This invention relates to the production of structural materials from gypsum and more particularly to the production of reinforced materials thereof having improved strength, modulus, and resistance to cracking.

In recent years, gypsum has found increasing popularity as a structural material both in the form of rock lath to be used as a plaster base and as a finished wallboard for the so-called "drywall" construction. Poured gypsum has found increasing use as a structural material as for the roof decking for large buildings such as factories and storage. Gypsum decks are generally installed by first placing a suitable supporting deck of formboard on the supporting purlins of the building and simply pouring the gypsum, which may be slightly foamed to give it a lower density, over the formboard and purlins in the same manner a sidewalk is poured in place. It is then screeded to the proper depth, smoothed by lightly troweling and dried in place to form the gypsum deck. This ease of installation, combined with good compressive strength, have combined to make poured in place gypsum one of the most popular building materials for roofing. However, it possesses very little tensile strength and for this reason it can be used only when a suitable supporting member is placed beneath the entire deck or when it is adequately reinforced. It is common practice to place a heavy, open mesh woven wire cloth over the entire deck before the gypsum is poured in place to reinforce it and aid in providing the essential tensile strength.

A major deficiency of this type of poured in place gypsum deck has been a pronounced tendency to craze and crack. This cracking weakens the deck and stresses the roofing material thereabout, inducing failures and leaking in it. It has been found that this tendency of a poured in place gypsum deck to crack can be materially reduced by incorporating reinforcing glass filaments, strands and yarns therein. While the reinforcing action of these fibers is not sufficient to offset structural defects in the building resulting from improper design they will help compensate for thermal stresses and temporary overloading. The fibers may be evenly dispersed throughout the gypsum to form a continuous reinforcement but preferably they are concentrated in the upper stratum to more effectively prevent cracking of the gypsum surface and the resulting failure of the roofing material.

Trials with this type of reinforcing wherein short lengths of chopped glass filaments were added in the mixing tank were unsuccessful because when passing through the pumps on the way to the pouring nozzle the lengths of glass fibers will agglomerate and tend to clog the pumps. In order to overcome these difficulties, this invention provides a method for pouring an improved reinforced gypsum deck wherein the glass fibers are mixed with the gypsum slurry after it has passed the last pump so that this agglomeration of the glass fibers at the pump will not occur. Further, this invention provides a poured in place gypsum deck wherein the glass fibers are selectively placed in the gypsum to most effectively resist crazing and cracking.

An object of this invention is to provide an improved reinforced gypsum deck.

A further object of this invention is to provide a method and apparatus for mixing and pouring a slurry of gypsum and unagglomerated reinforcing glass fibers. A further object of this invention is to provide a crack resistant gypsum deck having only a small percentage of glass fibers selectively placed, therein.

A further object of this invention is to provide a poured in place gypsum deck having a crack resistant, fibrous glass reinforced surface.

Another object of this invention is to produce an improved gypsum wallboard.

Another object of this invention is to provide a gypsum wallboard having glass fiber reinforced surfaces.

Other objects and advantages of this invention will become apparent from the following specification and drawings in which:

FIGURE 1 is a side elevational view illustrating the pouring of a glass fiber reinforced gypsum deck built in accordance with this invention,

FIGURE 2 illustrates a completed gypsum deck built in accordance with this invention and covered with a suitable waterproof membrane,

FIGURE 3 illustrates a gypsum deck built in accordance with this invention wherein only the upper strata of the deck is reinforced with glass fibers,

FIGURE 4 illustrates a reinforced gypsum deck built in accordance with this invention wherein continuous glass yarns are embedded in the upper surface of the gypsum to prevent cracking and crazing thereof,

FIGURE 5 illustrates a reinforced gypsum deck built in accordance with this invention having a large open weave reinforcing cloth of glass filaments embedded in the upper surface of the gypsum,

FIGURE 6 is a section view of a lightweight reinforced gypsum deck built in accordance with this invention,

FIGURE 7 illustrates a nozzle for pouring a reinforced gypsum deck according to this invention wherein the reinforcing fibers are mixed with the gypsum interiorly of the nozzle.

FIGURE 8 illustrates a nozzle for pouring a reinforced gypsum deck according to this invention wherein the reinforcing fibers are mixed with the gypsum exteriorly of the nozzle.

FIGURE 9 illustrates a nozzle for producing a reinforced gypsum deck according to this invention wherein the reinforcing glass fibers are mixed with the gypsum as it flows from the nozzle to the deck,

FIGURE 10 illustrates a process according to this invention for producing a gypsum wallboard having its surfaces reinforced with short lengths of glass fibers,

FIGURE 11 illustrates the production of a glass filament reinforced gypsum wallboard wherein the continuous glass filaments are continuously incorporated into the surfaces of the wallboard while it is being produced. Referring in greater detail to FIGURE 1, a roof deck is constructed in accordance with this invention by first installing the main supporting purlins 9 in place. Sub-purlins 10 are welded to the main supporting purlins and suitable formboards 11 or other material are laid therebetween. These formboards are supported by the flanges extending horizontally from the bottom edge of the sub-purlins and form the supporting base for the gypsum slurry. A heavy open metal mesh reinforcing screen 12 is laid over the sub-purlins and formboards. Wet gypsum slurry 14 from a pouring nozzle 15 is poured onto the formboard and flows through and around the metal reinforcing screen. Reinforcing glass fibers 16 are mixed with the flowing gypsum slurry or are sprinkled onto the wet surface of the gypsum and pressed or rolled into it. Glass reinforcing fibers are normally produced.
by attenuating a plurality of fine filaments, coating them with a suitable sizing material and gathering the sized filaments into a multifilament strand. This multifilament strand is used as the reinforcing material for the gypsum or it is chopped to form short lengths of reinforcing material. If a water soluble sizing is used to hold the filaments into a strand, it will be dissolved when it is mixed with the gypsum slurry and break up into individual reinforcing fibers. By utilizing an insoluble size to bind the filaments together, the strand will be the elemental reinforcing material and a stronger, stiffer gypsum composite will be formed.

FIGURE 2 illustrates a completed reinforced gypsum deck in which composite strands have been incorporated to reinforce it. The completed deck has an open mesh wire cloth 12 extending almost continuously throughout to impart to the gypsum deck sufficient structural strength to withstand the loads imposed on it by snow, etc., thereabove. Short lengths of glass fiber strands 16 are mixed with the gypsum and dispersed throughout it. These short bundles of filaments reinforce the gypsum by functioning a discontinuous web of reinforcing material and prevent the enlargement and propagation of small cracks and fissures resulting from localized over stressing of the deck. A suitable waterproofing membrane such as multiple layers of a roofing felt and asphalt is adhered to the top of the gypsum deck. The chopped strand reinforcing intercepts the crystal boundaries of the gypsum and ties them together. The resulting reduction in cracking of the gypsum deck reduces the stresses on the waterproofing membrane and reduces the cracking and leaking thereof.

Often when pouring a gypsum deck, a first layer of gypsum slurry will be poured and screeded to a depth of about two-thirds the depth of the completed deck. After this first layer has at least partially dried, a second layer of another layer of gypsum is poured. This invention provides an improved crack resistant poured-in-place gypsum deck wherein only this second layer or cap is reinforced with short lengths of glass fibers. As illustrated in FIGURE 3, a first layer of gypsum slurry 13 is poured over the sub-puttins 10, formboard 11, and metal mesh reinforcing 12. A cap 19 of gypsum reinforced with short bundles of glass filaments is applied thereover. This cap of reinforced gypsum may be applied by mixing the reinforcing fibers with the gypsum at the pouring nozzle, as illustrated in FIGURE 1, or it may be sprayed on by simultaneously spraying the short lengths of fibers and the gypsum slurry from separate spray nozzles such as a "Rand" type gun onto the deck. With this construction, although the lower unreinforced layer of gypsum may crack, the upper reinforced stratum will tend to remain as an integral sheet.

In warmer climates, where the expansion and contraction of the gypsum deck resulting from temperature changes are minimized, a deck with only a surface reinforcing, as illustrated in FIGURE 4, is often satisfactory. To produce this type of deck, the gypsum slurry is poured to the desired depth and the reinforcing fibers are sprayed thereover. During the subsequent screeding operation the reinforcing fibers are worked into the surface of the gypsum. Also, the reinforcing fibers may be sprayed onto the wet gypsum surface after the screeding operation and subsequently pressed or rolled into the gypsum. Short lengths of glass strands may be used for this type of reinforcing, but it is preferred that continuous reinforcing strands 21 be sprayed onto the freshly poured gypsum deck 20.

FIGURE 5 shows another improved reinforced gypsum deck wherein a rather open weave glass cloth or scrim 22 is embedded in the upper surface of the freshly poured gypsum deck. This scrim or cloth is preferably laid onto the wet gypsum surface after it has been screeded to depth and then rolled or troweled into the surface.

FIGURE 6 illustrates in cross section an improved lightweight reinforced gypsum deck. While the gypsum slurry is being prepared by mixing the powdered gypsum with water, pellets 24 of glass foam having a diameter up to about the size of walnuts or golf balls, are mixed with slurry. These pellets become dispersed throughout the slurry and are poured as an integral part of the deck. These pellets may constitute any percentage by volume and as they are mostly cellular in nature and open on the inside the apparent density of the completed deck is considerably reduced. The glass fiber reinforcement is mixed with this glass foam pellet extended gypsum slurry at the pouring nozzle. The mixing of the glass fiber reinforcement 25 is preferably regulated so that a greater concentration of glass fibers will be positioned in the upper strata of the deck to better reinforce it. The entrapped air in the glass foam pellets, in addition to lowering the apparent density of the gypsum deck will lower the thermal conductivity of the composite. Further, the glass foam pellets have a lower coefficient of thermal expansion than the gypsum. Therefore, the tendency of the deck to expand and contract with changes in temperature will be reduced resulting in a more crack resistant deck. The glass fibers scattered throughout the deck will further enhance its crack resistance and by concerns and gypsum. Additional fiber guides may be fastened to the nozzle 40 to add larger quantities of fibers to the stream of slurry. FIGURE 9 illustrates another arrangement of the reinforcing fiber supply guides for adding the reinforcing strands of glass filaments to the gypsum slurry. A plurality of reinforcing fiber supply guides 45 are attached to the gypsum supply nozzle 46 by suitable braces 47. Glass strands 48 are fed through the fiber supply guides and deposited on the stream of gypsum slurry 49. When a pair of reinforcing fiber supply guides are utilized they are most advantageously arranged vertically so that the fibers from one guide are deposited beneath the gypsum slurry and the fibers from the other guide are deposited thereabove. In this way, the fibers from the lower guide are thoroughly covered and mixed with the gypsum slurry while the fibers from the upper guide fall onto the stream of slurry and are mixed therewith by the rolling action of the slurry when it impinges against the deck. The major portion of the fibers from the upper supply guide will be concentrated in the upper strata of the deck. Normally about 25-35% by weight of reinforcing strands are used with the preferred compositions containing about 10-15% reinforcement. The gypsum slurry shown in FIGURE 9 also has pellets 50 of glass foam in it for improved thermal conductivity.

As illustrated in FIGURE 10, the reinforced gypsum wallboard of this invention is produced by withdrawing a
continuous roving from a package 61, cutting it into short lengths with a suitable chopper 62 and depositing the short lengths of reinforcing strand 64 rather uniformly on a sheet of kraft paper.

A slurry of gypsum and water with suitable additives, extenders, such as pellets of glass foam, sawdust, and silicides for improved water resistance is prepared in a headbox 66. This slurry 68 is dumped from the head box on the paper and reinforcing strands. A guide shoe 71 forces the edge of the paper up to retain the slurry and another sheet of kraft paper 72 is placed on top of the slurry and adhered to the bottom sheet 65. A roller 74 forces the upper paper 72 against the top of the slurry and embeds the reinforcing fibers 70 therein. The paper faced slurry is carried through a curing oven 75 wherein the slurry is cured to a rigid board and the excess water is removed. The cured composite is cut to the desired length by a rotary saw 76 driven by an appropriate motor 78. The cut lengths are then packaged for shipment.

Continuous reinforcing strands can be used in place of the cut strands, shown in FIGURE 10. As illustrated in FIGURE 11, continuous reinforcing strands 80 are deposited on the kraft paper that forms one side of the completed wallboard. These continuous reinforcing strands are preferably attenuated directly from a suitable supply of molten glass by the attenuating wheels 81. However, they may also be withdrawn from other suitable strand supply sources such as packages of rovings or yarns. Additional reinforcing strands are deposited on the wet slurry after it has been spreaded to the desired depth to reinforce the upper surface. The continuous reinforcing strands will provide a more integral reinforcement and generally a stronger wallboard, than the chopped strands.

Although this invention was described in relation to the production of a poured in place reinforced gypsum deck, the principles described herein are applicable to the construction of other materials, sidewalks, protective shields over pipe lines, etc. Also, it has often proven advantageous to utilize glass wool fibers wherein the batt of wool is cut into short (one quarter to five inch) lengths and then shredded to separate single fibers and incorporating the single fibers into the gypsum slurry. These glass fibers help maintain the integrity of the gypsum composite when it is subjected to high temperatures such as a fire and being dehydrated.

It is understood that numerous changes may be made in the type of glass fiber reinforcement and the method or order of its application to the slurry without departing from the spirit of this invention, especially as defined in the following claims.

We claim:
1. A gypsum deck having a reinforced upper surface comprising:
supporting members,
a base for said gypsum deck extending between said supporting members,

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FRANK L. ABBOTT, Primary Examiner.
JACOB L. NACKENOFF, HENRY C. SUTHERLAND, Examiners.
J. L. RIDGILL, Assistant Examiner.