TECHNOLOGY

A New Look at Glass

Modern technology has made glass into one of the most versatile engineering materials in the world, with virtually limitless potentials

By Ruby Yoshioka

➤ GLASS, born of the forces of nature in the twilight periods long before human beings walked the earth, continues to be recreated again and again through man's ingenuity and increased knowledge of chemistry.

The first glass was obsidian, molded by the heat of volcanic materials that spread over the sandy soil, fusing it into a smooth amorphous solid. Today, glass is made in basically the same way—by the action of intense heat on silica sand.

Oldest Manufactured Product

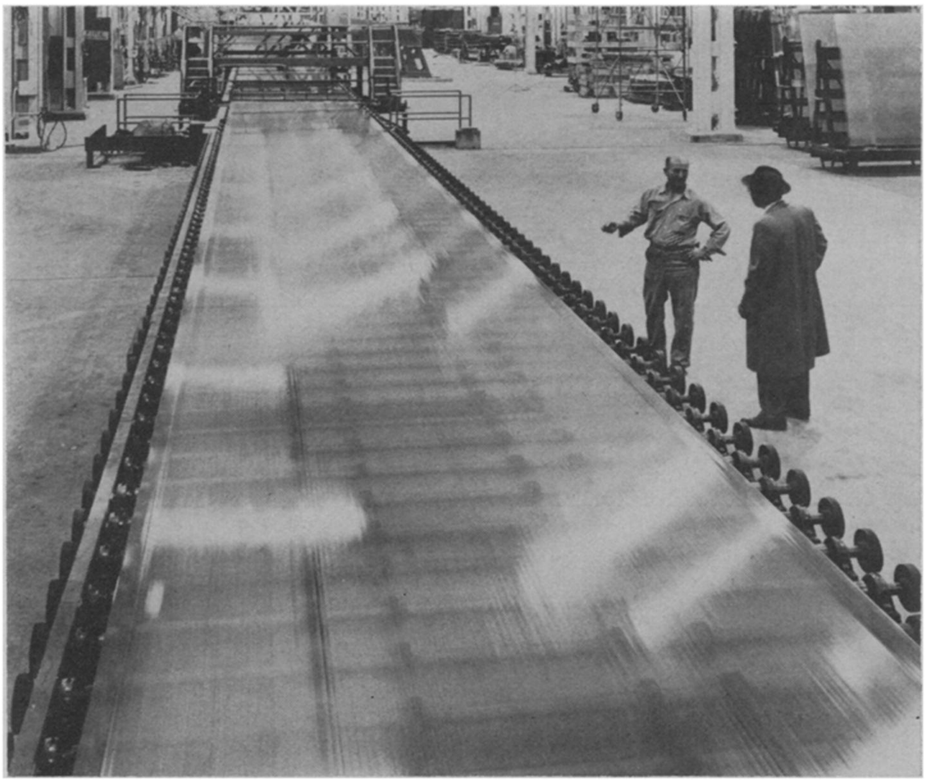
Glass is the oldest manufactured product in the world—thousands of years have passed since the first crude glass beads were made by ancient man. As through the ages glassmaking spread throughout the Western world, its products reflected the culture and technological progress of the times. And so today, glass tells the story of man's needs in a world of fast transportation, computers and space exploration.

Researchers today are searching deeper and deeper into the nature of glass—its molecular structure and its chemical and physical properties. Like medieval alchemists, they are adding a bit of this and a bit of that to the molten brew to make up new formulas with the desired characteristics. And they have come up with thousands upon thousands of "recipes" each with its own special quality.

Glass is a unique material. Although it looks and feels like a solid it is actually a liquid in a frozen state. When the makings of glass, silica (sand), an alkali and a few other substances are brought together and heated to a high temperature, they melt into a viscous fluid. But when it cools and hardens, it does not crystallize as most substance do in the solid state, but remains apparently amorphous. The exact nature of the inner structure of glass is not yet completely understood by scientists, but it is known to be a disordered crystal.

This structure, neither purely crystal nor truly liquid, is what gives glass its unique properties and versatility.

Glass is an inert substance and in its molten state can dissolve most of the 103 known elements and their compounds. Any chemical added to it disperses throughout the liquid glass. But when the glass cools it becomes rigid and the chemical, which precipitates when the temperature is lowered, remains suspended in position unable to settle out. The new property imparted by the added chemical is thus uniform throughout the glass.



Libby-Owens-Ford

HOT GLASS FLOATING—An endless ribbon of molten glass leaves the furnace and moves across a bath of molten tin in Libbey-Owens-Ford Company's automotive glass fabricating plant in Rossford, Ohio.

With all the possible combinations of chemicals that can be added to the molten mass, there seems to be no limit to the new types of glass an imaginative chemist can design.

The importance of glass in everyday life is obvious. But now, glass has made a giant step from its limited uses devoted mainly to the commonplace—windows, glassware and optical instruments—to one of major engineering importance. The very nature of glass, its inertness, strength, noncorrosiveness and flexibility are qualities that help make it a good structural material.

In the age of fast transportation, by car, plane or train, glass is not only a convenience for outdoor vision, it becomes part of the structure itself. Its resistance to stress, strain and impact and how it fits into the design of the vehicle itself are all taken into consideration.

Corning Glass Works, Corning, N.Y. has designed an ultrahigh strength glass by a special chemical treatment they call Chemcor. Glass made by this process is five times stronger than regular glass and can be bent and twisted without breaking. This chemically strengthened glass is used for the back windows of sports cars.

Pittsburgh Plate Glass Company in Pennsylvania has also designed a method for tempering glass chemically rather than by the conventional method of heating and quenching. The process involves ion exchange that takes place right in the glass, giving it great strength. Glass so treated can be made very thin, and can be bent around corners to satisfy present-day streamlined designs, while still maintaining its strength.

One new windshield is formed in an S-shaped curve integrated with the automobile's metal body and extending up into the roofline to provide maximum visibility.

Laminated safety glass has been in use for some time, but now to provide greater safety, the Libbey-Owens-Ford Company of Detroit has devised a windshield that balloons out when struck by a person's head. Even at a speed of 40 miles per hour, the windshield will not break in case of accident from such an impact. This new laminated glass is made with a plastic layer designed to allow some slipping between the glass and plastic when struck, giving the windshield room to stretch while still maintaining the bond and the clarity of the glass.

Heated Windshields a Reality

Electrically heated windshields are already a reality, on aircraft and an occasional super-luxury car. Fogginess and condensation are eliminated much more quickly with such a glass than with general heating systems, providing another safety factor. This development strangely enough is a by-product of a need in an altogether different field.

One of the problems with glass is that it does not conduct electricity, so it retains the electrostatic charge caused by friction. This static electricity interferes with the function of sensitive electrical instruments. Also, electromagnetic energy from fluorescent light fixtures often overlaps with the radio frequency ranges of various instruments, causing interference.

To combat these problems, Libbey-Owens-Ford developed Electrapane, a glass on which a thin, transparent metallic oxide film has been applied to either or both surfaces. The film, only five to seven millionths of an inch thick, is grounded to dissipate electrostatic charges. The glass provides protection for radar screens, instrument dials, meters, gauges and other electronic equipment. It also shields sensitive hospital equipment and cardiograph rooms from electrostatic disturbances. Electrical energy is supplied to the film by bars located along the opposite sides of the glass, the electric current passing through the film from one side to the other.

The heat generated by the Electrapane in this process is what makes it useful in aircraft, ships, control towers and train cabs to prevent build-up of ice or condensation. The Coast Guard Cutter Mackinaw, a giant icebreaker, is equipped with Electrapane window for all-weather vision.

A glass with high potential applications is photochromic glass developed by Corning. This glass turns dark in sunlight and becomes clear again in the dark. Submicroscopic crystals of silver halide, which turn dark in sunlight, are dispersed throughout the glass and are responsible for the darkening. The silver halide crystals are so tiny they do not interfere with transparency.

Windshields made with this glass would protect against glare while not hindering vision. Since the chemical reacts only to ultraviolet light and is not affected by oncoming headlights, or tungsten and fluorescent lighting at normal distances, it would not interfere with night driving. Photochromic sunglasses are already being manufactured.

Glass has become more and more widely used in architecture, not only to provide light, but also to add functional beauty to buildings.

Many modern skyscrapers utilize glass for walls, providing the tenants in the building with a panoramic view of the surroundings while the observer on the street sees a beautiful building. Two perfect examples are the United Nations Secretariat with 5,000 large tinted windows and the new Pan American Building with some 8,000 windows extending from floor to ceiling, both well-known structures in New York City. Other similar designs are scattered throughout the nation.

Architectural requirements for more and more large plate glass windows have been a challenge to glassmakers. To meet the increasing demand, L-O-F has adopted the technique of rolling glass over molten tin that has been foamed into tiny bubbles. The hot glass floats on the surface of the foam in huge continuous sheets. This process, although suitable only for thinner plate glass, gives it a flawless surface and eliminates the long polishing process required by the usual method.

Another glass coated with a thin, light gray, transparent metal oxide that reflects light and absorbs heat is among the newest developments for glass walls.

Thermopane is well known as a heat insulating glass. It is made with two panes of glass separated by a one-fourth-inch dry air space, allowing the sun's rays to penetrate and trapping its energy to warm the house.

One-way glass, now widely used in grocery stores and markets, could be applied to home architecture in a variety of ways such as at entrances, where the homeowner who wishes to maintain privacy can still look out onto a pleasant garden.

Glass does not ordinarily crystallize when it is cooled. However, when a nucleating substance, a chemical that serves as the base on which a crys-

Owens-Illinois

TELESCOPE MIRROR BLANK—The three men dressed in protective outfits examine a 41-inch telescope mirror blank made of Owens-Illinois' new low-expansion "Cer-Vit" materials just out of the melting furnace and still more than 2,000 degrees F. hot. Left to right they are John Wilson, technician, who is checking the temperature, John Drayton, also a technician, reading an optical pyrometer and Loran Lapsanszky, manufacturing supervisor.

Corning

TWISTABLE GLASS—Glass of such high strength that it can be twisted without breaking has been developed by Corning Glass Works, New York. Called Chemcor, the glass is made by a method involving several different chemical treatments and special glass compositions that make a product five times stronger than heretofore possible.

tal forms, is added to molten glass and then cooled, an opaque substance known as a glass-ceramic is formed which is harder and stronger, and more heat and abrasion resistant, than the original glass.

Corning has such a product called Pyroceram, which has been used for everything from stove tops to nosecones.

Owens-Illinois has a glass ceramic called Cer-Vit, which can be made transparent, translucent, opaque, or even luminescent. Cer-Vit is important in the making of reflective mirror blanks, since it shows practically no expansion when exposed to extreme temperatures. Mirrors 41-inches in diameter are being processed for several observatories.

Another highly stable glass, also used in telescopes, is fused silica. High-purity silica, made from a combination of noncrystalline materials, is an improvement over conventional silica made from natural quartz crystals.

The most transparent glass ever made, it has the ability to transmit ultrasonic elastic waves with little distortion or absorption, making it excellent for use in radar installations. It is also resistant to damage by atomic radiation and so is the preferred material for a wide range of space needs.

A new phase of glass technology is being devoted especially to the study of effects of radioactivity and electron radiation on glass in space. Radioactivity discolors glass while electron radiation cracks it. The refractive index of glass, even if changed ever so slightly at the sixth decimal, could degrade the quality of the image.

The heat resistance of glass in spacecraft is of utmost importance. Aluminosilicate glass, a high temperature glass, also used for stove-top cooking ware, has found use in space vehicle windows.

Corning has developed a glass which absorbs deadly gamma rays and is used for transparent shields in nuclear laboratories and aboard atomic ships. Other glass is made sensitive to gamma radiation and is developed for radiation dosage indicators.

A glass that will transmit up to 82% infrared light has proved useful for the heat-seeking Redeye missile. The easily formable new glass of calcium aluminosilicate is used for the nose dome of this surface-to-air missile.

Fused silica can be made either photoluminescent or cathodoluminescent, and can be readily drawn into fibers which still retain their luminescent properties.

A porous form of Corning's 95% silica glass containing billions of submicroscopic holes is known as "thirsty glass" and is used to keep moisture from semiconductor and electrochemical devices, as well as for virus separation.

Hollow glass balls for exploring the depths of the oceans are another unusual use of glass. Unharmed by hydrostatic pressure, glass tends to become stronger as it goes deeper into the ocean, a characteristic known as "depth hardening." Corning has produced massive glass hemispheres 44.5 inches in diameter and an inch thick as working models of manned deep-diving submersibles. The spheres could take "aquanauts" to the bottom of the sea, retaining normal atmospheric pressure inside at all times, thus eliminating the need for decompression when they emerge.

Bubble Made of Bricks

Another deep sea bubble is made of bricks reinforced with fiber glass in which the glass filaments in the bricks are arranged radially rather than circumferentially for greater strength. Developed by U.S. Rubber Company, New York, these spheres could descend and maneuver at 20,000-foot depths, bringing 98% of the ocean within our reach.

The uses of fiber glass as an engineering material increase with each year. It is now being woven into cloth and impregnated with epoxy for the manufacture of propeller blades. Also, Aerojet-General is planning jet wings wound around with glass fiber to increase their strength.

Another highly useful glass is photosensitive glass. This glass when exposed to ultraviolet light and heat behaves like photographic film or paper. An image is formed penetrating the glass and becoming a permanent part of it. A difference in chemical solubility between the exposed and unexposed areas is created and the pattern produced by the exposure can be etched out with an acid. The glass can then be heat-treated and converted into a stronger, opaque ceramic material.

Using a master mold made with photosensitive glass, a system has been devised for making many rubber circuit boards of the same pattern.

Thus the chemical control of glass has opened wide a field that researchers have still only tapped and as the technological needs of our world grow and change, glass, the most flexible of engineering materials, can no doubt meet the challenge.