Jan. 12, 1965 D. W. GASTON 3,164,947

CORDAGE AND METHODS OF MANUFACTURE THEREOF

Filed Feb. 28, 1963

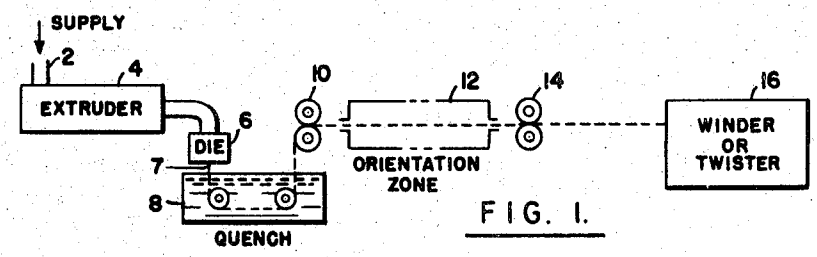

FIG. 1.

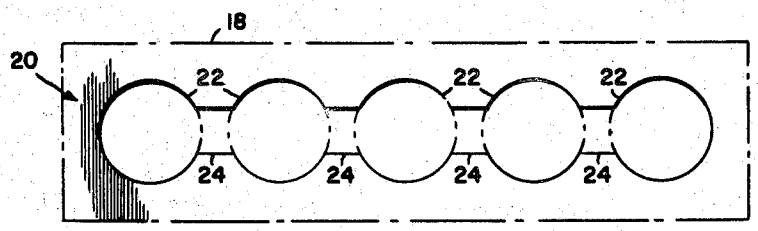

FIG. 2.

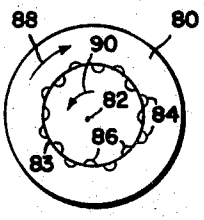

FIG. 9.

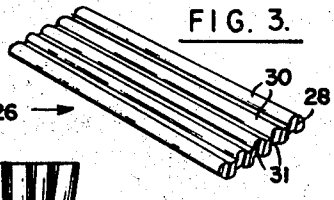

FIG. 3.

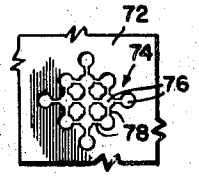

FIG. 8.

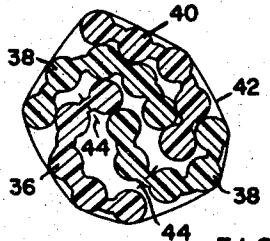

FIG. 5.

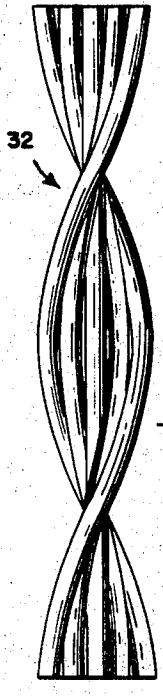

FIG. 4.

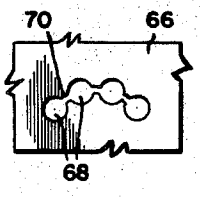

FIG. 7.

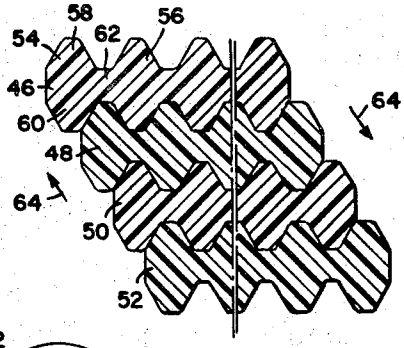

FIG. 6.

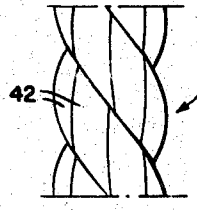

FIG. 10.

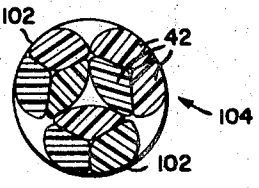

FIG. 11.

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Patented Jan. 12, 19(

3,164,947

CORDAGE AND METHODS OF MANUFACTURE THEREOF

Dexter W. Gaston, Delanco, N.J., assignor to Wall Rope Works, Inc., Beverly, N.J., a corporation of New Jersey

Filed Feb. 28, 1963, Ser. No. 261,658
24 Claims. (Cl. 57—140)

This invention relates to cordage and methods of manufacture thereof and has particular reference to the manufacture of rope or other cordage from extruded plastics.

As will appear, the invention basically relates to yarn formation, and yarns provided in accordance therewith may be associated in various ways for the formation of cordage. For consistency of description, primary reference will be made to the formation of twisted rope as the end product. But it will become evident that the yarns produced in accordance with the invention are equally applicable to braided or plaited rope, cable or the like, and it will therefore be understood that the invention is not limited to twisted rope.

The conventional practice in the formation of twisted ropes from synthetic plastic material involves the drawing of filaments, the twisting of the filaments into yarns, commonly referred to as threads or singles yarns, the twisting of these yarns to form what are known as plied yarns, ply yarns, or, simply plies, the formation of these plied yarns into strands, generally involving the formation of concentric twisted layers of the plied yarn, and finally the laying, with twisting, of the strands into rope. The ropes, in turn, may be laid together to form cables. Variants of the foregoing are made involving, for example, the twisting of plied yarns into cords which are in turn formed into strands; or yarns may be plaited to form strands; or plaited yarns may be formed into cords, in turn plaited or braided to form strands, or strands, formed of twisted yarns may be plaited to form ropes, etc.

The major difficulties in the making of rope from synthetic plastic materials arise in the production and handling of the filaments. Extrusion of the conventional 6 and 12 mil monofilaments is a very critical process entailing precise equipment and controls and a great amount of skill. The fabrication of these monofilaments into plied yarn is expensive and involves low productivity because of the small deniers and the high twist necessarily involved.

In accordance with the invention disclosed and claimed in Stratford application, Serial No. 261,659 filed February 28, 1963, ribbons, using this term in a broad sense as will hereafter appear, are extruded, the ribbons taking the form of filaments of different or similar shapes which are continuously or intermittently interconnected by reduced thickness bridges. Through the formation and use of these ribbons numerous advantages are obtained which may be briefly referred to as follows:

The sensitivity of the extrusion process is greatly reduced due to the fact that the cross-sectional areas of the extrusion openings in the dies are greatly enlarged avoiding difficulties of clogging and the like.

Another aspect of reduction of sensitivity of the extrusion process is involved in the possibility of drawing contaminated, substandard or reprocessed materials at draw ratios as great as 12 to 1 in spite of the presence of foreign particles creating points of stress concentration, the foregoing being due to the large deniers of the ribbons.

Plying operations are eliminated together with the overtwist involved in making yarn, thereby greatly reducing the throwing costs. In fact, the ribbons may be put directly into the strands of a rope, cable, braid or plait, totally eliminating yarn and ply making operations.

Universal winding of the ribbons may immediat follow the extrusion operation. The improvement packaging thus achieved permits the maintenance of ventory between extrusion and yarn making.

The formed ribbons may be fully locking or se locking and have advantageous winding characteristics contrasted with filaments of circular cross-sections.

The use of ribbons in accordance with the inventi reduces yarn or strand twist, or both, depending on r bon shape and the final desired rope. The advantage reduction of twist will be evident when it is consider that for a given load applied to a final product, the ro the existence of twist increases the lengthwise stress the filaments as an increasing function of the amount twist. Theoretically, for the attainment of maxim strength filaments should be extending in the direction the applied force, i.e., they should be untwisted a should lie parallel to each other; but twist is necess from a practical standpoint to form a compact structi which will withstand wear and prevent separation of individual filaments which would cause them to be dividually broken in use, permit snagging, and per them to twist on themselves with resultant breakage. accordance with the present invention, the amount twist may be greatly reduced, thus providing a better proach to the theoretically desirable condition of fi ments in respect to the direction of applied load.

Because of the formation of ribbons as hereafter m fully described, they exert wedge-like action in stra preventing relative movement and giving rise to h resistance to hockling.

The reduced thickness bridges of the ribbons prov excellent reservoirs to hold lubricants permitting relat movements of the components of the structure.

Because of the large deniers involved, yarns or stra may be twisted directly from the ribbons as they p from the extruding devices, this being because of the l twist involved.

The foregoing advantages are involved in said St ford application and matters pertaining thereto claimed in said application. The present invention lates to further improvements over the prior art wh may be summarized as follows:

Because of the large deniers of ribbons which may used, lubricants and other materials may be incorpora in the plastic as extruded. Internal lubrication parti larly may be thus achieved as is highly desirable in vi of the fact that in use the elements of a rope must nec sarily move relatively to each other and adequate ex nal lubrication has obvious disadvantages.

Fillers may also be incorporated in the plastic m rial to provide special properties such as lubrication avoid sticking on bitts, etc., achievement of desired gre or less density, securing of luminous or reflecting pr erties, fire resistance, and others. The use of mi resins is also made possible.

The general objects of the invention are concer with the attainment of the foregoing and other adv tageous results, and these objects and others will beco more fully apparent from consideration of the follow description, read in conjunction with the accompany drawing, in which:

FIGURE 1 is a diagram illustrative of the extrud and associated operations which may be involved accordance with the invention;

FIGURE 2 is a face view of a portion of a typ extrusion die;

FIGURE 3 is a perspectve view showing the form a ribbon produced by the type of die shown in FIGURE

FIGURE 4 is an elevation showing the helicoidal fo taken by the ribbon of FIGURE 3 when partially twist a single ribbon being shown for illustration though,

ll appear, in general a plurality of ribbons will be isted together;

FIGURE 5 is a cross-section of a yarn provided by twisting of four ribbons of the type shown in FIGRE 3;

FIGURE 6 is a diagrammatic section of an alternative e of yarn provided by the association of four ribbons ving special interlocking characteristics;

FIGURE 7 is a fragmentary view showing an alterative form of die in which a ribbon of curved cross-tion is formed;

FIGURE 8 is a diagrammatic view of an alternative m of die which may be used in accordance with the vention for the formation of a ribbon;

FIGURE 9 is a view similar to FIGURE 8 but show another form of die;

FIGURE 10 is a fragmentary elevation of a strand vided in accordance with the invention for the formation of a rope; and

FIGURE 11 is a transverse section of a rope formed m strands of the type illustrated in FIGURE 9.

The invention is generally applicable to the formation cordage from a great variety of extrudable materials ich may be handled, so far as extrusion is concerned, accordance with the individual known procedures applile to them. Such extrudable materials are polypylenes, polyethylenes, polyamides, polyesters, polyyl chlorides, polyvinylidene chlorides, polyurethanes, lyallomers, polycarbonates, acetyl resins, Teflon, or lers. Any of these, including the various forms thereof, mixtures thereof may be supplied in conventional shion through a supply conduit 2 of a conventional truder 4 which delivers them to a die indicated at 6. nerally speaking, such an extruder includes heating ans and an advancing screw to provide the plastic to die in molten condition. Various materials may be corporated in the plastic for special purposes. Graphite, estos, or the like may be incorporated for lubrication rposes; if it is desired to provide a heavy rope which ll sink in water, a weighting material such as barium lphate or barium stannate may be incorporated, these o acting as lubricants. Modifying agents such as crossking material may also be incorporated to secure sired physical properties of the rope. The invention, wever, is not concerned with the chemical aspects of extruded plastic, though it is concerned with added terials which will be discussed more fully hereafter, d it will be understood that, in general, any extrudable mposition may be used which will produce satisfactory pe or other cordage for its intended purposes by reason tensile and other properties.

Following the extrusion from the die 6, the plastic terial is subjected to other conventional process. For ample, the extruded ribbon or ribbons indicated at 7 ss with desired drawing while in molten or soft conion (which reduces cross-section) into a quench bath wherein the molten or semi-molten plastic is cooled effect solidification. While a gap is illustrated beeen the die and the surface of the liquid (usually ter or oil) in the quench tank, it may be desirable in case of various plastics to extrude directly into the enching liquid. From the quench tank the ribbon or bons, now solidified, pass through relatively slowly erating draw-off rollers 10 and thence through an entation zone 12 and through faster operating rollers . The orientation zone is generally a heating zone volving infra-red, dielectric, microwave or induction ating or passage through an oil or similar heated bath. e bath may provide an external lubricant for the prodt. During this passage elongation is produced, suitle for the particular plastic in accordance with known ocedures, by reason of the differential speed of the llers at 10 and 14. As is known, this procedure inases the ultimate tensile strength of plastics of the e here involved. Following the rollers 14, the ribbon ribbons pass to winding mechanism indicated at 16. In view of the fact that ribbons are produced, the winder may be of universal type to provide packages which may be stored as inventory.

Instead of a winder at 16, however, a twisting device may be provided for twisting a plurality of ribbons together to form a yarn or strand which may, in turn, be wound by universal winding to provide packaging. It may be noted however that in contrast with a procedure involving the winding of filaments on beams, twisting of the ribbons into yarns or strands may be directly effected as just indicated. This is made practical by the fact that while the ribbons emerge from the rollers 14 at a high linear rate, the twisting necessary to form yarns or strands is relatively small so that the twisting devices can be operated at practical speeds. Twisting of the usual monofilaments at this point is not practical because their linear speed of emergence is so high that the twisting devices, to secure the high amount of twist necessary would be obliged to operate at extreme and impractical speeds, or, alternatively, would require slowing down of the extrusion process.

Reference may now be made to FIGURE 2 which indicates at 18 the die plate of the die 6. As will be evident, this may contain a large number of openings to produce a number of ribbons corresponding thereto; but since these openings are duplicates of each other, only one opening 20 in the die plate is illustrated in FIGURE 2. This opening, as shown, comprises what are essentially circular openings 22 joined by connecting slots 24. For convenience of reference, the portions of the plastic coming from the circular portions of the openings 22 (or other enlargements as described hereafter) will be referred to as filaments, while those portions extruded from the connecting slots 24 will be referred to as bridges. The number of filament-forming openings 22 may be of any desired number, and it has been found convenient to use arrangements producing in a ribbon 4 to 11 or more filaments. The diameters of the circular openings 22 may, practically, range from about 0.010 inch to 0.050 inch, more or less. Draw ratios in the orientation zone which are practical may be around 9 to 1, meaning that the final cross-sectional area of the formed ribbon is correspondingly reduced from that approaching rollers 10, this being substantially less than the cross-section of the die opening. The draw ratio may, however, be as great as 12 or more, depending on the material. While the dimensions of the individual filament openings are not large, the complete cross-sectional area of the opening 20 is large, and consequently stoppage of flow and necessity of cleaning are much reduced. Even the constricted portions of the opening at 24 are effectively maintained clear by the abutting flow through the larger portion of the opening.

A portion of the ribbon formed by the use of the described die is illustrated in FIGURE 3 at 26. The cross-section 28 is geometrically similar to the die opening, but reduced in dimensions in view of the draw effected between the die and the first roller in the quench bath (so that the cross-section of the ribbon as it solidifies may be considerably less than the cross-section of the opening in the die) and in view of the draw effected in the orientation zone 12 by the differential speed of the rollers 10 and 14. The filaments are indicated at 30 and the bridges at 31.

At this point consideration may be given to the significance of the ribbon. If individual filaments were drawn in accordance with conventional practice, a group of them would not be usable without their association or compacting into a singles yarn by twisting, the twisting being essential to hold them together to avoid snagging, disassociation, or individual breakage. Furthermore, a high twist of monofilaments would be required for this purpose. In the case of the ribbon 26, however, they are associated, and integrally so, as a group, and twisting of this group as such is unnecessary. A plurality of ribbons may, therefore, be twisted together to form what is the

equivalent of a plied yarn. In that case the twist is very much less, and as noted above, the twisting together of ribbons may be effected at reasonable speeds as the ribbons emerge from the rollers **14**.

FIGURE 4 shows, disassociated from other ribbons, the form taken by a single ribbon when twisted into a yarn, though curvature is here not indicated. The twisted ribbon, **32**, has a generally helicoidal form. The illustration is primarily to explain how flexibility is secured. The ribbon in its original flat condition as illustrated in FIGURE 3 would, of course, have flexibility in a direction transverse to its width dimension comparable to the flexibility of its individual filaments, but would not be flexible at right angles to this direction. However, as will be evident from FIGURE 4, when twisted it has, from a macroscopic standpoint, flexibility in all directions. This flexibility is of the same order as that of a twisted singles yarn of the same number of filaments; but it may be made greater or less, depending upon the particular die design and resultant product cross-section by varying the width-to-thickness dimensions of the ribbon or the shapes and dimensions of the bridge and/or filament sections, resulting from the geometric configuration of the die opening. There is still another matter of significance evident from FIGURE 4: the filaments in the twisted ribbon have a lead which is substantially greater than they would have if adequately twisted into a singles yarn. This represents better conformity to the desirable condition of extension of filaments as far as possible in the line of applied tension.

FIGURE 5 shows a cross-section of a yarn provided by the twisting together of four ribbons **34**, **36**, **38** and **40**, each being of the type shown at **26** in FIGURE 3. In such twisting of the ribbons together to form the yarn **42**, they will, in general, assume curved cross-sections as indicated. Even further curvature may be produced in the compacting resulting from twisting, FIGURE 5 being illustrative of the effect of twisting to a less than completely tight condition. As will be evident from this figure, the ribbons are to a considerable extent interlocked by entry of their various filaments into the hollows between other filaments. In other words, they are not free to slide laterally with respect to each other. This is a desirable condition which is effective in promotion resistance to hockling.

Another situation of significance is also indicated in FIGURE 5. While the plastics suitable for rope making are more or less flexible and elastic, they do have a degree of rigidity which will, in some cases, particularly if polypropylene is used, and also in the case of polyethylene, cause the ribbons to resist transverse curvature to small radii. Accordingly, on twisting and compacting, some of the bridges between the filaments may be stressed to a condition producing breakage at surfaces such as indicated at **44**. This, however, is not disadvantageous. Such breakages will only locally separate pairs of the filaments in the ribbon. They may thus become only intermittently connected, but since the breaks will be irregularly distributed throughout the ribbons, there will still remain the characteristic that the ribbons represent groups of filaments adequately connected to provide units which are equivalent to, but with their own advantages, twisted singles yarns. It will be readily seen that when breaks do occur locally, the groups of filaments on opposite sides of the breaks will generally have stresses relieved so that further breakages in a ribbon at a given cross-section are not likely to occur.

It may be noted that the filaments of a ribbon need not all be of the same size or shape; for example, large and small filaments may alternate across the width of a ribbon.

If it is desired to provide yarns by association of ribbon in a highly compact structure, the cross-sections of the ribbon may be desirably modified from that heretofore described by adopting the ribbons indicated, somewhat conventionalized, in FIGURE 6. In this figure the fou associated ribbons are indicated at **46**, **48**, **50** and **5** Each filament here comprises the central rectangular po tion **54** and trapezoidal portions **58** and **60** involving th 60° angular relationship illustrated. The bridges **62** a geometrically chosen so that, in the ideal condition, th ribbons may fit tightly together as illustrated. It will b evident that this represents in a minimum cross-section area a maximum amount of plastic, with substanti elimination of such inherent openings as must occur i a bundle of cylindrical elements. Rounding of corne will, of course, occur both in the extrusion from the di the drawing before solidification, and later in the drawin of the ribbon. But there is a close and significant a proach to what would be ideal: a yarn which had a solid filled cross-section and nevertheless flexibility. Of cours the ideal exhibited in FIGURE 6 will not ordinarily b achievable since difficulty would be encountered in pr ducing the complementary interlockings as shown. B they will occur to a sufficient extent if the ribbons are fe parallel and in engagement with each other to produc considerable compacting of the yarn. The various ribbo are nevertheless free to move lengthwise with respect t each other, and when twisting occurs as indicated by th arrows **64**, there will be achieved the flexibility of th generally helicoidal ribbon configuration as was describe in reference to FIGURE 4.

The ribbons as formed need not be flat, and FIGUR 7 illustrates a die plate **66** provided with an extende opening in which circular openings arranged in an arc a circle are interconnected by bridge passages **70**. R turning to FIGURE 5, it will be evident that the curve ribbons produced by the die plate **66** could be associate and twisted without such stressing as might, in the cas of a similar flat ribbon, result in breakage of the bridge Many other ribbon configurations may obviously b adopted with substantially equivalent results. In fact, ribbon might be extruded closed upon itself to form tube of bridged filaments, which tube in use, and due t twisting, might be flattened to bring its opposite sides t gether with the filaments of the sides interlocking. Suc a flattened tubular ribbon may, of course, be direct extruded.

There may also be extruded a ribbon having a cros sectional area with a circumscribing outline of conside able extent in two dimensions as by the use of a die 7 having an opening **74** providing filament-forming openin **76** and bridge-forming openings **78**, as shown in FIGUR 8. A ribbon thus formed will, on twisting, compact in a cross-section with abutting filaments.

It will now be understood that the term "ribbon" used herein has a broad connotation of indicating fil ments which are joined continuously or intermittently exemplified by the foregoing and also by what will no be described with reference to FIGURE 9.

As described heretofore, the filaments of a ribbon we continuously connected along their lengths by bridges, least as originally formed. It was also pointed out th under compacting stresses these bridges might be inte mittently broken, nevertheless maintaining the assemb of filaments into ribbon units. It is, however, quite u necessary to have the filaments connected to each oth except at intermittent quite limited spots, so long as t connections are sufficient to prevent such substantial se arations of the filaments as might lead to snagging. Wh the ribbons are twisted together in a yarn or strand, ev though the twist is relatively loose, there is a furth contribution to compacting, so that the connections b tween the ribbons may be relatively sparse. FIGURE illustrates the formation of a ribbon in which filame interconnections are minimized.

The die illustrated in FIGURE 9 comprises outer a inner concentric members **80** and **82** having bearing su faces at **83**. The inner surface of the outer member provided with outwardly extending openings **84** while t outer surface of the inner member is provided with i

dly extending openings **86**. If the members are rela-
ly rotated as indicated by the arrows **88** and **90**, fila-
ts will be extruded through the openings **84** and **86**
:h will meet or intersect intermittently to provide
ges. What is formed, of course, is initially a cylin-
al mesh which, on being drawn, will collapse to a
on in which the component filaments will extend
thwise. This mode of formation of a mesh is known,
hown in Mercert Patent 2,919,467.

he produced ribbon may be twisted after formation
drawing; but twist may also be effected by suitable
tive and absolute rotations of the die members, for
nple, both may be rotated in the same direction but
ifferent speeds so that relative rotation will determine,
onection with the linear rate of extrusion, the fre-
ıcy of occurrence of bridges along the length of the
on while the mean rate of rotation will determine the
t.

he last described extrusion also exemplifies another
:edure for extrusion which may be more generally
owed: as the plastic material leaves a die it is liquid
emi-liquid and consequently if filaments are extruded
ıugh non-bridged openings and immediately brought
:ther so as to touch each other they will cohere to pro-
: the desired bridging.

ibbons produced as described with reference to FIG-
E 9 will obviously have high flexibility to provide
/ed cross-section and will also provide effective inter-
:ing action.

eginning with the yarns, the formation of the rope is
ventional, and may be carried out as usual through
:ting, braiding and/or plaiting operations.

ıs is usual, it is desirable to provide opposite twisting
he steps of forming yarn from the ribbon, strands
n the yarns, and rope from the strands, though this
rnation may be varied if desired. The various opera-
ıs are carried out in conventional fashion. When flat
)ons are used, as shown in FIGURE 3, they may be
wisted when assembled and fed to the twister to form
ı, i.e., being untwisted prior to this yarn formation,
procedure differing, thus, from the twisting of fila-
ıts in the usual formation of singles yarns prior to
:mbly by reverse twisting into plied yarns. But if the
)ons are not flat (e.g., as produced by the dies of
)URES 8 and 9), they may or may not be twisted
themselves before being twisted into yarns or strands.
)ne of the major advantages of the invention is that
/ very few ribbon extruding devices need be provided
ı rope making plant to provide a great range of ropes.
fact, ribbons of only three different deniers need be
vided for ropes ranging from ¼ inch to 9 inches. For
nple, for ropes in the range from ¼ inch to ⅞
ı in nominal diameter, only 9,000 denier ribbons
d be produced. In this range the ribbons per yarn
/ range from 2 to 6, and the yarns per strand from
) 8 to make three strand rope. For the range of ropes
n 3 inches to 6 inches (nominal circumference) rib-
s of 27,000 denier may be provided. In this range the
)ons per yarn may be 7 to 9, while the yarns per strand
/ range from 3 to 9. For 6½ inch to 9 inch ropes,
extruded ribbons may have a denier of 52,000. The
)ons per yarn will then be 8 or 9, and the yarns per
nd 6 to 10.

ıs specific examples for three strand ropes, the fol-
ing may be cited:

'or a ¼ inch rope, two 9,000 denier ribbons may
n each yarn, and two yarns may form each strand,
resulting strand having a denier of 36,000.

'or a ⅜ inch rope, four ribbons, each of 9,000 denier,
/ form a yarn, three yarns may form a strand, and
:e strands a rope. FIGURES 3, 4, 5, 10 and 11 may
considered as illustrating specifically this rope and its
)ponents and steps in its formation.

'or a ⅞ inch rope, six 9,000 denier ribbons may form
h yarn, and eight yarns each strand.

For a 5 inch rope nine 27,000 denier ribbons may form each yarn, and six yarns may form each strand.

For a nine inch rope, nine 52,000 denier ribbons may form each yarn, and ten yarns may form each strand.

It is considered that for the practical attainment of the objectives of this invention the denier of ribbon used should not be less than 500, and desirably should be 3,000 or more, but may range upwardly to 60,000 or more, the upper limit depending upon the flexibility of the plastic used and the thickness of the ribbon; i.e., if the ribbon is thin, though wide, flexibility may be acceptable.

While the strands may be of layered formation, if desired, and are highly resistant to hockling because of the structural characteristics of the assembly as heretofore described, the additional complexities of forming layered strands may be avoided by twisting yarns of the type described into strands without layering. Also, ribbons may be twisted into strands without intermediate formation of yarns.

The elimination of layering has another very important advantage in that by this elimination there is greater translation of material and yarn strengths into finished rope strengths. As ordinarily practiced layering involves greatly different contributions of yarns in the various layers to rope strength, whereas if layering is not used more uniform contributions of the yarns to rope strength are attained.

For purposes of illustration, FIGURE 10 shows diagrammatically a strand **102** formed of twisted yarns **42**, while FIGURE 11 shows a section of a rope **104** laid from the strands **102**. The yarns **42** are, for illustration, shown in solid sections, but it will be understood they have component ribbons as shown in FIGURE 5.

The ribbons which are associated to form the cordage component, i.e., yarn or strand, need not have the same composition, but may differ from each other to secure desired properties; for example, to cite a single instance, a yarn or strand may be formed for mixed ribbons some of which may be of polyethylene and others of polypropylene to secure the improved property of non-sticking on bitts. Various advantageous compositions of the ribbons will now be discussed, and it will be understood that when special compositions are used these may provide only some of the associate ribbons, though all of the ribbons may be of the same composition.

It has been found particularly advantageous to provide ribbons which, to the extent of their plastic content, comprise mixtures which are largely or entirely of polypropylene and polyethylene. Highly effective are compositions containing polypropylene and polyethylene in approximately equal proportions. When ribbons of such a composition are extruded and radiant heat is used in the orientation, unusually high strengths are secured.

Also usable are mixtures of polyolefins (such as polypropylene or polyethylene or mixtures thereof) with polyamides, polyesters, or the like, as may be desirable to secure various properties as may be desired.

The use of various solid fillers is highly advantageous. Heretofore when small denier filaments were extruded it was impractical to incorporate solid materials except in very minor proportions (such as pigments, which may be used in very small percentages) because the solid materials produced great difficulties in maintaining smooth flow through the dies. This was the case even when the solid materials were very fine because some agglomeration would occur in their suspension in the molten plastic carrier and this would particularly show up as high stress points in the filaments making them quite weak, as well as causing clogging of the small die openings. Attempts to use other than very finely pulverized materials were completely futile, excluding the possible uses of fibrous materials, glass beads, or the like. However, with the extrusion of high denier ribbons as heretofore described, the denier, of course, referring to the final ribbon, the overall die openings become sufficiently large

to permit the very free inclusion of solid materials of many types. This is true even though the individual filament openings may themselves be small since the action seems to depend largely on the total area of the opening rather than on the matter of local restriction. While with finely powdered solid materials as fillers successful operation may be achieved in producing ribbons of deniers as low as 500, it is most desirable to produce ribbons of deniers upwardly of 3,000, and if fibrous materials or glass beads or the like are to be incorporated, ribbons of even greater deniers should desirably be produced. No difficulties are experienced with ribbons of 9,000 denier which, as indicated above, may be used for the production of even the smallest commercial sizes of ropes.

The solid materials are, of course, incorporated in the plastic materials in the molten state of these materials with thorough mixing with conventional apparatus well known in the art, and as the initial material for the present procedures such mixture is provided in the form of small pellets to the extruder.

The solid materials used may be of great variety depending on the desired properties, and in various instances, as will appear, several desirable properties may be secured using the same material or materials.

Consideration may be first given to increasing the specific gravity of the rope material. In many cases the low specific gravities of plastics such as polypropylene and polyethylene are highly advantageous, making for easier handling of ropes and providing ropes for the advantage in some cases of floating on water. But in other instances this is disadvantageous and it is desirable to have ropes which will sink. Thus it sometimes becomes desirable to provide quite heavy ropes. In these cases weighting materials may be used among which may be cited barium sulphate, aluminum silicates (or pulverized rocks in general) and fibrous materials such as asbestos and glass fibers. A material such as barium sulphate is highly effective and may be readily incorporated in large quantities up to around 50% or more by weight of the final composition. This, of course, represents a relatively lower volume as compared with the plastic composition such as polypropylene or polyethylene in which it is incorporated. The fibrous materials such as asbestos and glass fibers also impart flame resistance to the product.

As lubricants there may be incorporated barium stearate or other lubricating materials such as other metallic stearates or salts of other fat acids, graphite, molybdenum sulphide, aluminum sulphide, waxes, or the like. The use of such materials provides lubrication for the relative lengthwise movements of the rope elements, making unnecessary the use of external lubricants such as oils or greases which have been commonly provided in connection with cordage. Sticking on bitts or other elements about which a rope is trained is also avoided by the use of these incorporated lubricating materials.

In some cases electrical conductivity of a plastic rope or cable is desired to avoid the collection of static charges, to provide grounding, or even to transmit signals. Conductivity may be secured by incorporating various forms of carbon or metallic powders.

If, on the other hand, high dielectric properties are deisred, a material such as barium stannate may be used.

While flame retarding may be provided by various materials already mentioned, other flame retardants may be used such as aluminum sulphate, chlorinated paraffin, a tungstate, or the like.

Luminescent properties of various types may be provided. If high reflectivity is desired so that a rope in the dark may become visible by reflecting distant lights, small glass beads may be incorporated in the ribbon-forming material, these being effective particularly if a fairly transparent or translucent plastic is used. Alternatively, phosphorescent materials such as the usual barium sulphide-calcium sulphide mixtures may be used which will glow in the dark after exposure to daylight or artificial lights. Fluorescent materials may also be incorporated to increase visibility by enchancing the effective intensity of incident light.

Another modification of the ribbons may be effected by incorporating in the plastic fed to the extruder foaming or blowing agents which, by the heat of extrusion will in usual fashion liberate gas in the form of small bubbles to increase the bulk of the extruded material with major decrease of density. Ropes provided from ribbon which thus entrain gas bubbles will be very light and may be used as centers for wire cables or the like where high weight rather than strength is required.

While twisted ropes have been primarily considered in the foregoing, it is obvious that yarns or strand provided in accordance with the invention may be used to form braided or plaited ropes and cables, the constructions of which will be conventional except for their origin in ribbons.

It will also be evident that other light cordag may also be provided in accordance with the invention It is accordingly to be understood that the invention i not to be regarded as limited except as required by th following claims.

What is claimed is:

1. Cordage comprising a plurality of strands compactly assembled with each other, each of said strands comprising a plurality of extruded and oriented plastic elements compactly assembled with each other, each of which elements comprises a plurality of continuous filaments at least intermittently integrally joined together with substantial freedom of said filaments for movements relatively to each other, said elements presenting externally to each other irregular surfaces impeding their relative lateral movements, said elements having individual deniers of at least 500, at least some of which plastic elements are formed of a thermoplastic composition and a non plastic solid material substantially uniformly dispersed in said plastic composition.

2. Cordage according to claim 1 in which said non plastic solid material has lubricating qualities.

3. Cordage according to claim 1 in which said non plastic solid material is a weighting material.

4. Cordage according to claim 1 in which said non plastic solid material is fibrous.

5. Cordage comprising a plurality of strands compactly assembled with each other, each of said strands comprising a plurality of extruded and oriented plastic elements compactly assembled with each other, each of which elements comprises a plurality of continuous filaments at least intermittently integrally joined together by bridging portions of less thickness than the filaments, said elements presenting externally to each other irregular surfaces impeding their relative lateral movements, said elements having individual deniers of at least 500, at least some of which plastic elements are formed of a thermoplastic composition and a non-plastic solid material substantially uniformly dispersed in said plastic composition.

6. Cordage according to claim 5 in which said non plastic solid material has lubricating qualities.

7. Cordage according to claim 5 in which said non plastic solid material is a weighting material.

8. Cordage according to claim 5 in which said non plastic solid material is fibrous.

9. Cordage comprising a plurality of strands compactly assembled with each other, each of said strands comprising a plurality of extruded and oriented plastic elements compactly assembled with each other, each said elements being in the form of a ribbon having a width multiple times its thickness and having a denier of at least 500, at least some of which plastic elements are formed of a thermoplastic composition and a non-plastic solid material substantially uniformly dispersed in said plastic composition.

10. Cordage according to claim 9 in which said non plastic solid material has lubricating qualities.

1. Cordage according to claim 9 in which said nontic solid material is a weighting material.
2. Cordage according to claim 9 in which said nontic solid material is fibrous.
3. Cordage comprising a plurality of strands comly assembled with each other, each of said strands prising a plurality of extruded and oriented plastic ients compactly assembled with each other, each of elements being in the form of a ribbon having a width tiple times its thickness and having a denier of at least order of 9000, at least some of which plastic elements formed of a thermoplastic composition and a nontic solid material substantially uniformly dispersed in plastic composition.
4. Cordage according to claim 13 in which said nontic solid material has lubricating qualities.
5. Cordage according to claim 13 in which said nontic solid material is a weighting material.
6. Cordage according to claim 13 in which said nontic solid material is fibrous.
7. Cordage comprising a plurality of strands comtly assembled with each other, each of said strands prising a plurality of extruded and oriented plastic nents compactly assembled with each other, each of elements being in the form of a ribbon having a th multiple times its thickness and having a denier of east 500, at least some of which plastic elements are ned of a thermoplastic composition containing gas stantially uniformly dispersed therein.
8. Cordage comprising a plurality of strands comtly assembled with each other, each of said strands prising a plurality of extruded and oriented plastic nents compactly assembled with each other, each of l elements being in the form of a ribbon having a th multiple times its thickness and having a denier of east the order of 9000, at least some of which plastic nents are formed of a thermoplastic composition coning gas substantially uniformly dispersed therein.
9. Cordage comprising a plurality of strands comtly assembled with each other, each of said strands prising a plurality of extruded and oriented plastic nents compactly assembled with each other, each of l elements being in the form of a ribbon having a width ltiple times its thickness and having a denier of at st 500, at least some of which plastic elements are ned of a thermoplastic mixture comprising primarily stantial amounts of each of polypropylene and polyylene.
10. Cordage comprising a plurality of strands comtly assembled with each other, each of said strands prising a plurality of extruded and oriented plastic nents compactly assembled with each other, each of l elements being in the form of a ribbon having a width ltiple times its thickness and having a denier of at st the order of 9000, at least some of which plastic elents are formed of a thermoplastic mixture comprising primarily substantial amounts of each of polypropylene and polyethylene.
21. Cordage comprising a plurality of strands compactly assembled with each other, each of said strands comprising a plurality of extruded and oriented plastic elements compactly assembled with each other, each of said elements being in the form of a ribbon having a width multiple times its thickness and having a denier of at least 500, at least some of which plastic elements are formed of a thermoplastic mixture comprising primarily approximately equal amounts of polypropylene and polyethylene.
22. Cordage comprising a plurality of strands compactly assembled with each other, each of said strands comprising a plurality of extruded and oriented plastic elements compactly assembled with each other, each of said elements being in the form of a ribbon having a width multiple times its thickness and having a denier of at least the order of 9000, at least some of which plastic elements are formed of a thermoplastic mixture comprising primarily approximately equal amounts of polypropylene and polyethylene.
23. Cordage comprising a plurality of strands compactly assembled with each other, each of said strands comprising a plurality of extruded and oriented plastic elements compactly assembled with each other, each of said elements being in the form of a ribbon having a width multiple times its thickness and having a denier of at least 500, at least some of which plastic elements are formed of a thermoplastic mixture comprising primarily at least one polyolefin and at least one thermoplastic of non-olefinic type.
24. Cordage comprising a plurality of strands compactly assembled with each other, each of said strands comprising a plurality of extruded and oriented plastic elements compactly assembled with each other, each of said elements being in the form of a ribbon having a width multiple times its thickness and having a denier of at least the order of 9000, at least some of which plastic elements are formed of a thermoplastic mixture comprising primarily at least one polyolefin and at least one thermoplastic of non-olefinic type.

References Cited in the file of this patent

UNITED STATES PATENTS

2,382,355	Warren	Aug. 14, 1945
2,385,890	Spanagel	Oct. 2, 1945
2,694,606	Etzkorn	Nov. 16, 1954
2,945,739	Lehmicke	July 19, 1960
2,959,839	Craig	Nov. 15, 1960
2,991,147	Thomas	July 4, 1961
3,015,150	Fior	Jan. 2, 1962
3,039,174	Radow et al.	June 19, 1962

FOREIGN PATENTS

861,114	Great Britain	Feb. 15, 1961