

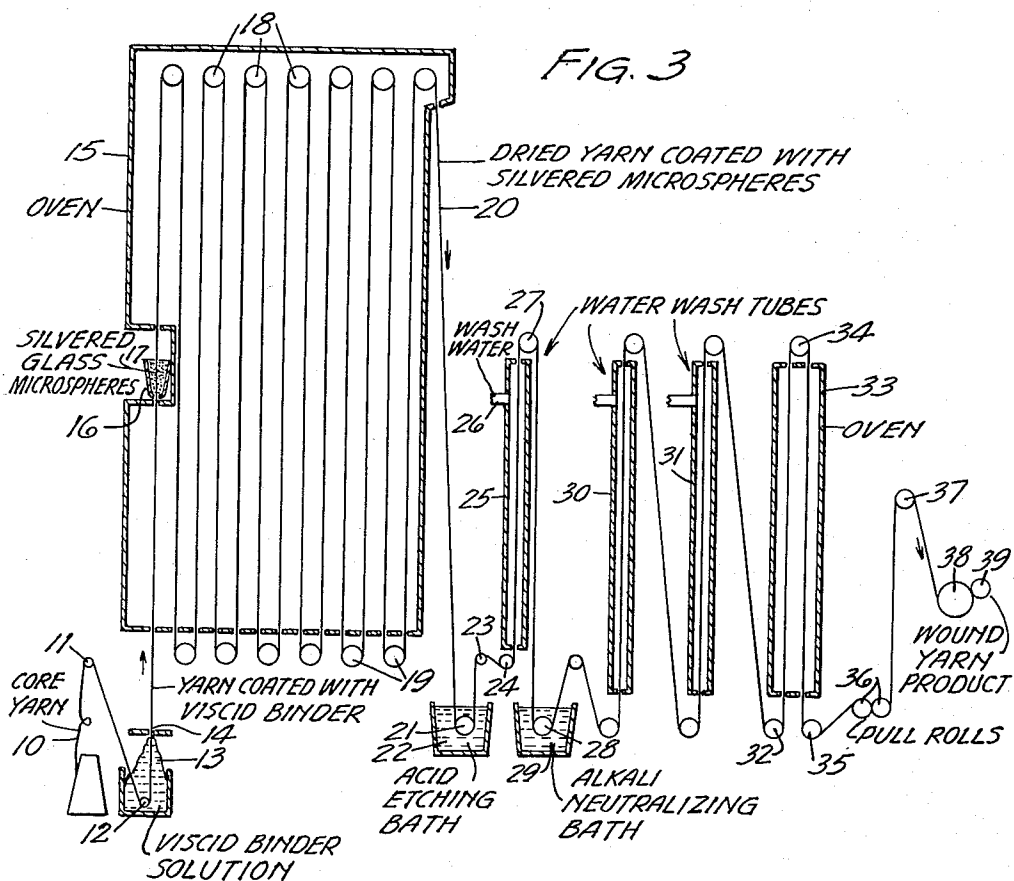
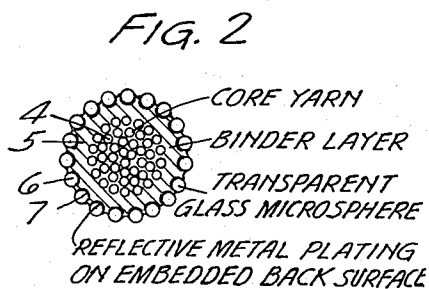
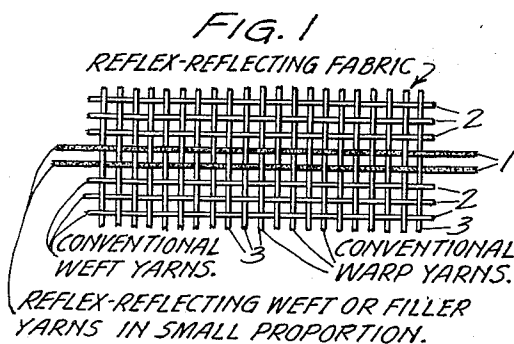
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REFLEX-REFLECTING TEXTILE YARNS AND FABRICS

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REFLEX-REFLECTING TEXTILE YARNS AND FABRICS

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This invention relates to the manufacture of reflex-reflecting textile yarns adapted to be included in woven or knitted fabrics in combination with conventional yarns to produce a composite fabric which retains desired properties but has imparted to it a highly effective reflex-reflecting characteristic. The invention embraces the novel yarns and process of manufacture, and novel fabrics in which the yarns are incorporated.

The present yarn is strong, pliant and durable, and lends itself to inclusion in the fabric during weaving or knitting as though it were a conventional yarn. It may also be incorporated in fabrics by sewing. We have discovered that this novel yarn has extraordinary reflex-reflecting properties and can be used even in very small proportion to obtain fabrics of unprecedented reflex-reflection utility. Its use permits of fabric designs having attractive appearances under all viewing conditions and its presence does not materially affect the hand and drape of the fabric.

These fabrics can be employed to advantage in outer wearing apparel, such as coats, jackets and dresses, and in accessories such as stoles, scarves and mittens, to provide the wearer with greater safety at night when crossing streets, when standing in or moving along a highway, and when getting out of or into the driver's side of an automobile. The fabric attracts attention because of the brilliant appearance and long-range visibility of the reflex-reflecting yarn elements exposed to view when illuminated by the headlight beam of an approaching vehicle, as seen by the driver and occupants of the vehicle. At dusk and at night and in foggy or rainy weather, when motor vehicles have their lights on, visibility to the vehicle driver is relatively poor and especially so as to pedestrians when they are not at close range in the main beam of light. The present fabric makes for a great improvement and attracts attention even when the wearer is illuminated only by weak light at the side or front fringe of the beam.

Children are particularly prone to injury by motor vehicles because of their propensity for carelessly running into traffic lanes and unexpectedly darting into or across streets. The driver of an approaching vehicle often has very little time for maneuvering and braking. If the child's wearing apparel includes reflex-reflecting yarns of the present invention, the chance of being struck by a vehicle is greatly diminished. The driver's visual reflexes respond more quickly and earlier because of the brilliant flashes of light which he sees, and which stimulate attention and make for visibility at a greater distance and when the child may still be off to one side. Attention stimulus and visibility are each important factors in promoting safety. Older children and adults are also benefitted by the opportunity for increased safety. And safety packets can be provided for dogs to reduce the hazard of injury whether walking on a leash or roaming at will.

The effectiveness of the present yarn is due to its extremely brilliant wide-angle reflex-reflecting character-

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istics which produces the desired result even though this yarn is physically a very minor component of the fabric structure. Its utility depends also upon its suitability as a durable component of fabrics, and its acceptability by designers of fabrics and garments and by the purchasing public. Otherwise it would not be adopted for substantial commercial use and would not have an opportunity to materially contribute to public safety. Experience shows that there is little sale for safety garments and accessories unless they are durable, attractive and not unduly expensive. Acceptability requires that the safety feature be sufficiently pronounced and striking to induce buyers to pay the premium in price necessitated by the added cost of manufacture.

The reflex-reflecting and physical characteristics of the present yarn are due to the fact that it is constructed of a flexible textile core yarn which is concentrically coated with a flexible and durable binder layer in which is bonded a concentric surface layer of half-embedded catadioptric reflex-reflecting elements consisting of transparent glass microspheres (minute glass beads) that are specularly reflectorized on the embedded hemispherical surface by a metal plating. The exposed portions of the microspheres are penetrable by impinging light rays. The transparent microspheres serve as sphere-lenses and refract the impinging light rays both before and after reflection from the metallic back surfaces thereof, in such a way that a brilliant cone of light is reflected back toward the source of light. This is true despite the fact that the yarn has a small-radius cylindrical structure and may be positioned at a substantial angle away from perpendicularity to the impinging light rays, so that the impinging light rays are at substantial angles to the optical axes of most of the sphere-lenses. It is this ability to efficiently return light toward the source of angularly incident light rays that is designated by the term "wide-angle reflex-reflection," in contradistinction to reflective surfaces which have either specular or diffusive reflection properties, and also in contradistinction to types of reflex-reflecting surfaces that do not provide brilliant reflection of rays incident at substantial angles relative to the optical axes of the reflective elements.

The reflective surfaces of the yarn provides a vast number of reflex-reflecting spots per inch or centimeter of length. The human eye cannot distinguish between the light rays emanating from adjacent individual spots, and so the yarn appears to the viewer as having a uniform continuous surface.

The glass microspheres are so minute that the yarn has a relatively smooth surface, adequate flexibility and pliancy, and is not unduly enlarged in size. The high ratios of surface area to volume and to weight permit the microspheres to be strongly bonded and to resist dislodgement under the innumerable repeated flexings to which the yarn is subjected during manufacture of the yarn and fabric and the normal wearing life of the garment or accessory in which incorporated. A bond is provided at the interface between the metal coating on the rigid microsphere and the flexible binder coating on the yarn, and it has been discovered that an adequately durable bonding is possible between such materials. It has been further discovered that a strong metal-plating bond can be effected with the small-radius glass surface of the microspheres. Both of these bonds are important to maintenance of the unity of the product.

The invention is illustrated in the accompanying diagrammatic drawings wherein:

Fig. 1 shows a diagram of a small area of a woven reflex-reflecting fabric which includes a small proportion of yarns of the present type, as illustrated by the pair of reflex-reflecting weft or filler yarns 1 used in

combination with the conventional weft yarns 2 and conventional warp yarns 3.

Fig. 2 shows the reflex-reflecting yarn 1 in greatly magnified schematic cross-section. It is comprised of a conventional core yarn 4 which is concentrically coated with a flexible binder layer 5 in which a layer of reflex-reflecting reflectorized transparent glass microspheres 6 are approximately half-embedded, these microspheres having a specularly reflective metal plating 7 on the back or inner surface which is embedded in the binder layer, the exposed glass surface being free of metal and being optically exposed to incident light rays. Thus the metal-plated microspheres are intrinsically reflex-reflecting catadioptric elements. The core yarn may consist of continuous filaments in either twisted or untwisted relation. The binder layer impregnates the interstices of the surface portion of the yarn and thereby obtains a mechanical anchorage to the yarn and locks the surface fibers or filaments in place.

Fig. 3 is a flow-sheet schematically illustrating the manufacturing apparatus and procedure hereinafter described in the "Example."

The optimum size of the transparent glass microspheres for present usage is in the range of approximately 10 to 75 microns. A micron is a thousandth of a millimeter. (There are 25 microns in a mil, which is a thousandth of an inch, so this range is approximately 0.4 to 3 mils.) These microspheres are so minute that a dry mass thereof flows like a liquid and has a smooth unctuous feed when rubbed between the fingers; the microspheres appearing to the eye to be of flour-like fineness.

The glass must have a refractive index of about 1.9 in order to produce high-brilliance wide-angle reflex-reflection. Ordinary glass beads have a refractive index of about 1.5 and cannot be used for present purposes.

The reflex-reflected light as seen by the occupants of a motor vehicle whose headlight beam provides illumination, is whitish-silvery in color when silvery clear (colorless) glass microspheres are used, that have been silver-plated or aluminized. Such yarn has a light grey appearance when viewed by diffused light, as in normal daylight viewing, but this is not objectionable inasmuch as the present yarn can be incorporated in fabric designs which either render it inconspicuous or which employ its light grey color as a distinctive but attractive element of the overall design. Desirable color effects both by day and night can be obtained by employing microspheres that are colored so as to act as color filters, as by using microspheres made from transparent colored glass or provided with a transparent concentric colored coating. Non-silvery reflection is also obtained when a non-silvery reflective metal coating is employed on the microspheres, such as a coating of gold or copper. The binder coating may include coloring material to alter its effect on the appearance of the yarn.

The effectiveness of the present yarn in achieving the previously mentioned objectives and features is due to its extreme degree of brilliancy under reflex-reflecting viewing conditions. It has the combination of properties which enables it to surmount the barriers to commercial acceptance that have been indicated. A reflex-reflecting yarn that would be almost good enough would not achieve the desired success. Thus it has been found that from the standpoint of success in filling the needed requirements, the present yarn may properly be regarded as critically differing (in kind rather than in mere degree) from a seemingly similar type of yarn which differs structurally only in that the glass microspheres are bonded in a reflective binder pigmented with finely divided aluminum flakes, instead of having a specular silver or aluminum plating on the back surface. Such yarn does exhibit considerable reflex-reflection brilliancy but the present yarn is 4 to 6 times brighter and this difference has been found to be of critical importance.

On the other hand, in the case of structures employed

to provide reflex-reflecting areas of substantial width as in the case of flat surfaces coated with glass beads to form the lettering, symbols or backgrounds of signs and markers, the use of glass beads embedded in an aluminum-pigmented reflective binder layer supplies an ample degree of reflex-reflection brilliancy. The use in such structures of beads of 1.9 refractive index which are silvered on the back surface, in lieu of using a reflective binder layer, has been regarded as unsatisfactory because of the poor daytime appearance (a drab gray) which is not offset by any marked advantage of nighttime performance. And so far as we are aware the latter type of reflex-reflecting area structure has not been employed in commercial practice in manufacturing signs and markers, although the theoretical possibility as an alternative was briefly mentioned in U.S. Patent No. 2,326,634 (August 10, 1943).

It will have been noted that the present invention provides an entirely different approach to the fabrication of reflex-reflecting garments than in the case of garments that have been reflectorized by use of fabric or film areas carrying a reflective binder layer film or coating in which glass beads are embedded to provide areas of substantial width that are uniformly reflex-reflecting. Cf., U.S. Patents Nos. 2,407,680 (September 19, 1946) and 2,567,233 (September 11, 1951). That approach may be characterized as based on the use of reflex-reflecting areas (having substantial width relative to length) to obtain adequate nighttime visibility, and such areas are a conspicuous and often undesirable feature of the daytime appearance. Furthermore, they often decrease the flexibility of the garment area so as to result in a poor drape or hand.

The present approach is based on the use of reflex-reflecting "lines" (the width of a yarn being very small compared to its length) which occupy only a minute portion of the total area of the fabric in which incorporated and yet impart an effective reflex-reflection quality to the whole of such area without interfering with a normal daytime fabric appearance, and without materially affecting the hand and drape of the fabric.

The success of the present approach depends upon optical illusion effects made possible by the extreme degree of reflex-reflection brilliancy of the yarn. In the first place, the yarn produces an intensity of reflected light when viewed under reflex-reflecting conditions that makes it seem to be incandescent and the eye sees a brilliant radiant glow that appears to have a width several times greater than the actual physical thickness of the yarn. This remarkable effect can be strikingly demonstrated by viewing an individual yarn in a dark or semi-darkened place at a distance of about 100 feet, holding a flashlight near the eye; the yarn seeming to be as brilliant as a neon lamp tube would be expected to be when of a size several times larger than the yarn. Under the same viewing conditions, a conventional white thread of the same size is invisible. An individual yarn of the present type is visible at distances as great as 500 feet, or even more, under nighttime highway viewing conditions. In the second place, a fabric containing the present yarn in the form of widely separated individual threads or pairs of threads (for instance, a woven cloth having a weft containing individual yarns spaced apart $\frac{3}{4}$ inch or pairs of yarns spaced apart $1\frac{1}{2}$ inches) will nevertheless appear at long range as though reflective all over, the eye not being able to distinguish the individual reflective yarns; the reflected light seeming to blend together, so that the fabric area is visible even at distances of 800 feet or more under nighttime highway viewing conditions.

The present yarn, employing silvered glass microspheres, is 300 to 1,000 times brighter than conventional white yarns under typical nighttime highway viewing conditions. A dramatic illustration of the magnitude of difference is provided by comparing a conventional white

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woven cloth with a woven black cloth embodying present yarns in the weft in the thread count proportion of 1:50, such that there is one reflective thread per inch. This "black" cloth has an over-all reflection value per unit of total area that is 2 or 3 times as great as that of the white cloth. The actual visibility and noticeability of such "black" cloth under reflex-reflecting nighttime high-way viewing conditions is, moreover, many times superior to that of the white cloth owing to the attention stimulus caused by the intensity of reflection from the individual reflex-reflecting yarns, as previously mentioned. Hence it has been found possible to successfully utilize the present yarn in dark-colored fabrics to be used in making clothing of high safety value. This is an important feature not only because dark-colored clothing is oftentimes in the height of fashion, but because outer garments such as coats and jackets are prone to dirtying and when made of dark fabrics they do not need to be cleaned as often. This is an especially important point in respect to children's garments. They have often been made light colored in an attempt at nighttime safety that is lacking when they are dark colored.

The fact that the present yarn can be employed in a small proportion in the fabric structure to produce the abovementioned results is crucial to economic feasibility owing to the relative high cost of this yarn in comparison with conventional textile yarns. As an example, when it is used in a square weave fabric (equal warp and weft thread counts) to provide one reflex-reflective weft thread and 99 conventional weft threads per inch, it constitutes 1/2% of the total fabric threads on a total yarn length basis. A typical yarn of the present type runs to about 8,000 yards per pound. Even if priced as high as \$30.00 per pound, the present yarn is economically feasible, adding about 15 cents per square yard to the cost of the fabric.

The present type of yarn can also be utilized in making desirable fabrics for uses in which safety is not a desideratum, such as drapery and upholstery fabrics, and fabrics for women's evening gowns and stoles, etc. These can be designed to produce novel and attractive appearance effects due to the unexpected glittering appearances of the yarn elements as seen by viewers at times when they chance to be in appropriate positions relative to the fabric and to sources of light to permit of reflex-reflection viewing.

The present yarn is not limited to usage in woven and knitted fabrics or to incorporation by sewing. It can be included in nonwoven textile fabrics such as felted fabrics and those made of carded and calendered fiber webs wherein the fibers are bonded together at crossing points by fusion or by an adhesive agent. In such fabrics the present yarn can be incorporated in continuous length bonded into the fiber web at an intermediate stage of manufacture, or it can be chopped into short lengths (say 1/2 to 2 inches long) which are mixed with the conventional fibers, constituting a small proportion of the total fiber content.

The present yarns can be manufactured in continuous fashion by passing a textile yarn through a solution of a vulcanizable rubbery bead binder material and then through an orifice to control the thickness of the concentric binder coating, applying fully metal-plated glass microspheres to the binder layer coating while still soft and tacky so as to half-embed a concentric surface layer thereof, drying the yarn and then passing through an etching bath to dissolve off the exposed metal from the front surfaces of the microspheres, followed by washing and drying. Heating or baking to cure the binder can be conducted at any suitable stage after the embedding of the microspheres, and the binder layer can be partly cured before the etching step and completely cured thereafter. A transparent sizing coating can be applied if desired but it should be thin enough to provide a corresponding spherulate or lenticular contour exposed to the atmos-

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phere so as not to materially interfere with the desired optical function of the beads.

The binder coating material is preferably chosen to provide a binder layer for the finished yarn that strongly bonds to the metal coating on the back surface of the glass beads, that is flexible and resilient, that is heat-resistant and non-thermoplastic, that is waterproof, and that is resistant to common dry-cleaning solvents. Flexibility and resiliency can be obtained by employing a vulcanizable rubbery polymer as the binder, with inclusion of a compatible reactive curing agent to permit of curing to a firmer and more heat-resistant and insoluble state without loss of adequate flexibility and resiliency. Such curing agent serves as a "vulcanizing agent" in the broad sense of the term and need not be a sulfur-type agent but may, for instance, be one of the heat-advancing reactive phenol-aldehyde resins which are well-known as agents for curing rubber polymers to improve heat-resistance, increase firmness and toughness, and to decrease solubility. The binder should be resistant to the etching bath employed for dissolving off the exposed metal. A preferred type of rubbery polymer is provided by the copolymers of butadiene and acrylonitrile ("Buna N" rubber). A preferred tube of curing ("vulcanizing") agent is provided by the known class of heat-advancing ketone-soluble benzene-insoluble phenol-aldehyde resins. This binder is resistant to acidic oxidizing solutions that may be employed in removing the exposed metal from silver-plated microspheres. Curing also serves to greatly increase the bond strength between the binder coating and the metal-plating on the glass surface of the microspheres.

The core yarn may be either a continuous-fiber yarn (made from a twisted or untwisted bundle of fibers in the form of continuous filaments) or a yarn spun from staple fibers. The presently preferred yarns are continuous-filament "polyester" yarns, by which is meant, as is well-known in the textile industry, yarns composed of filaments formed from a high molecular weight linear polyester of a dihydric alcohol (such as ethylene glycol) and a dicarboxylic aromatic acid (such as terephthalic acid), such as "Dacron" yarns. However, use can be made of cellulosic yarns (such as rayon), wool yarns, and "Orlon" (polyacrylonitrile) yarns, for example.

Example

This example describes in some detail the manufacture of the presently preferred type of reflex-reflecting yarn, employing the apparatus and procedure illustrated in Fig. 3, but the invention is not limited thereto and embraces equivalent constructions.

Referring to Fig. 3, a core yarn 10 is continuously withdrawn from a supply cone and is pulled through the tensioning guide 11, the yarn thereafter being drawn through the entire apparatus under tension provided by the terminal wind-up device. The yarn passes down around a grooved positioning bar 12 located within a pot of viscid binder solution 13 and is drawn vertically upwards to and through a plate having a circular orifice 14, which serves to remove excess binder and to provide a concentric binder coating of desired solids weight per unit length which, upon subsequent drying, will result in a binder coating of desired thickness. The coated yarn advances upwardly to and through a lower side section of oven 15 which serves to remove part of the solvent and thereby somewhat solidify the binder coating and render it more tacky, although still viscid or plastic. The yarn emerges from this section of the oven and is drawn upwardly through the bottom inlet opening of a funnel-like hopper 16 which contains a dry fluid-like mass of minute silvered glass microspheres 17. A vibrator (not shown) causes vibration of the hopper and thereby vibrates the mass of microspheres such as to result in a concentric packed mono-layer of silvered glass microspheres becoming picked up and partially embedded in the binder coating, the excess being driven off. The coated yarn ad-

vances upwardly into and through an upper side section of the oven, and thereafter travels through the oven in alternating downward and upward passes directed by series of upper guide pulleys 18 and lower guide pulleys 19. The oven heat is adjusted so that the binder coating will be dry enough when the yarn reaches the first pulley such that picking (transfer of coatings to pulley) will not occur during the first turn around. The capillary action of the tacky plastic binder coating and the pressing action of the pulleys results in the silvered microspheres becoming embedded approximately half-way in the binder coating by the time it has become substantially dry in passing through the oven, the temperature and rate of travel being appropriately adjusted. In the final stage of oven travel the solvent is fully eliminated to fully dry the binder coating and a partial curing occurs.

The dried yarn 20 leaves the oven and is drawn downwardly to and around a pulley 21 located in an acid etching bath 22 which dissolves off the exposed silver from the glass microspheres, thereby exposing the outer or front glass surface of each microsphere while permitting the silver coating on the embedded or back portion to be retained. This results in a yarn product having the structure shown in Fig. 2.

The yarn then passes upwardly from the etching bath and around guide pulleys 23 and 24 and thence enters an inlet in the bottom end of the vertical wash tube 25 wherein it passes countercurrently to a descending stream of wash water introduced through port 26 in the upper part of the tube. The water escapes through the opening in the bottom of the tube and is collected by a drain (not shown). The washed yarn passes down around pulley 27 to and around pulley 28 located in alkali neutralizing bath 29, which serves to neutralize the residual acidic water clinging to the yarn and to dissolve any salts present from the etching operation. The yarn then passes through successive water wash tubes 30 and 31 in the manner previously described in connection with wash tube 25 (and which need not be repeated). The fully washed yarn passes down to and around pulley 32, up through tubular drying oven 33, around pulley 34, back down through the oven to and around pulley 35 located below the oven. The oven temperature is adjusted to dry the wet yarn to a moisture content of less than 2%. A series of such ovens, rather than a single oven, can be employed to provide the necessary drying time.

The dry yarn advances through pull rolls 36 which draw the yarn under tension through the entire preceding apparatus previously described. The yarn passes over guide pulley 37 and then around a driving and guiding drum 38 and is wound up on a cylindrical core 39 which is in rotatable contact with the drum. The yarn is wound in an open diamond pattern to form a "cheese."

The cheeses of yarn as thus produced are baked in an oven (not shown) in order to fully cure the binder coating, and are subsequently rewound to provide cones or packages of desired length ready for sale.

Details involved in making a preferred product by this procedure are as follows:

The core yarn is an untwisted bright "Dacron" (polyester) yarn of 100 denier weight composed of 34 continuous filaments of high-tenacity.

The binder coating solution has the following composition:

	Parts by weight
Buna N rubber (e.g., "Hycar 1001 or OR-15" having a Mooney value of 85-115 and a butadiene-acrylonitrile ratio of about 2:1)-----	100.0
Phenol-aldehyde curing resin (heat-advancing ketone-soluble benzene-insoluble phenol-aldehyde resin, e.g., "Durez 175")-----	66.6
Diocetyl phthalate (ester plasticizer)-----	20.0
Methylisobutyl ketone (volatile solvent)-----	505.0

This solution has a solids content (non-volatiles) of

about 27% by weight and is of a coatable viscosity. The viscosity can be adjusted as desired by varying the proportion of solvent. The ingredients are thoroughly blended by mixing in a heavy duty internal mixer (such as a "Mogul" mixer). A rubber anti-oxidant is preferably included as is well understood by those familiar with rubbery adhesive formulations. Such anti-oxidant is included in the "Hycar" rubber of the above formula, as received from the producer.

The glass microspheres have a refractive index of 1.9 and vary in diameter in the range of 20 to 45 microns. It is not necessary to employ microspheres of uniform diameter. These are silver-plated by the following procedure:

(1) Prepare an alkaline solution by dissolving 1.5 lbs. of potassium hydroxide in 20.5 lbs. of deionized water. Store in a cool place until ready for use.

(2) Prepare a silver nitrate solution in a 55 gallon stainless steel drum by dissolving 3.0 lbs. of silver nitrate in 300.0 lbs. of deionized water.

(3) While agitating the silver nitrate solution, slowly add 30.0 lbs. of the glass microspheres. Then add, one pound at a time, a total of 6.0 lbs. of 28% ammonium hydroxide solution.

(4) To the cool potassium hydroxide solution stir in 2.5 lbs. of dextrose and continue stirring until the solution is clear. Rapidly pour this solution into the mixture containing the glass microspheres and continue agitation for 30 minutes to complete the reaction whereby the microspheres are silver plated.

(5) Recover the silver-plated microspheres by filtration (preferably using a stainless steel filter, such as "Nutsche" type). Wash four times with 40 lb. portions of deionized water and flush as dry as possible. Dry with hot air. Store in polyethylene lined containers. This procedure results in an opaque silver plating having a thickness of the order of 0.05 micron.

The acid etching bath employed for desilvering the exposed portions of the microspheres of the yarn is a solution of 100 parts of water, 9 parts of 98% sulfuric acid, and 2.33 parts of potassium dichromate (oxidizing agent), by weight. This bath is maintained at an operating temperature of 160 to 180° F.

The alkali neutralizing bath is a 1.5% ammonium hydroxide solution and is employed at room temperature.

These baths are replenished during use in the manufacturing process so as to maintain a substantially uniform composition.

The binder solution 13 is applied to the yarn so as to provide an ultimate dry coating weight of binder solids amounting to about 0.02 lb. per thousand lineal yards; the coating weight being controlled by the coating orifice 14. In passing through the oven to the hopper 16 where the silvered glass microspheres are applied, the coated yarn is subjected to an air temperature of about 160° F., which serves to partially dry the coating and to increase its tackiness, the yarn moving at a rate such it takes about four seconds to move through this heating stage. In the final stage of passage through the oven, the yarn is subjected to a temperature of about 380° F. which suffices to complete the removal of solvent, and to partially cure the binder so that it will better resist the action of the acid etching bath and subsequent washings. The final curing of the yarn product is effected by subjecting the yarn "cheeses" to an oven temperature of 190° F. for 48 hours.

The reflex-reflecting yarn product as thus manufactured has a weight of one pound per 8,000 yards. The overall average caliper diameter is about 12 mils, when measured so as to avoid flattening. The yarn is readily deformable or yieldable in a crosswise direction and may acquire a width of 25 mils or more when flattened out; the resiliency of the rubbery binder, however, causing the yarn to gradually spring back when restraint is removed, unless it has been permanently deformed as when a

fabric thereof has been subjected to heat and pressure in order to flatten the reflective yarns and thereby increase the effective reflective area.

We claim:

1. A process of making reflex-reflecting textile yarns of the character described, comprising continuously coating a textile core yarn with a solution of a vulcanizable rubbery binder material to provide a concentric binder layer that is resistant to the subsequently used etching bath, half-embedding in the binder layer while still soft a concentric surface layer of transparent glass microspheres of about 1.9 refractive index that are fully metal plated, drying the yarn, passing the yarn through an etching bath to dissolve off the exposed metal, and washing and drying the yarn; the binder layer being appropriately cured subsequently to the embedding of the microspheres.

2. A reflex-reflecting textile yarn adapted to be incorporated in woven or knitted fabrics of the character described, comprising a textile core yarn, a flexible and durable concentric binder layer coated thereon and, bonded in the binder layer, a concentric surface layer of half-embedded transparent glass microspheres having a specularly reflective metal plating on only the back surface so as to be intrinsically reflex-reflecting, the glass having a refractive index of about 1.9 and the microspheres having a diameter in the range of about 10 to 75 microns.

3. A yarn according to claim 2 having a binder layer comprised of a heat-cured blend of a rubbery butadiene-acrylonitrile copolymer and a ketone-soluble benzene-insoluble heat-reactive phenol-aldehyde resin.

4. A useful reflex-reflecting textile fabric formed of a combination of conventional yarns or fibers and a small

proportion of distributed reflex-reflecting yarn defined in claim 2.

5. A woven textile fabric characterized by having a waven structure formed of a combination of conventional yarns and a small proportion of reflex-reflecting yarns defined in claim 2 which imparts a useful reflex-reflecting characteristic to the fabric.

6. A reflex-reflecting flexible textile yarn comprising a core yarn of continuous filaments coated with a cured rubbery binder layer that is flexible and resilient, heat-resistant and non-thermoplastic, waterproof and resistant to common dry-cleaning solvents, and which is bonded to a half-embedded surface layer of silver-plated glass microspheres that are desilvered on the exposed portions to provide catadioptric reflex-reflecting elements, the glass having a refractive index of about 1.9 and the microspheres having a diameter in the range of about 10 to 75 microns.

7. A textile fabric having incorporated in the structure a small proportion of yarns as defined in claim 6 which impart to the fabric a greatly increased visibility under nighttime reflex-reflecting highway viewing conditions but which do not materially impair the hand and drape of the fabric nor its daytime appearance.

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