblers by means of metal paints, consisting of the metal or its compounds mixed with an essential oil. The paint is applied to the surface of the article, then fused in. For large-scale production the entire operation is done mechanically, plain tumblers being fed into the machine by an attendant and removed with metallic bands applied and fused in.

For various mechanical purposes it is desirable to have metal lugs firmly attached to glass. Platinum or silver films, electrodeposited or painted and fused, form a basis for soldering such attachments. In high-vacuum work in the chemical industries, glass tubing must sometimes be hermetically sealed into metal forms. The same metallized areas and soldering solve this difficulty also.

WIRE-DRAWING—Not all glass-metal combinations consist of metal films on glass, however. A recent development in the wire-drawing industry illustrates an entirely different type of use. A difficulty in drawing wires of steel or stainless steel is the need for feeding thoroughly annealed metal into the wire dies, in which it must undergo severe cold-working. The metal must be free of surface oxides also, as these would be forced into the wire during the drawing operation. A means of annealing the wire has been found in which a bath of molten glass is used. The wire is fed into the bath, which has a temperature of 1900 to 2300 degrees, Fahrenheit, according to the type of steel, held there for from 10 seconds to three minutes for annealing, then withdrawn from the opposite side of the bath and coiled. A coating of glass adheres to the wire, preventing contact with air during the cooling period. As cooling progresses below the temperature range at which rapid oxidation occurs, the glass shatters and separates from the wire, taking any oxides with it. The glass may be collected and re-used.

The same process may be used for narrow steel strip and its use for sheet steel and bar stock has been predicted. By a slight modification of the process, in which molten glass is sprayed onto the metal by spray



Right: Glass linings protect medicinals — in this case, a glandular concentrate

Courtesy Pfaudler Company

guns, the method has been adapted to annealing rods.

To reduce corrosion of stainless steel wire during annealing, it had been standard practice to coat it with lead. The lead was difficult to remove completely. Glass processing was found to be not only satisfactory in itself, but also to provide a means of removing the lead coating when desired.

Chemical equipment frequently makes use of the corrosion resistance of glass, but finds the strength and freedom from breakage of steel desirable also. For large vessels not easily fabricated from glass alone, steel may be formed or partially formed to the required shape and lined with glass which is fused to the steel surface. By present techniques it is possible to weld such steel-glass vessels to similarly lined pipe, and so to form the equipment into a single unit. Apparatus of this type finds use especially in the preparation of dyes, drugs, and medicinals, including vaccines and penicillin, which must be free from even minute particles of contaminating material.

Godet wheels, used in the rayon industry, may be economically formed of glass, and here the corrosion resistance of glass is of great importance also. However, the glass wheel must be mounted on a steel spindle for operating. It has been found possible to cast a lead bushing into the glass wheel, and to machine this bushing to fit the steel spindle accurately, so that the wheel functions with runout held to very close limits.

The chemical industry also appreciates the resistance to chemical attack offered by glass to the extent of constructing centrifugal pumps of this material. Here again there arose the problem of attaching the glass impeller to the metal drive quill. Use was made of those low-melting bismuth alloys that have been adapted to so many new purposes within the past few years. The steel quill was inserted into the glass impeller, and locked in place by pouring Wood's metal around it. Final finishing of the intricate glass part then took place.

An even simpler method of permanent attachment of glass and metal is used in the case of a glass float. The float must be attached to a metal rod to actuate a liquid shut-off valve to a tank. In fusing the end of the glass float to seal it, a slight flange is formed in the glass. A threaded brass spud is then spun over the flange, and the rod screwed into the spud.

METAL INSERTS—It is frequently necessary to insert a small metal part, often threaded, in a glass form in order to attach other metal parts. Because of the difference in expansion of glass and metal when heated, it has heretofore been almost impossible to make these insertions at the time of forming the molten glass. A new process, called multiforming, offers a solution of the insert problem. Here the glass is powdered, then formed in a mold with the insert in place, and finally sintered at a relatively moderate temperature.

Metallic lead has been quite generally used for shielding operators from the harmful radiations from X-ray equipment, but it is frequently desirable to view the work during the period of radiation. A type of glass containing 61 percent lead has been produced, offering X-ray protection equivalent to about one third its thickness of metallic lead. It is about twice as heavy as ordinary glass.

Applications in which glass and metals are close collaborators without becoming a unit material are exceedingly diverse. Several recent developments are the use of metal-supported glass fibers as filter units for air conditioning; steel-framed glass bricks for construction; glass fiber insulation of copper wire and other electrical conductors in applications where temperatures make combustible insulation undesirable; watchmen's booths of armor steel and bullet-proof glass; and metal-supported glass fibers for heat insulation in domestic ranges, aircraft, and pipe lagging.

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ALUMINUM BEARINGS

Stand Up Well Under Hard Service

A SIGNIFICANT development in the bearings field is the growing use of aluminum-alloy bearings for heavy-duty service. Alloyed with tin, and running against hardened shafts or journals, the aluminum bearings are successfully withstanding high loads in truck, tractor, and automobile engines.

Among the most valuable properties they possess for this service is their high heat conductivity, which keeps surface temperatures down, and their good frictional characteristics. Lightness, too, is often an important mechanical advantage.

The aluminum bearings are made as solid bearings (rather than as linings)—usually cast. Considerable interest has recently been shown in aluminum bearings made from metal powders, which possess the additional advantages of lighter weight and greater oil-carrying ability because of their characteristic porosity.

PREPLATED METALS

Save Materials and Speed Production

JUST taking hold at the war's outbreak, the idea of using "preplated" metals for various corrosion-resisting products has found wide acceptance in the past few years.

Instead of the conventional practice of buying strip steel, stamping or punching out the required parts, and then electroplating or lacquering them individually, the manufacturer may now purchase sheets or coils of steel or other base metal already plated in bright chromium, nickel, copper or brass. The preplated strip may then be stamped or formed, the plate being such as to withstand any but the most severe operations without flaking or peeling.

Preplated metals are reported to have saved tons of critical corrosion-resistant alloys and much production time during the war period.

BLACKENED STAINLESS

Developed for War; Has Peace-Time Possibilities

DEVELOPED originally to provide a corrosion-resistant metal that would not reflect light when used in gun parts, a new group of blackened stainless steels are now being studied by post-war-planning engineers for possible peace-time uses.

The process, patented by Rustless Iron and Steel Corporation, may be applied to straight chromium or nickel-chromium stainless steels and consists of immersing the parts to be blackened in a molten bath of sodium (or other) dichromate at about 750 degrees, Fahrenheit. An adherent, ductile, abrasion-resistant, 0.00001-inch-thick black coating results that does not harm the corrosion-resistance of the steel.

Used in the Army's Garand rifle and in the Navy's Bludworth depth sounder, the blackened stainless steel is believed to have interesting possibilities for such peace-time products as bolts, screws, molding, trim, motion picture projectors, photographic equipment, surgical instruments, jewelry, and other black parts requiring corrosion and heat resistance, stratospheric cold-toughness, non-magnetic properties, and high strength-weight ratio.

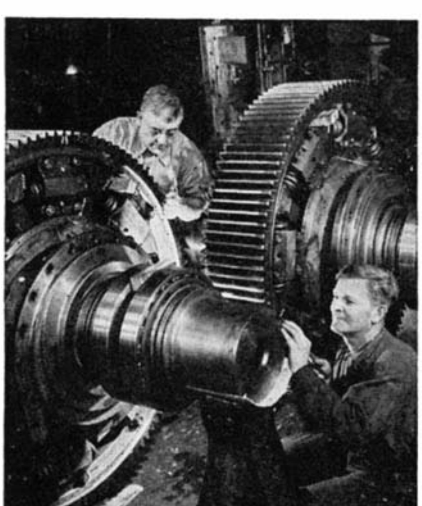
Turbines On Rails

At Operating Speeds, the First Locomotive In America to be Driven by a Steam Turbine Geared Directly to the Driving Wheels Compares Favorably With the Most Economical Reciprocating Units. A New Era of Rail Power May be in the Making as this Locomotive Accumulates Mileage. The Unique Gears are Being Carefully Watched by Engineers

FAMILIAR steam cylinders, crossheads, and main driving rods of the conventional locomotive are missing on the Pennsylvania's No. 6200, and a large covered pipe extends alongside the boiler on the right side of the locomotive. These are the superficial earmarks of the first gear-drive steam-turbine locomotive in America.

Structurally, this locomotive follows well-established lines. The usual cylinder castings have been replaced by a steam-turbine driving unit, which consists of forward and reverse turbines and speed-reduction gears which connect the turbines to the Number 2 and 3 pairs of driving wheels. The large pipe on the right side of the boiler carries the exhaust steam from the forward turbine casing to the exhaust nozzle in the smokebox. This creates the draft just as in the reciprocating steam locomotive, except that the steam and gases issue from the stack with a steady blow, unaccented by the customary sharp beats of the exhaust of the reciprocating locomotive.

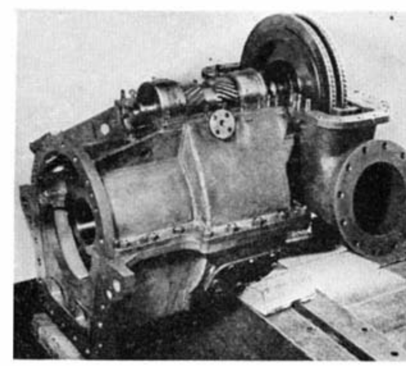
The Pennsylvania Railroad became interested in 1937 in improving the performance of steam passenger locomotives by the use of a geared steam turbine instead of the customary reciprocating steam engines. In the development of the design, engineers of the Baldwin Locomotive Works worked with those of the railroad and of Westinghouse Electric Corporation. The drawings were ready late in 1941. Wartime difficulties in getting materials required a number of changes, but the locomotive was finally delivered to the railroad in September, 1944.


Driving-axle and main driving-gear assembly. When completed the cushion springs between the gear and the axle-spider arms will be enclosed

The locomotive is designed to deliver 6900 turbine shaft horsepower in forward motion and is intended for high-speed freight or passenger service. The length and weight of modern passenger trains have grown so great, and the speeds demanded of freight trains have become so high, that the same kind of locomotive has become suitable for both services.

Because of the greater weight required by the substitution of certain non-critical materials for the stronger or lighter materials originally specified, it became necessary to replace the four-wheel leading and trailing trucks with six-wheel trucks and the locomotive is designated as a 6-8-6 type (six-wheel leading truck, eight-coupled driving wheels, and a six-wheel trailing truck). The boiler carries a working steam pressure of 310 pounds. The pressure at the steam turbine inlet is 285 pounds per square inch gage, and steam is delivered from the superheater to the turbine at temperatures up to 750 degrees, Fahrenheit.

Three features of this locomotive are of outstanding interest. These are the turbine and reduction-gear unit, the unique adaptation of the quill drive so well established on electric locomotives, and the method of single-lever control of the speed and direction of the locomotive.


The reverse-gear turbine and transmission unit are bolted to the main gear casing. Clutch is at the left

TURBINES AND GEARS—The turbines (there is a separate turbine for moving the locomotive backwards) and the reduction gears are assembled in a rugged casing which accurately maintains the alignment of all shafts. This casing fits into the space between the two main side frames of the locomotive and is supported at each end by a frame cross member. When assembled it completely surrounds the second and third driving axles.

The forward turbine comprises one Curtiss two-row stage and five single-row reaction stages. Steam is admitted through four nozzle groups, each fed by a three-inch steam pipe. A steam header and throttle valve are located at the top of the smokebox behind the smoke stack. Steam from the superheater units is admitted to the nozzle pipes by four cam-operated valves which are opened in succession and which can be moved in small increments. Close regulation of speed and power is thus attained.

At a locomotive speed of 100 miles

an hour the turbine shaft rotates at approximately 9000 revolutions per minute. The double-helical high-speed pinions are on a hollow shaft. The drive shaft extends through the hollow shaft and is connected to it at the opposite side of the unit.

The reverse turbine is a single Curtiss double-row stage which is mounted on an extension of the reverse pinion shaft. This double-helical pinion drives a double-helical reverse gear which, in turn, drives the main pinion through a dog clutch on the end of the main pinion shaft. The forward turbine is permanently connected to the gears and rotates when the locomotive moves backward.

Steam is admitted to nozzles in the base and cover of the reverse-turbine cylinder from a single inlet pipe, which is supplied through a cam-operated valve similar to those which supply the forward-motion turbine. The maximum speed at which the locomotive should operate backward is 22 miles an hour. At this speed the reverse turbine rotates at approximately 8300 revolutions per minute and develops 1500 shaft horsepower.

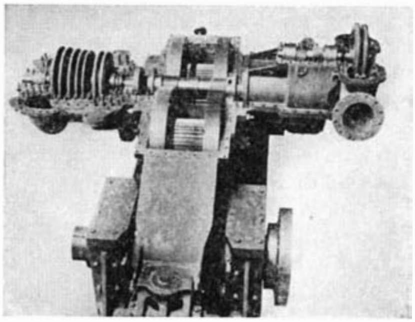
The main double-helical high-speed pinion meshes with two pairs of double helical gears. Between the double helicals are the single spur gears, each of which, in turn, meshes with one of the large axle drive gears.

Several features in this unit are unusual. The tooth loads and the surface hardness of the contact surfaces of the helical pinions and gears are more than double the values customarily used. Again, great care was exercised in the design to prevent any possible locomotive frame distortion from being transmitted through the gear case to the heavily loaded gears and their bearings. To accomplish this the attachment of the gear case on the locomotive frames is through a three-point suspension. At one end of the case is a wide horizontal tongue which fits into and is secured to the jaws of a horizontal bracket. The bracket is secured to the frame cross-member. Bosses both top and bottom along the sides of the tongue fit snugly between the jaws of the bracket and provide two points of suspension which fix the vertical alinement of the gear case between the frames. The position of the case is stabilized at this end by rubber compression blocks between the sides of the gear case and the bottom rails of the frames.

Instead of a jaw-and-tongue attachment, the bracket which supports the other end of the gear case on the locomotive frames has a longitudinal trunion which fits in a bearing in the end of the case. It will be seen that the gear case is thus completely relieved of stresses which rigid connections would transmit to it from slight torsional or lateral bending strains in the frames.

QUILL DRIVE—Since the gear case is attached to and alined with the locomotive frames, and the frames are supported on the driving boxes by springs and equalizers, it is evident that the alinement of the driving axles varies through a considerable range from a parallel and concentric relationship to the axis of the driving gears. The quill drive was developed to meet this situation and has been used on a large number of electric locomotives. In these locomotives the frames and journal boxes are usually outside the wheels; the driving motors, which occupy the space between the driving wheels, are rigidly attached to the frames. The rotation of the main gears is transmitted directly to the driving wheels by spring-cushion cups on lateral projections on the gear which extend between and bear against the spokes of the wheels. The driving axles pass through the hollow shafts of the main gears with ample clearance to permit them to adjust themselves for the necessary changes in relative alinement.

The same principle is employed on the steam-turbine locomotive. But because the driving wheels are outside the frames, the drive comprises a single low-speed spur gear for each of the two axles. Each gear is located on the longitudinal center of the frame and around the axle


Transmission unit with covers removed from main gear casing, forward turbine (left), and reverse turbine (right). Spur gears between the helical gears mesh with the axle gear

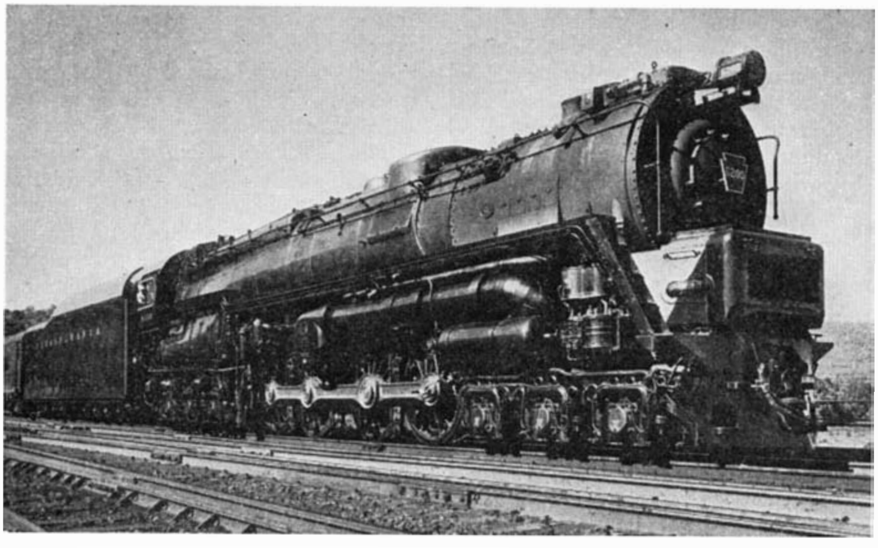
which it drives through a single spider pressed on the axle.

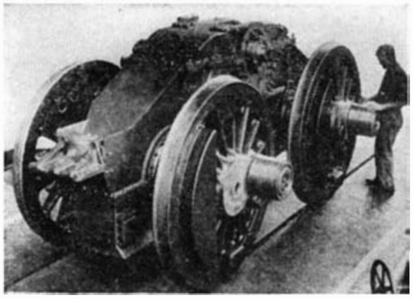
The hardened faces at the ends of the radial arms of the spider bear against spring-cushioned cups which slide in sockets on the inside of the low-speed spur-gear rim. The quill constitutes seats for roller bearings, one on each side of the gear center. The gear is alined by the outer housings of these bearings which are bolted in the sides of the gear case.

The spring cups serve to cushion the turbine and gearing from the shock of sudden changes in velocity of the locomotive, as well as to transmit rotation between two misalined systems. Enclosed in the reduction-gear case, they are lubricated by a bath of heavy oil.

Each gear delivers power to two pairs of driving wheels. To equalize the load on the two gears, all four pairs of drivers are connected by roller-bearing side rods.

The bearings of the high-speed pinion and the high-speed gear are lined with a tin-base babbitt. Because of the high linear velocity of the high-speed pinion shaft in its bearings, more than the usual amount of clearance is required in the bearings. The bearings of the high-speed gears are internal, being mounted in the hollow-bored ends


The first direct-driven steam-turbine locomotive built in the United States



Reduction-gear casing and driving-axle assembly with the turbines removed. The clutch for the reverse drive is seen at the upper center

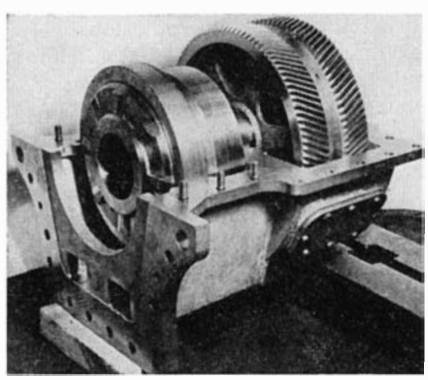
of the spur pinion shaft on which the two helical gears are shrunk. The bearings rotate with the gears on fixed steel trunions secured to the sides of the gear case.

SINGLE-LEVER CONTROL — A single lever at the right side of the cab and immediately in front of the engineman's seat controls both the speed and direction of the locomotive. The lever moves forward and backward in a slotted quadrant. The slots are parallel but not in line with each other and at the central position of the lever in the middle of the quadrant it can be crossed over from one slot to the other. The central position of the lever is the "off" position. Moving it into the forward slot controls the flow of steam to the forward turbine. The flow of steam and the speed of the locomotive are increased as the forward movement of the lever is increased. Moving the lever back towards the center of the quadrant reduces the steam flow and at the center stops it entirely. With the locomotive at rest, crossing the lever over and moving it backward in the rear slot first engages the clutch between the backward turbine reduction gear and the end of the double-helical high-speed pinion shaft in the main gear case and then admits steam to the backward turbine. Until the clutch is engaged, steam cannot be admitted to the turbine.

These functions are performed by a so-called "pneudyne" control system furnished by the Westinghouse Air Brake Company. The pneudynes are pneumatic cylinders controlled by air valves. The one for the forward motion is located on the engineman's side of the locomotive and rotates the throttle-valve cam shaft through a rack and pinion. The reverse pneudyne is located on the fireman's side of the engine and is connected by lever to the reverse-throttle cam shaft. The system includes over-speed and low-lubricating-oil-pressure protection valves. These operate to close either throttle by exhausting the control air to the atmosphere if the locomotive speed exceeds 110 miles an hour forward and 25 miles an hour backward, or if the oil pressure falls below five pounds per square inch.

The clutch which transmits power from the reverse turbine to the main gear case is hydraulically actuated. Engagement or disengagement of the clutch when the locomotive is moving is prevented by a "zero speed" interlock in the pneumatic-control circuit.

BOILER—The boiler is of large capacity with a total combined evaporative and superheating surface of 7042 square feet and a large firebox and combustion chamber with a grate area of 120 square feet. Its largest outside diameter is 102 inches. One of the reasons which makes the large boiler possible is the small diameter of the driving wheels. Because of the desirability of keeping piston speeds within certain limits, the diameter of the driving wheels of reciprocating steam locomotives intended for high-speed service are usually not less than 78 inches and are frequently 80 inches. Because of the absence of pistons, the uniform torque of the turbine, and the com-



Reverse-gear casing with top removed

plete rotating balance of the wheels and their side rods, there is no need to keep down the revolutions per minute of the turbine locomotive driving wheels. They are only 68 inches in diameter on No. 6200. This admits of a larger boiler without exceeding top clearances.

No. 6200 carries 260,000 pounds on the driving wheels and the total engine weight is 580,000 pounds. The tender, loaded with 18,000 gallons of water and 37½ tons of coal, weighs 449,400 pounds. The locomotive exerts a starting tractive force of 70,500 pounds forward and 65,000 pounds backward.

STEAM CONSUMPTION — Unlike the reciprocating steam locomotive, when steam is admitted to the steam turbine there is nothing to prevent it from blowing through to the exhaust even though the blades of the turbine rotor are stationary. In the reciprocating engine, it is only after movement of the pistons that steam can be exhausted from the cylinders. Hence, the steam turbine has a very high rate of steam consumption, measured in pounds per horsepower hour, in the starting and slow-speed range.

The unit consumption drops rapidly, however, and in the normal range of operating speeds the steam consumption of the turbines seems likely to compare favorably with the most economical reciprocating locomotives, if not better than some of them. In measuring this performance against the high efficiency of the steam turbine in central-station practice, it must be remembered that the turbines on locomotive No. 6200 operate at relatively low initial pressure and that they exhaust to the atmosphere—that is, they operate non-condensing.

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TURBINE LOCOMOTIVES

Three More Types Coming Along

PARTICIPATING in a co-operative development of a steam-turbine-electric locomotive which has been under way since November, 1944, are General Electric Company, Babcock and Wilcox Company, and nine railroads. This locomotive will burn pulverized coal, will generate steam at 650 pounds per square inch, and will develop 6900 shaft horsepower in a non-condensing turbine. By the use of pulverized fuel the sponsors anticipate the production of a horsepower-hour at the drawbar with one third less fuel than required by the most efficient conventional steam locomotives.

Turbine-driven steam locomotives departing from the conventional locomotive form have been proposed by the Pennsylvania and the Chesapeake & Ohio Railroad. In general arrangement the two locomotives will look somewhat alike. The one for the Pennsylvania, however, will be driven by two geared steam turbines developing a total of 9000 horsepower. That for the C. & O. will be driven by a 6000-horsepower steam turbine through electric generators and motors. The basic designs have been completed by the Baldwin Locomotive Works. The electrical equipment will be built by the Westinghouse Electric Corporation.

Solarization

Glass in Ultra-Violet Lamps Tends to Deteriorate or Solarize as the Lamps are Used. A New Glass Has Now Been Developed which Transmits Ultra-Violet Radiation Freely but Does Not Solarize. How it Was Determined that Alkali in Glass is the Cause of Solarization

By DR. HARVEY C. RENTSCHLER
Director of Research, Lamp Division
Westinghouse Electric Corporation, Bloomfield, New Jersey

THE EFFICIENCY of an ultra-violet lamp is dependent upon the ability of the glass to transmit short-wave ultra-violet radiation; in many commercial lamps the life of the electrode governs the life of the lamp. Together, then, the glass and the electrode govern the overall useful production of ultra-violet radiation.

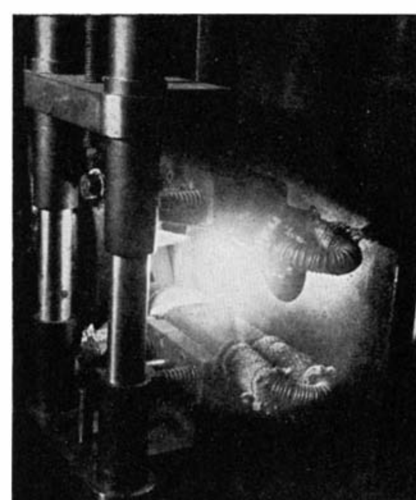
There are now available bactericidal ultra-violet lamps having electrodes of indefinite life, but full advantage of these long-lived electrodes could not be taken because of the deterioration or "solarization" of the glass which resulted in a decrease in its ultra-violet transmission efficiency.

Recently, however, there has been introduced a new glass which practically solves this problem. Manufactured by the Corning Glass Works under the trademark Vycor, it possesses the unprecedented characteristics of being able to transmit almost perfectly all ultra-violet radiation of wavelengths longer than about 2500 angstrom units and shows very little, if any, solarization upon exposure to short-wave radiation. At the same time, this glass transmits very little radiation below 2000 angstroms. This factor eliminates the production of excessive quantities of ozone by these short wavelengths, which is one of the objections to using quartz for bactericidal lamps.

Vycor is a borosilicate glass containing about 96 percent silica. In some respects, it is similar to quartz. It has an expansion coefficient of of 7.5×10^{-7}, which makes it necessary to join several types of glass to form a graded seal so that a glass having an expansion coefficient close to that of the metal electrode leads can be used to produce a vacuum-tight joint at the point where the leads are sealed into the lamp.

Zschimmer (*Physik, Zeitsch.* 8, p. 611-1907) pointed out that boric oxide, B_2O_3, and silica, SiO_2, in their pure state are very transparent evei below 2000 angstroms, that the addition of metallic oxides lessens the transparency, that sodium oxide, Na_2O, acts more strongly than potassium oxide, K_2O, and that lead oxide, PbO, absorbs very strongly.

Dr. Rentschler, the author of the accompanying article, inserts (left) a carbon cup containing powdered glass into the lower jaw of the spectroscope's arc stand. It was in the course of such work that the cause of solarization of glass by ultra-violet rays was determined. Right: A close-up of a burning sample in the carbon electrode after igniting

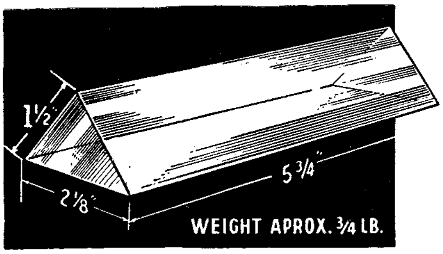


METAL OXIDES—The absence of transmission of ultra-violet in ordinary window glass is generally attributed to the presence of metallic oxides in the glass. In addition to the alkali oxides mentioned above, all glasses contain small traces of iron, magnesium, aluminum, manganese, and titanium. Solarization has been commonly attributed to the action of the ultra-violet in converting the metallic oxides from one form to another.

The fact that Vycor and quartz show only negligible solarization as compared with the solarization associated with all the glasses that

SENSATIONAL WAR BARGAINS

in LENSES & PRISMS



SILVERED TANK PRISM
90-45-45 degree, 5¾" long, 2⅛" wide, finely ground and polished. Would normally retail from $24 to $30 each.
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(Illustrated booklet on Prisms included FREE)

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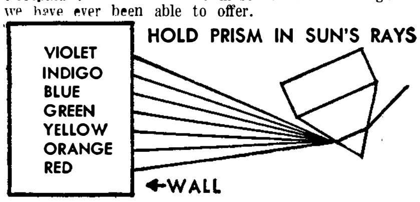
Postpaid . . . This is the most sensational bargain we have ever been able to offer.

HOLD PRISM IN SUN'S RAYS



TANK PRISMS

90-45-45 degree prisms of huge size—5¾" long, 2⅛" wide, finely ground and polished. Used to build a Periscope . . . excellent also for experiments, classroom demonstrations at high schools, colleges, camera clubs, astronomy clubs. Some of our ingenious customers have used these Prisms to make camera stereo attachments, photometer cube, range finder, etc. Normally, these Prisms would retail from $24 to 30 each.

SEE THE COLORS OF THE SPECTRUM

It's easy to remove the silvering from a silvered prism to make an interesting experiment. Hold prism in sun's rays as shown in drawing. White incident light which passes through prism is thus broken up into a band of primary colors known as the spectrum—a beautiful sight! By looking through a tank prism at a certain angle, you can see a world of colors everywhere. Truly amazing!

All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections Which We Guarantee Will Not Interfere with Their Use. Come Neatly Packed and Marked.

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Telescopes, Magnifiers, Photographic Gadgets and Hundreds of Experiments with these Low Cost Lenses.

To translate millimeter measurements: 25.4 mm. equals one inch.

8 MM. MOVIE PROJECTING LENS SET—Consists of 2 Achromatic Lenses, diam. 15 mm. and a F.L. when combined of approx. one inch. Each lens has the new magnesium fluoride low reflection coating.
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POLAROID (Dyed to reduce light transmission)—**Suitable for Experimentation.**
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Set #15-S — "The Experimenter's Dream" — 62 Lenses, Prisms and Optical Items, and New 50-Page Book, "Fun With Chipped Edge Lenses." $15.00 Postpaid. The variety of Lenses and Prisms in this set will enable you to conduct countless experiments, build a great variety of Optical Equipment. **A sensational buy.**

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Contains wide variety of projects and fully covers the fascinating uses of all Lenses in sets listed above . . . only $1.00 Postpaid.

RAW OPTICAL GLASS . . . An exceptional opportunity to secure a large variety of Optical Pieces both Crown and Flint glass (seconds) in varying stages of processing. Many prism blanks.
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KELLNER EYE PIECE LENS . . . Focal Length 1¼ inches. Diameter of eye lens 16 mm. Diameter of field lens 25 mm. Eye achromat already cemented.
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PERFECT ACHROMATIC TELESCOPE OBJECTIVE LENS . . . Diam. 1¾ inches, F.L. 20 inches.
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CLEANING BRUSH SET . . . For Lenses, Optical instruments, etc. Perfect quality — 12 inch Flexible Plastic handle, hollow circular const. Range from stiff to very soft. 4 Brushes to set.
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3006-S	Porro Abbe Prism. Each	$0.25
3016-S	Pentagon Prism. Each	.75
2024-S	10 Pieces Circular A-1 Plate Glass (Diam. 31 mm. — for making Filter)	.25
1004-S	2 Reducing Lenses	1.20
3001-S	Lens Surface Prism. Each	2.00
503-S	No. 1 Sable Hair Lettering Brush. Dozen	1.00
3021-S	Amici Roof Prism (3rd Grade). Each	.25
4009-S	Heat Absorbing Glass 4" x 5". Each	.35
4010-S	Heat Absorbing Glass 2" x 2". Each	.10
2020-S	40 mm. Neg. Lens, Cross Lines. Each	.25
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523-S	Six Threaded Metal Reticle Cells	.25
26-S	First Surface Aluminized Mirror, Diam. 1¼". Each	.25
624-S	Neutral Ray Filter size 4¾"x2½"	.25
3022-S	Round Wedge 65 mm. Diam. Each	5.00
3036-S	Roof Prism — 80 degree, face 1⅝" wide. Each	4.00
22-S	Inclinometer—Aircraft type. Each	.25
704-S	Lens Cleaning Tissue, one ream (480 sheets), size 7½" x 11"	1.50
6002-S	Educational Set. 1 blank and 1 finished Porro Prism (3rd grade) Set	.25
1003-S	50 Power Microscope Lens Set	.70
1028-S	8 Power Mounted Magnifier Each	.35

Minimum order—$1.00

WAR SURPLUS ACHROMATIC LENSES

Stock No.	Dia. in mms.	F.L. in mms.	Comments	Price
6017-S*	12	80	Cemented	50c
6019-S*	15	41	Cemented	60c
6023-S*	25	95	Cemented	75c
6078-S*	33	140	Uncemented	70c
6081-S*	35	55	Uncemented	70c
6082-S*	37	57	Uncemented	70c
6084-S*	41	66	Uncemented	70c
6085-S	45	135	Uncemented	$1.00
6086-S*	49	75	Uncemented	90c
6089-S	56	90	Uncemented	$1.00
6094-S	16	75	Perfect-Cemented	$1.00
6111-S	16	36	Cemented	75c
6116-S*	41	66	Cemented	$1.00

ASTERISKED ITEMS may be requested with new low reflection Magnesium Fluoride coating at 10c extra.

COLOR FILTERS

1 Red and 1 Yellow Filter in following Diam.
(Prices below include 2 filters)

20 mm. (seconds)	40¢
32.5 mm. (seconds)	70¢
37 mm. (seconds)	70¢
45.5 mm. (seconds)	90¢
31 mm. (seconds)	70¢

(Minimum Order on Above—$1.00)

LENS FOR KODACHROME EYE-VIEWER . . . Color corrected cemented lens 41 mm. diam., 66 mm. F. L.
Stock #6116-S ....$1.00 Postpaid

TANK PERISCOPE

Complete Set Mounted Components

Rugged, strong, originally constructed for U. S. Tank Corps. Consists of 2 fine Periscope Mirrors mounted in metal and plastic. Only plywood body frame is required to finish this exceptional Periscope. First surface mirror is well protected by glass windows. Set weighs 2¾ lbs. Overall length of mount 6⅛", width 2⅛". Would normally retail at $40 to $50.
Stock #700-S.......$3.00 Complete Set Postpaid

TWO SETS (4 UNITS).................... ....SPECIAL $5.50 Postpaid

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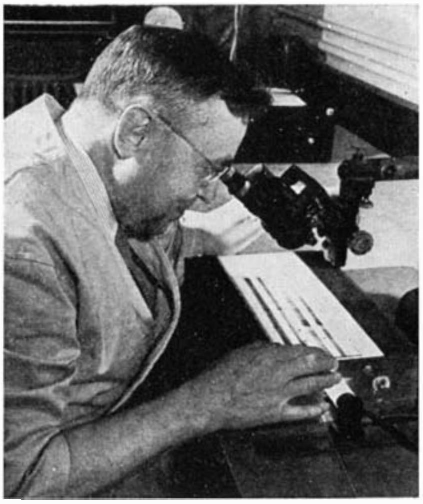

Examining spectra of glass samples

have been used in bactericidal lamps suggested that a spectroscopic analysis be made of the different glasses as well as of Vycor and quartz in an effort to detect traces of the impurities which might be responsible for causing the solarization.

In making this analysis, the material to be tested—Vycor, quartz, or glass—was ground into a fine powder in an agate mortar. A mixture of equal amounts of the powder and of sucrose carbon was placed in a hollow spectroscopic carbon electrode. An arc between this electrode and a second carbon, focused on the slit of a large spectrometer, vaporized the material contained in the cup and the resulting spectrum was photographed in standard manner.

The spectral region used spans wavelengths from 550 to 3570 angstroms. All the metallic elements which are commonly present in glass have strong lines in this region of the spectrum and a comparison of the relative intensities of the lines of the metals in the different samples makes it possible to detect relative amounts of impurities in the various materials examined.

Spectrograms were taken for a number of glasses which have at one time or another been used in making Sterilamp bactericidal ultraviolet tubes. In addition to these, a number of samples of Vycor and of both fused quartz and quartz crystals were likewise tested.

The spectrograms of the glasses, the Vycor, and the quartz all showed the same amount of iron in all the samples tested, as nearly as can be judged from the intensities of the prominent lines on the spectrograms. Similarly, the spectrograms indicated the presence of the same amounts of magnesium, manganese, aluminum, calcium, and titanium in all the samples.

INFLUENCE OF ALKALI—The sodium doublet of wavelengths 3302.9 and 3302.3 angstroms was strong in the spectrograms of all the glasses but was completely absent in the spectrograms of all the Vycor and quartz samples, indicating that the presence of alkali in some form or another influences the solarization of the glasses and explaining the absence of this action with Vycor and quartz.

Another interesting observation about Vycor was made in an investigation carried out in addition to the spectroscopic analysis. It was found that the intensity of bactericidal radiation from a discharge through mercury vapor in Vycor, at one meter from the lamp, is more than that from a similar quartz lamp. This is because a negligible amount of ozone is generated by the Vycor lamp to absorb the 2537-angstrom radiation.

Although there are difficulties in processing Vycor into the lamps, this is more than compensated for by the longer life and more uniform output during the life of a Vycor lamp. This is highly important because, for most effective protection against contamination, it is essential that bactericidal ultra-violet radiation be continuous and of uniform intensity.

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FIRE-PROOF GASOLINE

Developed by Petroleum Industry

A GASOLINE with an octane rating equal to that of aviation fuel, but which is as safe to handle as ordinary kerosine, is one of the newest commercial developments in the petroleum industry. Experts claim that its use in airplanes will reduce the fire hazard by almost 90 percent. Recent tests of this new gasoline showed that it will not ignite even when splashed *directly over an open flame.* Tested under the same conditions, ordinary high-octane gasoline exploded and burned when splashed eight feet away from the open flame.

As long ago as 1931, Standard Oil Company (New Jersey) developed in the laboratory a gasoline which was practically free from the danger of accidental ignition under normal operating conditions, and which was at the same time equal or superior in octane rating to the best of the flammable types of gasoline in operating efficiency. (This work was first reported in Scientific American in March, 1932.)

Since that time the expansion of high-octane production facilities required by the war effort has made it necessary to construct large amounts of equipment which can now be used in the manufacture of this fire-proof gasoline.

The advantages of flame-proof gasoline in the safe operation of the giant Clippers carrying over 200 passengers, which Pan-American World Airways plans to operate in its post-war global service, is obvious. In the event of a forced landing on water, in which the fuel tanks are damaged, spilling several tons of gasoline on the water, the chances of an explosion and fire is minimized to the point of being almost negligible.

TENSION VIBRATOR

Supplies Data on Effects of Small Stresses

FATIGUE resistance testing, by vibration, of cords for tires, belting, and a long list of products in which fabrics play a leading role, as well as filaments for other purposes, is accomplished by a new cord tension vibrator which makes it possible to supplement information on tensile strength with new data on the ability of the cord, fabric, or filament to withstand repeated small stresses far below the tensile strength of the material. This has been designated by the broad term "fatigue resistance."

Setting up the cord tension vibrator which includes provision for determining effects of heat on cord life

Effects of variation in temperature, yarn composition, and the fiber structure on the fatigue resistance of the material under test can be accurately measured with the new Goodrich apparatus. Vibration rate can be changed and heat can be applied, to meet the needs of the particular test.

FM RECEIVER

Can be Built to Cover Wide Wave Band

EXPERIMENTS at the John Meck Industries, Inc., laboratory prove that it is possible to manufacture a frequency-modulation receiver which will operate not only in the 42-50 figure megocycle band but will also cover the proposed wide range of 84 to 102 megocycles now being considered by the Federal Communication Commission. The circuit is not a two-band set, and does not call for remodeling of an original set at the factory or by local service men. The wavelength bands are not changed by means of switches, but the circuit will not cover the unused band between 50 and 84 megocycles. However, if the Commission should change its mind and use the wavelength between 50 and 84 megocycles, a set could be built to cover the entire wavelength band.

GREENHOUSE LAMPS

Kill Plant Enemies And Provide Vitamins

SOIL sterilizing units and ultra-violet ray lamps are stamping out disease and stepping up production in greenhouses, according to electrical manufacturers.

The sterilizer heats the soil to a temperature of 160 to 180 degrees for 30 minutes, killing plant disease organisms as well as insects, fungi, and weeds.

At the same time, the plants receive an extra dash of vitamin D. Ultra-violet lamps supplement the sun in providing the vitamin supply. Infra-red lamps provide localized applications of heat.

Fluorescent lighting, duplicating daylight, is used to exhibit the flowers and plants in their natural colors.

TUNGSTEN

Broadens Its Use With New Technology

POWDER metallurgy utilizes various properties of metals to their best advantage and is a vital element in the production and control of millions of dollars worth of products each year in tungsten alone, Dr. Zay Jeffries recently said at the Powder Metallurgy Laboratory of Stevens Institute of Technology.

"A good example of the application of powder metallurgy is the cemented carbide," said Dr. Jeffries. "This material, which consists essentially of hard particles of tungsten carbide sintered with a small quantity of metallic cobalt, utilizes the tremendous hardness of the carbide for cutting and wear-resistant properties and it utilizes the toughness of cobalt to keep the hard, brittle tungsten carbide in one piece in service.

"Another example of the use of powder metallurgy is in the production of tungsten rod and filaments for the lamp, radio, electrical contact, and other industries. In this case, the melting point of tungsten is so high that no satisfactory method has ever been found of melting and casting it into ingots. The tungsten powder is produced by reducing tungsten oxide with hydrogen. The powder is pressed into briquets and heated by the passage of electric current to a temperature near 3200 degrees, Centigrade. At this temperature the briquet consolidates into an ingot which is then worked into rod and wire. Not only is powder metallurgy practically necessary for shaping tungsten but, by adding certain ingredients to the powder, vital grain size control is effected which, so far, has been found impossible to duplicate by the fusion method."

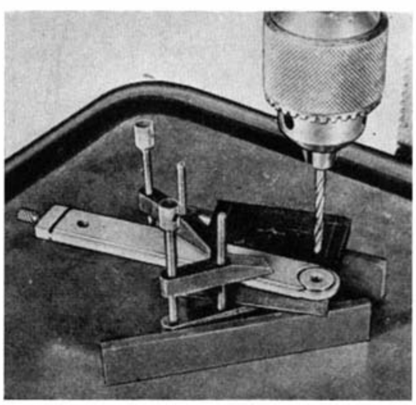
New Products and Processes

CENTER LOCATOR

Uses Magnifying Glass For Greater Accuracy

MACHINISTS can speed up many operations in constructing tools, dies, molds, and patterns and at the same time obtain a fine degree of accuracy with the new optical center locator illustrated.

After the work has been laid out, the compound magnifier is clamped into the holding fixture and it is then slowly moved over the intersecting layout lines. Once the reference circle, which is etched on the sight glass, is exactly centered over the layout lines, the holding fixture is clamped to the work. The magnifier is then removed from the holding fixture and the correct



Drilling holes where you want them and not a few thousandths off center is assured by using this new device

size drill bushing is substituted. All drill bushings are hardened, then precision ground to be concentric.

The outside diameter of each drill bushing is exactly the same as the diameter of the lower magnifier ring which contains the sight glass on which the reference circle is etched. When a drill bushing is substituted for the magnifier in the holding fixture the center of the bushing is precisely located over the intersecting layout lines. Holes can easily be located and drilled with an accuracy of .001 inch. The work is usually placed on parallel bars to facilitate alinement of the bushing and the drill.

STEAM CLEANING

Expedited by Powerful Emulsifier

A HEAVY-DUTY steam cleaning compound, marketed under the name of Steam-Off, has proved to be particularly effective in the removal of the heaviest and most stubborn grease and dirt from iron and steel surfaces, concrete, brick, and structural materials, gasoline and Diesel engines, steam shovels, tractors, locomotives, and road building machinery.

Extremely powerful in its penetrating and emulsifying actions, this new Turco compound combines a high degree of quick cleaning energy with the maximum ability to soften water, which results in producing reliably clean work, rinsing freely, and leaving no film, curds, water spots, or streaks. It was designed to function without the loss of cleaning power in the hardest water, and to prevent the depositing of hard water scale, which clogs coils and other vital parts of steam cleaning machinery.

Used as a stronger solution, Turco Steam-Off has the ability to remove unwanted painted surfaces as it cleans, making it a particularly effective product for complete overhaul or reclamation projects.

PLASTICS YARN

Is Adaptable to Many Post-War Industrial Uses

A PLASTICS yarn has recently been developed which promises to make long-wearing sheer hosiery and fill many other uses in the post-war world. Sheer dress materials that are resistant to perspiration and mild acids; auto seat covers immune to grease, oil, and alcohol; drapes and furniture upholstery that are fire-retardent and self-extinguishing are all possible with the new Plexon yarn, a product of Freydberg Bros.-Strauss, Inc.

The new yarn is a combination of existing fibers such as cotton, silk, rayon, or Fiberglas with plastic solutions, making possible an almost in-

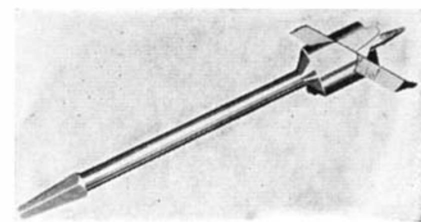
Just a few of the hundreds of post-war articles which can be made by combining a new plastics and standard fibers

finite variety of physical properties. Seventeen different plastics formulas are available and can be used, depending upon the final requirements of the finished yarn. It can be made either fine or heavy, stiff or soft, smooth or rough, transparent, translucent, or opaque, and with bright or mat finish. The threads can be made round, oval, triangular, or square. The present color range consists of 120 shades, and these can be increased at will. Plexon can be power loomed, woven, twisted, braided, or knitted.

EXPANSIVE BIT

Has Sharp Point, Long Life

DESIGNED on an entirely new principle, an expansive bit created specifically for use in hand braces to cut holes in



Another handy bit for your tool kit

wood is announced by Bruno Tools. The center lip which cuts away the core at the center of the hole extends back to form a clamp which firmly holds the adjustable blade at the diameter set. The clamp is locked tight by means of a screw. Once locked in the positive wedge-lock groove the cutter remains securely in place.

An improved diamond shaped screw point gives longer life by lessening the chance of breakage. The lead screw is threaded finer than is usual for this type of tool. This feature helps pull the bit through the wood, requiring only light pressure to cut quickly and cleanly because the lead screw is continuously and firmly engaged while the adjustable blade is cutting. The threads differ on models available to correspond to the capacity of each tool. Thus, regardless of the diameter of the hole being cut, whether through thin material or thick, clean, true holes are cut with a minimum of effort. A large open throat keeps the cutters clean of chips.

WELDED SEAMS

Produced Rapidly by Automatic Machine

DUPLEX resistance seam welders, designed for simultaneous seam welding of two or more seams on one surface, for rapid fabrication of sheet metal ammunition boxes, offer definite economies for many similar types of fabricating operations.

The machines, made available by Progressive Welder Company in a wide range of capacities and sizes, are air operated and fully automatic. A duplex head on the machine accommodates either two or four welding wheels. All wheels are free rotating. They are driven by contact with the moving work under welding pressure.

The work itself is carried on a work table mounted on horizontal slide rails. The top of the work holding fixture is formed by a flat copper plate which provides the lower path for the welding current between the welding wheels. Welding wheels, lower electrode, and welding transformer are all water cooled. A deep coolant trough is integral with the moving work table.

The entire assembly—bearing the work to be welded—moves in and out of the machine as the welding operation proceeds. Operation of the moveable table is accomplished by an air cylinder connected with hydraulic cylinders acting as dash pots to insure uniformly smooth table travel.

Machine operation is completely automatic. The operator loads the rotary fixture and depresses the foot switch. The table moves forward into the machine; the welding heads depress simultaneously at the proper point; and the outside pair of welding wheels make two parallel seam welds of predetermined length. The head rises while the rotary table indexes—rotating through 90 degrees—and then the inside wheels weld on the "out" stroke of the table. Thus, two separate pairs of seam welds—each pair at right angles to the other—may be produced. The fixture indexes a second time back through 90 degrees at the completion of the "out" stroke and the table stops at the loading position.

DOVETAILS

Produced Automatically in "Wood-Welding" Process

NORMAL dimensional limitations of lumber in the prefabrication of things made of wood—from ironing boards to houses—are eliminated in a new Muskegon Machine Company, Inc., set-up which produces new results by the combination of various known principles, applied to automatic mass prefabrication. With the process, panels, ranging from ½ to 3 inches thick, from 10 inches to 16 feet in length, and of practically any width desired, can be made "in one piece," automatically, on a single machine, using only three men per machine—two to feed untrimmed lumber of any size into the two ends of the machine, one to remove the jointed assembly from the center.

The machine used in the process is an evolution of the well-known Linderman machine, used for over a quarter century to eliminate waste in the lumber industry. Prime characteristic of this machine is that it "welds" wood together in such a manner that a wider piece made from two narrow pieces is at least as strong and frequently stronger than would be a single piece of the same width. This is accomplished by use of a double-tapered dovetail joint with one or more dovetails for the pieces, supplemented by an automatic gluing process. The joint locks the wood sections together solidly and the glue "fuses" the assembly, the glue being forced into the cells of the wood at the joint to form a "welded" bond even stronger than solid wood.

In using the new Linderman automatic fabricating process to produce solid panels for such items as bookcases, ironing boards, table and desk tops, doors, house construction accessories, caskets and boxes of all kinds, and so on, square-edged lumber or even lumber with the bark still on the edges may be employed. In operation, two pieces of lumber are fed in from opposite ends of the machine. As the lumber moves into the machine, cutters trim the board and cut tapered dovetail tongues and grooves in the edges. Boards moving in from one end are tongued. Boards from the other end are grooved. As the boards approach the center of the machine, the grooves and tongues are automatically covered with glue, using conical rollers (excess glue is removed with stationary "wipers" and returned to the reservoir). As the boards near the center of the machine, the tongue slides into the groove. As the movement continues, the fit becomes tighter and tighter, until the two boards are locked together.

If the finished panel is to be wider, the jointed boards are returned to one end of the machine, where they are again fed in to meet a single board coming from the opposite end. The panel then is three boards wide. This is repeated until the desired width is obtained. Finally, the assembled panel is ripped to the desired width. The edging is passed back into the machine for use in the next panel, making the operation continuous.

The process is not limited to fabricating panels by edge assembling. Lumber may also be assembled by running the stock on edge on to a flat piece, as for making molding stock. Likewise, lumber may be run across the grain for various uses such as flooring and cutting blocks.

GLASS MATS

Possess Desirable Characteristics For Many Industrial Uses

THIN, porous mats of bonded glass fibers have been successfully applied to a number of entirely new uses by the process and electrical industries.

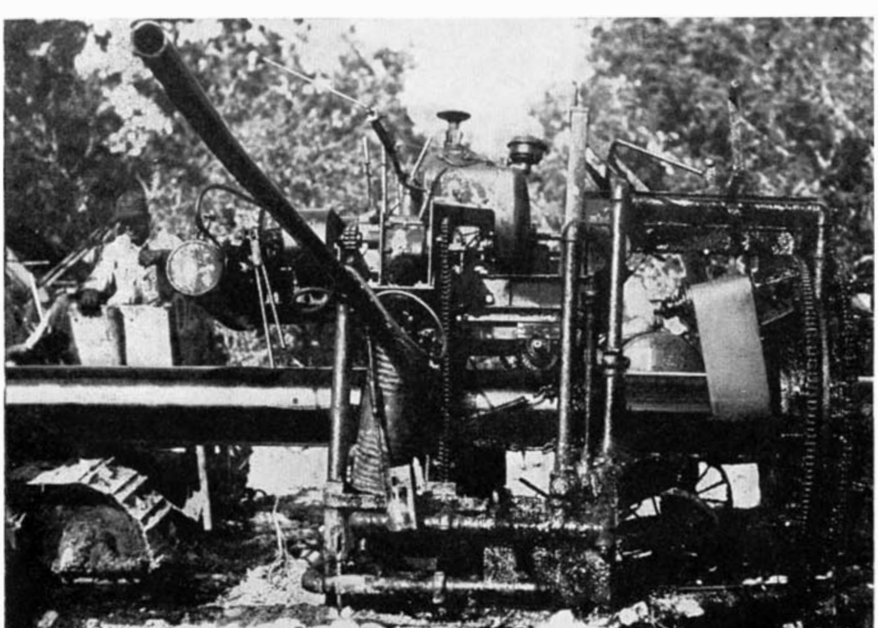
In roll form, the Fiberglas mat is being employed as a material for wrapping underground oil, gas, and other pipe lines to protect them against corrosion and electrolytic action. The material can be wrapped around bitumen or coal-tar coated pipe, thus forming a continuous water-tight bond. The glass fibers are non-corrosive to metals. The material has negligible moisture pick-up. Its tensile strength is preserved through a wide range of temperatures and exposures to organic solvents and soil acids. The millions of fine intertwined glass fibers reinforce a larger amount of bitumen or coal-tar coating for a given thickness of wrapping, as compared to other carriers.

Primarily because of the high tensile strength and non-hygroscopic characteristics of the individual glass fibers, the Fiberglas mats are being employed as the base for a new plastics laminated material. Possessing a low and stable loss factor over a wide frequency range, the laminate greatly extends the field for plastics coil forms, condenser spacers, stand-off insulators, and so on, in radio, television, and other high-frequency electronic devices.

In building up the laminate, the Fiberglas mats are impregnated with a thermosetting aniline-formaldehyde resin, and are cured under high pressure. In addition to its low loss factor, the laminate possesses high strength, high temperature resistance, dimensional stability, resistance to fungus attack, and good machinability.

Fiberglas mat is also being employed as a base material for gaskets and sheet packing. The mat acts as a carrying medium for synthetic resins suitable for applications requiring resistance to heat, oil, and acids. Glass-base gaskets now being manufactured show high pressure resistance, good chemical durability, and little flow under flange pressure.

Made by Owens-Corning Fiberglas Corporation, Fiberglas mat is composed of fine glass fibers intertwined in random orientation and bonded together to form a thin, highly porous, felt-like material. The glass fibers have an average diameter of 0.0005 inch. Several types of binders—starch, gelatine, furfural, or phenolic—may be used, depending upon the requirements of the end use.



Wrapping Fiberglas mat around an underground oil pipe line

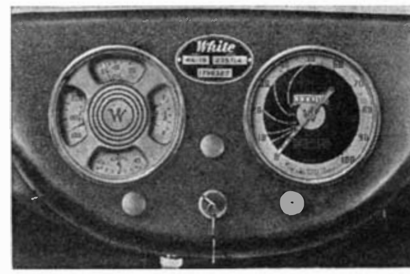
TRUCK OPERATION

Simplified by Instrument That Correlates Data

COMBINING the features of an ordinary speedometer with those of a tachometer and adding instructions governing various engine speeds, an "economy range finder" for trucks has been developed by the White Motor Company. With this device on the instrument panel the driver can increase the life of the engine by keeping it within its most efficient range of operation.

Even for the most experienced truck driver, gaging the engine speed and hence the proper time to shift gears is extremely difficult because of the varying ratios between engine speed and chassis speed (miles per hour). Grades encountered and the necessity of using various transmission gears to meet different conditions provide a constant change. Expecting a driver to pulse the engine speed without visual aids is like forecasting weather without benefit of scientific instruments.

The economy range finder helps drivers in shifting gears, saving fuel, conserving trucks, and making schedules. Not only can they read the engine speed directly on the speedometer dial, but instructions are clear. A spiral white line for each transmission gear is offered on the dial, and this is combined with a scale of engine speeds printed on the speedometer pointer. As the speedometer pointer moves around the dial, the edge of the pointer crosses the spiral white line for each gear. A white area on the pointer indicates the ideal operating range from 1700 to 2400 revolutions per minute, and at either end is a red area which indicates when the engine is operating outside the proper range. When the pointer reaches the outer end of the spiral line for any gear, the engine speed (noted in the red) will be 2800 revolutions per minute, at which the governor is usually set. As this recommended maximum is approached, the bearing loads, piston speeds, and vibrations are increased, thereby tending to shorten the life of the engine. Similarly, the red at the lower end of the pointer shows when the engine is laboring and in need of relief through shift to a lower gear. Such a shift will prevent strain and excessive wear by allowing the engine to operate more easily at a higher speed. As steeper grades slow the engine down, the greater load on bearings, pistons, and rings is much the same as when the maximum engine speed is reached or exceeded.



Instrument panel on a standard White truck showing how the "economy range finder" is built into speedometer dial

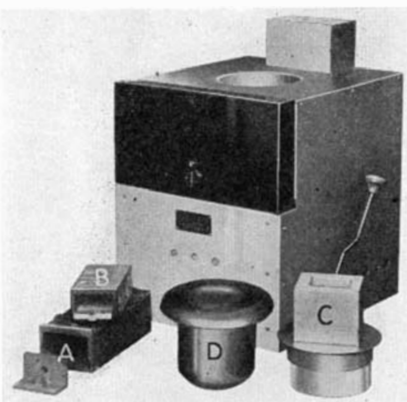
Thus the economy range finder is a simple but effective device to guide the driver in selecting the various transmission gears in which to operate under existing conditions. When the pointer crosses a white line at the outer end of the line, it indicates that the recommended maximum engine speed has been reached and that the driver should shift into the next higher gear. And when the pointer crosses a white line at the inner end it suggests a shift into the next lower gear.

BENCH FURNACE

Offers Versatility for Shop or Laboratory

DESIGNED to provide for a wide variety of applications, a new "three-way" bench-type universal laboratory furnace has been made available by Surface Combustion Corporation. The furnace combines three different types of furnaces in one casing. It may be used as a direct-fired oven unit at temperatures from 300 to 2400 degrees, Fahrenheit. For direct heating a muffle can be placed on the hearth. If an atmosphere is desired a diamond block can be used in the muffle. A removable plug built into the arch of the furnace provides a means of inserting a pot.

This laboratory furnace is ideal for small shops or laboratories where a wide variety of heat treatments in relatively small quantities of small parts must be performed. Such operations as annealing, carburizing, hardening, cyaniding, and tempering, with or without a furnace atmosphere, can be handled by the one furnace. It func-



The new bench-type laboratory furnace with accessory equipment including (A) muffle, (B) protective atmosphere equipment, (C) plug, and (D) pot

tions as a direct-fired oven, indirect heated muffle, gaseous atmosphere, salt or lead bath type and may also be used for melting soft and light metals.

The furnace is equipped with three atmosphere-type gas burners, each of which can be independently controlled. The burners are arranged under the hearth to provide uniform and rapid heating throughout the heating chamber. A gas pressure regulator assures uniform control of burner operation. Manufactured or natural gas or butane or propane may be used.

WELDER'S SHOCK

Eliminated by Reducing Voltage

ARC WELDERS' apprehension of shock, and possibly subsequent nervous exhaustion, has been eliminated by a new safety panel invented and perfected by electrical engineers of Pullman-Standard Car Manufacturing Company. High open-circuit voltages of most welding equipment create a definite hazard to operators. The voltage encountered varies with different machines, but in general ranges from 85 to 110 volts. Since this voltage is ordinarily present at all times when not welding, physical contact of the operator from his welding electrode to grounded metal surfaces may have serious consequences.

When the welding contact is broken, the newly patented Pullman-Standard safety panel automatically reduces this open-circuit voltage of the electrode (which creates the welding arc) to a mere 24 volts. Accidents among welders are rare, but the new safety panel contributes greatly to the ease of mind of the welders. No longer must they be constantly on the alert while changing electrodes and the relief in nervous tension is quite noticeable when the new safety panel is used.

ARC-OXYGEN

Cuts Heavy Steel Quickly and Easily

ONE of the most valuable industrial tools to come out of World War II is the arc-oxygen electrode, which somewhat resembles an ordinary pea shooter. The electrode, information about which has until recently been restricted, combines the tremendous heat of the electric arc with the cutting effect of pure oxygen to cut steel many feet below the surface of the ocean.

The development of the electrode by the Metal and Thermit Corporation in co-operation with the United States Navy has helped to make possible the tremendous speed with which invasion harbors have been cleared of sunken ships by Navy Salvage and Seabee Forces. Ragged shell and torpedo holes in war vessels afloat are also trimmed underwater and temporary patches welded, enabling stricken vessels to proceed to drydock for permanent repair.

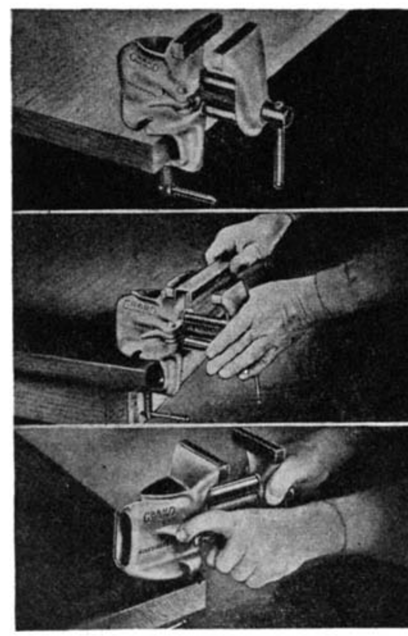
The arc-oxygen process utilizes the heating properties of an arc flame, ranging from 6000 to 10,000 degrees, Fahrenheit, to kindle steel plates and beams much as coal is kindled by wood splinters. Into the molten steel thus produced, a jet of pure oxygen is introduced to cut cleanly through the steel.

The process allows divers easily and rapidly to cut large sections of steel, formerly impossible due to heavy diving gear, restricted movement, and poor visibility below the ocean's surface. So fast is the new steel-cutting electrode that quarter-inch steel plate 40 to 50 feet below the surface of the ocean, for instance, can be cut at the rate of 62 inches a minute, or considerably faster than ordinary newspaper piled to like thickness can be cut with a pair of scissors in the comfort of your living room.

SPEED VISE

Opens or Closes Without Turning Screw

MANUALLY operated, a new "Quikcet" vise, manufactured by Grand Specialties Company, eliminates running in or out the screw to close or open the vise. It is claimed that this new speed vise can be set and closed in a jiffy by simply pushing on the body of the free jaw, which slides in swiftly on ratchet screw and two precision guide rods and tightens with a turn of the handle. The vise is equipped with a trigger-release pawl with 3/4 inch of thread which holds the hardened screw under spring tension. The vise is said to open instantly to full 3 inches by pressure of thumb or finger on trigger release after tension has been eased by a single turn of the loose-proof handle. The Quikcet vise is then ready, without further adjustment, for instant closing on any other work.



Trigger releases vise screw

ELECTRIC MARKER

Makes 7200 Cutting Strokes per Minute

ANYTHING and everything can be marked with an electric marker just announced by the Ideal Commutator Dresser Company. Although small in size, only six inches long and ten ounces in weight, life tests prove that this new marker can be used continuously on the toughest of marking jobs.

The power of the cutting stroke has been increased by 30 percent over previous models, yet an adjusting nut makes it possible to vary the impact

High speed, variable impact marker

so that it can even be used to mark on glass. Shaped to fit the hand, it can be held and used to write almost as easily as a pencil.

The new marker operates from any A.C. electrical outlet. Working like a small electric hammer, it makes 7200 cutting strokes per minute, cutting right into the surface and leaving lines that cannot be wiped away or worn off with ordinary usage. It permanently marks sizes, names, numbers, and other important information on tools, parts, and finished products.

EXTINGUISHER VALVE

Gives One-Hand Operation of Large Portable Units

TRIGGER control, which has been confined to smaller sizes of carbon dioxide fire extinguishers, has now been extended to the larger portable models. Operated entirely with one hand, the new streamlined Kidde model is controlled by an upward pull of the index finger, the largest extinguisher requiring approximately the same trigger force as the smallest. It can be latched open when desired by a slight forward motion, and as easily disengaged to avoid wasting gas.

This new control represents the perfection of a valve which provides an on-and-off control of discharge with a minimum of effort; permits a high rate

Valve speeds extinguisher action

The Editors Recommend

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**

HIGH FREQUENCY INDUCTION HEATING — *By Frank W. Curtis.* Answers many questions concerning induction heating and its utility in industrial processes. Thoroughly practical in scope. **$2.85**

MANUAL OF LABORATORY GLASS-BLOWING — *By R. H. Wright.* A practical book containing latest information on the fundamental operations of glass blowing, both elementary and advanced. 90 pages, illustrated. **$2.60**

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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**

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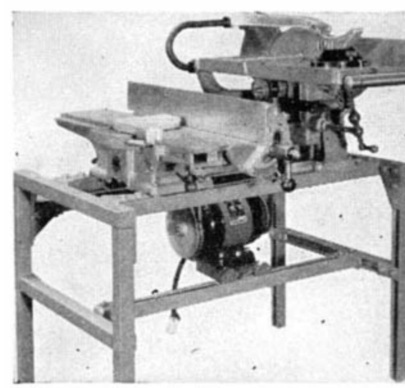
of flow of the carbon dioxide, avoiding directional changes in its passage insofar as possible; allows easy locking-open with one hand; and incorporates these features in a small, compact part relatively light in weight and simple in design. The one-piece handle closure protects the valve itself, is light in weight and fits the hand comfortably.

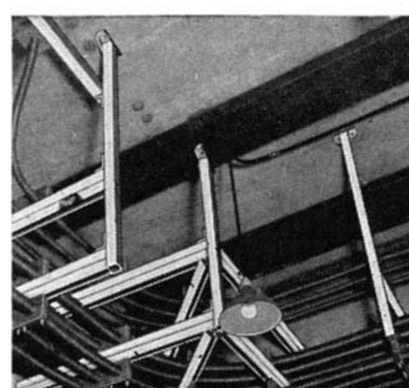
HOLLOW STRUTS

Permit Easy Erection of Frames, Racks, and Hangers

Fabrication of any type of metal frame, stock rack, support, or hanger for industrial, electrical, commercial or public building use now can be quickly and easily completed right on the job by the new Unistrut method. Basis of this method is a slotted hollow-square steel or other metal section with standard spring-held nut attachments. The struts



Above: A stand for router and saw and, below, cable hangers, both made on the job with standardized steel struts



do not require drilling of holes, riveting, or welding, and can be cut to any desired length with a hack saw.

The nut attachment can be slid along in the hollow square to any point where it is desired to attach it to another member, a supporting structure, or to the floor, ceiling, or wall. The nut has serrated teeth which bite into the inturned edges of the hollow square section, and hold the attachment firmly in position when the nut is tightened with an ordinary wrench. However, the nut can be easily loosened, the attachment moved to a new location and again tightly fastened.

Because of its hollow square design, Unistrut has the necessary properties for use as a compression or tension member, strut, column, or beam. It is furnished in sections of several sizes or gages, and eliminates the delay otherwise frequently caused by waiting for delivery of structural steel from a mill or warehouse.

VOLTS AND AMPS

Both Read by New Instrument

SIMULTANEOUS readings of current and voltage are taken with the new voltammeter, Model 601, manufactured by Associated Research. Contained in the sturdy compact case of this one instrument are an alternating-current voltmeter and an alternating-current ammeter, ready for instant use. The

Double-purpose electrical meter for indicating both voltage and current

ammeter measures from 0.2 to 500 amperes in eight current ranges and the voltmeter measures from 30 to 600 volts in three ranges. The voltmeter can also be used on direct current.

An inserted primary current transformer with eight foot secondary leads facilitates the measurement of current on the 0-100, 0-250, and 0-500 ampere scales without subjecting the meter to stray magnetic fields. The range selector switch on the panel permits quick reading of currents in all the eight ranges. Large instant reading scales have white backgrounds with figures in jet black, covered by glass.

IRRIGATION

Uses Plastics Tubes to Distribute Water

SIPHON tubes extruded of transparent Tenite plastics are finding wide use in irrigation on farms in western states. This method of irrigation, developed through the University of Nebraska

Plastics tubes distribute water

Agricultural Division, is said to offer economic advantages in installation, labor, and maintenance.

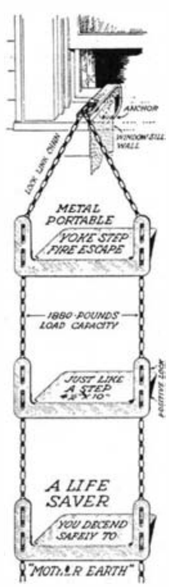
The plastics irrigation tubes consist of four-foot lengths of tubing bent to hang over irrigation ditch banks at intervals to drain into the rows. To start the water running, the tube is filled by immersing it in the lateral, one end is covered by the hand, and the tube is then hung over the bank. With one end completely submerged in the lateral and easily adjustable, the tube does not become clogged with trash which floats on the surface of the water. No digging or maintenance of the bank is necessary, and soil erosion from irrigation is prevented.

Tenite is extremely light in weight and is easily shipped and carried; an armload of the tubes weighs only a few pounds. Because of the transparency of the plastics, possible air locks are readily located. The smooth surface of the plastics tubing makes for maximum uniform flow of water.

STEEL FIRE ESCAPE

Stored in Carton, Used When Needed

RECENTLY placed on the market for use in homes, apartment houses, hotels, and factories, a portable fire escape is said to have a load capacity of 1880 pounds, and comes stored in a carton ready for use. In order to operate the fire escape, it is only necessary to open



Broad steps and steel chains are features of this portable fire escape

the carton, hook the anchor over the window sill and then drop the carton containing the fire escape to the ground.

When this is done, the broad steel steps suspended on steel chains fall into place, making descent to the ground easy. Manufactured by the Metal Portable Fire Escape Company, these units are offered in three sizes, for second, third, and fourth story windows respectively. The maker claims that they will anchor on any window sill with safety.

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.)

PUSH-BUTTON BRAZING is described in issue Number 32 of *Low Temperature Brazing News.* This four-page folder gives information on a rapid metal fabricating method using low temperature silver brazing alloys for the fabricating of small and medium size parts in large quantities. *Handy and Harman, 82 Fulton Street, New York 7, New York.—Gratis*

NINE-INCH SOUTH BEND PRECISION LATHES is a 36-page catalog describing a complete line of nine-inch engine and toolroom lathes suited for production of small precision parts, and for general and specialized use in machine, maintenance, repair, and laboratory shops. Request Catalog 9-G. *South Bend Lathe Works, 388 East Madison Street, South Bend 22, Indiana.—Gratis.*

VIBRAFLEX ENGINE MOUNTINGS is a single sheet presenting a simplified means of selecting rubber insulated engine mountings that stop engine vibration. Dimensional drawings show the four types available for handling loads of from 20 to 600 pounds. Request Bulletin BU-23. *Bushings, Inc., 3442 West Eleven Mile Road, Berkley, Michigan.—Gratis.*

PATHWAY TO EXECUTIVE SUCCESS is a 24-page booklet—one of a series of management-idea booklets. Topics covered are: how individuals progress, how they can plan for success, and how they can apply the principles of success to their own careers. *Hammermill Paper Company, 1541 East Lake Road, Erie, Pennsylvania.—Gratis.*

SAVE AND SERVE WITH PROPER LUBRICATION is a 20-page manual printed as an authoritative guide on correct lubrication practices, covering operating temperatures, contamination, lubricant application, lubrication schedules, and so on. Industrial maintenance men will find this a concise guide to better lubrication. *Sun Oil Company, Industrial Products Department, Philadelphia, Pennsylvania.—Gratis.*

THE EDLUND OFFSET BACK SPOTFACER is a four-page bulletin containing diagrams and engineering data on typical applications and specifications of standard models, cutters, and pilots. Request Bulletin BSF445. *Edlund Tools, Inc., 4473 Woodward Avenue, Detroit 1, Michigan.—Gratis.*

SURFACING WITH TARMAC is a 16-page brochure based on 14 types of paving treatment, their advantages and methods of application. Among the methods discussed are the soil stabilized base course and the double surface treatment with hot and cold application. Road repairs, which will be numerous as the result of war-time restrictions, are also discussed. *Koppers Company, Inc., Tar and Chemical Division, Koppers Building, Pittsburgh 19, Pennsylvania.—Gratis.*

GEIGER-COUNTER SPECTROMETER FOR INDUSTRIAL RESEARCH, by H. Friedman of the Naval Research Laboratory, is an eight-page illustrated booklet discussing the theory underlying X-ray powder diffraction, how the spectrometer works, its performance and applications. *North American Philips Company, Publicity Department, 100 East 42nd Street, New York 17, New York.—Gratis.*

EVERYWHERE IN INDUSTRY is a 20-page bulletin on synthetic rubbers. Compiled for engineers, designers, production men, purchasing agents, and industrial executives, the bulletin describes the manufacture, characteristics, properties, and applications of several available types of synthetic rubber. *Hycar Chemical Company, 325 South Main Street, Akron 8, Ohio.—Gratis.*

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By Thomas Collison

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By Robert S. Allyn

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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"

REPRODUCED on this page at 7/16 original size are several pages from Sir Isaac Newton's classic "Opticks" (1704). The selection begins at the fateful point where Sir Isaac made the famous mistake that led him just to miss discovering the achromatic lens principle—but also to invent and make the first Newtonian telescope. In it, the amateur telescope maker of today may see Newton, himself essentially an amateur, at work on the first telescope mirror of record.

First-edition copies of Newton's "Opticks" are sold by rare book dealers at prices current from about $30 to $70. Let not the old-ftyle s of Newton's time difmay you, fince after remarkably little reading it no longer tripf you up.

The first complete sentence on Newton's 75th page begins on line 2 with the word "But," and contains the statement which delayed discovery of the achromatic lens almost a century. After a sketchy experiment Newton had jumped to the conclusion that refractive index and dispersion were proportional, so that by no two-component objective lens dodge could lenses be freed from chromatic aberration. The pundits long blindly accepted Newton's dictum.

Plaintively, Newton next states that, so far as the reflector is concerned, he supposes people would simply have to go on using the same old principle, the one-lens objective of Kepler which had immense focal length to minimize aberrations, and obtain any improvements by still further increasing these focal

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might Teleſcopes be brought to ſufficient perfection, were it not for the different refrangibility of ſeveral ſorts of Rays. But by reaſon of this different refrangibility, I do not yet ſee any other means of improving Teleſcopes by Refractions alone than that of increaſing their lengths, for which end the late contrivance of *Hugenius* ſeems well accommodated. For very long Tubes are cumberſome, and ſcarce to be readily managed, and by reaſon of their length are very apt to bend, and ſhake by bending ſo as to cauſe a continual trembling in the Objects, whereby it becomes difficult to ſee them diſtinctly: whereas by his contrivance the Glaſſes are readily manageable, and the Object-Glaſs being fixt upon a ſtrong upright Pole becomes more ſteddy.

Seeing therefore the improvement of Teleſcopes of given lengths by Refractions is deſperate; I contrived heretofore a Perſpective by reflexion, uſing inſtead of an Object Glaſs a concave Metal. The diameter of the Sphere to which the Metal was ground concave was about 25 Engliſh Inches, and by conſequence the length of the Inſtrument about ſix Inches and a quarter. The Eye-Glaſs was plano-convex, and the Diameter of the Sphere to which the convex ſide was ground was about 1/5 of an Inch, or a little leſs, and by conſequence it magnified between 30 and 40 times. By another way of meaſuring I found that it magnified about 35 times. The Concave Metal bore an aperture of an Inch and a third part; but the aperture was limited not by an opake Circle, covering the Limb of the Metal round about, but by an opake circle placed between the Eye-Glaſs and the Eye, and perforated in the middle with a little round hole for the Rays to paſs through to the Eye. For this Circle by being placed here, ſtopt much of the erroneous Light, which otherwiſe would have diſturbed the Viſion. By comparing it with a pretty good Perſpective of four Feet in

K 2 length,

lengths. But Newton goes on to say that users could at least avoid the long, slender, and cumbersome tubes which this had made necessary by using Huygens' new and really manageable mounting. After finishing with Newton we shall return, in this antiquarian optical amble, to this new Huygens aerial mounting for which Newton puts in so strong a plug.

"I contrived a perspective," Newton writes on the same page. Old term for telescope.

The fraction on the same page, in tiny type even on the original, is 1/5.

While, as Newton states, he stopped his aperture to 1 1/3″, this was not the full diameter of his bell-metal speculum, which was 2 1/16″. Even then his focal ratio became $f/4.7$, and it is remarkable that this gave performance, especially on a sphere—if it really was a sphere in the lack of a test. But any amateur knows the tendency with a soft lap to work toward

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length, made with a concave Eye-Glaſs, I could read at a greater diſtance with my own Inſtrument than with the Glaſs. Yet Objects appeared much darker in it than in the Glaſs, and that partly becauſe more Light was loſt by reflexion in the Metal, then by refraction in the Glaſs, and partly becauſe my Inſtrument was overcharged. Had it magnified but 30 or 25 times it would have made the Object appear more brisk and pleaſant. Two of theſe I made about 16 Years ago, and have one of them ſtill by me by which I can prove the truth of what I write. Yet it is not ſo good as at the firſt. For the concave has been divers times tarniſhed and cleared again, by rubbing it with very ſoft Leather. When I made theſe, an Artiſt in *London* undertook to imitate it; but uſing another way of poliſhing them than I did, he fell much ſhort of what I had attained to, as I afterwards underſtood by diſcourſing the under-Workman he had imployed. The Poliſh I uſed was on this manner. I had two round Copper Plates each ſix Inches in Diameter, the one convex the other concave, ground very true to one another. On the convex I ground the Object-Metal or concave which was to be poliſh'd, till it had taken the Figure of the convex and was ready for a Poliſh. Then I pitched over the convex very thinly, by dropping melted pitch upon it and warming it to keep the pitch ſoft, whilſt I ground it with the concave Copper wetted to make it ſpread evenly all over the convex. Thus by working it well I made it as thin as a Groat, and after the convex was cold I ground it again to give it as true a Figure as I could. Then I took Putty which I had made very fine by waſhing it from all its groſſer Particles, and laying a little of this upon the pitch, I ground it upon the Pitch with the concave Copper till it had done making a noiſe; and then upon the Pitch I ground the Object-Metal with a brisk

Motion

the hyperboloid, and maybe Newton luckily landed squarely on the paraboloid without knowing it. He did know a paraboloid was needed, but neither he nor anyone else knew how to figure one.

The bottom line on page 75 refers to a refractor, obviously a Galilean type.

Page 76, line 6, mentions "overcharged." Empty magnification. Beginners still cry for it.

Line 8, "two of these." Of the two telescopes only the second, too often mislabeled the "first," survives. It is at the headquarters of the Royal Society of London, where your scribe once was permitted to examine it. The treasure was perched atop a cabinet at eye level, entirely in the open but in private office quarters. The accompanying photograph was obtained at that time.

The competent workmanship clearly proves that Newton was himself a good amateur telescope maker and mechanic, and there is record that he bought a lathe while at Cambridge University. On that lathe and with his own hands he must have turned up the wooden base, the cup and ball mounting so simple and ingenious, and the eyepiece shell.

Newton made these two reflectors respectively in 1668 and 1671 and, since they were approximately alike, the question whether the one that survives is the first or the second is, after all, of lesser moment. He and others in 1674 communicated several items concerning them to the Royal Society

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Motion, for about two or three Minutes of time, leaning hard upon it. Then I put freſh Putty upon the Pitch and ground it again till it had done making a noiſe, and afterwards ground the Object Metal upon it as before. And this Work I repeated till the Metal was poliſhed, grinding it the laſt time with all my ſtrength for a good while together, and frequently breathing upon the Pitch to keep it moiſt without laying on any more freſh Putty. The Object-Metal was two Inches broad and about one third part of an Inch thick, to keep it from bending. I had two of theſe Metals, and when I had poliſhed them both I tried which was beſt, and ground the other again to ſee if I could make it better than that which I kept. And thus by many Trials I learnt the way of poliſhing, till I made thoſe two reflecting Peſpectives I ſpake of above. For this Art of poliſhing will be better learnt by repeated Practice than by my deſcription. Before I ground the Object Metal on the Pitch, I always ground the Putty on it with the concave Copper till it had done making a noiſe, becauſe if the Particles of the Putty were not by this means made to ſtick faſt in the Pitch, they would by rolling up and down grate and fret the Object Metal and fill it full of little holes.

through its periodical (still being published) the *Philosophical Transactions*. He did not write his book, "Opticks," until about 1687 and then delayed its publication until 1704.

There are replicas of Newton's telescope in the planetariums in Philadelphia and Chicago and in the Buffalo Museum of Science. As a pure sporting proposition, any modern amateur who makes a copy of Newton's telescope might at least consider the whim of foregoing those advantages which Newton could not enjoy, which would prove to be more than at first appears, and afterward ascertaining whether his work would pass the test to which Newton put his telescope. "I found," he writes, "that I could read in the *Philosophical Transactions,* placed in the Sun's light, at an hundred foot distance, and that at one hundred and twenty foot distance I could discern some of the words.

Page 76, "as thin as a groat." Your scribe caught up with a Henry VIII groat at the Scott Stamp and Coin Co. and, though not much worn, it was very much thinner than a badly worn dime.

"Putty" is tin oxide.

RETURNING now to the old long-focus, one-lens Kepler refractors, typical examples of its kind are: 3″ lens, 30′

f.l. (f/120); 5½" lens, 100' f.l. (f/219); 7¾" lens, 200' f.l. (f/258). The long, slender, floppy, shimmying tubes were skeletonized and braced laterally by spreaders and hung on multiple bridles from tall poles, but in his new aerial mounting Huygens substituted for all this cumbersome gear one single simple silken cord of seven-pound strength (finest modern bait casting line nine pounds test—Abercrombie and Fitch). This line alone linked together and controlled the objective in a delicately counterpoised cell on a ball-and-socket pivot, and the eyepiece.

Details show in the accompanying illustration from Smith's "Compleat System of Opticks" (1738). A little crook in the tail of the cell stick offsets the angle of sag (sketch 614) of the line. Sketch 615 shows the large eyepiece on a stick, the line and its guide, also the violin peg adjustment for f.l. (The scissors-like part is a variable rhombus attachment on a rest, by which a star, once found, could be held long enough to enable an inexperienced observer to get to the eyepiece.) Sketch 616 is a Mr. de la Hire's lens cell control.

The whole, after study, ceases to seem ludicrous.

Some years ago, in the *Proceedings of the Royal Society of Edinburgh*, the astronomer Sampson and the famous professor of optical design Conrady, with R. Westlake, today professor at the University of Rochester and lens designer for Eastman Kodak, examined, tested, and described three of these old one-lens, long-focus objectives preserved at the Royal Society of London. One was a 7⅞" of 122' f.l., diamond-signed by Huygens in 1686, together with the original apparatus for adjustment of his aerial telescopes,

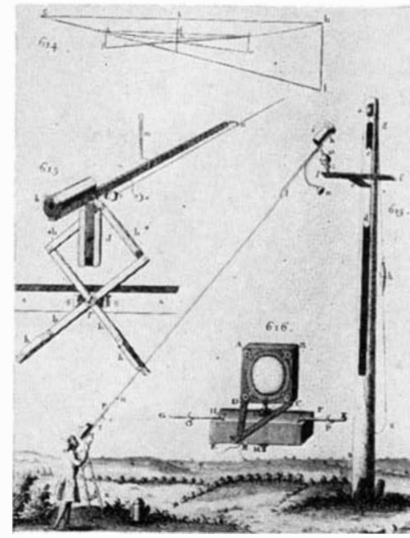
Made by I. Newton, amateur

including eyepiece of 2¼" aperture and 6" f.l. The second was an 8⅜" of 170' f.l., signed by Huygens 26 June 1686 and later owned by Newton. The third was a 9⅛" of 210' f.l.

These examiners reported: "In comparison with even the cheapest of modern window or bottle glass, that in Huygens' lenses is extremely bad. Besides numerous bubbles and small stones and frequent black particles of considerable size . . . the entire disks are simply one tangle of innumerable mostly fine veins which would render really regular refractive effects quite impossible." The refractive index for the 170' was 1.53, for the 210', 1.58, corresponding to modern plate.

The plano side of the 210' was found to be "amazingly close to flat." Centering was precise within 0.0016" and 0.0056", yet Huygens centered by miking lens edges with a hand vise.

The two authors add: "There is a widely current misapprehension in the



From Smith, "Compleat System of Opticks" 1738
Huygens' aerial telescope

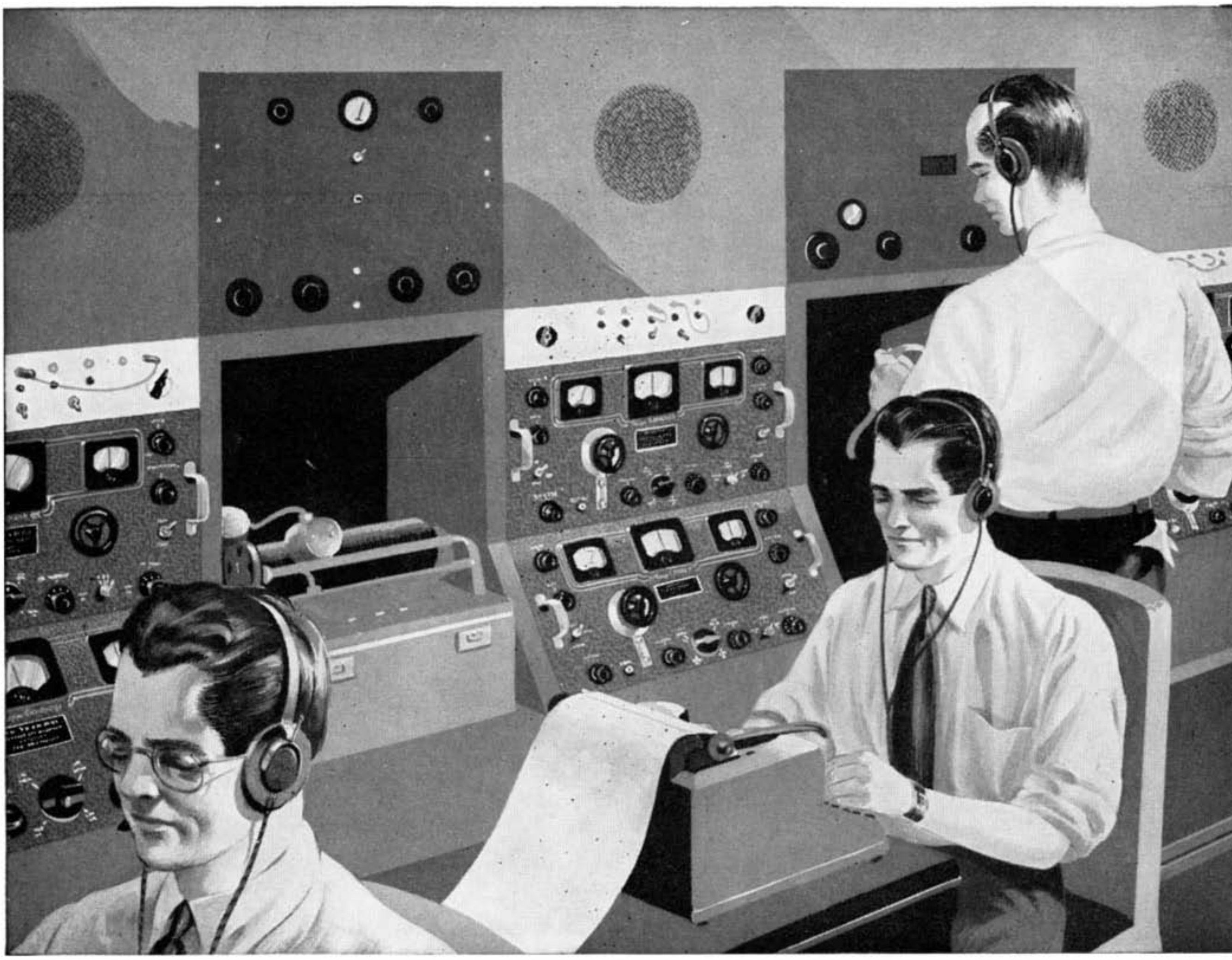
matter of achromation in relation to these early systems. If the ocular is also a single lens and made of glass of the same dispersion, then for the combination, focused to infinity, the angular magnification is measured by the ratio of the focal lengths, and from this ratio the refractive index of the glass eliminates itself and leaves a function of the curves alone. Hence the image would be achromatic. The case is not so simple as this because the combination cannot be focused to infinity simultaneously for different colors, but a good approximation to it may be reached by focusing in the orange-yellow. We conclude," say Sampson and Conrady, "that the chromatic faults of these combinations were less noxious than is generally believed."

Suppose a Kepler-Huygens aerial telescope were today or post-war made and set up beside a Newtonian of comparable aperture as a demonstration, what widespread attention it would attract! Utility, low. Scientific demonstration value, interesting, somewhat instructive. Such stunts should, however, be done for the fun of it—justification enough.

A few possibilities, from a table of Huygens' standards, are: a 5.48" of 100' f.l., hoisted up and down on a 75' pole, eyepiece 6.03" f.l. Or a 3.87" of 50' f.l., with 4.26" eyepiece and a 40' pole.

Specific directions for ordering from large libraries photostats of the Newton, Smith, and Sampson-Conrady writings, giving working data, are available from this department.

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



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