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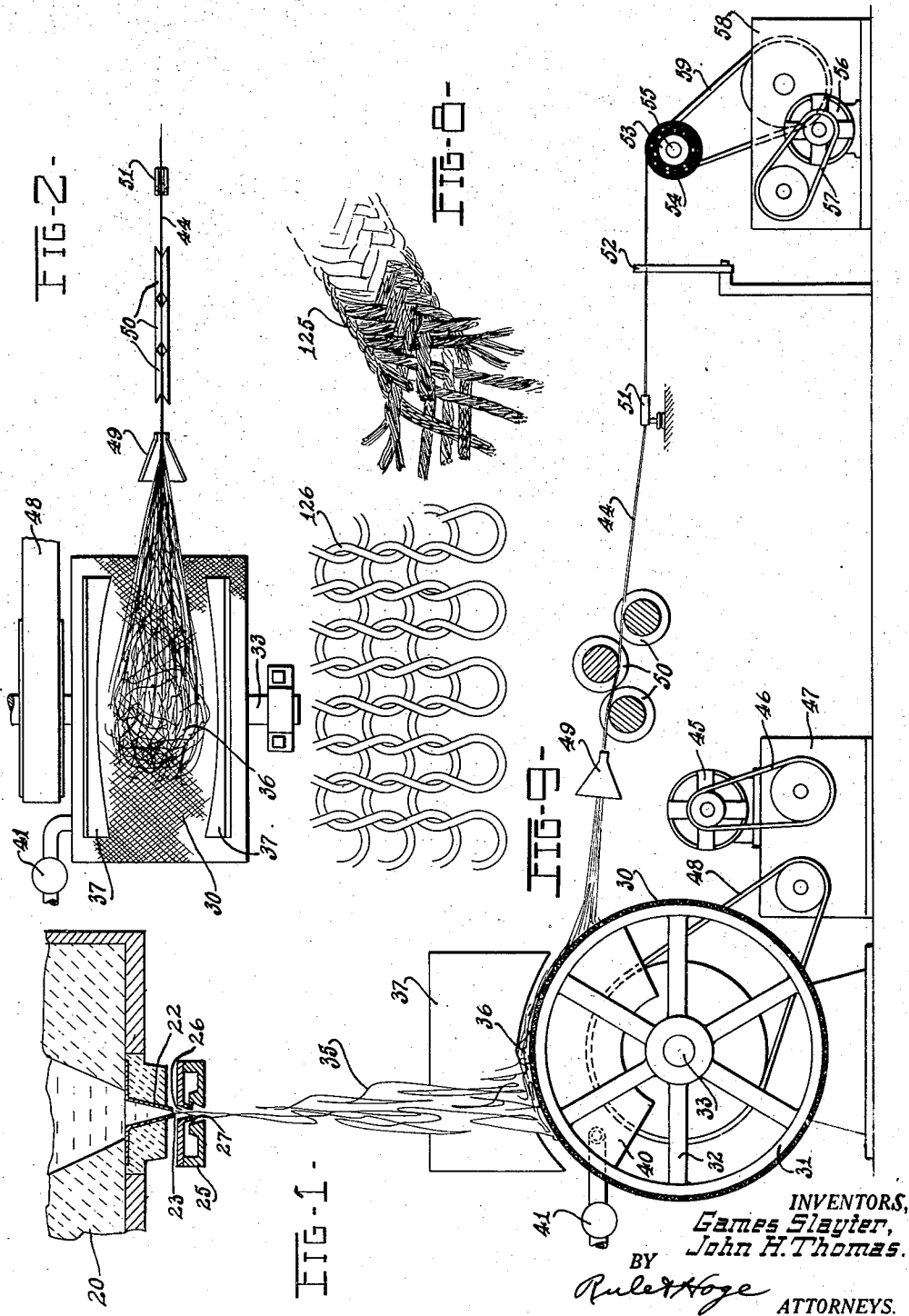
G. SLAYTER ET AL

2,133,238

GLASS FABRIC

Filed June 22, 1937

2 Sheets-Sheet 1



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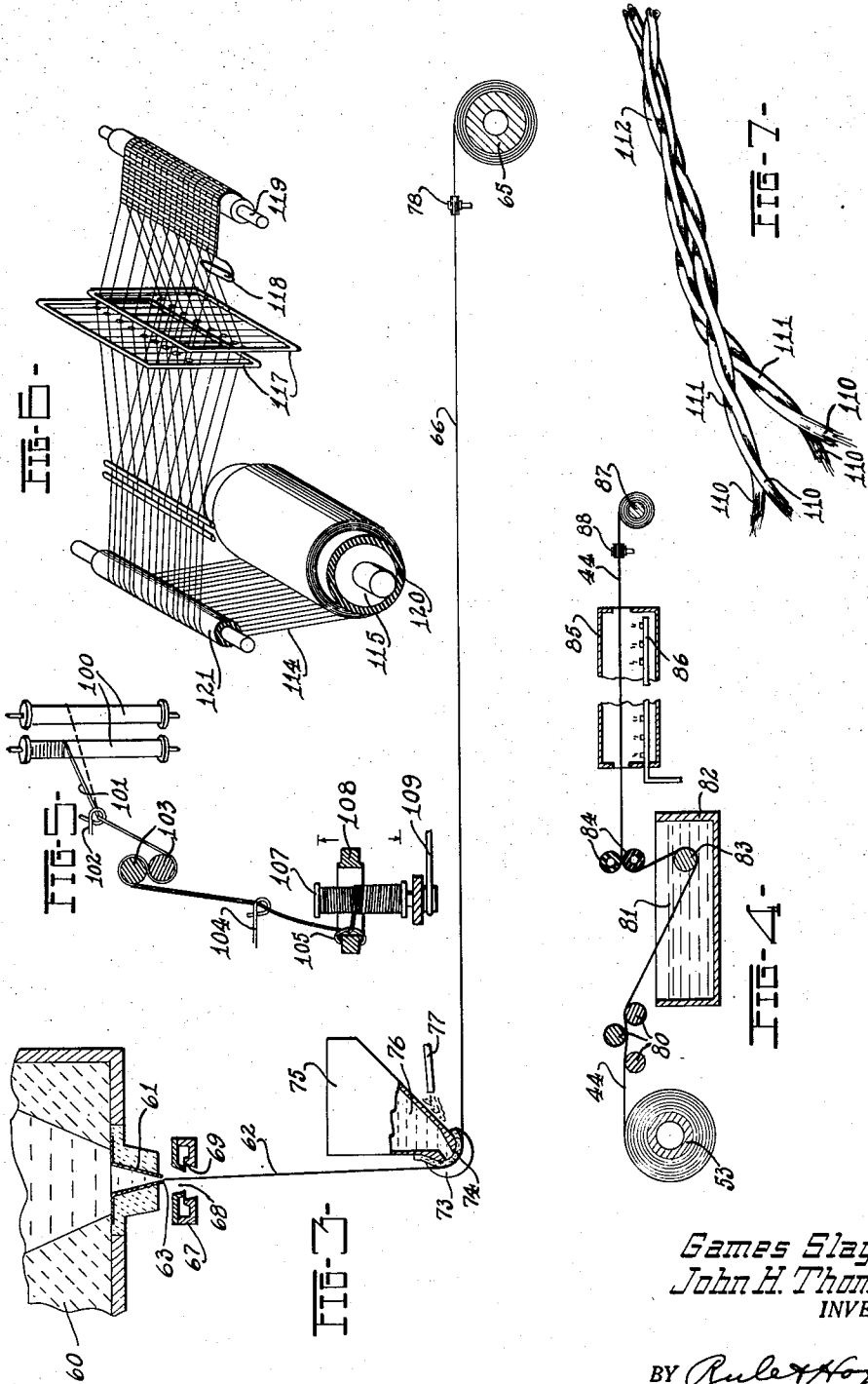
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,133,238

GLASS FABRIC

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Application June 22, 1937, Serial No. 149,672

7 Claims. (Cl. 117—52)

5 The present invention relates to glass textile
fabrics, and more particularly to improved
knitted, woven, and braided fabrics, or the like,
which are extremely strong, flexible, and may be
folded and flexed a great many times without ma-
terially injuring the same. Thus the present in-
vention relates to a textile material composed of
fine glass fibers having improved properties and
qualities, rendering them extremely useful in the
arts.

10 Heretofore it has been attempted to produce
interwoven fabrics using glass filaments, but these
fabrics were extremely limited in their usefulness
and in their properties. The fabrics heretofore
15 formed were relatively stiff and resisted flexure.
If the fabrics were folded or creased, they would
break apart at the fold, and if they were flexed
back and forth for a relatively small number of
times, they would break apart. It has even been
20 attempted to produce a garment using a fabric
composed of glass filaments, but in order to piece
the material together, it was necessary to secure
it to a backing cloth of organic fibrous material.

25 Another serious disadvantage of the prior fab-
rics composed of glass fibers, was that they were
brash and irritated the skin to an unbearable
degree. We aim to overcome these objections
and to largely, if not entirely eliminate brash-
ness and irritation from our fabrics.

30 Another defect of the prior art, was the fact
that the textile materials composed of glass fibers
heretofore in use could not be processed through
the ordinary and conventional textile machines
such as winding and spinning machines and
35 through the conventional loom. In order to fab-
ricate glass fabrics in a practical commercial
manner, it is necessary to process them through
a conventional machine loom, and the present
invention provides a glass textile which may be
40 processed through the conventional textile ma-
chine operations, to produce a fine, high quality
piece of merchandise.

45 One of the serious objections heretofore found
in attempting to weave yarns composed of glass
fibers in a conventional loom, was the difficulty
caused by the relative non-elongation of glass
fibers or their lack of elasticity.

50 It is an object of the invention to provide a
textile material which may be wholly composed of
glass fibers; such material to have strength, flex-
ibility, foldability, and substantial freedom from
brashness or irritation so that it will find com-
mercial uses in many of the arts. In thus fabri-
cating the textile materials, we also aim to pro-
55 duce yarns, threads, ply yarns, intertwisted yarns,

and cables composed, if desired, wholly of glass
fibers, these yarns and threads being of sufficient
strength, elasticity, and yieldability that they
may be processed through the ordinary and
conventional textile machine into interwoven, 5
knitted, braided or other types of textile fabrics
as desired.

An important phase of the present invention is
the provision of fibers having a fineness below a
critical diameter which we have found to be in 10
the neighborhood of about .0004 inch in diameter,
and preferably below about .0002 inch in diameter.
If the fibers are above this critical diameter, the
fibers are too brittle and coarse to permit them
to be intertwisted into yarns, without resorting 15
to special and highly expensive means such as
a high degree of sizing, and special machinery
which would seriously limit the commercial and
practical value of the yarns. Even when such ex-
pedients are resorted to, the fibers cannot be 20
intertwisted to a sufficiently high degree to render
them thoroughly practical in the art. The fibers
break and project out of the yarn and the re-
sulting fabric in a bristly manner so that handling
thereof causes a serious irritation to the skin. 25

We have also found that the fiber diameter is
extremely important from another point of view,
that is, the increased flexibility produced by using
a very fine fiber diameter. Fabrics, properly
made up, may be extremely flexible, even limp 30
and soft, if the diameter of the individual fibers
is below the critical range.

The fiber diameter is important from another
point of view, and that is brashiness. Fibers
which are above the diameter of about .0002 inch 35
generally feel coarse and brash and the fabrics
thereof are irritating to the skin. However, when
the fiber diameter is reduced below this figure,
all brashness is eliminated and the fabrics are
smooth and have a soft feeling to the skin. 40

Another important feature of the invention
which is tied in with fiber diameter, is the ratio
of fiber diameter to yarn diameter. This ratio
of yarn diameter to fiber diameter has a definite
bearing upon the degree of bending to which the 45
individual fibers will be subjected when the fabric
is folded or creased. This ratio should be at
least as high as about 10 to 1, depending upon
the fiber diameter itself.

The radius of curvature to which each fiber is 50
subjected when the fabric is folded is the radius
of curvature of the yarns themselves, since the
yarns are folded over each other, or, at least, the
yarns extending in the transverse direction. Thus
the thinner the yarns, the smaller will be the 55

radius of curvature and the more likelihood of fracturing the yarns when the fabrics are folded.

The number of fibers, therefore, composing each yarn also has a bearing on the above ratio.

5 That is to say, if a large number of fibers go to make up the individual yarns, there will be less likelihood of fracture due to creasing or folding the fabrics, and conversely, the smaller the number of fibers in the yarns, the greater will be the

10 tendency of fracture owing to bending or creasing of the fabrics.

Thus, in order to produce a usable, thin, flexible cloth, it is necessary to build up the individual yarns with a multiplicity of individual fibers

15 having diameters below the diameter indicated. The number of fibers in each yarn which is to be woven or interlaced with other yarns into a textile fabric should have at least about 70 and preferably more than about 100 fibers. Of course,

20 when plying the yarns, it is the total number of fibers in the final yarn which is important.

In fabricating these yarns composed of a multiplicity of glass fibers, we may use an adhesive or lubricant or sizing which increases the mass

25 integrity of the group of fibers, and inhibits mutual scratching of the fibers and facilitates the handling, winding and unwinding of the yarn upon spools, and various other steps of the process. The sizing or coating material may be of

30 any suitable type such as wax, oil varnish, shellac, cellulose products or derivatives, resins, plastics, gelatins, agar agar, starch, casein, paraffin, rubber, latex, acetate, aryl phosphate, tricresyl phosphate, halogenated hydrocarbons of both the aliphatic or aromatic types, or the like.

If desired, the sizing or coating material may be removed after the fabrication, and other types of coating materials may be substituted in their place if desired. These latter are generally such

40 substances as lubricants, as for example, light oil or the like. The glass fibers may also be dyed with any suitable substances to provide the proper color hues, shades or designs.

The present application is a continuation in

45 part of our co-pending applications, Serial Number 704,028, filed December 26, 1933; Serial Number 82,293, filed May 28, 1936; and Serial Number 105,405, filed October 13, 1936, these applications illustrating and describing more fully the

50 methods and apparatus which we may use in order to produce the fine fibers called for in the present application.

Other objects and advantages of the present invention will become apparent from the following

55 description taken in conjunction with the drawings, in which:

Fig. 1 is an elevational diagrammatic view shown partly in section of an apparatus adapted to produce fine glass fibers by means of a gaseous

60 blast, and form them into a sliver or yarn;

Fig. 2 is a fragmentary plan view of a portion of the device illustrated in Fig. 1 showing the fiber collecting means used for forming the sliver;

Fig. 3 is a diagrammatic elevational view illustrating another apparatus which may be used for

65 producing long, fine fibers, particularly of the continuous fiber type, and forming them into a thread or yarn;

Fig. 4 is a diagrammatic elevational view of an apparatus which may be used to coat the yarn

70 with a suitable sizing or coating material;

Fig. 5 is a diagrammatic elevational view of a winding or spinning device adapted to twist the strands or slivers into twisted yarns or cables;

75 Fig. 6 is a diagrammatic perspective view of a

loom adapted to interweave the glass fibers into woven fabrics;

Fig. 7 is a more or less diagrammatic perspective view of a cable yarn composed of yarns twisted in one direction, and which have themselves been intertwisted together in the opposite

5 direction to produce a balanced cable yarn;

Fig. 8 is a diagrammatic view of a braided tubular fabric composed of braided glass yarns; and

Fig. 9 is a diagrammatic plan view of a knitted

10 fabric composed of glass yarns.

The formula heretofore generally used in mechanics for deflection on central loading of a beam is:

$$\text{deflection} = \frac{Pl^3}{48EI} \quad 15$$

where P is the load, l the length of span, E the modulus of elasticity and I the inertia, which for a rod section is $0.05d^4$ where d is the rod diameter. As this equation is applied to a glass

20 fiber by bending it into a loop and pulling the loop down to the point just before which it will break, the deflection is equal to $1/''$. Substituting now in the above equation and combining constants, we have

$$l^2 = \frac{c'd^4}{P} \quad 25$$

which means that the circumference of the loop at breaking is proportional to the square of the fiber diameter. That means that the loop that can be made from a fiber 1 unit in diameter will be $1/4$ as large as the loop that can be made from a fiber 2 units in diameter. These values, however, do not tell the complete story for the size of the loop is also a function of the tensile strength which increases markedly as the fiber becomes smaller so as to permit a still smaller loop to be drawn. It also happens that E increases slowly as the fiber is drawn smaller, thus making a further correction in the proper direction. Thus, we have found that the size of the loop that may be drawn, decreases with a decrease in the square of the fiber diameter, as a quadratic function of the diameter because of the increased tensile strength, and as some other less important function of the modulus of elasticity.

Another significant observation is that the open area of the loop decreases in turn as the square of the diameter of the loop. Since the area of the loop determines the yarn diameter over which the fibers of the transverse yarns are bent, the area of this loop is extremely important in determining creasability of fabrics and

50 knotability of yarns.

We have also noted a marked acceleration in the tensile strength increase as the fibers are drawn below .0004 and particularly at or below .0002 inch. An equation which we submit for the relation between tensile strength and diameter is:

$$T_s = 20 + \frac{550}{(d+.2)} + \frac{600}{(d+.2)^2} \quad 60$$

where T_s is the tensile strength in thousands of pounds per square inch and d is the diameter expressed in units of ten-thousandths inch.

The presence of this last term has not been known or appreciated heretofore.

The significance of the above equation may be stated in words as, the tensile strength of glass fibers is equal to the bulk strength of glass where flaws are numerous, plus the increase in strength due to the reduction of flaws at the surface of the glass fiber, plus the increase in strength due to the decrease of flaws in the body of the glass.

75

We also believe that the surface tension in the fibers at this extremely low diameter has an effect of maintaining the surface more perfect and more resistant to stresses.

As a result of the above considerations, we have discovered a critical value in fiber diameters for producing successful weavable yarns. Moreover, when the fiber diameter is maintained below .0004 inch and preferably not more than about .0002 inch, the fibers may readily be twisted, flexed, and compounded into yarns comprising a multiplicity of fibers which are free from brassiness or skin irritation. Moreover, the fiber diameter should be maintained below the critical range if it is desired to produce yarns having a sufficient number of individual fibers therein, that is, at least about 70 or preferably more than 100, and yet produce a yarn which is not bulky but which is notably thin, flexible, pliable, and workable. The fabric is also relatively thin in spite of the large number of fibers composing the yarns.

Referring now more particularly to Figs. 1 and 2, a conventional glass furnace 20 has been illustrated, having an electrically heated bushing 22, preferably composed of a platinum alloy or platinum metal, forming an outlet feeder having a plurality of individual orifices 23 arranged at the lower end thereof for the emission of a plurality of glass streams. If it is desired, and it has been found practical to do so, the glass may be melted from cullet or batch material directly in the electrically heated bushing 22, thus dispensing with the furnace 20.

Spaced beneath the outlet orifices 23 is a blower 25 which is formed in two parts, separated by a slot 26 through which the glass streams flow and are attenuated by gaseous blasts emanating from a series of jets 27.

Below this blower a convenient distance is an endless foraminous surface 3 which may be in the form of a screen, mounted upon the rotating drum 31, supported by spokes 32 and rotating upon the shaft 33. As the glass streams emerge from the bushing 22, they are attenuated into long, fine fibers 35 having the desired characteristics, and then are conveyed by the gaseous blast upon the foraminous surface 30 where they are arrested and collected into the form of a web 36. Baffles 37 may be adjustably placed on each side of the region of the surface 30 upon which the fibers collect, these baffles 37 serving to conduct all of the fibers 35 to the proper region upon the surface 30 where they may be compactly collected into the form of the web 36.

Underneath the surface 30 is a suction box 40, which communicates with a suitable suction blower or other suitable exhausting means 41, the suction box serving to withdraw the vehicular blast and facilitating the retention of the web 36 upon the surface 30 as it is being collected and drawn off into the form of a sliver or yarn 44.

The drum 31 is driven by any suitable means such as a motor 45 which is mechanically connected to the drum 31 through the pulleys 46, the adjustable speed change box 47, and the belt 48.

After the fibers have been collected in the form of the web 36, they are drawn off in the general direction of travel of the screen or surface 30, although at a higher speed than the peripheral speed of the surface 30; and then drawn through a compacting device or trumpet 49; then through suitable folding devices such as the diablo-shaped rolls 50, which serve to compact the web and to fold in the loose edges and loose fibers which

may otherwise project outwardly from the sliver 44; then through the guide 51; through the traverse 52 and then over the spool 53 into the form of a package 54. The spool 53 is mounted upon a suitable drum or shaft 55 which is driven by the motor 56. The mechanical drive connection between the motor 56 and the shaft 55 includes the belt 57, the speed change gear box 58, and the belt 59.

The relative speeds of the spool 53 and the surface speed of the drum 31 are preferably maintained at a sufficient value, generally in a range of about two to four, so that the sliver 44 may be drafted from the web 36 into a fine sliver in which the individual fibers lie predominantly in a longitudinal direction parallel to the sliver, although incompletely parallel and being mutually intermatted with one another to form a coherent strong sliver which may be processed as desired, as, for example, by twisting, winding, spinning, weaving, or the like. These yarns or slivers may also be drafted into fine attenuated threads which may then be compounded into ply yarns, balanced yarns, and fine textile fabrics.

Referring now more particularly to Fig. 3, we have diagrammatically illustrated an apparatus capable of producing a yarn or thread composed of a multiplicity of continuous glass filaments. The glass may be melted in a suitable glass furnace 60 having a suitable bushing 61 at the lower end thereof to feed a multiplicity of glass streams through a series of outlet orifices 63. The glass streams are mechanically attenuated by means of a rotating spool 65 over which the thread 66 formed by the grouping of the individual fibers together, is wound.

Spaced beneath the bushing 61 is a suitable blower 67, which also may be formed in two parts having a slot 68 therebetween through which the individual fibers 62 are drawn. The blower 67 serves to direct a blast of cooling gas such as air, or the like, through the jets 69 onto the individual fibers, chilling them within a short distance of the outlet orifices 63. The blasts emanating from the jets 69 also serve to induce a draft of cool atmospheric air over the top of the blower and down through the slots, whereby it tends to cool the glass as it emerges from the outlet orifices.

The individual fibers 62 may be grouped by means of a suitable device such as that formed by a V-shaped slot 73 having a pad 74 in the groove thereof, over which the fibers may be drawn into the thread 66. Arranged in conjunction with the pad 74 is a lubricant reservoir 75 adapted to be filled with a suitable lubricant or sizing or coating material supply body 76. If the supply body 76 is composed of a thermoplastic substance, such as wax, asphalt, or the like, it may be heated by any suitable means such as the burner 77.

When using a thermoplastic substance or one which requires evaporation in order to harden it over the thread, it may be desirable to expose the thread 66 over a relatively long distance applying heat or drying air to the same before winding upon the spool 65. Assisting in the formation of a neat package which may be readily unwound from the spool 65, is a traverse 78. When winding the thread, however, at extremely high speed, such as 5 to 10 or even 20,000 feet per minute, the traverse may be dispensed with and the thread would directly upon the spool 65.

In producing fine long fibers by means of such an apparatus, we have found it important to

maintain the temperature of the molten glass within the bushing 61 in a relatively high range. Temperatures ranging from about 2100° F. to about 2500° F. have been found suitable, depending, of course, upon the particular type of glass which is being melted and the degree of attenuation which is desired. From this relatively high temperature, which is generally in the neighborhood of about 2200° F. to 2400° F., the glass as it is drawn out of the outlet orifices and is attenuated, attains a relatively high speed, at least about several hundred feet per minute, and preferably more than about 1000 feet per minute, and for most economical results, more than about 5000 feet per minute.

The cooling blasts from the jets 69 serve to chill the glass and permit it to be sufficiently viscous that it may be drawn down into an extremely fine fiber within an unusually small range below the orifices 63. The glass instead of producing a viscous fiber which is gradually attenuated into a finer fiber, draws down directly from the molten glass into a fine fiber form where it is suddenly chilled into that form while it is still within about an inch or so from the outlet orifice.

The degree of attenuation to which these fibers may be subjected is extremely high, and it is possible to produce fibers having diameters of about .0002 inch more or less without difficulty. The diameters of the orifices 63 are also relatively small, and may be about .030 to about .060 inch in diameter, more or less, as desired.

The fibers produced by the methods illustrated in Figs. 1 and 2 and by the apparatus illustrated in Fig. 3, are not only extremely fine, but are also extremely long, and have strengths ranging in the order of magnitude of about 300,000 pounds per square inch as an ordinary matter, and in certain instances, much higher and in the order of magnitude of about one million to three million pounds per square inch. These fibers are also extremely flexible and are substantially free from brash or skin irritation.

The threads formed by these methods of production, may be processed through any of the usual textile machines to produce twisted yarns, ply yarns, cables, balanced yarns, and fabrics of any desired type such as knitted, interwoven, or braided fabrics, as brought out more fully hereinafter.

If it is desired to weave the slivers 44 directly into yarns without twisting the same, it has been found preferable to coat the same with a suitable sizing, and for this purpose the apparatus illustrated in Fig. 4 may be used. The sliver 44 is drawn from the spool 53 over the guide rolls 80 and then into the bath 81 of the sizing material within a tank or reservoir 82. For this purpose we have found that gelatin or other sizes mentioned hereinabove are satisfactory.

A roll 83 may be submerged in the bath 81 around which the sliver 44 is drawn. In order to remove excess sizing or coating substance, coating rolls 84 may be arranged over the container 82, these rolls serving as a wringer. If desired, the thread or sliver 44 may then be dried in a suitable heating chamber 85 which may be provided with burners or other suitable heating means 86. From here the thread or sliver 44 may be again wound upon a spool 87, with the assistance of the traverse 88.

The yarns formed by the mechanism shown in Fig. 3 or Figs. 1 and 2, or the sized yarns or threads produced by the apparatus in Fig. 4,

may be twisted, either singly or in groups, to form twisted yarns. A conventional apparatus for this type of twisting has been shown in Fig. 5, in which one or more spools 100 may feed in the required number of threads 101 through an eye 102, around the rolls 103 forming a bite for the yarn, then through the eye 104, through the drag 105, and then around the rotating spool 107. The drag 105 is mounted upon a traversing means 108 which serves to distribute and wind the thread 101 uniformly over the spool 107, to form a neat package. The spool 107 is rotated by any suitable means such as the belt 109.

The degree of twist induced by this apparatus may be relatively high if desired, as, for example 6 to 12 or more turns per inch; the degree of twist, of course, being dependent upon the diameters of the fibers and the number of fibers composing the individual threads which are being twisted. We have found it possible to twist, on conventional twisting apparatus, strands composed of only a few fibers such as only 5 to 10 fibers or even less, these fibers having, however, diameters less than .0004 inch, and for best results, less than .0002 inch.

By intertwisting the fibers into a twisted yarn form, with a sufficiently high degree of twist, it is possible to overcome the inherent objection to glass fibers caused by their non-stretchability, or tendency not to elongate. Ordinarily the degree of stretch which any individual fiber may possess before breaking, is extremely small, and even for fine fibers, is seldom more than one or two, or at the most about 3 per cent. Owing to the inherent non-stretchability of the fibers, it has been found substantially impossible to weave them in a conventional loom. As such a warp of yarns composed of glass fibers is being fed into the warp of the loom, any stresses or vibrations caused by the loom cause the entire load to be borne by the tightest end; these loads being frequently sufficient to break an individual yarn or end, before the load can be distributed to the other ends in the warp. When the tightest end breaks, the load is transferred to the next tightest end which also does not have sufficient strength to carry the entire load, and it also breaks in turn before the load can be distributed among the several ends. However, we have discovered that by providing yarn having sufficiently fine fibers, which may be intertwisted a sufficiently high degree, the yarns themselves may possess a relatively high degree of elongation, in the order of magnitude of about 10 to 30 per cent before breakage. The degree of stretch, of course, in the twisted yarns is also dependent upon the sizes of the yarns compared to the fiber diameter; the smaller the yarns, the less being the elongation before breakage.

In this connection, it is to be noted that the yarns formed from the slivers produced by the apparatus shown in Figs. 1 and 2, have an especially high degree of elongation and stretchability, owing to their particular structure. The fibers of these yarns are intermatted and interlaced with one another and are not in substantially complete parallelism and alignment as are the continuous filament yarns formed by the apparatus shown in Fig. 3. Owing to their inherent intermatted nature, these yarns seem to possess a higher degree of yieldability, and when they are twisted into the form of a twisted yarn, the intermatted fibers of the yarn appear to yield and distribute the stresses and loads induced in the yarn throughout the yarn as a whole, thus

substantially increasing the total strength and resistance of the yarn.

The twisted yarns produced by the winding apparatus shown in Fig. 5, may be intertwisted with one another to form balanced yarns, an example of which is illustrated in Fig. 7.

In Fig. 7 two original yarns 110 are intertwisted to the right for a sufficient number of turns as, for example, 6 to 12 turns an inch to produce the twisted ply yarns 111, and then two of these twisted yarns 111 are intertwisted to the left for the required number of turns, generally slightly more than half of the original degree of twist to form a balanced cable yarn 112. Balanced yarns or cables of other various types may be formed, such as two, three, or four-ply or various other types of ply yarns or cables, or the like.

Referring now more particularly to Fig. 6, we have diagrammatically illustrated a loom which may be used to weave threads or yarns composed of glass fibers. In weaving glass cloths, it is possible to use any desired construction such as plain weave, twill, or manifold others, and in doing so, it is possible to produce cloths having any degree of hardness which is desired. In other words, we are not limited in weaving glass cloths having the individual yarns of the warp or filler spaced apart from one another in order to provide sufficient flexibility and pliability to the materials. On the contrary, it is possible to place the ends of the warp extremely close together, and to pack the filler yarns tightly into place. The resulting cloth will have excellent properties of flexibility, strength, foldability, and general resistance to wear.

In Fig. 6 we have shown the warp 114 wound upon the warping beam 115. From here the warp is trained over the whip roll 116 which is preferably arranged in such a position that the individual ends of the warp 114 make contact over a relatively wide arc on the surface of the whip roll and are turned through a relatively wide angle. We have found that this arrangement materially reduces the number of breaks in the ends by permitting the whip roll to relieve the individual yarns of unusual stresses and enables the individual yarns to be held at a constant tension.

The remaining portions of the loom may be of the conventional type, and thus, may comprise the heddles 117, operating to produce the shed into which a shuttle 118 travels, and cloth beam 119 over which the woven fabric is wound.

In weaving glass cloths, we have discovered that the difficulty caused by the non-elongation of the individual glass yarns may be overcome by providing resilient coverings 120, composed of rubber or other suitable yielding material over the warping beam 115. A resilient cover 121 may also be provided over the whip roll 116. By the use of this resilient material over the warping beam and the whip roll, and of the arrangement of the whip roll in relation to the warping beam whereby the warp is caused to turn through a substantial angle, it is possible to maintain an even tension on the individual yarns or ends between the heddles of the loom and the warping beam. Thus, as vibrations or pulsations are induced into the ends by the reciprocatory movements of the heddles, the whip roll 116 and the resilient cover therefor 121, yield and take up a large portion of these vibrations. Any unusual stresses in the individual ends may also be relieved by the resilient cover 120 on the warping beam 115.

We have discovered that when sufficient yarn is

wound upon the warping beam to weave an entire bolt of cloth, that is, when there are about eighty yards of yarn per end, the warp on the beam is of considerable diameter and consequently possesses a sufficient resilience and yieldability of its own which may be called upon to relieve any unusual stresses in the individual ends. However, when the beam has run through nearly the entire weaving operation, and there is little warp left upon the beam, the resilient cover 120 is adapted to relieve any unusual stresses in the individual ends. Thus, by means of this novel construction of loom, it is possible to weave an entire bolt of cloth several yards in width, if desired, with substantially no breaks throughout the entire weaving operation.

Various other types of textile fabrics may also be made from our novel yarn or threads, another example of which is illustrated in Fig. 8 showing a braided article 125. This braided article is in tubular form although, of course, any other type or construction of braid may be used. When in tubular form, it has particular application as a wire covering or other covering means. The braiding operations may be performed by any conventional textile machine now in use.

Another example of a textile fabric which we may make using our novel glass yarns, is illustrated in Fig. 9 showing a knitted fabric 126. The knitting may be done on any conventional machine, and may be made with any desired construction. We have found it possible to weave directly from glass yarns, various articles such as socks, gloves, sweaters or the like. The knitted articles may be knitted with a tight construction, if desired, and we have found that such fabrics possess an extremely high flexibility, resilience and stretchability; although when pulled out of shape, they will return to their normal position after the stresses are relieved.

Modifications and variations may be resorted to without departing from the spirit and scope of the present invention as defined in the appended claims.

We claim:

1. A textile yarn composed of at least forty fine glass fibers having average diameters not more than about .0004 inch, the fibers of said yarn being twisted in order to produce a yarn of substantial flexibility, mass integrity, strength and stretchability to permit knotting without rupturing said yarn.
2. A glass textile fabric comprising interlaced textile yarns as called for in claim 1.
3. A textile yarn composed of at least forty fine glass fibers having diameters not more than about .0003 inch, the fibers of said yarn being intertwisted in order to produce a yarn of substantial flexibility, mass integrity, strength and stretchability to permit said yarn to be folded over itself without rupturing said yarn.
4. A flexible, closely woven textile fabric capable of being folded and creased without fracture, which comprises interwoven yarns as claimed in claim 3.
5. A textile yarn composed of a multiplicity of fine glass fibers lying predominately parallel to the longitudinal direction of said yarn and being intermatted with one another in said yarn, the fibers of said yarn having diameters not more than about .0004 inch, and said yarn being twisted to produce a yarn of substantial mass integrity, flexibility and strength to permit knotting without rupturing said yarn.
6. A flexible, closely woven textile fabric cap-

able of being folded and creased without fracture, which comprises interwoven yarns each composed of a multiplicity of intertwisted fine glass fibers having diameters not more than about .0003 inch, and having a lubricant coating said fibers, the ratio of the yarn diameter to fiber diameter being not less than about 10 to 1.

7. A workable, weavable textile yarn composed of at least seventy fine glass fibers having diam-

eters not more than about .0002 inch, the fibers of said yarn being intertwisted to produce a yarn of substantial flexibility, mass integrity, strength and stretchability to permit said yarn to be folded over and wrapped around itself without rupturing said yarn.

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