

Fiberglas

A New Basic Raw Material

GAMES SLAYTER, Owens-Corning Fiberglas Corporation, Newark, Ohio

Glass fibers possess desirable properties not found in any other commercially available material. These fibers are produced as a wool-like fiber, largely used for thermal insulation, and as a textile fiber, either continuous or in staple lengths, employed to form yarns, threads, and woven fabrics. Glass fibers are inorganic, incombustible, nonabsorptive. They possess extraordinary tensile strength, electrical properties, and heat resistance. They are chemically stable and resist attacks of many chemicals. They do not rot, decay, or feed fungus growths or vermin. Colors in the glass itself are sun-fast and durable; dyes may be used for surface coloring of the fibers.

Wool forms are used for insulation of houses, ships, trains, aircraft, ranges, refrigerators, and similar equipment, and for industrial insulation at temperatures from below 0° to over 1000° F. Textile forms are used for electrical insulation, electric storage battery retainer mats, chemical and fume filtration services, and a wide variety of industrial applications. Decorative fabrics have found many practical applications. Glass fabrics are not recommended for wearing apparel.

LEADERS of science and industry have shown great interest during the past few years in the development of a new all-glass fiber which has come to aid the other basic fibers in doing the work of the world. This interest is understandable when we remember that glass fibers possess properties and characteristics not found in similar combination in any other commercially available material.

We all know the attributes of glass which make it one of the most perfect of all man-made materials—its plasticity when molten, its hardness and strength, its cleanliness and its great durability. All of these desirable attributes of glass in solid form are retained when glass is transmuted into fibrous form. But in addition, the original properties are extended by many new properties not found in other organic or inorganic materials of comparable utility.

There are two basic forms of Fiberglas—a wool form and a textile fiber form. Wool-like fibers are used primarily for thermal insulation purposes; coarser fibers of this same

basic type are also extensively used for air filtration in air conditioning systems. The textile fibers are made in either of two ways—as a continuous filament or as staple length fibers; these, in turn, are employed to form yarns and threads and are subsequently woven into fabrics of wide utility. It is this second form that will be discussed here.

Production

The production of Fiberglas in all its forms begins with the manufacture of virgin glass from carefully selected silica sand, limestone, and other pure mineral ingredients according to precision formulas. The raw materials are checked with great accuracy, the batches are compounded under the protective control of automatic recording scales, and the ingredients are melted under close temperature control. Various types of glasses are produced in this manner, each designed to provide the desired characteristics of the product ultimately formed.

The glasses used in the production of textile fibers are further refined by remelting in electrical furnaces just prior to drying into fibers. There are two Fiberglas textile processes. One produces staple fiber and the other makes continuous filament. The staple process is named after the common textile term measuring a limited length. Glass staple fibers average 8 to 15 inches in length, which is much greater than the length of the best long-staple cotton. The fiber diameter most commonly made averages 0.00027 inch, but recent developments have shown the desirability of making fibers of other diameters, and we are now beginning the production of staple fibers of somewhat larger size. To translate these figures into more commonly understood terms, our standard fibers have a diameter about one fifteenth that of a human hair. The individual fibers are smooth and substantially cylindrical.

In the staple process the glass cullet is melted electrically and the molten glass pours from orifices beneath the furnace. High-pressure jets of steam or air tear the stream of glass and draw the particles into long-smooth fibers. These are gathered on a traveling belt in the form of a web or ribbon of interlaced fibers, from which they are gathered, without twist, as a sliver. In the gathering process the fibers are slightly drafted so that the majority lie parallel to the length of the strands.

This is the raw material of staple fiber rovings and yarns. Glass textile terminology is the same as that of other textiles. A roving is a sliver with a low twist and is formed simply by twisting the sliver on a standard twister or flyer twister. A yarn is a sliver or roving given a higher twist. Fine yarns of Fiberglas staple fiber are made by drafting sliver in a manner similar to the worsted spinning process. Coarse yarns are made without drafting.

A small amount of mineral oil lubricant is used on staple fibers. This lubricant improves the processing characteristics and minimizes friction between the individual fibers, which tends to cause scratching and breakage. This lubri-

1568

PLAINTIFF'S
EXHIBIT
WV-03323

PLAINTIFF'S
EXHIBIT
84810



EQUIPMENT FOR ACCURATE PROPORTIONING OF RAW MATERIALS ACCORDING TO PRECISE FORMULAS FOR MAKING FIBERGLAS

Beneath each storage bin is a weigh hopper connected to a recording scale. The proper amount is weighed out into the hopper, and then the batch of combined materials is gathered by a collecting car running on rails beneath the bins.

cant may readily be removed by washing with soap in hot water or by carbon tetrachloride or ether.

The process of making Fiberglas as a continuous filament is different from the staple fiber process. The continuous filament form is unique in that the glass is drawn continuously to indefinite lengths, the latter being limited only by the problems of packaging. The average diameter of the individual filaments is 0.00022 inch, although here again we can make finer or coarser filaments to vary the characteristics of the final products.

A large number of filaments (generally 102 or more) are drawn simultaneously, gathered together in a strand, and caught on a winder that draws them at a speed in excess of a mile a minute. These combined strands are still so fine that they can scarcely be seen as they are gathered by the winder; yet the speed at which they are produced is incontrovertible evidence of their great tensile strength.

A small amount of lubricant and coating is used on the continuous strand. This material serves to facilitate manufacturing operations and to keep the individual glass fibers apart. Glass fibers may be thought of as very small glass rods which few substances will scratch, but which will scratch one another. Once scratched, the fibers are easily broken. The coating used is generally composed of starch and vegetable oil. It may readily be removed by washing with soap in hot water. Being organic, it is also removable by heating the finished textile at 600° to 700° F. in a well-ventilated oven for one hour.

Fiberglass yarns are processed on standard textile machinery after slight modification and adjustment found desirable in plant operations. Practically every type of weave which may be made with other textile materials can be made with glass fibers. The continuous filament strands are twisted together in any desired construction to form yarns or threads. The staple fibers are treated much like worsted yarns. They are drawn into slivers and yarns of various counts, some moderately fine to coarse, according to their subsequent use.

The textile fibers made of Fiberglas are subjected to numerous quality control tests. In one test the fiber is magnified hundreds of times so that an operator can check for diameter

uniformity. In another test a quality control checker examines the twist in Fiberglass yarns. Still another test determines the tensile strength of the yarn. Representative samples are taken from production at regular intervals to ensure uniformity in tensile strength. Standard textile



CAREFUL INSPECTION OF EACH PURE REFINED GLASS "MANGLE", THE RAW MATERIAL USED IN THE MANUFACTURE OF FIBERGLAS TEXTILES

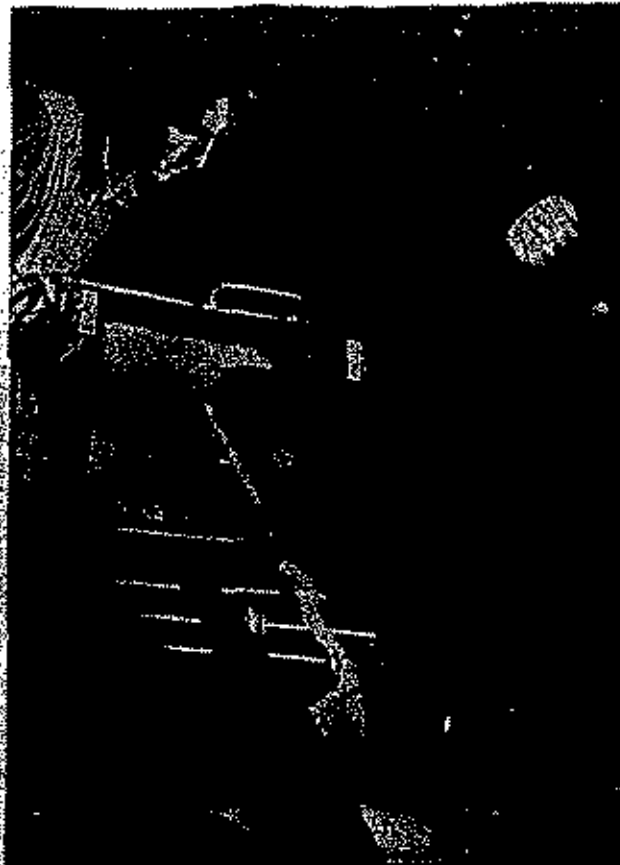


Photo by Robert Farwell Nichols

STEAM-DRAWING PROCESS FOR GLASS STAPLE FIBERS

The molten glass pours from orifices through a high-pressure steam jet; the fibers are driven downward onto a rapidly revolving drum from which they are immediately gathered into a roving and are wound on a spindle or spool.

Testing machinery is employed in these tests, which are made constantly in order to ensure uniform quality at all times.

Properties

The utility of Fiberglass lies in its unique combination of physical, electrical, and chemical properties. Let us think for the moment of the properties of glass in its more common forms—in windows, in bottles, in the glassware essential to every chemical laboratory, and in cooking ware now becoming essential to most housewives. Think of it also as electrical insulators on telephone and power lines, as a structural material, and as a sanitary product indispensable to the modern hospital. In all of these applications we find glass to be clean, hard, strong, durable, and usually brittle.

When glass is reduced to the form of fine fibers it retains all of these properties, even brittleness, but the latter disappears as a practical consideration. In place of brittleness there is flexibility and resiliency. But in addition, there is also extraordinary tensile strength. We have produced fibers in the laboratory which have a measured tensile strength in excess of 2,000,000 pounds per square inch. Fibers of the size used in continuous filament have a tensile strength in excess of 400,000 to 500,000 pounds per square inch, which is considerably greater than the tensile strength of hand drawn, steel piano wire.

These glass fibers are inorganic, incombustible, and non-

absorbent. Being inorganic, they do not provide sustenance for vermin, fungus growths, or other forms of decay.

Glass is an incombustible material; the fibers will melt but they cannot burn. Their temperature resistance is high when formed in the mass or woven as a fabric. Fiberglass yarns, tapes, and fabrics used in the electrical industry can safely withstand temperatures in the neighborhood of 1000° F. At 800° F. electrical tapes of Fiberglass have a greater strength than is presented by cotton tapes of similar size and thickness at ordinary room temperatures.

The electrical properties of glass have long been known to the scientific world. These properties are retained by glass in fibrous form, augmented by the use of glass compositions that are free from metallic oxides. The resulting Fiberglass electrical insulation products combine high dielectric strength and electrical insulation resistance with extremely low moisture absorption. These insulating materials combine well with electrical varnishes and impregnants. In consequence, Fiberglass electrical insulation materials have already achieved a high place in that industry.

Glass is also known as a chemically stable product. It is not harmed by any acid except hydrofluoric. Nevertheless the advanced chemist knows that different glass compositions have different degrees of solubility and show minute, but measurable, reactions with many different substances and solutions. This characteristic is of no importance to glass in solid form, but when the surface area of the glass is expanded many thousands of times, as it is in the formation of glass fibers, one must become cautious in discussing complete immunity from attack.

Broadly speaking, glass fibers are chemically resistant. One of their new and important uses is in the formation of



FIBERGLAS-INSULATED DIVING SUIT FOR SALVAGE VESSELS ATTENDING UNITED STATES NAVY SUBMARINE SQUADRONS

In these electrically heated insulated suits, divers can stay at great depths twice as long as in the present equipment.

battery retainer mats for use in storage batteries. These mats, which greatly extend the life of the battery by keeping the active material in place on the battery plates, render good service because the glass is resistant to the acids of the battery solutions and at the same time possesses the desired electrical insulation characteristics.

Fiberglass fabrics have found other uses in the chemical field, notably for anode bags in electroplating processes and as filter cloths in a number of applications involving liquids or gases at temperatures that are destructive to other filtering materials or under conditions which would be corrosive to other materials but not to the gases employed.

The thermal properties of Fiberglass wool have resulted in its widespread use wherever heat is conserved, controlled, or excluded. The unusually desirable electrical properties of Fiberglass have resulted in its use wherever electricity is employed for power or light. The filtering characteristics result in the use of Fiberglass in the great majority of modern air-conditioning systems. If only these factors were considered, it can readily be understood why Fiberglass has become important to every industry, to every branch of commerce, and almost to every form of human activity.

Present and Future Uses

Although the wool forms of Fiberglass are not strictly within the scope of this paper, they constitute an important use of this fiber and deserve brief mention. Fiberglass thermal insulation materials are used extensively for the insulation of houses, ships, and vehicles of all types, including trains and aircraft. It is employed in ranges, refrigerators, water heaters, and similar domestic and industrial equipment. It is used for industrial insulation at temperatures ranging from below 0° to over 1000° F. These and other uses have followed the introduction of Fiberglass because the material combines light weight, high thermal efficiency, great durability, and low cost.

The principal use for the textile forms of Fiberglass is found in the electrical industry. The fine yarns are utilized for insulating magnet wires; coarser yarns, for heavier wires and cables. Woven into tapes, braided sleeves, cloths and tying cords, Fiberglass is now extensively used in the insulation of electric motors, generators, transformers, and other types of operating and distribution equipment.

Next in importance in the textile field are parallel developments in decorative and service fabrics. Industrial uses range from the fabrics enclosing all-glass turbine blankets to wicks for kerosene or oil lamps and stoves.

The decorative applications of Fiberglass fabrics have attracted world-wide attention. Today we are making gleaming damasks, shimmering brocades, lustrous satins, rustling taffetas, and sheer nets entirely of glass. They are woven in the smartest of designs on standard Jacquard looms, all 50 inches wide and made of pure glass thread. These new products include overdrapes, glass curtains, shower curtains, bedspreads, tablecloths, lamp shades, and awnings. In addition there are neckties, hats, and other articles. Fiberglass draperies and other textile products are being used today in homes, offices, hotels, restaurants, public buildings, clubs, Pullman cars, ocean liners, and transcontinental and transoceanic airplanes.

Aside from their novelty, these new fabrics have many advantages over better known fabrics, chief among which are their colorfast properties and durability. Fiberglass fabrics are not affected by climatic conditions and therefore will not sag or shrink. They are fireproof and heat resistant to a high point. Even a cigaret may burn out its length on this fabric and not destroy it; the resulting stain is easily removable with soap and water.

Fabrics of Fiberglass are practically soil-proof and are definitely mildew- and vermin-proof. Dust or dirt remains on the surface much the same as flecks of dust on a mirror, and can be wiped off with a damp cloth. Fiberglass fabrics at the present time come in seventeen different designs with others being added constantly.

There are several colors to choose from. Drapery materials come in pure white, ecru, medium dark gray, a light and a medium dark periwinkle blue. And we are working on the development of other colors.

In spite of the many advantages that are apparent in Fiberglass as a textile material, it does not have universal applicability. It is not suitable in its present forms for dress fabrics of any type. You may have seen pictures of charming young ladies dressed in wedding gowns and other forms of glass cloth. These are all imaginative previews of future potentials. But today we do not sell or recommend any form of Fiberglass for use as a clothing material except as the products may be combined in shoes, hats, dress accessories, or even neckties.

Fiberglass is not the competitor of many modern textile fibers. It is only occasionally the competitor of the more commonplace fibers which the world has known for many generations. Fiberglass is finding usefulness in places where other fibers, lacking some of the qualities combined with others in our product, do not render fully satisfactory service.

There are many such applications where the characteristics of glass in fibrous form open new doors for textile products. Looking into the future, we see potential applications in the aircraft industry which require light weight combined with great strength, complete fire resistance, and durability. It may prove advantageous to use Fiberglass for sandbags in military defense or protection against floods, because Fiberglass will not rot in such service, and bags can be made up long in advance of need and stored ready for the emergency. We are already far into the development of awning fabrics of Fiberglass, which will not be burned by cigarets thrown down from above and which will be permissible even in the most strictly controlled fire zones of our largest cities.

Fiberglass is the product of research and its future growth depends upon continued research. Although the industry is scarcely nine years old, it is today producing Fiberglass at the rate of many carloads daily.

Correction—P-V-T Relations of Propylene

Dr. E. Roper has pointed out that the apparent discrepancy (4) in the determinations of the vapor densities of propylene at 25° C. and 1 atmosphere (2, 4) and at 0° C. and 1 atmosphere (1) is nonexistent. If the compressibility factor, $Z = PV/RT$, at 0° C. and 1 atmosphere is computed, there are obtained from Roper's data (5), 0.9809; from Batuecas', 0.9803; and from Vaughan and Graves' (by interpolation on a Z vs. P plot), 0.980. The perfect agreement is noteworthy. We have found that although Batuecas' density, 1.9149 grams per liter at 0° C. and 1 atmosphere, is correctly given in our paper (4), an error of omission of a digit was made in the calculation to 25°, giving rise to the question. It may now be said that all of the data (1-4) are well coordinated.

Literature Cited

- (1) Batuecas, *J. chim. phys.*, 31, 165 (1934).
- (2) Powell and Giauque, *J. Am. Chem. Soc.*, 61, 2366 (1939).
- (3) Roper, *J. Phys. Chem.*, 44, 835 (1940).
- (4) Vaughan and Graves, *IND. ENG. CHEM.*, 32, 1282 (1940).

WILLIAM E. VAUGHAN AND NOEL R. GRAVES