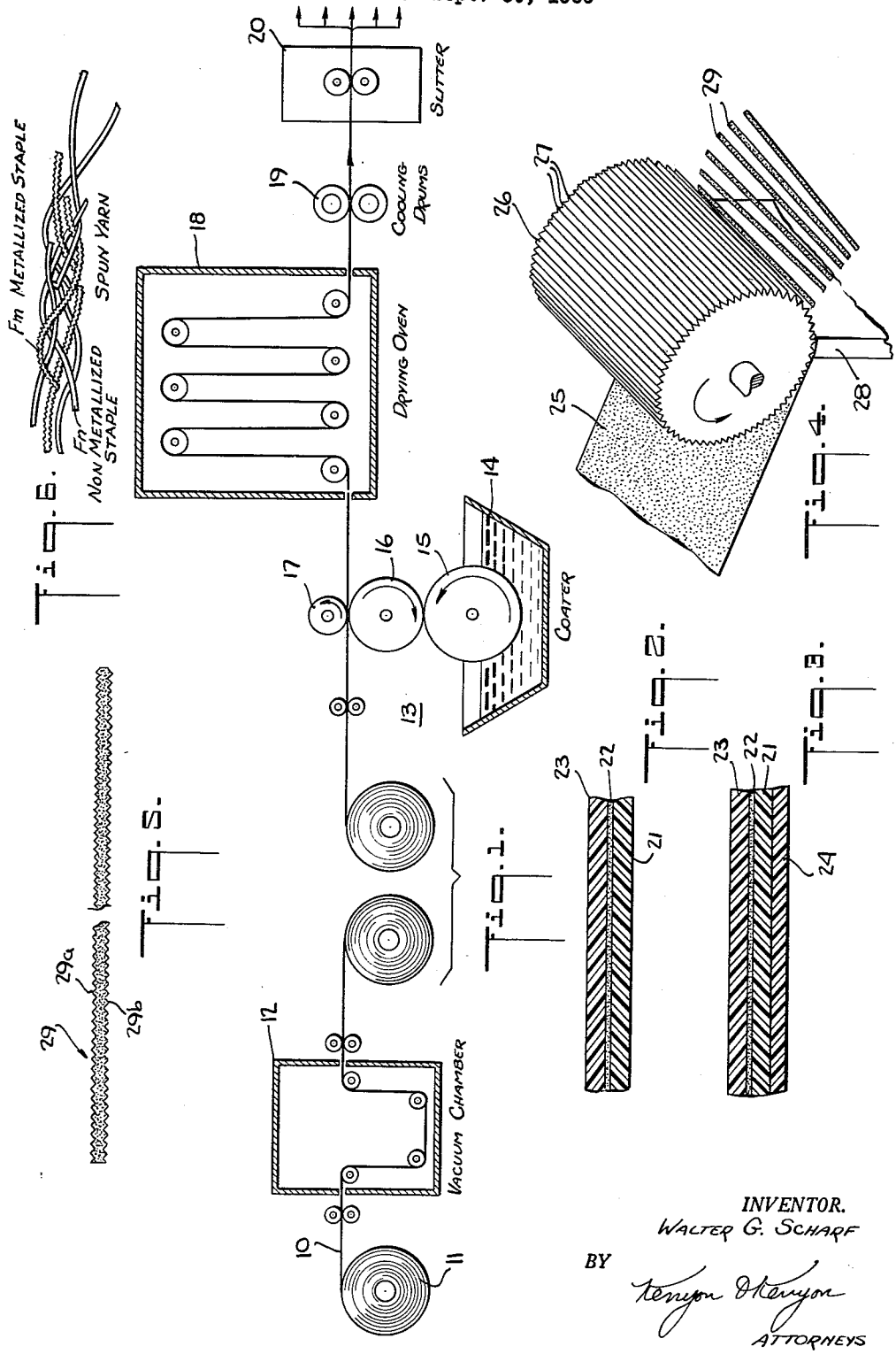
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METALLIZED SYNTHETIC SPUN YARN

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METALLIZED SYNTHETIC SPUN YARN

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This invention relates generally to metallized textile materials, and more particularly to the manufacture of staple fibers formed of synthetic metallized ribbons and usable for spun yarn. This invention is a continuation-in-part of my earlier application filed June 18, 1956, issued March 7, 1961, as Patent No. 2,974,055.

The use of metallized threads in fabric design to enhance the beauty of the fabric is of ancient origin. In order to obviate certain drawbacks inherent in threads made entirely of metal or those having a core of natural fiber, it has been the practice in recent years to form such threads by combining metal with synthetic materials of superior tensile strength.

In one known commercial form, a continuous filament is composed of two narrow plastic ribbons bonded together by adhesive, the interior surface of one ribbon being coated with a metal deposit. In another commercial form, a strip of metal foil is sandwiched between two plastic ribbons and bonded thereto. In either laminated form, the ribbons may be made of cellulosic material, such as cellulose butyrate, although non-cellulosic lamina may also be used such as Mylar (polymerized ethylene glycol terephthalate).

Fabrics woven of continuous metallized filaments have a ribboned surface and are limited in their design possibilities, particularly since the basic thread is flat, not round as with conventional threads. The resultant fabric does not have the hand or appearance of fabrics formed with round fibers. Moreover, the use of adhesive between the ribbon plies which form the filament gives the resultant thread a tendency to delaminate in the course of chemical or mechanical processing such as sanforizing, dyeing, commercial washing and dry cleaning. Also adhesive acts to reduce the brilliance of the thread.

A more serious limitation of laminated metallized threads from the standpoint of textile design is that the practical use of such threads is confined to continuous filament applications. While it is known to convert continuous filament thread of synthetic material into staple lengths which are thereafter spun into yarn, such conversion has not heretofore been possible with laminated metallized threads. Such threads, if cut into staple lengths, are excessively thick and heavy and cannot be spun effectively. They tend to be thrown out of the spinner and will not wrap around and interlock with each other.

Accordingly it is the principal object of the invention to provide staple fibers derived from a metallized synthetic tape and usable for spun yarn.

More specifically, it is an object of the invention to provide a composite metallized tape which is exceptionally thin and light and is convertible into staple fiber, the tape being constituted by a transparent base ribbon having a metal layer deposited thereon, the metal layer being coated with a transparent film which is related structurally to and has an affinity for the base ribbon. A tape in accordance with the invention is produced entirely without adhesives, it is inherently incapable of delamina- it is highly flexible and has improved tensile strength.

It is also an object of the invention to provide metallized staple fibers formed of composite material whose integrity is maintained when the fibers are processed chemically or mechanically.

Briefly stated, spun yarn in accordance with the invention is fabricated by cutting into staple lengths and spinning fibers derived from a continuous tape formed by a transparent flexible plastic ribbon coated on one side with a deposit of metal, the surface of the metal deposit being covered with a plastic solution or suspension which when dried and cured affords an adherent transparent film, the plastic coating being a material related structurally to the ribbon and having an affinity therefor.

For a better understanding of the invention as well as other objects and further features thereof, reference is made to the following detailed description to be read in conjunction with the accompanying drawing.

In the drawings:

FIG. 1 is a schematic diagram showing the process in accordance with the invention adapted to produce a metallized synthetic web.

FIG. 2 is a sectional view of one embodiment of a metallized tape according to the invention.

FIG. 3 is a sectional view of another preferred embodiment of a metallized tape.

FIG. 4 schematically illustrates one method for converting a tape of metallized material into staple fiber.

FIG. 5 is a magnified view of a single staple fiber.

FIG. 6 illustrates a spun yarn made of staple fiber in accordance with the invention.

Referring now to FIG. 1, there is shown a process in accordance with the invention for producing a metallized web which may be slit to form a relatively narrow tape, the tape then being cut into fiber lengths. A continuous web of transparent thermoplastic material **10** is drawn from a supply roll **11** and is caused to travel through a high vacuum chamber **12** wherein one surface of the film is metallized. The web may be constituted by cellophane, acetate, tri-acetate, acetate butyrate, polymerized ethylene glycol terephthalate (Mylar) or any other suitable transparent and flexible material capable of being vacuum-plated. The thickness of the web for ordinary yarn should not exceed 2 mils and is preferably of ½ mil thickness.

In the vacuum chamber **12**, one surface of the film is metal-plated by gold, silver aluminum, magnesium, titanium, nickel or any other metal, the thickness of the metal layer being molecular and not exceeding $\frac{1}{50,000}$th of an inch. The deposition may be carried out by known thermal evaporation or cathodic sputtering techniques. In thermal evaporation, metal vapor is generated by direct heat such as an electric arc source or a glowing filament. To effect maximum adherence of the plated film, the metal atoms should pass linearly from their source to the surface to be coated and this requires the maintenance of pressures of about 10^{-4} of mercury in the vacuum chamber.

In cathode sputtering, a high voltage is impressed between an anode and a cathode of the plating metal. The cathode is vaporized by positive-ion bombardment, some of the vapor diffusing away from the cathode and depositing on the web to be plated. The voltage requirements depend on the nature of the cathode metal. At pressures of 0.01 to 0.10 mm. of mercury necessary to maintain the glow discharge, the ordinary laws of diffusion prevail. After plating, the web is re-rolled on take-up drum **11'** in preparation for the next step.

To produce a yarn having the color properties of the metal deposit, the metallized web is then coated on the metal side with a transparent plastic in solution or suspension which is related structurally to and has an affinity for the web which is metallized. That is to say, the plastic coating must have substantially the same tensile strength and elongation characteristics as the web material. Since the metal layer is of molecular thickness it

is inherently permeable to the liquid plastic coated thereon.

The plastic coating can be applied by a roller coater, a reverse roller coater, or by the flexographic or rotogravure process. By way of illustration, FIG. 1 shows a direct three roll coater. The coater, generally designated by numeral **13**, includes a bath **14** for containing the liquid, a first roller **15** which is rotatable within the bath and acts to apply the liquid to a second roller **16** which engages the metallized surface of the web **10**, the web being pressed against the second roller by means of a third roller **17**.

The wet plastic coating formed on the web **10** is then dried and cured by passing the web through a suitable oven **18** which is properly heated and vented to drive off all solvents and at the same time to effect the curing of the coated material. For heating purposes, steam, gas heat or infra-red radiation may be employed, as desired. The temperature of the oven and the travel time therethrough are determined by the specific web and coating materials. The coating is further cured by cooling drums **19** disposed at the opposite end of the oven. Cooling may be accomplished by a circulating water system or a refrigerant. Thereafter the metallized and coated web is longitudinally severed or slit in a conventional slitter **20** into tapes each having a width appropriate to staple fibers.

In FIG. 2 there is shown a section taken through the tape. The tape is composed of a thermoplastic base strip **21**, a thin metal coating **22** being deposited thereon and a plastic film **23** being intimately bonded to the surface of the metallized strip to form an integral structure. Preferably the strip is about ½ mil in thickness and the film is about ⅛ mil thickness, the thickness of the deposit being negligible. Thus the total thickness is less than one-thousandth of an inch.

The color or luster of the tape produced in the above-described technique is determined by the natural color of the metal deposition. However, it is also possible to generate other colors by adding a dye or pigment to the plastic coating fluid, in which event the resultant color in the finished tape is the combination of the metal and pigment hues. For example, as shown in section in FIG. 3, a gold effect may be realized by a silver or aluminum metal deposit **22** in combination with a plastic covering **23** having an amber dye or translucent pigment therein. To have the gold effect on either side it is also necessary to color the non-metallized surface of the base strip and this is best accomplished by applying the pigmented or dyed liquid plastic **24** to this side as well as the metallized side, so that a film is formed on both sides of the base strip.

As pointed out previously, it is important that the plastic coating on the metallized web be related structurally and have an affinity for the web material. Where the web material is constituted by Mylar, it has been found that an effective coating is one in which the basic make-up of the solids are approximately as follows on a ratio basis per weight:

1 part Vinylite VAGH
1 part Vinylite VMCH
1 part nitrite rubber
.12 ultra-violet light absorber

The ratio basis of the above constituents may be varied without materially impairing the efficacy of the mixture by reducing the Vinylite VAGH to an extent not exceeding about 30%, and by increasing the Vinylite VMCH to an extent not exceeding about 30%. Alternatively, the Vinylite VAGH may be increased by 30% and the Vinylite VMCH decreased by 30%. However, the nitrite rubber should be held more or less constant, as well as the ultra-violet light absorber.

The light absorber acts as an anti-oxidant relative to the rubber and in lesser amounts than above indicated is not fully effective. On the other hand, an increased amount would not significantly improve the ultra-violet light resistance of the dried film laid down with the coating composition. The light absorber prevents discoloration of the film.

The nitrite rubber is available commercially from several sources. The nitrite content may run between 30 to 36% and the balance made up of butadiene. This type of rubber is higher in acro-nitrite content, giving a harder polymer which is necessary to add to the compositions for a non-blocking coating and one that will resist boiling of coating when the coated material is formed into metallic yarn and subjected to various dye and cleaning processes, etc.

The Vinylite VMCH is manufactured by Bakelite Corp. under their trade name, the chemical composition being as follows:

	Percent
Vinyl chloride	86
Vinyl acetate	13
Inner polymerized di-basic acid	1

Vinylite VAGH is also manufactured by Bakelite Corp., the chemical constituents being the following:

	Percent
Vinyl chloride	91
Vinyl acetate	3
Organic material having hydroxyl group (2.6 times greater when calculated as vinyl alcohol)	6

The function of the Vinylite VMCH is to effect adherence to metallic surfaces and also to plain polyester surfaces. The Vinylite VAGH gives better range for hardness and overall compatibility which allows the introduction of a wider range of colors.

The Vinylite VMCH does not tolerate the addition of many pigments or dyes, and resort is therefore had to VAGH for broader compatibility of colors to be added, as well as to good adhesion, along with a material that is hard, thereby imparting a non-blocking character to the coating film itself. Various types of light fast azo dyes, vat dyes and various types of pigment dispersions are compatible in this mixture.

This mixture may be dissolved in a straight ketone system, such as acetone or M.E.K. where high volatility and evoparation of solvents is desired. For general coating operations on reverse roll coaters, the solvent system may be ⅔ methyl ethyl ketone and ⅓ aromatic hydrocarbon, such as toluol solvent. The solids may range between 18 to 23% for a low viscosity mixture.

A metallized tape formed in accordance with the above described process and including a Mylar base or web will afford increased yardage per pound of Mylar as compared with conventional laminated structures since only one ply of Mylar is entailed. And since no adhesive is employed, the plastic coating being integrally bonded to the web, the tape and the staple fibers derived cannot delaminate.

As pointed out above, the broad metallized web is slit down to tape size. In practice, a web having a 48 inch width is cut down to a narrow tape whose width is equal to the preferred length of staple fiber. Thus, the width of the tape may run between about one and three inches, as is the case with standard short and long staple lengths in natural fibers, such as cotton or wool.

As shown in FIG. 4, the continuous tape **25** is fed through a staple cutter or chopper which may take the form of a cutting drum **26** having an array of radially extending blades **27** arranged circumferentially thereon. The blades, which cut the tape transversely against a platen **28**, are spaced from each other at distances equal to the desired width of the staple fibers **29** which are cut from the tape. The width of the staple fiber preferably is about $\frac{1}{120}$ of an inch. Alternatively a reciprocating blade may be used to chop the tape into fibers. The in-

dividual staple fibers are extremely thin and light and are readily spun into yarn by known spinning techniques such as those described in "Man Made Textile Encyclopedia," edited by J. J. Press and published by Textile Book Publishers, Inc. (1959). The objects of spinning are to reduce the bulk fed to the desired size, to insert twist and to produce a firm package suitable for the next operation. A spun yarn is a continuous strand of fibrous material which has received its final attenuation and has been twisted to give it sufficient strength or other desired characteristics.

In order to improve the spinning qualities of the staple fibers of metallized material, the tape is cut by blades having a serrated cutting edge, whereby as shown in FIG. 5, the edges **29***a* and **29***b* are similarly corrugated or serrated to augment the interlocking characteristics of the fibers. While the individual fibers are flat, the yarn resulting from spinning these fibers are generally round, the spun yarn, when woven, provides a fabric having a soft hand an appearance which differs significiently from that obtained with continuous metallized flat threads. It has been found that the spun metallized yarns provide a rich and warm metallic glitter not achieved by any other form of yarn.

It is also possible to intermix metallic staple fibers of different colors to provide unusual color effects, or to combine metallic staple fibers with conventional staples of natural or synthetic material to produce radiant spots of color and to achieve other remarkable decorative effects. The metallized staple fibers may also be combined with paper in a paper making machine, the fibers being deposited on the wet web in the machine and forming an integral part of the finished sheet when the web is dried.

The metallized staple fibers are also usable as a reflective tinsel or chaff which may be jettisoned from an aircraft to effect deceptive jamming effects in connection with radar or other military detection devices. The extreme lightness of the chaff causes it to float in the atmosphere for long periods.

The plastic film for the metallized carrier or web material may also be derived from polyester resins and epoxies in solution which when dried and cured form a film having a strong affinity for the carrier particularly when the carrier is Mylar. The metallized staple fibers may be intermixed with non-metallic fibers of natural or synthetic material to form composite spun yarns, as shown in FIG. 6, spotted with metal and having a decorative glitter. Such non-metallic staple fibers as wool, silk and cotton may be used in this connection. The spun yarn is made up of metallized fibers F_m and non-metallized fibers F_n.

While there have been shown what are considered to be preferred embodiments of the invention, it will be manifest that many changes and modifications may be made therein without departing from the essential spirit of the invention. It is intended, therefore, in the annexed claims to cover all such changes and modifications as fall within the true scope of the invention.

What is claimed is:

1. The method of fabricating metallized spun yarn comprising the steps of slitting a web of metallized plastic material into tapes having a width equal to the length of staple fibers and having a thickness not in excess of about 2 mils, said web being constituted by a base layer of synthetic material having a metal deposit thereon coated by a plastic film, cutting said tapes transversely at spaced positions into staple fibers of narrow width whose longitudinal edges are serrated to facilitate interlocking of said fibers, and spinning said fibers into yarn.

2. The method, as set forth in claim 1, wherein said web has a thickness of less than one mil.

3. The method, as set forth in claim 1, wherein said tape has a width of between 1 to 3.5 inches.

4. A metallized spun yarn constituted by staple fibers each of which is of a thickness not in excess of about 2 mils and is formed by a base of transparent flexible thermoplastic material having a metal deposit coated thereon and a layer of plastic film directly adherent to said deposit and of a material related structurally to said base and having an affinity therefor, said fibers being formed by flat strips having serrated longitudinal edges.

5. A yarn, as set forth in claim 4, wherein said fibers have a thickness of less than one mil.

6. A yarn, as set forth in claim 4, wherein said fibers have a width in the order of $\frac{1}{120}$ of an inch.

7. A metallized spun yarn constituted by staple fibers each of which is of a thickness not in excess of about 2 mils and is formed of a base of transparent flexible thermoplastic material having a metal deposit coated on one side thereon, a first layer of pigmented plastic film directly adherent to said deposit and a second layer of pigmented plastic film directly adherent to the other side of said base, said films being formed of liquid plastic which is dried and cured and which is of a material related structurally to said base and has an affinity therefor, said fibers being formed by flat strips having serrated longitudinal edges.

8. The method of forming metallized spun yarn comprising the steps of fabricating a tape having a width equal to the length of staple fibers and a thickness not in excess of about 2 mils and formed by a transparent flexible plastic ribbon coated on one side with a metal deposit whose surface is covered with a liquid plastic which when dried and cured affords an adherent transparent film of a material related structurally to the ribbon and having an affinity therefor, cutting said tape into staple length fibers whose longitudinal edges are serrated to facilitate interlocking thereof, and spinning said metallized fibers with non-metallized fibers to form a composite spun yarn.

9. The method as set forth in claim 8, wherein said non-metallized fibers are of wool.

10. The method as set forth in claim 8, wherein said non-metallized fibers are of silk.

11. The method as set forth in claim 8, wherein said non-metallized fibers are of cotton.

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