April 25, 1967 W. L. CARRANZA 3,315,454
SYNTHETIC BALING AND TYING TWINES
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Fig. 1.

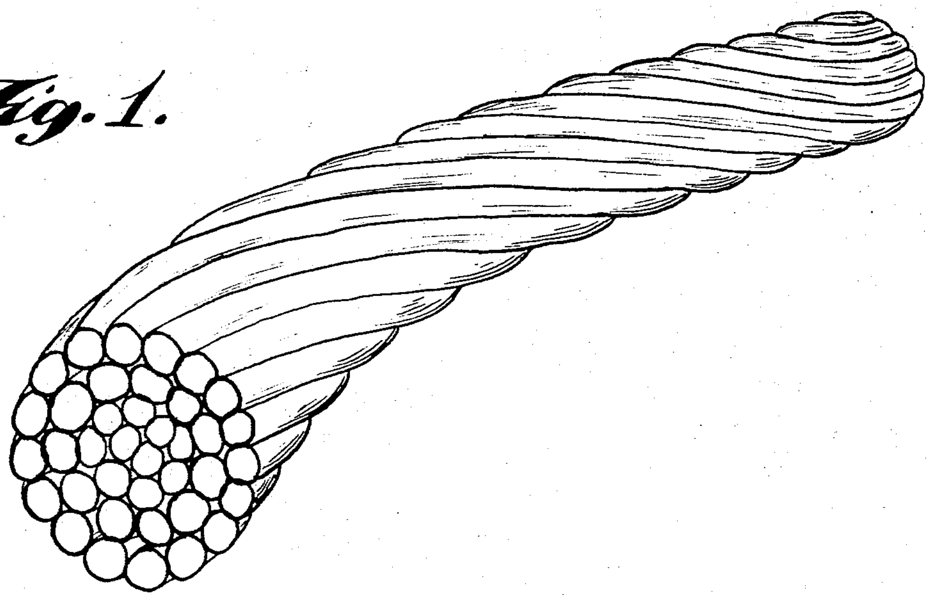
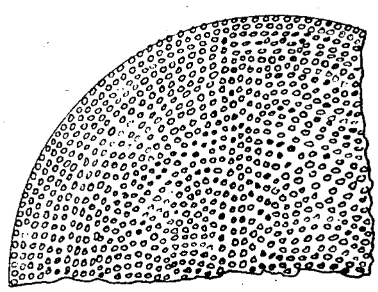


Fig. 2.



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SYNTHETIC BALING AND TYING TWINES

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The present invention relates to twine and more particularly to a synthetic twine suitable for use in automatic knot tying machines such as hay balers and the like. The twine is composed of filaments of synthetic high polymer, preferably polyethylene or polypropylene, which have been impregnated with a gas—for example air—to alter their properties and overcome their natural unsuitability for automatic knot tying.

In agriculture and many businesses, it has now been found uneconomical and undesirable to tie packages by hand. Large packages require several people working together with resultant high labor costs. Even in the case of smaller packages, binding with twine and tying of knots is slow. Unless experienced persons are employed, the twine may not be wrapped properly and the knots will not be consistently tight.

Consequently, a wide variety of machine have been developed which automatically wrap a package with twine, cut the twine and tie a knot. Perhaps the most commonly known are the hay balers which generally tie single loop knots. "Tying machines" are used to tie newspapers, currency, bundles of mail, catalogs, magazines, paper products, tobacco products, meats, laundry, textile goods, leather goods such as soles and insoles, nursery stock such as seedling plants, bushes and small trees, coils of wire and hundreds of other kinds of hard and soft packages. The "tying machines" often are capable of adjusting, sometimes automatically, to different sizes of packages. They may tie several types of knots, single loop, double loop, bow, etc., and can wrap and tie packages at the rate of 15 to 30 per minute. Thus, the terms "tying" twine and "baling" twine as used herein is intended to comprehend twines useful in all of the above types of machine.

For the most part, these machines use twines composed of natural fibers, principally cotton, jute and sisal, a particular twine being selected on a basis of strength and other requirements. For example, cotton twines tend to be soft although not as strong as sisal and would be used when the articles being tied are soft. However, these natural fibers for the most part are available only in certain parts of the world and their supply and price depend on crop conditions, availability of shipping and other factors. Like all natural products, their quality is not uniform. Consequently, there is a genuine need for a twine composed of synthetic material.

Considerable effort has been expended in the search for a suitable synthetic twine. Many types of synthetic fibers have been tested. However, they have been found generally unsatisfactory because they cannot be tied in conventional knots by the above machines. Because of slippery surfaces and other properties, the knots do not remain tied and the twine slips loose. Consequently, synthetic twines have not been widely accepted.

In a previous application, I have described a solution to the problem in which the twine is polyethylene or polypropylene which carries an adhesive and abrasive to increase friction in the appropriate amount and otherwise adapt the twine to automatic knot tying. While that twine is fully satisfactory, I have continued my research in an effort to further reduce costs.

In accordance with the present invention, a twine is made from a synthetic resin, preferably from a polyolefin and more preferably from polyethylene or polypropylene,

which has been impregnated with a controlled amount of gas. In general, gas impregnation may have a tendency to reduce the tensile strength of plastics, and increase their elasticity, but I have found that by limiting the amount of gas to about 35% by volume, sufficient tensile strength remains while the properties of the twine are adapted to automatic knot tying machines.

Surprisingly, the new twine is suited for mechanical knotting even though its surface has not been treated to alter friction characteristics. The reason for such behavior is not completely understood, but it is believed to be related at least in part to changes in the flexibility and compressibility of the twine. Thus, while knot slippage of synthetic twine has always been thought to be caused by the relatively slippery surface of the plastics, it has been found that it is at least partially the result of relative inflexibility and incompressibility.

The invention is illustrated in the drawing in which

FIGURE 1 shows in perspective one form of a twine comprising a plurality of filaments embodying the principles of the invention; and

FIGURE 2 is an enlarged view of a portion of one filament of the twine of FIGURE 1 viewed from the end thereof.

The synthetic resins preferred are polyethylene and polypropylene. The polyethylene used may be a so-called "high density" polyethylene, such as is described in Peters United States Patent No. 2,692,259 or is obtained by the so-called "Ziegler" process. These high-density polyethylenes have extremely good tensile strength. Other types of polyethylene may be used, provided a sufficient number of strands of suitable size are used, to give a satisfactory over-all tensile strength. The polypropylenes include those developed by Natta which were described in the Journal of the American Chemical Society, vol. 77, pages 1708–10 (1955) and have more recently been described in greater detail. These and other suitable thermoplastic polyolefins may be treated with carbon black, anti-oxidant to increase their resistance to light or atmospheric agents, or small amounts of additives which alter somewhat the surface friction coefficient, preferably before the thermoplastic is spun into filaments. It will be understood that the terms polyethylene and polypropylene include also copolymers with each other or different monomers which are similar to polyethylene and polypropylene and are suitable for twine except for the above knot tying difficulties.

The polymer may be impregnated with air or another inert gas prior to or after extrusion or other shaping into the form of filaments, preferably in such manner as to provide, in addition to dissolved gas, small, discrete, connected or isolated vesicles of gas which are substantially uniformly distributed throughout. Suitable methods for making such filaments already are well known to those skilled in the art and form no part of the present invention. However, by way of illustration, such methods may include injecting air or other gas into the polymer while it is in an extruder prior to extrusion as filaments. It also is possible to impregnate the polymer under pressure with a volatile liquid which is gaseous at normal temperatures and allow the liquid to evaporate, say, when the polymer is heated to a temperature where it is partially softened, or "relaxed." In another embodiment, the gas may be supplied by chemical agents which release gas at elevated temperatures.

The amount of gas used should be the maximum. It will vary somewhat among various types and grades of material but, in general, the upper limit is about 30–35%. There is no actual lower limit, since as much as possible should be used, but at least about 5%, preferably at least 10%, should be in the plastic to take advantage of the principles of the invention. Any substance, which is a gas at ordinary temperatures (above about 40°) may be used, the selection depending on the method of introducing it. For example, air, Freons, carbon dioxide, nitrogen, etc. are suitable. The substance should not, of course, attack the polymer.

The twine is composed of a plurality of such filaments which may be twisted together. It will be appreciated that the term "filaments" is used to refer to single elongated bodies of plastic. This term sometimes is used to specify a single integral continuous body of plastic, i.e., a monofilament, as distinguished from threads which have been formed by spinning staple fibers. However, no such limitation is intended since spun filaments and monofilaments are equally useful in the practice of the invention.

In general, the size and structure of the twine will vary in accordance with the kind of tying for which it is intended. However, overall size will be in the range about 6,000 to 28,000 deniers. Tying twins will be in the range 6,000–18,000 deniers and baling twines in the range 19,000 to 28,000 deniers. In certain cases, the baling twines may be used for heavy tying machines, but thick twine of this type will nevertheless be designated baling twine for the purpose of classification. The individual filaments may vary in size from about 65 to 950 deniers, i.e., about 4 to 15 mils, and they may be of the same or different sizes. The filaments may be round, square or have any other round or non-round shape.

The sizes of the filaments and twine will determine the number of filaments. That is, larger numbers of filaments must be used as their diameter is decreased. The total number of filaments should give a tensile strength of 12.5 lbs. or more for tying twines and at least 180 lbs. for baling twines. The filaments may be laid together and, if desired, twisted. In most cases, twisted twines are preferred, but untwisted twines are suitable for some purposes. When the twine is twisted, the degree of twist may vary. However, usually it will not exceed ten turns per inch and preferably it will be less than five turns per inch. Very satisfactory twines have a twist of ½ to ⅔ turn per inch.

In some cases, it may be desirable to pre-assemble the filaments into several small bundles of the same or different sizes and to use these together. The individual bundles may be twisted in the same or opposite directions before they are twisted together.

The individual filaments and/or the twine may be subject to any stretching, shrinking, heating or cooling treatment which does not remove or undesirably alter the gas composition and distribution. For example, the twisted twine may be heat set under sufficient tension to prevent shrinkage, or stretched up to 10%. However, excessive heating to near or above the softening point may lead to an undesirable loss of the gas or to the equally unsatisfactory accumulation of gas in a few large bubbles of irregular size. A mild heat setting of twisted twines is desirable as it tends to fix the twist and compact the structure.

The finished twine may, if desired, be coated with adhe-

sive and abrasive in the manner described, but this is regarded as unncessary for most uses.

The following example illustrates the invention.

Example

A twine was made by twisting together forty polypropylene filaments at about ⅔ turns per inch. Each filament was about 9 mils diameter blown with sufficient air to increase its diameter to about 11.5–12 mils. The twine, which was about 23,000 denier in diameter, was heat set briefly while under sufficient tension to prevent shrinkage. It was subjected to tests in a conventional hay baler and consistently tied tight, non-slipping, single-loop knots.

A similar twine was made using 60 ends of 6 mil filaments blown to about 8–9 mils and twisted ½ turn per inch with satisfactory results.

The invention now having been described by reference to specific embodiments, it will be appreciated that various changes may be made in details of construction and mode of operation without departing from the true scope thereof, as defined in the claims.

What is claimed is:

1. Synthetic twine suitable for forming non-slipping knots in baling, tying and other automatic knot tying machines which comprises a plurality of filaments of a thermoplastic synthetic resin selected from the group consisting of polyethylene and polypropylene, said filaments having a diameter of about 65 to 950 deniers and containing dispersed therein a substance which is a gas at ordinary temperatures in an amount up to about 35% by volume based on the volume of the resin, said twine having a denier in the range about 6,000 to 28,000.

2. Synthetic twine as set forth in claim **1** in which the twine is twisted.

3. Synthetic twine as set forth in claim **2** in which the degree of twist is less than ten turns per inch.

4. Synthetic twine as set forth in claim **3** in which the degree of twist is less than five turns per inch.

5. Synthetic twine as set forth in claim **1** in which the amount of said gas is about 5% to 35% by volume based on the volume of the resin.

6. Synthetic twine as set forth in claim **5** in which the amount of said gas is about 10% to 30% by volume based on the volume of resin.

7. Synthetic twine as set forth in claim **1** in which said resin is polypropylene.

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MERVIN STEIN, *Primary Examiner.*