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STEEL

The Magazine of Metalworking and Metalproducing

VOL. 120, NO. 10 — MARCH 10, 1947

NEWS

TECHNICAL

MARKETS

* Denotes regular features.

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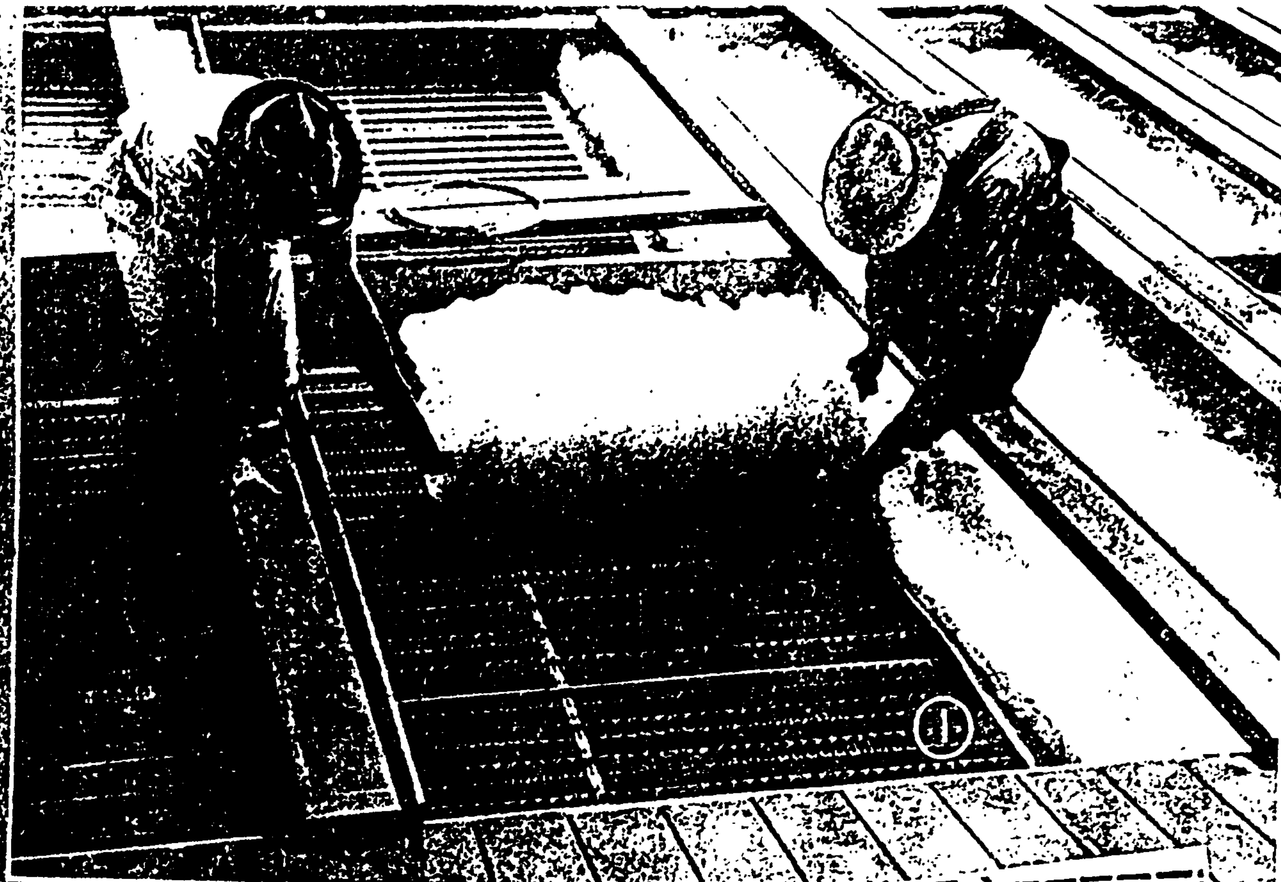


Fig. 1—Glass-fiber thermal insulation being installed in the roof of an industrial plant

Fig. 2—Light-weight glass-fiber material possesses acoustical as well as thermal insulating properties. Here it is being installed in the cabin of an airplane

Fig. 3—These glass-fiber reinforced plastic aircraft parts illustrate adaptability of the material to fabrication of complex and compound-curve parts

Fig. 4—Strength properties attainable with cross-laminated glass-plastic laminates and parallel-laminated glass-plastic laminates as compared with corresponding properties of 24 ST aluminum and structural steel to their yield point. Values are based on laminates made with heat-treated non-directional glass cloth and a representative low pressure resin molded at 15 psi pressure

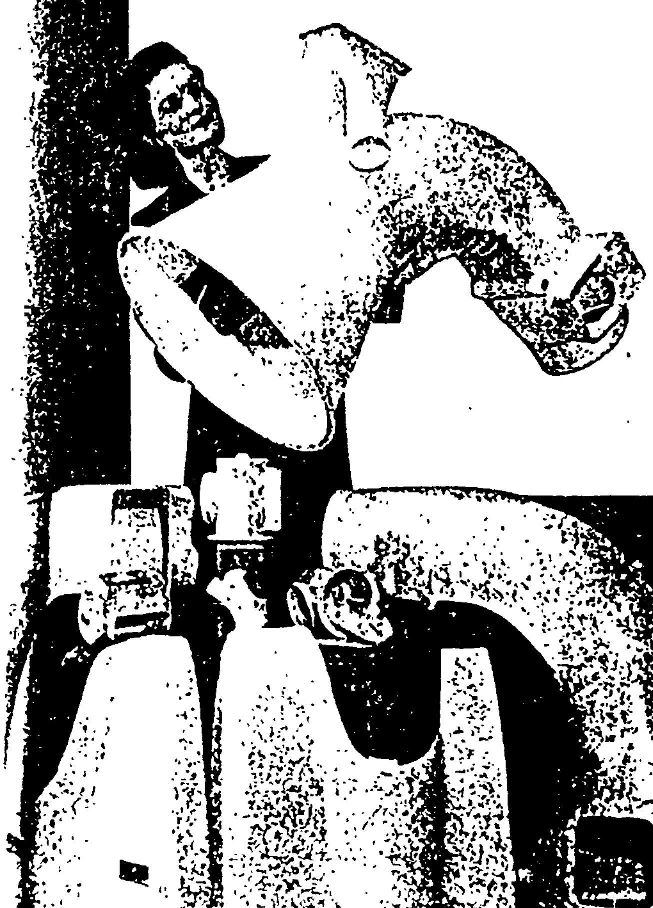
Fig. 5—Comparison of the energy absorbing values of glass fibers and other materials

GLASS FIBERS *as engineering mater*

GLASS fibers possess the greatest tensile strength-weight ratio of any commercial material either occuring in nature or synthesized by man. Fibers averaging 23 one-hundred-thousandths in. in diameter have a tensile strength of more than 250,000 psi. Experimental glass fibers have been produced with a diameter of 2 one-hundred-thousandths in. and with tensile strengths considerably higher than this value.

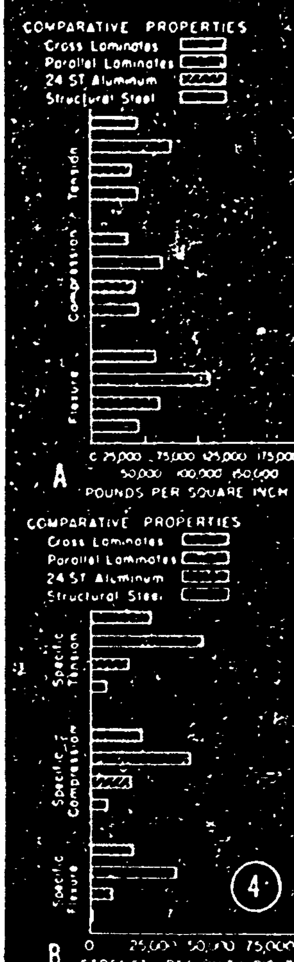
Fibrous glass is an engineering material in the same sense that steel, copper and aluminum are engineering materials, and like them, it is produced in a great variety of types and forms. Real start toward commercially useful glass fibers was made in 1931. In that year, research aimed at the development of the necessary processes was initiated in this country by Owens-Illinois Glass Co., manufacturer of glass containers, and by Corning Glass Works, manufacturer of glass specialties ranging from light bulbs to laboratory glassware and giant telescope mirrors.

From 1931 to 1938 Owens-Illinois and Corning, working separately toward the same goal, spent millions of dollars on the experimental and development work required to create the manufacturing processes and acquire the knowledge needed, not only to produce glass in useful fiber form, but to make practical its production on a commercial scale. Rapid progress was made in improved manufacturing processes and products, and in developing markets.



Late in 1938 Owens-Corning Fiberglas Corp. was formed to continue the manufacture of Fiberglas (glass fiber) materials, to carry on further research, to explore additional new uses, and to adapt the materials to still other uses which their inherent properties made them uniquely qualified to serve.

Properties of Fibrous Glass: There is no universal engineering material, in the sense of a material that pos-



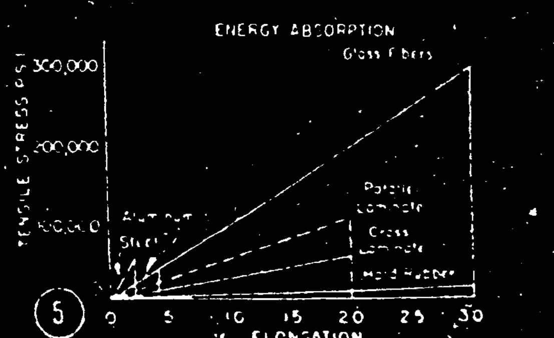


Fig. 6—Installing glass-fiber thermal insulation in the refrigerated compartment of a merchant ship

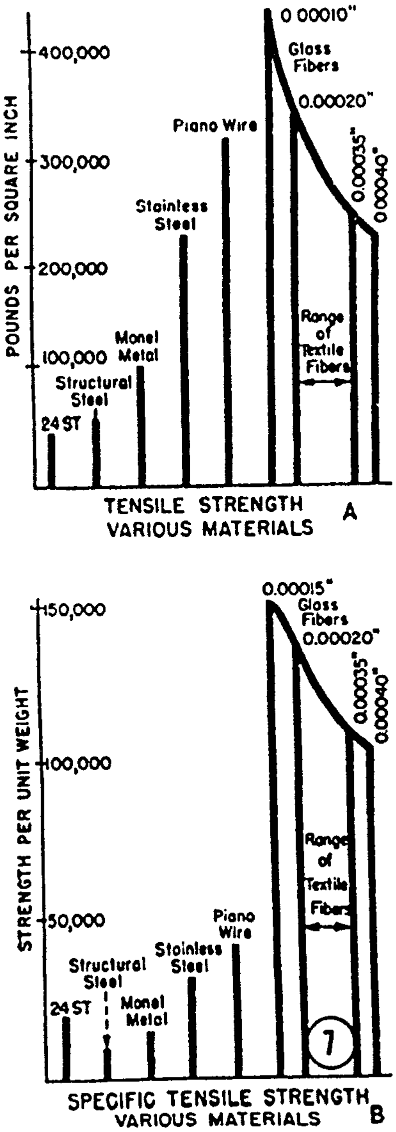


Fig. 7 — Tensile strength of individual glass fibers, in the order of 300,000 psi, is compared with the tensile strengths of a number of other materials. Chart A shows tensile strengths per sq in.; chart B shows specific tensile strengths, obtained by dividing tensile strength by specific gravity—in other words the answer thus derived expresses the strength as strength per pound

sesses properties which fit it to meet all requirements for all conceivable end uses. With any material therefore, a first step is to determine what properties it does possess—both those which will contribute to its wide acceptance and those which may prove a handicap. The next logical step is to determine what end uses its combination of properties fit it for.

Flexibility is the property of glass fibers which distinguishes them from all other forms of glass. Glass fibers are flexible for just one reason. They are almost incredibly thin in relation to their length. Steel is rigid in a thick, short piece, but heat it and draw it out into a fine wire and it becomes extremely flexible. The same is true of glass, but to be truly flexible the diameter of the glass must be much smaller in relation to length, than is required in the case of steel.

Cast aluminum, bulk glass and glass fibers all have about the same specific gravity—2.6 for aluminum, 2.5 for bulk glass, and 2.4 for glass fibers. However, a cubic foot of uncompressed glass fibers of the wool-like type used for thermal insulation weighs only 1½ lb, and is approximately 100 times lighter than a cubic foot of bulk glass. Figs. 5 and 7 give some physical properties of glass fibers in comparison with other materials.

Glass fibers possess high dimensional and physical stability. Although they may be as fine as gossamer, the fibers are neither more nor less than microscopically thin glass rods. Because they have no cellular inter-structure they cannot absorb moisture. Their surfaces can be wet, but moisture cannot get into the fibers. Moisture, therefore, cannot cause them to shrink, stretch or swell.

At tension approaching breaking strength the fibers show an elongation up to 3 per cent. The fibers cannot rot or oxidize, for the elements of the glass are already in a complete state of oxidation. They are unaffected by weak alkalis, and by acids in their most concentrated forms, except hydrofluoric and phosphoric acids. Finally, the fibers are completely incombustible.

In meeting requirements for thermal insulating materials that would stand up under the strains, stresses, vibration and humidity conditions to which combat ships and bomber and fighter planes were subjected during World War II, the Fiberglas Corp. and applicators of its materials developed many improvements in products and insulation methods. These are reflected in the postwar uses of glass fibers in such standard prewar applications as the thermal insulation of homes, refrigerators, food and beverage containers, roasters, stoves and water heaters... freight and passenger planes, railroad cars, trucks, buses and merchant ships... factories and other types of industrial and commercial buildings and their equipment.

Forms and Applications: The resilient mass of intricately interlaced glass fibers which is the basis of all forms of Fiberglas thermal and acoustical insulation may be composed of fibers ranging in diameter from 5 to 55 one-hundred-thousandths in., depending upon the purpose for which the insulation is to be employed. The wool-like mass can be installed in the form of bats, rolls, bulk fibers or shredded fibers. Blankets into which the mass can be formed can be faced with paper, a fabric or a metal mesh. Sheets and boards into which the mass can be fabricated can be given a variety of surface treatments, including a sanded, smooth finish on one side, a paper or fabric facing on one side, and an overall asphalt coating. They can be given a hard surface by facing them on one or both sides with sheets of plywood or even with a plastic material.

Predetermined density of the rigid and semirigid forms can range from 2.5 to 9 lb per cu ft. Density of the other forms can be varied by compression over a similar range. The K factor, at 50° mean temperature difference, ranges from 0.28 for the wool-like uncompressed forms at normal density of 1½ lb per cu ft., to 0.23 for a 9 lb density board. Low thermal conductivity is due primarily to the millions of air spaces entrapped by the interlaced fibers. These air spaces are poor conductors of heat. In addition, where the fibers cross and touch each other they have exceedingly small contact points. Heat, therefore, cannot pass readily from one fiber to another.

Air spaces, and the tremendous surface area presented by the mass of fibers, absorb and break up sound waves. When glass fiber bats, rolls, blankets, sheets or boards are installed immediately behind a perforated surface of metal, asbestos board, fiber board or similar material, a noise reduction factor as high as 0.95 may be obtained, the exact figure depending upon the form, thickness and density of the fibrous glass, the type of finish and the method of installation.

Glass fiber thermal and sound insulating materials are inherently firesafe and possess immunity to rot and decay. In addition, the materials provide no sustenance for insects or vermin of any kind. Properly installed, they do not settle down under shock or vibration, leaving gaps for heat or sound to pass through; rather, unless bonded with a resin, the compressed fibers tend to fluff out filling any voids. The amount of moisture picked up by the massed fibers from humid air is small.

Fiberglas thermal and sound insulation is one of the group of mineral wool insulations, including rock wool and slag wool, with which applicators and users have been familiar for a half century. The bat, roll, bulk and shredded forms are suitable for use in all temperatures from subzero to approximately 1000° F. Bats and rolls are widely used in stoves, roasters, water heaters, industrial ovens —also for the insulation of homes and other buildings, railroad cars, ships, buses, and trucks. Bulk fibers are generally employed as an accessory material, for stuffing or packing into odd spaces. The shredded form of insulation is used wherever pneumatic application is called for.

Fibrous glass blankets faced with flameproofed muslin or Kraft paper are used extensively to insulate buildings, refrigerated freight cars, railway passenger cars, trucks, trailers and buses. Blankets with a facing of noncombustible glass fiber cloth are used to insulate aircraft and aircraft equipment such as gasoline heater exhausts, heat exchanger ducts, and other high-temperature pipes, tubing, ducts and fittings. With a metal-mesh facing, the blankets are employed for the insulation of heated equipment such as boilers, tanks, industrial ovens, large ducts and breechings.

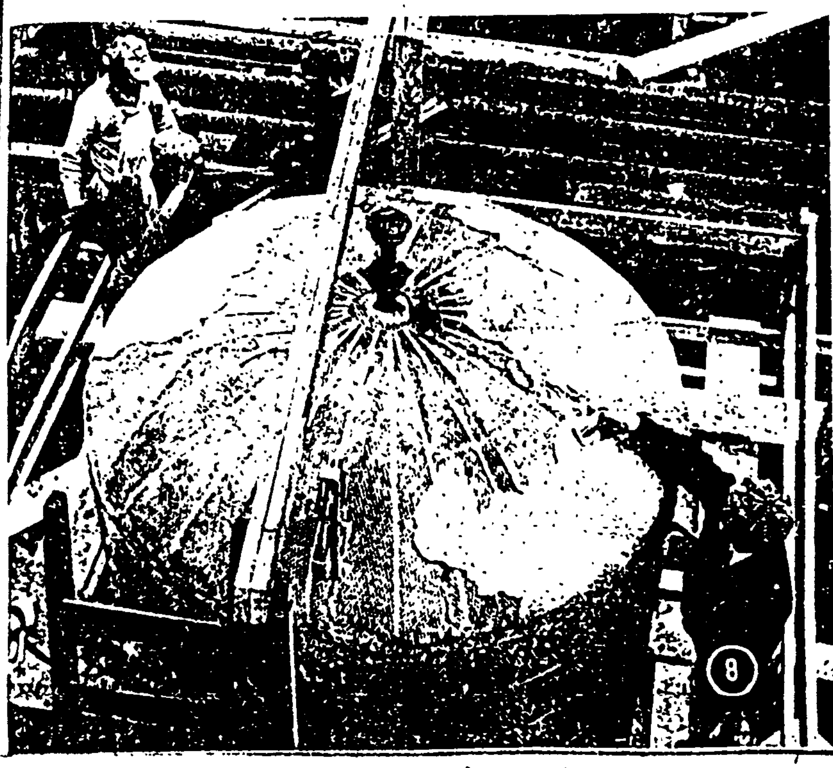
Glass fibers in the form of semirigid sheets or boards are used for building insulation and for shipboard hull and bulkhead insulation. They are also employed in all types of low and medium-temperature equipment up to about 600° F. In equipment operating at temperatures above 450° F, the resin used as a binder disappears from the hot side, leaving a layer of unbonded fibers which fulfills its insulation function with unimpaired efficiency up to 1000° F, so long as it is enclosed by supporting surfaces.

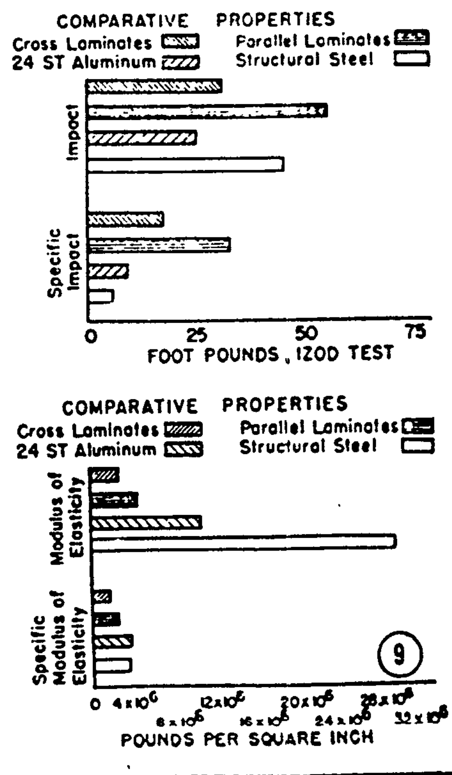
Sheathed on all sides with a tough, durable asphalt coating, a board made of the glass fibers is widely used in cold storage service, and performs efficiently under conditions of moisture and temperature variations such as exist in refrigerated spaces. An asphalt-enclosed board with a density of 9 lb per cu ft can be

(Please turn to Page 127)

Fig. 8—Fiberglas insulating cement being applied over Fiberglas metal mesh blankets used to insulate a large tank

Fig. 9—Comparative strength properties attainable with cross-laminated glass-plastic laminates and parallel-laminated glass-plastic laminates as compared with corresponding properties of 24 ST aluminum and structural steel to their yield point





Glass Fibers

(*Continued from Page 99*)

used for the insulation of floors and the construction of self-supporting—but not load-bearing—partitions. A 6-lb density, asphalt-enclosed board is made for use only on ceilings, and on walls where the structure carries the whole load.

These boards, which can be molded into cylindrical form, provide a convenient and efficient material for insulating steam and other pipes in all standard sizes up to 30 in. inclusive for temperatures up to 600° F. A blanket-type insulation with a metal-mesh facing is employed for insulating pipes up to 1000° F in sizes from 3 in. up. A high-temperature block is available for insulating boilers, breechings, heated tanks, casings, ducts and other heated process equipment operating at temperatures up to 1800° F.

Fabrics: Incombustibility and dimensional stability are largely responsible for the numerous current uses of glass fiber textiles. Tensile strength of standard glass textile fibers is in the order of 250,000 psi. Average fiber diameters range from 22 to 38 one-hundred-thousandths in. Realizable strength, after the fibers have been fabricated into yarns and fabrics, is somewhat less than the strength of the individual fibers, and is influenced by the construction of the yarn and weave of the fabric. The breaking strength, however, is considerably higher than that of other textile materials of comparable thickness and construction.

The incombustibility and dimensional stability of the glass fibers are retained in the yarns and fabrics. Like the fibers, the yarns show an elongation up to 3 per cent at maximum tension. Fabrics have little or no stretch, except that due to the weave. Moisture changes do not cause stretch or shrinkage. Both yarns and fabrics have good electrical insulating characteristics. Like the fibers, the fabrics are unaffected by weak alkalis, and by acids, except hydrofluoric and phosphoric acids.

Fabrics of Fiberglas coated with synthetic rubbers and resins developed for war uses have high tear strength, withstand repeated flexing, are resistant to destruction by fungi, and have high dimensional stability. Other properties vary with the coating employed, but coated glass fabrics are being produced which are flameproof and have high resistance to moisture penetration and to the effects of contact with gasoline, oil, chemicals and greases.

Present uses include aircraft battery covers, oil pressure switch diaphragms, aircraft tape for expansion joints of hot air ducts, protective clothing for workers in chemical plants and protective carrying cases for precision instruments. Performance of the material in this last application has created a potential demand for it in other similar applications where leather or organic fabric construction has been used. One such application is durable, light-weight luggage.

Glass fiber tapes, braids, cloths and sleevings, impregnated with a suitable varnish were being widely employed as electrical insulation in motors, generators, transformers and other electrical units before the war. The same characteristics that caused this kind of electrical insulation to be so widely used in war applications—a small space factor and resistance to high temperatures and moisture penetration— are proving a major aid to design engineers in their continuing efforts to give electrical equipment greater stamina and to reduce the size and weight of units required to do a given job. For special uses, glass fiber insulated motors have been made that weigh only a pound per horsepower.

Glass-Reinforced Plastics: In fabricating glass fiber-reinforced plastics, layers of Fiberglas cloth are impregnated with a low-pressure, thermo-setting resin and are placed, one on top of another, until a laminate of the desired thickness is built up over or in a mold; or the laminate may be built up and then draped over, or shaped in, a mold. The mold, and the laminate formed to the desired shape, are placed in an oven where the laminate is cured.

Because the low, or contact, pressure resins polymerize without giving off volatiles, it is possible to cure them in any desired shape merely by holding them in contact with the mold. This makes possible the fabrication of very large parts—the whole top of a railway car or the hull of a boat, for instance—without the expense and physical limitations imposed by the use of high-pressure presses.

It also means the elimination of expensive dies and jigs for since high stresses are not applied to the molds they can be of inexpensive construction. All this adds up to the fact low-pressure, glass-reinforced plastics can simplify and lower the cost of fabricating many parts, particularly large parts and those involving compound curves. They permit a frequency of design change that is uneconomic where there is a heavy investment in costly dies.

In general, their field appears to be the range and variety of parts that are produced in the hundreds or thousands rather than in the millions, and in the production of which, because of their relatively small volume, the cost of expensive metal dies is a prohibitive or burdensome factor.

Glass-plastic laminates can be given a highly polished finish in any desired color by spray-painting them with cellulose-acetate or cellulose-nitrate based finishes. Also, a polished, color finish can be applied by impregnating the glass mat with a resin to which the color has been added, and bonding the mat to the laminate in the mold.

In machining glass-plastic combinations, ordinary machine shop equipment is used, but at higher speeds than in the machining of metals. The mechanic who could make a part if it were metal can, with a little experience, do an equally workman-like job on glass-plastic laminates. For longer tool life, carbide or carbide tipped tools should be used.

These glass plastic combinations possess extremely high strength in proportion to their weight. Test specimens have shown tensile strengths of from 50,000 to 80,000 psi, compression strengths of over 50,000 psi, and impact strengths of over 30 ft lb, as compared with 2 ft lb for ordinary plastics. Comparative properties of glass-plastic laminates, steel, and aluminum are given in Figs. 4 and 9.

Aircraft parts have provided the most spectacular applications of glass-plastic combinations, but they are also widely used for the fabrication of tools, dies and jigs, and for panel boards on which electrical control instruments are mounted. Designers and engineers are experimenting with the material for such products as boats and canoes, passenger car and truck body parts, furniture, kitchen and bathroom assemblies, refrigerator and radio cabinets, and dozens of additional articles where attainment of light weight combined with high strength and ease of fabrication is the goal.

Air Filters and Tower Packing: One of the first commercial uses of glass fibers was for air filtration, in which pads of relatively coarse fibers, treated with an adhesive, were employed to strain dust and pollen from the air circulated by forced-warm-air heating systems, and air conditioning systems. Today glass fiber air filters are becoming a standard requirement for these systems in homes, factories, stores, theaters and other buildings. They are also widely employed in industrial plants to collect abrasive dusts created by manufacturing processes.

A recent development is the use of these coarse fibers as packing for distillation columns, acid coalescers, catalyst towers, and scrubbing or washer towers. The fibers are used for this purpose by the petroleum chemical, distilling, steel and other industries. The great surface area and large free volume of the material increase operating efficiency and speed production.

Fibrous Glass Mats: The thin, felted Fiberglass mats which, by holding the power-producing material in place, gave longer life to storage batteries in military automotive equipment during the war, were used for the same purpose in passenger cars, buses and trucks before the war, and are again being widely used in storage batteries for peacetime automotive equipment. In addition, new uses for the mat have been developed.

In roll form, it is being employed as a material for wrapping undeground oil, gas and other pipe lines to protect them against corrosion and electrolytic action. It can be wrapped around bitumen or coal tar-coated pipe, thus forming a continuous water-tight bond. The material has negligible moisture pick-up and its tensile strength is preserved through a wide range of temperatures and exposure to organic solvents and soil acids.

These mats are being employed as the base for a new plastic laminated material. Possessing a low and stable loss factor over a wide frequency range, the laminate greatly extends the field for plastic coil forms, condenser spacers, stand-off insulators, etc., in radio, radar, television and other high-frequency electronic devices. In building up the laminate, glass fiber mats are impregnated with a thermo-setting 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 and resistance to fungus attack. Good machinability is another important property of the laminate.

Fibrous glass 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.

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LISTS ELECTRODE INCORRECTLY

In the January 6, 1947 advertisement of The Champion Rivet Co., Gray Devil No. 2 electrode was listed as a 6013 rod. This was an error as the rod is, in reality, 6012. The Graydac is the Champion 6013 rod.

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Publication of a new 168-page manual, No. 15, by Bantam Bearings Division, Torrington Co., South Bend, Ind., completes a series of three volumes published to provide full bearing engineering data and to furnish an authoritative guide in the propet selection of suitable antifriction bearings for all types of installations.