

United States Patent

Burr

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[54] STRANDING APPARATUS

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[51] Int. Cl. D01h 7/92, D02g 1/02

[58] Field of Search..... 57/34, 34 AT, 51.6, 77.3, 77.4, 57/77.42, 156

[56] References Cited

UNITED STATES PATENTS

3,045,416 7/1962 Ubbelohde..... 57/51.6 x

3,052,079 9/1962 Henning 57/34
3,025,656 3/1962 Cook 57/34
3,434,275 3/1969 Backer et al. 57/34
3,443,370 5/1969 Walls 57/34
2,289,568 7/1942 Bloch 57/140 X

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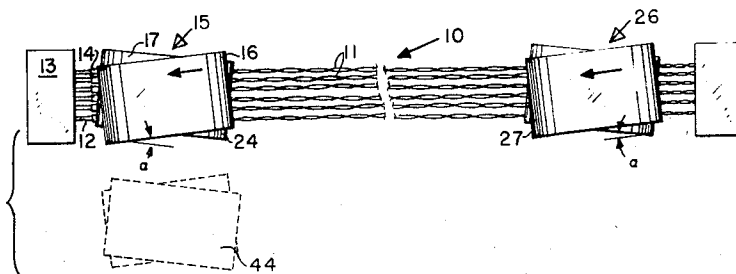
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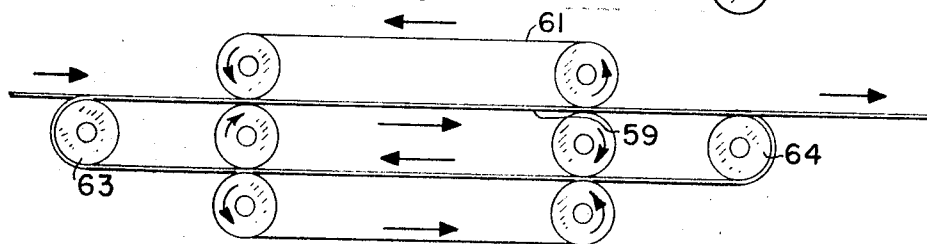
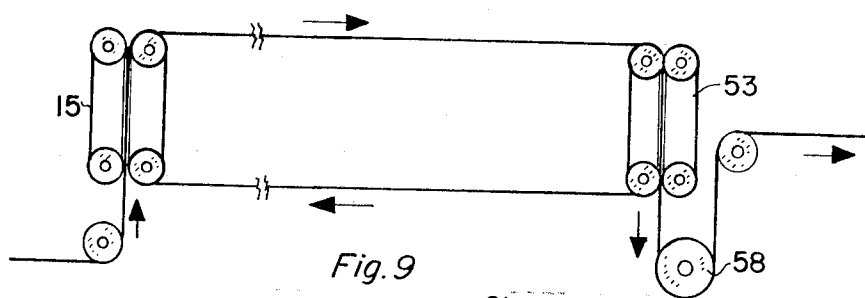
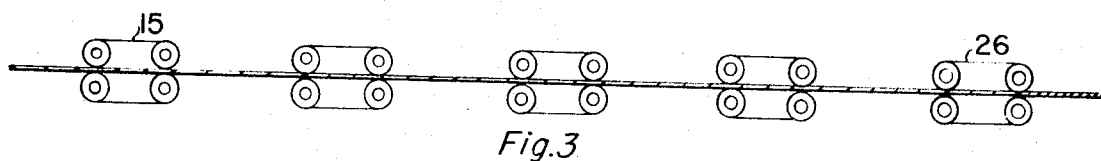
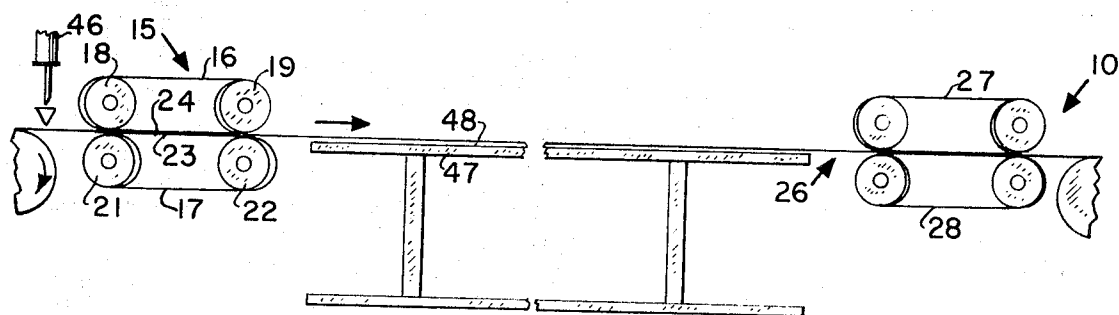
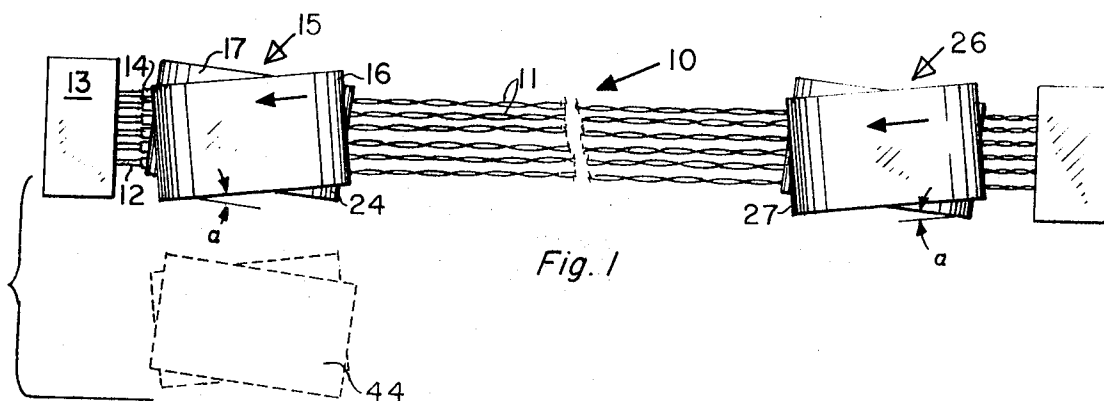
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ABSTRACT

A strand is twisted by passing it between the facing surfaces of two or more pairs of parallel endless bands that are mounted at an acute angle to each other. The band mountings are pivoted periodically to reverse the direction of twist, the period being equal to the time it takes a point on the strand to pass through all the pairs of bands.

19 Claims, 9 Drawing Figures





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HIS AGENT

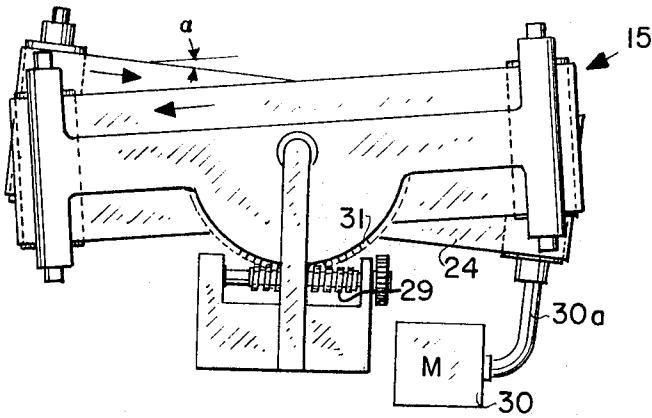


Fig. 6

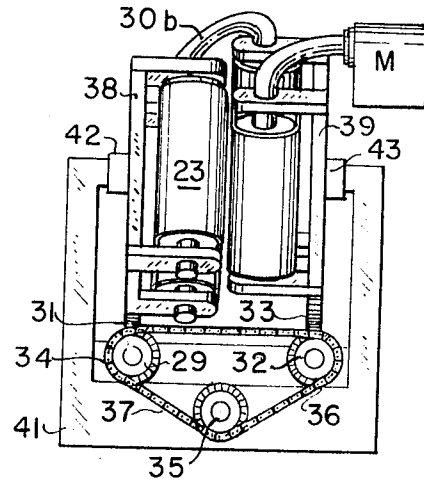


Fig. 7

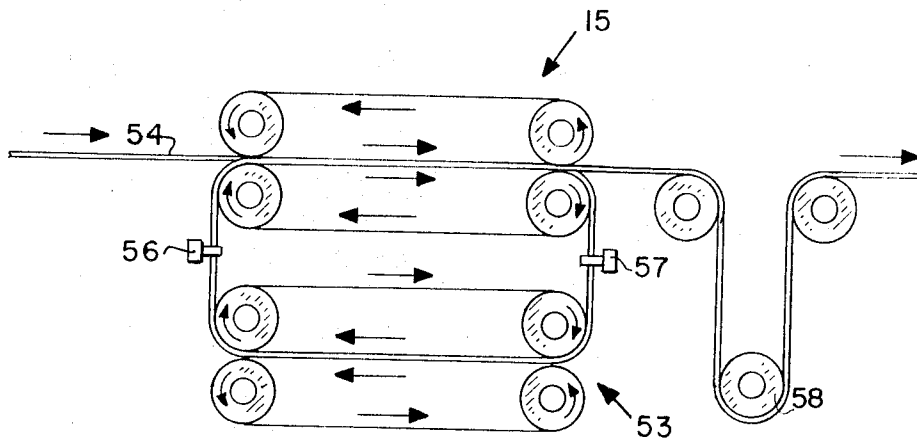


Fig. 4

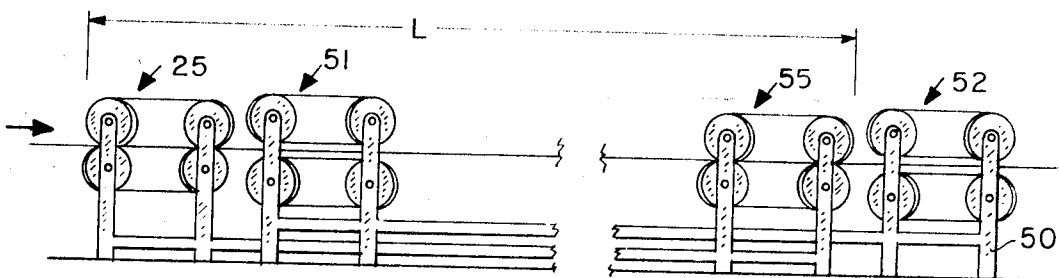


Fig. 8

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STRANDING APPARATUS

BACKGROUND OF THE INVENTION

In Corral et al. U.S. Pat. No. 3,169,360 it was suggested that a reversing twist could be imparted to an advancing strand by periodically reversing the direction of rotation of an accumulator through which the strand was continuously passed. This apparatus has two serious shortcomings: Firstly, an accumulator that is capable of holding a significant supply of strand has considerable mass and a resultant high moment of inertia. High-speed reversals of such massive units require expensive machinery and large power expenditures. Secondly, a practical accumulator necessarily takes the form of grooved sheaves, and, in order to reduce the inertia, it is desirable to minimize the sheave diameters. This results in an undesirable amount of bending and working of the strands. The work hardening of metal telephone conductors by repeated reverse bending is particularly objectionable because of its effect of reducing the electrical conductivity.

Still, advantages of reverse lay, or false twisting remain. These include a simplified apparatus and the fact that the twist can be continuously applied in process without having one end of the strand available, or taking up the strand on a reel.

SUMMARY

I have invented an apparatus for twisting together a plurality of advancing strands comprising means supporting two moving surfaces on opposite sides of the strands and in frictional engagement with them. I further provide means driving the surfaces to move, at their engagement with the strands, at velocities having a first component substantially equal to the velocity of advancing of the strands and components, normal to the first component and opposite in direction to each other, comprising a twisting couple applied to the strands. These moving surfaces may advantageously be comprised on endless bands.

I have invented an apparatus comprising a first pair of parallel endless bands, with a surface of one band adjacent to a facing surface of the other and means that drive both of the bands at equal speeds. My apparatus also comprises a second pair of parallel endless bands, like the first, with means spacing the second pair downstream from the first pair. There are means paying a plurality of strands along a path between the adjacent surfaces of each of the pairs of bands, means mounting the bands comprising each of the pairs to advance along lines forming an acute angle intersected by the path of the strands, and means periodically pivoting the mounting of the bands so as to reverse this angle. The period of reversal advantageously corresponds to the time it takes a point on the strands to advance between the entrance to the first and the exit from the second pair of bands. In certain embodiments of my invention the angle formed by the line of advance of the second pair of bands is smaller than the angle for the first pair, such as one having a tangent of one-half the other.

One embodiment of my invention has the pairs of bands in different planes, with one pair spaced from the other and the strands forming at least one loop around a band from each of the pairs. In this embodiment I prefer the period of reversal of the angles to correspond to the time of advance of a point on the strands around the totality of loops.

In lieu of means for pivoting the bands to change the angle between them I have invented an apparatus comprising means continuously paying a plurality of strands from an upstream to a downstream station, a first pair of endless bands with a surface of one pair parallel to a facing surface of the other and means for driving both of the bands at substantially the same speed along lines forming an acute angle. This apparatus also comprises a second pair of endless bands with a surface of one parallel to a facing surface of the other, this second pair being mounted downstream of, and adjacent to, the first pair, and means for driving the second pair at substantially the same speed, along lines forming an acute angle differing from the first angle. In addition, there are a third pair of endless bands,

with a surface of one parallel to a facing surface of the other, mounted downstream of, and spaced substantially from, the second pair of bands. Means are provided for driving both bands of the third pair at substantially the same speed along lines forming a third acute angle. Finally I have provided a fourth pair of endless bands, a surface of one of which is parallel to a facing surface of the other, mounted downstream of, and adjacent to, the third pair; and means for driving both bands of the fourth pair at substantially the same speed along lines forming a fourth acute angle differing from the third angle. This apparatus also comprises means periodically separating the bands of the first and third pairs while bringing together the bands of the second and fourth pairs, so as to twist the strands by means of the second and fourth pairs; and alternately separating the second and fourth pairs and bringing together the first and third pairs so as to twist the strands by means of the first and third pairs. In a preferred embodiment of this embodiment of my invention the first and third angles are substantially equal while the second and fourth angles are substantially in reverse of the first angle.

I have invented the method of twisting together a plurality of insulated conductors comprising the steps of continuously advancing two endless bands mounted in parallel so that the surface of one of the bands is adjacent to a facing surface of the other, while the surfaces move at equal speeds at an acute angle with each other. The strands are continuously grouped together at a point upstream of the bands and paid between the adjacent surfaces, in frictional contact with them, in a line intersecting the angle formed by the two bands, so that the conductors are rolled over each other and twisted together while, at the same time, being urged forward by the friction of the surfaces. For forming a strand with a reversing lay, I periodically change the lay at which the conductors are twisted together. This lay is advantageously changed by reversing or otherwise changing the acute angle between the surfaces of the bands, and after leaving the bands the strands may preferentially be passed between an additional pair of bands spaced downstream in the line of advancement of the strands and the period of changing the lay of twisting timed to correspond to the length of time required for a point on the strands to pass completely between the two pairs of bands. I have invented the method of continuously forming an electric cable by passing conductors into an extrusion means thereby applying layers of insulation to form insulated conductors and, in the same operation, continuously passing a plurality of the insulated conductors advancing from the extrusion means between two spaced-apart pairs of endless bands, each of which pairs comprise two facing band surfaces mounted to advance at an acute angle to each other and thereby twist the strands together. Periodically I change the lay of twist of the strands at least one of the pairs of bands.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a plan view of an apparatus of my invention, employing the method thereof.

FIG. 2 shows an elevation of the apparatus of FIG. 1.

FIG. 3 shows a side view of another embodiment of my invention.

FIG. 4 shows a side view of still another embodiment of my invention.

FIG. 5 shows a side view of still another embodiment of my invention.

FIG. 6 shows a detailed plan of an element of my invention.

FIG. 7 shows a front view of the element of FIG. 6.

FIG. 8 shows a side view of still another embodiment of my invention.

FIG. 9 shows a side view of still another embodiment of my invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1 a plurality of pairs 11 of insulated conductors 12 from a plastic extruder are shown entering my apparatus, indicated generally by the numeral 10. Means of extruding multiple strands from a single extrusion head are known but the insulated conductors 12 may be paid from a plurality of heads and through appropriate cooling troughs (not shown) by means of known types of sheaving, within the scope of my invention. Also, it should be recognized, that although the processing of strands directly from an extruder has great advantages, my invention is not limited to an in-line operation but may also be applied to strands that are being paid from reels, cannisters, or other sources. Each pair 11 is brought together by means of a die or guide 14 which directs it into a unit pair of endless bands 16, 17 mounted, respectively, on rolls 18, 19 and 21, 22 (FIG. 2). Although the apparatus 10 is directed to the twisting of insulated conductors into pairs, it will be understood that it is not limited thereto. For example, the conductors 12 might be stranded into quads by paying four conductors into each of the dies 14. The unit 15, shown in greater detail in FIGS. 6 and 7 comprises an essential feature of my invention, and affords, I believe, an entirely novel means for twisting insulated conductors. In the illustrated embodiment the bands 16, 17 take the form of timing belts with relatively soft facing surfaces 23, 24 between which the conductors 12 are paid. The bands 16, 17 advance at the same speed but not in the same line so that the line of advance of the band 16 forms an acute angle, alpha, with the line of advance of the band 17. When the speed of the bands, in a direction normal to the axis of the rolls 18-22, is designated as S, the velocity of the surfaces 23, 24 in the line of advance of the conductors will equal the component $S \cos(\alpha/2)$. A normal velocity component equal to $S \sin(\alpha/2)$ of the surfaces tends to twist or roll the strands. This twisting effect takes place without displacing the group of conductors from their line of advance, since the displacement of the conductors to the left by the upper band 16 is substantially matched by the displacement to the right by the lower band 17. Twisting of the conductors is thus accomplished without any sliding friction between the conductors 12 and the surfaces 23, 24. In the applications for which my invention is believed to have particular utility, such as the twisting of electrical conductor pairs and quads, the angle alpha is small, 1° - 15° .

If the conductors were merely advanced through the pair of bands 16, 17 the twist imparted by the passage between them would untwist immediately on the downstream side. For some purposes, such as pretwisting of strands entering a conventional strander, a transient twisting of this type will have utility, but in the present embodiment a second unit 26 of bands is mounted a substantial distance downstream of the unit 15. The unit 26 substantially duplicates the unit 15 having, in this preferred embodiment, the same angle, alpha, between the lines of advance of two bands 27, 28. As can be seen in FIG. 6 the angle between the bands is established by turning a worm 29 against a gear 31, to rotate the band 16 and, similarly, a worm 32 and gear 33 to rotate the band 17. The bands 16, 17 are conveniently driven by a motor 30 through flexible shafts 30a and 30b. By having the pitch of the worm 32 opposite to the pitch of the worm 29 both worms can be turned through the means of sprockets 34, 35, 36 and a chain 37, the sprocket 35 being driven by a motor, not shown. The gears 31, 33 are preferably integral with respective frames 38, 39 rotatably mounted in a c-support 41 by means of bushings 42, 43. By rotating the sprocket 35 the angle of each of the bands to the other center line can be changed as shown in dashed lines at 44 of FIG. 1. Thus the direction of twisting of the conductors will be reversed and, although the angle alpha may retain the same numerical value, it will have been changed in that the lines forming the angle will have been interchanged. As used in this application the word "change," in referring to the angle alpha, includes cases where a reversal takes place even though

the numerical value of the changed angle equals the value of the former angle. Where the angles alpha of the units 15 and 26 are originally identical, means are provided, of which various types are known, for actuating the sprocket 35 on the unit 15, and a corresponding sprocket on the unit 26 to reverse the angles alpha of both units simultaneously at intervals corresponding to the length of time it takes for conductors to pass from the entrance of the unit 15 to the exit of the unit 26. When the angles are thus reversed an additional twist will be imparted to the conductors at the downstream exit of the unit 26 having the same direction as the twist introduced at the upstream entrance to the unit 15. In other words, whatever the length of twist lay that is imparted in the unit 15, it will be halved on leaving the unit 26. When the angle alpha of the unit 15 is reversed, a reversal point of direction of lay of the conductors takes place at the entrance to the apparatus, and to prevent the strand from untwisting in the passage between the units 15 and 26, I prefer to bind these points by the periodic application of adhesive from an applicator 46. Suitable adhesive has been disclosed in U.S. Pat. No. 3,160,369.

Between the units 15 and 26 the conductors 12 are supported on a table 47 having a smooth, low-friction surface 48, but alternatively in FIG. 3 I have shown a plurality of similar units between the units 15 and 26, having the same angle alpha as those units, and programmed to reverse at the same time.

In FIG. 1 I have shown a plurality of cables being twisted simultaneously, and, indeed, the width of the bands can be increased to accommodate any desired number of cables. Since each cable requires only its own diameter in space on the band, except for a nominal spacing distance, it is quite practical, for example, to twist 25 or more telephone pairs or quads simultaneously with one of my apparatuses 10.

The angles alpha of both the above described units 15 and 26 are the same. This is not the only way, however, of constructing my apparatus and, indeed, other selections of alpha are preferable for different purposes. For example, with cables having a large number of strands so that the length taken up in stranding of the outer strands is significantly greater than the length of the inner strands it may be advantageous to set up the unit 26 with an angle beta smaller than the angle alpha so that it will impart a longer length of lay. For example, if the angle alpha is set to impart a 36 inch right hand lay, when the angles are reversed so that alpha gives a 36 inch left hand lay and the angle beta a 72 inch left hand lay, the cable will emerge from the unit 26 with a 36 inch right hand lay. It should be noted that the unit 15 imparts a 36 inch right hand lay, equivalent to the final lay of the cable. This ensures that there is sufficient length in the outer strands to prevent stress in passing through the unit 26.

Instead of applying adhesive by means of the applicator 46, shown in FIG. 2, a few turns having a tighter twist (short lay length) may be applied by the units 15 and 26 at each point of the length that will ultimately correspond to a reversal point. This may be very simply done by momentarily increasing the angle alpha. Since the angle is very small to begin with, as has been explained, doubling the angle will substantially double its tangent and halve the length of lay, and greater increases in the angle will have calculably greater lay-shortening effects. For standard solid copper telephone wires having polyethylene insulation I have found that a $1\frac{1}{2}$ inch lay of twist will withstand normal processing tension in size 19 Awg (American Wire Gage) and a $\frac{1}{2}$ inch lay, in 24 Awg.

In FIG. 8 I have shown two additional twisting units 51, 52 spaced closely downstream of respective units 25, 55. By using the additional units 51, 52 I can eliminate the automatic means for varying the angles between the pairs of bands comprising each unit. Thus, if units 25 and 55 are set up with the included angle alpha, units 51 and 52 may have the reverse angle of alpha. Then, instead of reversing the angle of the units 25 and 55, their bands are merely separated while the bands of the units 51 and 52 are brought together by any of a plurality of known means such as the hydraulic bearing mountings 50

shown diagrammatically in FIG. 8. If we consider the length "L" in FIG. 8 at any time during the operation of the apparatus, it will have an average twist lay length determined solely by the unit 55. Thus, if the unit 25 is replaced by a pair of rolls or a lay plate and the units 51, 52 left separated, or eliminated entirely, my apparatus will function if the angle alpha of the unit 55 is changed at appropriate periods. This would have the advantage of requiring only one pair of bands, but unless the distance L is quite short, will produce an uneven twist. Another useful mode of operation wherein the unit 51 may be left open or removed is illustrated by the following example, where the units 25 and 55 are set with angles alpha to produce a right hand lay of eleven turns per foot in the length L and the unit 52 is set with a smaller angle so as to produce 3 turns per foot. The following sequence of changes are then timed to a passage of a length L through the apparatus.

Period	units 25 and 52	unit 55	twists per foot in L	final twists per foot
1	closed	open	3 RH	start
2	closed	closed	11 RH	8 LH
3	closed	open	3 RH	8 RH
4	closed	closed	11 RH	8 LH

In this method of operation the pairs of bands are not required to be adjustable with regard to the angle alpha and the units 25 and 52 operate at a steady rate throughout. It should be noted in this regard that, when the pair of bands 55 is closed, the fact that the pair of the unit 52 is also closed does not affect the final lay since any twist imparted to strands entering the unit 52 is unwound on the downstream side. In the apparatus for this method of operation the units 55 and 52 may be replaced by a single unit, such as the unit 26, wherein the angle alpha can be varied to change the length of lay (twists per foot) imparted to the strand.

In FIGS. 4 and 5 I have illustrated embodiments of my apparatus that require less floor space when the apparatus 10 is mounted horizontally and less head room when it is mounted vertically. The embodiment of FIGS. 4 and 5 have particular application where only a single strand is required to be twisted, so that advantage cannot be taken of the width of the bands to twist a plurality of strands simultaneously. In FIG. 4 a unit 53 is mounted under the unit 15 instead of being in line as was the case for the unit 26. A strand being twisted passes between the bands of unit 15 and then down back between the bands of the unit 53 and up again through the unit 15, thus forming a loop around the lower band of the unit 15 and upper band of the unit 53. As many such loops can be formed continuously as required, and angle reversals will take place at intervals equal to the time it takes from the initial entry of a point on the strand into the unit 15 to its final exit from that unit. Two comb-shaped guides or separators 56, 57 keep the turns of strand properly spaced so that there is no danger that they will be caused to roll together by the bands. Indeed, similar guides may also be used to advantage in the embodiment of FIG. 1 to separate the different cables, although they have not been shown. An accumulator 58 that will accommodate the increase in speed of the strands during angle reversals may also be employed, although it has not been shown, in the other embodiments of my invention.

The embodiment of FIG. 5 is similar to that of FIG. 4 but requires one fewer band in that the upper surface of a band 59 cooperates with a band 61 to form the equivalent of the unit 53. Grooved rolls 63, 64 here serve to separate the strand turns.

The apparatus of FIG. 9 may be considered as a variant of that of FIG. 4 wherein the bands run vertically. This will provide a longer accumulation of wire between the two pairs of bands than the apparatus of FIG. 4, without requiring excessive headroom.

PROCESS

In the operation of a preferred embodiment of my invention for the high speed manufacture of telephone cables, insulated conductors pay from an extruder 13 into the twisting apparatus without being taken up on reels or stored meanwhile. Extruding speeds for economical operation are very high, up to 4,000 feet per minute and, prior to my invention, no twisting apparatus has been known to me to be capable of operating at such a speed. Since, however, my stranding apparatus involves no high-speed rotating members, except for the timing belts that comprise the bands, such as the bands 16, 17 and the small diameter rolls on which the bands are mounted, it can readily achieve speeds equal to the speeds of extrusion. When a large number of conductors are insulated in a single extrusion head color coding may be applied by passing the individual insulated conductors through suitable dye applicators, and where different extrusion heads are used for individual conductors, or small numbers of conductors, they can all be directed into a single plane upstream of the first unit 15 by suitable guide rolls or sheaves.

Each plurality of conductors to be twisted together is grouped by means of a die 14 directly upstream of the unit 15. Thus if pairs are being formed the total plurality of conductors will be divided into two's to pay into each die. If four conductors are paid into each die the unit 15 will twist them into quads.

If we consider the process of manufacturing pairs it will be readily seen that the manufacture of larger cables is analogous. Then each of the pairs leaving the downstream end of the unit 15 will have the same twist lay, which will be inversely proportional to $\tan(\alpha)$. In the plan view of FIG. 1 the pairs leaving the unit 15 have a twist with a left hand lay. This twist might tend to unwind unless one of the two methods of stabilizing it that I have described hereinabove are applied. These methods comprise the binding of the conductors of each group together at reversal points, and the tightening of the twist at reversal points. When the conductors are bound together by the application of cement the cement upstream of the unit 15, as described hereinabove, should set during the time the conductors are restrained by the bands 16, 17 and the length of the bands may be selected accordingly. As has been explained the unit 26 is spaced downstream of the unit 15, the distance between them being determined by the desired frequency of twist reversal. Since the entire twisting apparatus can be positioned overhead and need not be considered as occupying floor space a spacing of 100 feet is quite practical and will require an angle reversal every $1\frac{1}{2}$ second at 4,000 feet per minute or every three seconds at 2,000 feet per minute.

When the pairs enter the unit 26 it will be understood that no increased twist or shortened lay is thereby imparted to them if the bands 27, 28 also form the angle alpha. However, at the instant the initial point of one direction of twist of the twisted strand is about to emerge from the unit 26 the angle is reversed. Directly upon leaving the unit 26 the pairs receive an additional left hand twisting torque. This has the effect of halving the length of twist lay the pairs had while they were between the units 15 and 26. At the instant the unit 26 reverses the unit 15 also reverses and the applicator 46 applies a daub of adhesive, with the result that, advancing between the two units, there will be decreasing lengths of the pairs with a right hand lay, said lengths being divided by a reversal point that will not open up, due to the adhesive. Other means of binding the reversal point such as the application of a few turns of tighter twist, hereinabove discussed, and the application of ties may be used within the scope of my invention.

When the pairs leave the unit 26 they may be immediately taken up on reels or in drums where there will be no tendency to unwind the false twist. If the speed of twisting is not too great the pairs may pay directly into a strander. Indeed, by bringing a plurality of pairs together through a suitable die they can be stranded continuously by the above-described method that was used in the twisting of the pairs themselves.

When larger cables are made by my method they are ad-

vantageously wrapped helically with a binding thread or ribbon directly downstream of the unit 26. This means of binding will then take the place of the aforementioned adhesive. Although the foregoing description has been directed to the twisting or cabling of insulated conductors, I also recommend my invention for stranding together fine wires to form the flexible conductors that are employed in power, lighting, and control cables. Conductors so formed in my apparatus may be paid directly and continuously into an extrusion apparatus, thus eliminating the costly steps of winding on reels, storing and delivering the reels, and unwinding them into the extruder.

I have invented a new and useful apparatus and method of which the foregoing description has been exemplary rather than definitive and for which I desire an award of Letters Patent as described in the following claims.

I claim:

1. An apparatus for twisting together a plurality of advancing strands comprising:
 - A. means supporting two moving surfaces on opposite sides of said strands and in frictional engagement therewith, and
 - B. means driving said surfaces to move at said engagement at velocities having,
 - a. a first component substantially equal to the velocity of advancing of said strands, and
 - b. components, normal to said first component and opposite in direction to each other, comprising a twisting couple applied to said strands, the resultant of said components of each of said surfaces forming an angle with said first component of 1° - 15° .
2. The apparatus of claim 1 wherein said surfaces are comprised of endless bands.
3. A stranding apparatus comprising:
 - A. a first pair of parallel endless bands, a surface on one of said bands being adjacent to a facing surface of the other of said bands,
 - B. means driving both of said bands at substantially equal speeds,
 - C. a second pair of parallel endless bands spaced downstream from said first pair of bands, a surface of one of said second pair of bands being adjacent to a facing surface of the other of said second pair of bands,
 - D. means continuously advancing both of said second pairs of bands at substantially equal speeds,
 - E. means paying a plurality of strands along a path between said adjacent surfaces of said first and second pairs of bands, and
 - F. means mounting the bands comprising each of said pairs to advance along lines forming an acute angle intersected by said path, thereby twisting said strands.
4. The apparatus of claim 3 comprising means periodically pivoting the mounting of at least one pair of said bands so as to change said angle.
5. The apparatus of claim 4 wherein the period of said change corresponds to the time of advance of a point on said strands between the entrance to said first and the exit to second pair of bands.
6. The apparatus of claim 4 wherein said angle for said second pair of bands is smaller than said angle for said first pair of bands.
7. The apparatus of claim 6 wherein the tangent of one-half of said angle for said second pair of bands is one-half the tangent of one-half of said angle for said first pair of bands.
8. A stranding apparatus comprising:
 - A. a first pair of parallel endless bands, a surface of one of said bands being adjacent to a facing surface of the other of said bands,
 - B. means driving both of said bands at substantially equal speeds,
 - C. a second pair of parallel endless bands, a surface of one of said second pair of bands being adjacent to a facing surface of the other of said second pair of bands,

- D. means advancing both bands of said second pair at substantially equal speeds,
 - E. means mounting said second pair of bands spaced from said first pair of bands,
 - F. means paying a plurality of strands along a path forming at least one loop around a band from each of said pairs,
 - G. means mounting the bands comprising each of said pairs to advance along lines forming an acute angle, and
 - H. means periodically pivoting the mounting of at least one of said bands so as to change said angle.
9. The apparatus of claim 8 wherein the period of said change corresponds to the time of advance of a point on said strands around the totality of said loops.
10. A stranding apparatus comprising:
- A. means continuously paying a plurality of strands from an upstream to a downstream station,
 - B. a first pair of endless bands, a surface of one of said bands being parallel to a facing surface of the other of said bands,
 - C. means for driving both of said bands at substantially the same speed along lines forming a first acute angle,
 - D. a second pair of endless bands, a surface of one band of said second pair being parallel to a facing surface of the other band of said second pair, said second pair being mounted downstream of, and adjacent to, said first pair,
 - E. means for driving both of the bands of said second pair at substantially the same speed along lines forming an acute angle differing from said first angle,
 - F. a third pair of endless bands, a surface of one band of said third pair being parallel to a facing surface of the other band of said third pair, said third pair being mounted downstream of, and spaced substantially from said second pair,
 - G. means for driving both bands of said third pair at substantially the same speed along lines forming a third acute angle,
 - H. a fourth pair of endless bands, a surface of one band of said fourth pair being parallel to a facing surface of the other band of said fourth pair, said fourth pair being mounted downstream of, and adjacent to, said third pair,
 - I. means for driving both bands of said fourth pair at substantially the same speed along lines forming a fourth acute angle differing from said third angle, and
 - J. means periodically separating the bands of said first and third pairs, and bringing together the bands of said second and fourth pairs so as to twist said strands by means of said second and fourth pairs and alternately separating said second and fourth pairs and bringing together said first and third pairs so as to twist said strands by means of said first and third pairs.
11. The apparatus of claim 10 wherein said first angle is substantially equal to said third angle.
12. The apparatus of claim 10 wherein said second angle is substantially in reverse of said first angle and said fourth angle is substantially in reverse of said third angle.
13. The method of twisting together a plurality of strands comprising the steps of:
- A. continuously advancing said strands between two endless bands having a surface of one of said bands adjacent to a facing surface of the other of said bands, said surfaces moving at a substantially equal speed at an acute angle to each other,
 - B. continuously grouping said plurality of strands together at a point upstream of said bands,
 - C. paying said strands between said adjacent surfaces in frictional contact with said surfaces in a line intersecting said angle and thereby rolling said strands over each other and twisting the same together while, at the same time, urging said strands along said line by means of the frictional contact with said surfaces.
14. The method of claim 13 wherein said strands comprise insulated conductors.
15. The method of stranding together a plurality of advancing strands with a reversing lay comprising the steps of:

- A. continuously grouping said strands together at a point in the line of advancement of said strands,
 - B. downstream of said point passing said strands between a pair of endless bands mounted at an acute angle to each other and having a common component of surface velocity substantially equal to the velocity of advancement of said strands and thereby twisting together said strands, and
 - C. periodically changing the lay of said twisting together of said strands.
16. The method of claim 15 wherein said lay is changed by changing said acute angle.
17. The method of claim 15 comprising the step of passing said strands between an additional pair of endless bands spaced in the line of advancement of said strands from said first named endless bands, and timing the period of changing said lay of twisting to correspond to the length of time required for a point on said strands to pass completely

between the two pairs of bands.

18. The method of claim 17 wherein said lay is changed by changing the angle between at least one of said pairs of bands.

19. The method of making an electric cable comprising the steps of:

- A. paying a plurality of conductors into extrusion means thereby continuously applying a layer of insulation to each of said conductors to form an insulated conductor,
- B. continuously passing a plurality of said insulated conductors advancing from said extrusion means between two spaced-apart pairs of endless bands, each of said pairs comprising two facing band surfaces mounted to advance at an acute angle to each other and twist together said strands, and
- C. periodically changing the lay of twist of said strands at at least one of said pairs.

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