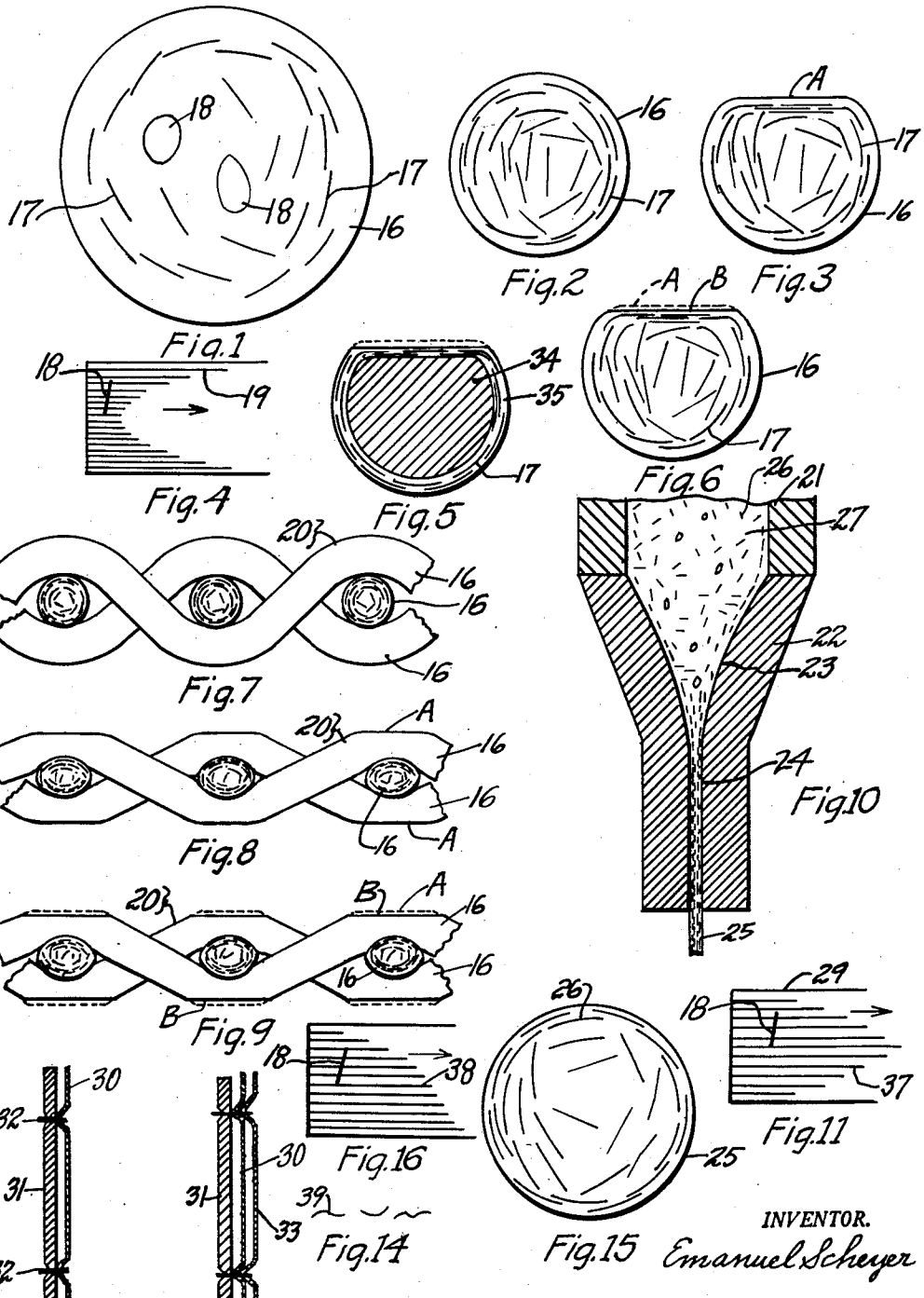
Oct. 30, 1962 E. SCHEYER 3,060,552

HEAT REFLECTIVE FILAMENT

Original Filed July 9, 1953



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United States Patent Office

3,060,552

Patented Oct. 30, 1962

3,060,552

HEAT REFLECTIVE FILAMENT

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Original application July 9, 1953, Ser. No. 367,055, now Patent No. 3,002,252, dated Oct. 3, 1961. Divided and this application May 8, 1961, Ser. No. 119,760
1 Claim. (Cl. 28—82)

This invention relates to heat reflective filaments having reflective flakes for use in a heat reflective fabric. It is a division of my application Serial No. 367,055, filed July 9, 1953, and now U.S. Patent No. 3,002,252. Such fabric elements or filaments are especially useful when the flakes are light reflective for producing ornamental fabrics and where the flakes have low emissivity for producing heat reflective mediums in the form of a fabric either woven, felted, knitted or in a batting or wadding. Said heat reflective mediums may be used in clothing, including shoes, hats, gloves and socks and in bed coverings, as a lining or interlining to hold back the heat radiated from the body. The heat reflective medium is useful also as window coverings, as a lining for draperies, as the draperies themselves and for shades. A large percentage of the heat given off from the body is in the form of radiated heat. With ordinary clothing and bed covering, a large part of the radiated heat escapes. The heat reflective medium in the form of a batting is especially useful in bed coverings such as quilts and comforters and in quilted interlinings. The heat reflective fabric as a bed spread, either used by itself or on top of the blankets is especially efficient in retaining the radiated heat. Experiments have shown that when the heat reflective layer or layer of low emissivity is on the outside it is most efficient.

It is well known in the art that high light reflectivity is not necessarily concurrent with small heat emissivity for infra-red radiation. Also it is known that metals are the most efficient for low heat emissivity. The secret seems to lie in the relative sensitivity of the metal to certain wave lengths. See FIG. 3, The Iron Age, February 14, 1935, page 12, "Metallic Insulators Are Effective Heat-Ray Traps" by Joseph F. Shadgen.

Heat reflective mediums form the subject of my Patent No. 2,357,851.

The filaments comprise a synthetic material such as nylon, polyethylene or the vinyls, in which are incorporated flakes of material, such as flakes of aluminum, in sufficient quantity and in proper orientation to render the fabric materially high light reflective or heat reflective or both. Other synthetic materials are mentioned in my patent. The materials noted above are by way of example and are not to be considered as limitative.

The usual filaments from which the yarn for fabrics are spun are of small diameter, say about 0.001 inch diameter. If pigment is incorporated therein, in order not to weaken the filaments the particles of the pigment are of the order of 0.4 micron or 0.0000156 inch. However, in the case of reflective flakes, such as metallic flakes, particularly flakes of aluminum, they cannot be obtained in the present state of the art in such small size. Accordingly, a filament in which they are incorporated must be of larger diameter to contain them and must be larger because their presence tends to have a weakening effect on the strength of the filament. A larger diameter filament is a stiffer filament. This is a reason why it is necessary to orient the flakes so that their flat surfaces are substantially parallel to the length of the filament. The thickness of a flake being much less than the extent of its flat surface, this parallelism reduces the tendency of the flakes to weaken the filament. It also permits a smaller diameter filament

to contain the same amount of flakes without corresponding reduction of strength. Another reason for orientation and parallelism is to produce a leafing of the flakes, the leafed flakes presenting a substantially continuous reflective surface which is substantially parallel to the outside surface of the filament. A transverse section through the flakes will form a polygon inscribed in the periphery of the filament. The reflective surface as presented to the heat rays is substantially continuous, but the flakes are not necessarily in continuous contact with each other even if leafed because they will be separated in most cases by a film of plastic between the individual flakes. This is the sense in which the expression "continuous surface" is intended to have in the claims. This is of advantage because it will prevent loss of heat in the filament or fabric element longitudinally. Should it be possible in the future to develop flakes of a small size approaching that of present pigments, unless such flakes were properly oriented, there would be little or no reflectivity. Hence even with such small flakes it will be necessary to orient them as with the larger flakes. While it is preferable to have the flakes leafed, if they are close together without leafing it will also serve. The method described herein improves orientation and parallelism regardless of the size of the flakes.

In all cases a sufficient amount of flakes must be incorporated in the plastic or synthetic so that when they are properly oriented and leafed they will produce in the filament a substantially continuous reflective surface. For best results this surface should be parallel to the surface of the filament and near thereto. The quantity of flakes required can easily be determined by experiment for each particular case. See also my Patent No. 2,357,851.

Filaments of a minimum size, to contain flakes by way of example, capable of passing through a sieve of mesh designation 325 would have to be of larger diameter than that normally used for synthetic yarns. The filaments forming such yarns are about 0.001 inch in diameter as noted above. The word diameter is used advisedly as many filaments are not circular. As will be seen hereinafter, even if they come out circular in spinning, they are flattened later on. The flakes last mentioned above must have at least one dimension measured flatwise not greater than about 44 microns or 0.0017". The steps of orientation described herein cause the flakes to assume a position in which their largest dimension is parallel to the length of the filament. It is evident that the filaments in common use at present are too small to contain such flakes. Larger diameter filaments tend to become stiffer. For this reason a synthetic must be used, as with certain forms of polyethylene and nylon, which are relatively flexible and soft. In the various non-rigid synthetics, even those of the same type, there are various degrees of flexibility and softness depending on the polymerization and arrangement of the molecules. See Patent No. 2,130,948 to Carothers. The use of plasticizers for controlling the characteristics of synthetics are well known to the art for increasing their flexibility and softness. A certain amount of stiffness, however, can be tolerated where the heat reflective material is used as a lining or interlining in winter coats, fur coats, leather jackets, gloves, shoes, bed spreads and other articles that are inherently somewhat stiff. Even so, it is desirable to keep down the stiffness to a minimum.

The presence of the flakes has a tendency to clog the spinnerets used for spinning the filaments. For this reason it is necessary to spin the filaments of a larger diameter than they will have later on in forming the reflective layer, medium or fabric. To reduce the filament to its proper diameter, a filament formed of a material which can be drawn such as nylon or polyethylene is elongated to its desired diameter. This elongation can be done in

a number of ways which are well known to the art such as cold drawing or passing through a die. The above examples of synthetics and ways of reducing the diameter of the filaments are by way of example and are not to be considered as limitative. Reducing the diameter or cross section of the spun filament by lengthening it serves several useful functions. The lengthening of the filament produces orientation and leafing of the flakes and brings a considerable portion of the flakes nearer to the surface of the filament. It also causes the flakes nearer the surface to set with their flat substantially parallel to their adjacent portion of the surface of the filament. It is well known that the thinner the layer of synthetic over the reflective surface, the smaller the emissivity of said surface. In addition to bringing the leafed flakes nearer the surface by lengthening the filament, the amount of synthetic overlying the flakes is further reduced as part of my invention by buffing the filament, usually after it has already been formed into the layer or fabric. Further to increase the reflectivity of the fabric it is an object of my invention to produce a flattened fabric by calendering the fabric by pressing it between hot or cold rolls or otherwise flattening it by pressure as is well known to the textile art.

Reducing the cross section of the filament also renders it more flexible, resulting in a softer fabric. As noted hereinbefore, elongating the filament reduces its cross section, thereby rendering the fabric made from it more flexible. Flattening the filaments after being made into a fabric also makes the fabric more flexible. Buffing the filaments also makes the fabric more flexible. The buffing done on a fabric takes off the synthetic from the outermost portions of the filaments, where the fabric is made of monofilaments. Where the fabric is composed of yarn or threads made from the filaments, the synthetic is taken off the outermost filaments.

Another way of reducing the cross section of filaments for increasing their flexibility and to reduce the thickness of the synthetic overlying the flakes, is to subject the filament or the already made fabric to the action of a solvent.

As a further object of my invention to assist in orienting and leafing the flakes and bringing them nearer to the surface of the filament, the mixture of synthetic and flakes is sent through elongated tubular spinnerets in the step of spinning. Such filaments and the process of making them were described in by abandoned application Serial No. 634,930, filed December 14, 1945.

In addition to producing properly oriented, parallel, leafed flakes and have them close and parallel to the surface for filaments having reflective flakes incorporated therein, it is an object of this invention to provide filaments, already spun, with a coating of synthetic with flakes incorporated in the coating, which flakes are oriented, parallel, leafed and near and parallel to the surface of the coating. Yarns or threads of natural fiber are also provided with a reflective coating.

Other objects and advantages will become apparent upon further study of the description and drawing in which:

FIG. 1 is a cross section of a filament with flakes incorporated therein after having passed through a spinneret, the filament being of larger size than ultimately to be used in the fabric.

FIG. 2 is the same filament after being stretched or otherwise elongated to a size to be used in the fabric.

FIG. 3 is the same filament showing how it has been flattened after having been woven into or otherwise used to form a fabric and the fabric then calendered or otherwise pressed.

FIG. 4 is a diagram showing one way the elements of a filament tend to bring a flake into parallelism when the filament is elongated.

FIG. 5 shows a coated synthetic filament with flakes in the coating after the filament has been stretched, flattened and burnished.

FIG. 6 is the filament of FIG. 3 after its flattened surface has been burnished or buffed.

FIG. 7 shows a fabric woven of the filaments shown in FIG. 2.

FIG. 8 shows the same fabric after having been calendered and flattened.

FIG. 9 shows the fabric of FIG. 8 after it has been burnished and buffed.

FIG. 10 shows an elongated spinneret through which the mixture of synthetic and flakes is being extruded.

FIG. 11 is a diagram illustrating the relative motions of the elements of a stream through a long narrow passage in relation to a flake for bringing the latter into parallelism.

FIG. 12 is a section through a portion of a garment or the like having my reflective material as a lining.

FIG. 13 is a section through a portion of a garment or the like having my reflective material as an interlining.

FIG. 14 shows cross sections of flakes.

FIG. 15 is a section of a filament to a larger scale than in FIG. 10, and

FIG. 16 is a diagram showing another way the elements of a filament tend to bring a flake into parallelism when the filament is elongated.

All of the above figures show the various filaments and parts to an exaggerated scale.

The filament **16** in FIG. 1 is a diagrammatic cross section of a synthetic filament after it has been spun from a plastic mixture of synthetic and flakes to a larger size than when it is to be used later on in the production of the reflective fabric.

To avoid clogging the spinnerets with the flakes, the filament is first spun to a larger size. The larger size is also necessary to enable the filament to be elongated after being spun. The very act of spinning tends to a certain extent to orient the flakes **17**. However, certain flakes, such as those marked **18**, may come through with their flat surfaces at a substantial angle to the length of the filament. Others of the flakes are likely to be scattered at random. Disorientation of the flakes will weaken the filament, especially those turned as flakes **18**. Disorientation will also reduce reflectivity, in fact if all the flakes were turned with their edges facing the periphery of the filament, the latter would appear dull.

By elongating the filament, such as by drawing it or passing it through a die, the flakes are oriented, causing their flat surfaces to assume parallelism with the length of the filament. Because the lengthening also crowds the flakes by reducing the diameter of the filament, see FIG. 2, they are caused to overlap or leaf. Further, because of the reduction in diameter, the flakes are brought nearer to the surface, with the outer flakes, especially, tending to become parallel to the surface of the filament.

It is true that in the prior art, it is common to lengthen the filament, say by cold drawing after it is spun, but this is for a different purpose and acts in a different way as far as the flakes are concerned. It is for the orienting of the molecules and thereby taking the stretch out of the filament. Applicant is faced with a different problem. He has flakes in the filament which are relatively large with respect to the diameter of the filament. It is these flakes which must be oriented, leafed and brought close and substantially parallel to the surface. Because of their relatively large size, the flakes cannot be compared with the minute particles of the pigment often present in filaments of the prior art. Further, there is nothing to be gained by orienting the particles of a pigment. Also it would have no meaning unless the particles were flat. Even if minute metallic flakes were obtainable of the order in size of the particles of present pigments, for reflective purposes, it would be desirable to orient, leaf them and bring them close to the surface. It would appear, however, that the larger the flakes, the more reflective the filament would be. On the other hand, larger flakes require a larger diameter filament resulting

in a thicker and stiffer fabric. Depending on the circumstances of use for the reflective fabric and the flexibility of the synthetic chosen, a choice must be made of the relative size of the flakes to the diameter of the filament.

As seen in FIG. 4, elongating the filament by gripping it causes the outer of its elements **19** to move a greater distance than those nearer the center or at the core. A flake **18** setting transversely across the path of the unequally moving elements **19** would have its outer portion moved more than its inner portion. This would swing the flake around so that its flat would lie lengthwise of the filament and at the same time be substantially parallel to the surface of the filament as are the diametrally outer flakes **17** of FIG. 2.

On the other head if the elongation causes the core elements **37** to move a greater distance than the other elements, as in FIG. 11, a flake **18** setting across the path of the unequally moving elements **37** would also be turned into parallelism. Where the filaments are wound from a slower moving spool to a faster moving spool, the elements **38** bear the relation shown in FIG. 16, in which case the flakes **18** are still caused to turn into parallelism. In general it can be said that parallelism results from unequal motion of the elements.

Further, because of the reduction in diameter, as between FIGS. 1 and 2, the flakes **17** of FIG. 2 are closer to the surface of the filament than the flakes **17** of FIG. 1.

Because of the relatively large diameter of the filaments as discussed above, a fabric made from them can be made from monofilaments, instead of yarn or threads. Such a fabric, indicated by numeral **20** in FIG. 7, is composed of filaments **16**.

Whether the fabric is composed of monofilaments or threads made up of filaments, I desire to flatten the fabric as shown for the monofilament fabric **20** in FIG. 8. The flattening is done by calendering, as is well known in the art, by passing the fabric between rolls or otherwise subjecting it to compression. Flattening the fabric will cause filaments **16** to have flat spots as at A. This will cause fabric **20** to have a smoother surface which will increase its light reflectivity and reduce its emissivity, that is increase its heat reflection. Also flattening the surface of the filaments will make it possible to produce larger buffed or burnished areas A. In FIG. 9, which shows fabric **20** after it has been buffed, the dotted lines indicate the outside of filaments **16** before being buffed. In FIG. 6 the dotted line shows the outside of filament **16** before being buffed. It is evident if the same depth of buffing were used for the filaments of FIGS. 2 and 7, a smaller buffed area than area B would be produced. To produce the same buffed area B of filaments **16** in FIGS. 2 and 7 as in FIGS. 6 and 9, a greater depth of buffing or grinding would be required, thereby weakening the filament and possibly removing some of the outermost flakes. A reason for buffing or otherwise thinning the skin of synthetic over the flakes is to increase their reflectivity, especially heat reflectivity. Another reason is to increase the flexibility of the fabric. A certain amount of skin, however, is useful to protect the metal flakes from corrosion.

Having a ring of leafed flakes near the surface of the filament is important for good reflectivity, as the thickness of the skin of synthetic over the flakes has a serious effect on the heat reflectivity. This matter is discussed in a paper entitled "Some Reflection and Radiation Characteristics of Aluminum" C. S. Taylor and J. D. Edwards—Heating Piping and Air Conditioning, January 1939, page 59, and the Trans. Am. Soc. Heat. Vent. Eng. 45, 179 (1939).

Increased smoothness of the filament itself before flattening or flattening and buffing will increase the smoothness of the finished fabric and thereby help insure the parallelism of the flakes to the periphery of the filaments and the evenness of the thickness of the synthetic coating over the flakes. It has been found that spinning by the melt process produces the smoothest type of filament where the latter is spun from a thermoplastic synthetic of which nylon is an example. See lines 39–44, first column, page 6 of Patent No. 2,130,948 to Carothers. For this reason it is preferred to spin the filaments of thermoplastics by the melt process.

Instead of buffing the filaments for reducing the thickness of the skin of plastic over the flakes, the skin thickness, as noted hereinbefore, can be reduced by applying a solvent to the filaments or to the fabric made from the filaments for dissolving away part of said skin.

Part of the skin can be dissolved away, either after filament **16**, as shown in FIG. 2, has been elongated or after it has been elongated and flattened as in FIG. 3 or after it has only been flattened or before it has been flattened. This also holds true for the coated filament of FIG. 5. It is especially useful to dissolve away part of the skin over the flakes where the base for the coating is an unstretchable material as the standard yarn and thread made of natural fibers. The dissolving can also apply to filament **25** of FIGS. 10 and 15, either as it comes from the elongated spinneret or after said filament has been elongated or after said filament has been flattened or after said filament has been elongated and flattened or before it has been flattened.

Dissolving away portions of the skin over the flakes can be done after the fabric has been made as in FIG. 7 or after it has been flattened as in FIG. 8. Where the solvent is applied after the fabric has already been made, as for example the woven fabric of FIGS. 7 and 8, there will be a tendency of the filaments to stick to each other after the solvent has evaporated. To overcome this, before the surface of the filaments has entirely hardened, the fabric is subjected to pulling, preferably on the bias in two directions substantially at right angles to each other. This will cause the filaments to separate where they have become stuck to each other.

Plastics and suitable solvents therefor which can dissolve away portion of the skin are well known to the art. For example, acetone can be used to dissolve away cellulose acetate. Polyethylene can have a portion of the skin dissolved away by a liquid hydrocarbon at 80–100 degrees C. Especially useful solvents for nylon are phenol and formic acid, as described in the Carothers patent mentioned before.

By streamlining the flow of the plastic dope with the flakes already in it on its way to and through the spinneret, as shown in FIGS. 10, 11 and 15, the flakes are caused to turn so that their flat sides lie parallel to the longitudinal axis of the filament. Further, more of the flakes are caused to move near the surface of the filament and assume positions in which their flat surfaces are parallel to the adjacent surface of the filament, forming substantially a polygon inscribed in the periphery of the filament.

Pressure chamber **21** has die **22** attached to it, the attaching means not being shown. The passage or opening through die **22** has a converging portion **23**, and a relatively long portion **24**, whose exit end, at least, is equal in cross sectional area to that of the filament **25**, preferably that of the filament before it is stretched or otherwise elongated to reduce its area to that of the filament as finally used in the fabric. The effect of this reduction in area has previously been explained. The part of portion **24** above its exit end while not necessarily equal to it in cross section, should not be much in excess of it. The drawing shows portion **24** to be of constant cross section as one embodiment. Portion **24** should be sufficiently long, so that by the time flakes **26** have reached its exit end, they will substantially all have their flat surfaces substantially parallel to the longitudinal axis of the filament. The length required for portion **24** will depend on its cross sectional area and the nature of the material passing through it.

The plastic stuff **27** while in solution or molten as well

known in the art, is mixed with the flakes and then forced from chamber **21** through portions **23** and **24** of die **22**. On emerging as a filament **25**, depending on the plastic used and its type of liquefaction, the filament is hardened by evaporation, cooling, or chemical reaction with another solution, as is well known in the art.

The effect of passing a stream through a narrow passageway is to be seen in FIG. 11. The length of a horizontal line **37** in this figure represents the velocity of an element in the location of the line. The velocity of the elements of the stream is a minimum near the wall **29** of the passage because of friction therewith. The velocity of the elements increases, the nearer they are to midstream. A flake **18** extending transversely of the stream, because of the unequal velocities of the stream elements, is forced to have its flat or sides turn parallel to the direction of the stream. The surfaces of the flakes are not always truly flat or in a plane but the term is used to distinguish the sides from the edges.

The effect of the difference in velocities of the elements **37** of the stream is also to cause the flakes near the perimeter of the filament to assume a position substantially parallel to the nearest or adjacent portion of the perimeter. This, as seen in FIG. 15, tends to produce a ring or tube of leafed flakes **26** near the periphery of the filament **25** and substantially concentric therewith, the flakes assuming a position substantially parallel to their adjacent portion of the periphery or surface of the filament.

Flakes of metal, say of aluminum, because of their method of manufacture, are not always truly flat. They may be of various cross section, longitudinally and transversely, as shown by way of example for the three flakes **39** in FIG. 14. Accordingly, in order to reduce as much as possible, the effect of the flakes in cutting down the strength of the filament and in interfering with proper leafing, such flakes are flattened by subjecting them to pressure, as by passing a roller over them before incorporating them in softened plastic.

In FIG. 12, a portion of heat reflective fabric **30** is shown attached, such as by stitches **32**, to outer fabric **31**, such as woolen cloth, which forms part of an overcoat or suit. In FIG. 13, the heat reflective fabric **30** is used as an interlining between the outer woolen cloth **31** and an ordinary lining **33**.

FIG. 5 shows a synthetic filament **34** which is provided with a reflective coating **35** comprising a synthetic in which are incorporated metallic flakes **17**. Filament **34** is of one of the plastics noted hereinbefore but without flakes incorporated therein. Filament **34** is coated with a synthetic coating **35** having flakes **17** therein by running the filament through an apparatus, by way of example, as shown in the drawing of my Patent No. 2,357,851. Synthetic coating **35** is of one of the plastics noted hereinbefore. Coated filaments were also described in my abandoned application Serial No. 518,109 filed January 13, 1944. The filament shown in FIG. 5, has already been reduced in cross section by elongation. The filament **34** is run through the synthetic and flake mixture **6** of the patent, when it is of a relative size as shown in FIG. 1 compared with that of FIG. 2. That is filament **34**, when it is of the larger size before elongation is run through the mixture **6** as shown in the patent for getting its coating. Filament **34** is then reduced in cross section by being elongated, as was explained for filament **16** in FIG. 2. Elongating filament **34** causes flakes **17** in coating **35**, which is simultaneously elongated, to become oriented, leafed and parallel to the outer surface as was explained for filament **16** in FIG. 2. After coated filament **34** is woven into a fabric as in FIG. 7 it can be calendered as in FIGS. 3 and 8. Finally the fabric can be buffed and burnished as in FIG. 9. Then coated filament **34** will appear as in FIG. 5. The dotted line shows the extent of filament **34** before being buffed. Instead of encasing a monofilament **34**, coating **35** could be used to cover a yarn or thread formed of unstretched synthetic filaments, in which case, for the purpose of illustration, the monofilament **34** can be considered to be such yarn or thread.

Coating **35** can be applied to finished yarn or thread of natural fibers such as wool, cotton, silk etc. In this case very little stretching is feasible, except in those types of yarn which are specially spun to be stretchable. Where stretching is not feasible with natural yarn and thread, coating **35** is only flattened, buffed and burnished as in FIG. 5. Further reduction of the coating can be effected by using a suitable solvent if desired. Where the yarn is stretchable, it can be elongated as was the synthetic filament in FIG. 5, after which it can be flattened and buffed.

The preferred weave for a reflective layer is one in which my filaments, fabric elements, yarn or thread, are woven into a fabric to produce a satin weave. This produces a smooth fabric. In a satin weave, the weft or pick threads are only crossed over occasionally by the warp threads or vice versa. A more complete description of the satin weave can be found in the magazine "Silk" volume 18, January 1925, pages 47–49 and volume 19, February 1925, pages 37 and 38.

For the purpose of describing this invention and in the appended claims, the term "fabric" is intended where consistent with the context, to have a meaning which includes woven, knitted, knotted, netted, felt or wadded fabric.

An ornamental effect can be produced by having some of the filaments or fabric elements provided with flakes of different material from the others. For example some of the filaments or fabric elements could have copper flakes and others could have aluminum flakes. Another way to produce an ornamental fabric is to have the plastic of the filaments or threads all dyed with the same color or different colors for different filaments. The dyes can be in the plastic before spinning or coating. As noted in the Taylor and Edwards paper referred to above, coloring with a dye has little adverse effect on heat reflectivity but pigment does because of the presence of the pigment particles.

Anodic finishes, electropolishing, electroplating and many other finishes well known to the art can be applied to the metallic flakes or the foil from which they are made to produce various ornamental effects in a fabric with fabric elements having said flakes. The oxide coating on the flakes in some of said finishes, however, will have a tendency to reduce reflectivity.

I claim:

A heat reflective spun filament for use in a heat reflective fabric, comprising a plastic, suitable for use in such a fabric, having incorporated therein heat reflective flakes in sufficient quantity to render the filament capable of being substantially heat reflective, a substantially greater concentration of flakes being near the surface of the filament than elsewhere in the filament, the flakes of the concentration being substantially leafed and having their flats substantially parallel to the adjacent surface of the filament, being close thereto and concentrated as a result of elongation of the filament after spinning.

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