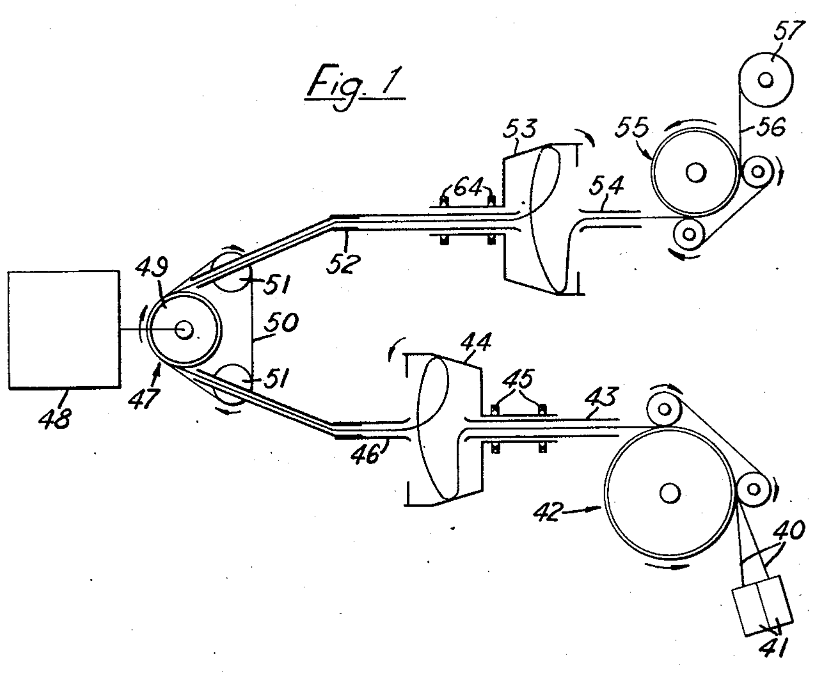
METHOD AND APPARATUS FOR STRANDING FLEXIBLE MATERIALS

Filed June 25, 1968 4 Sheets-Sheet 1

Fig. 1



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METHOD AND APPARATUS FOR STRANDING FLEXIBLE MATERIALS

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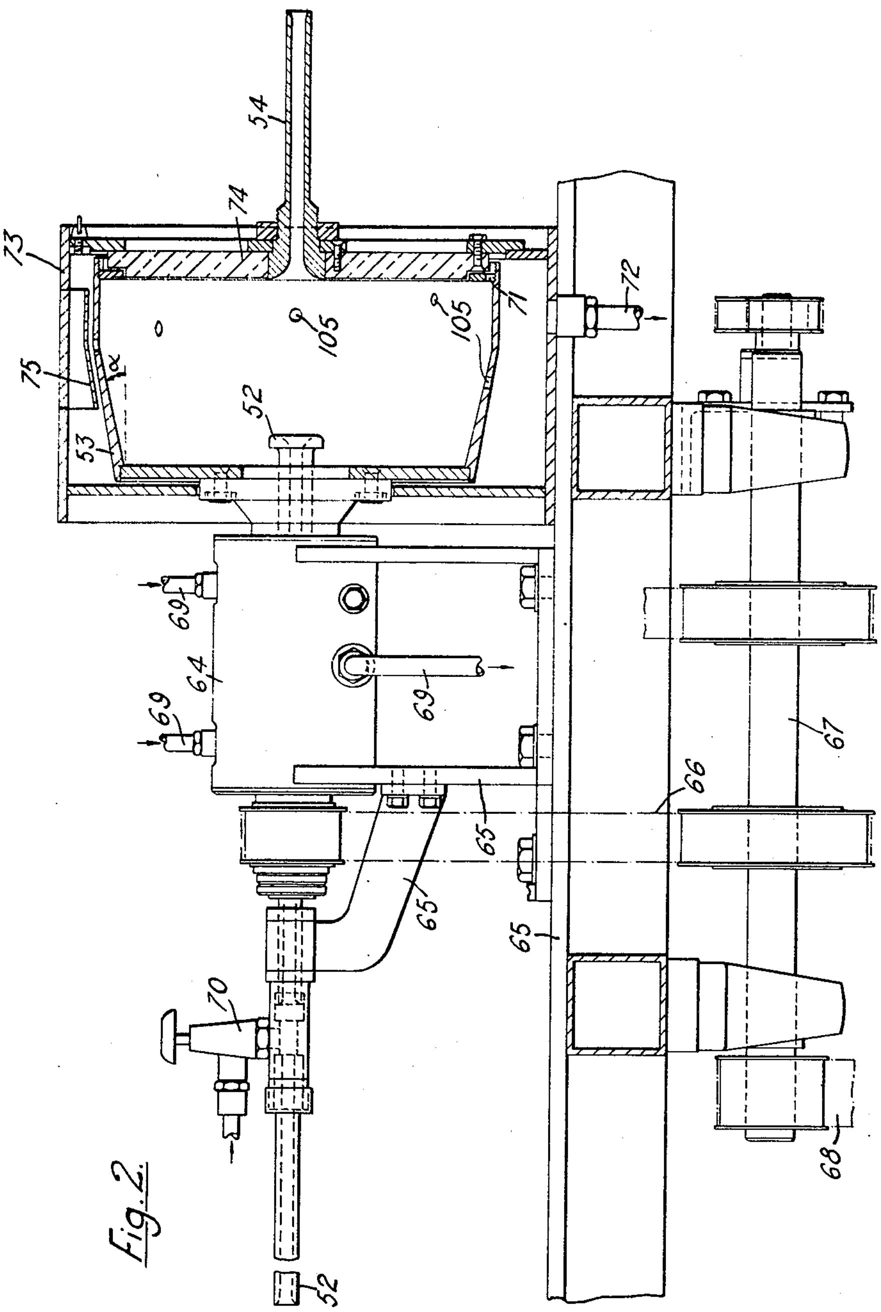

Fig. 2.

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METHOD AND APPARATUS FOR STRANDING FLEXIBLE MATERIALS

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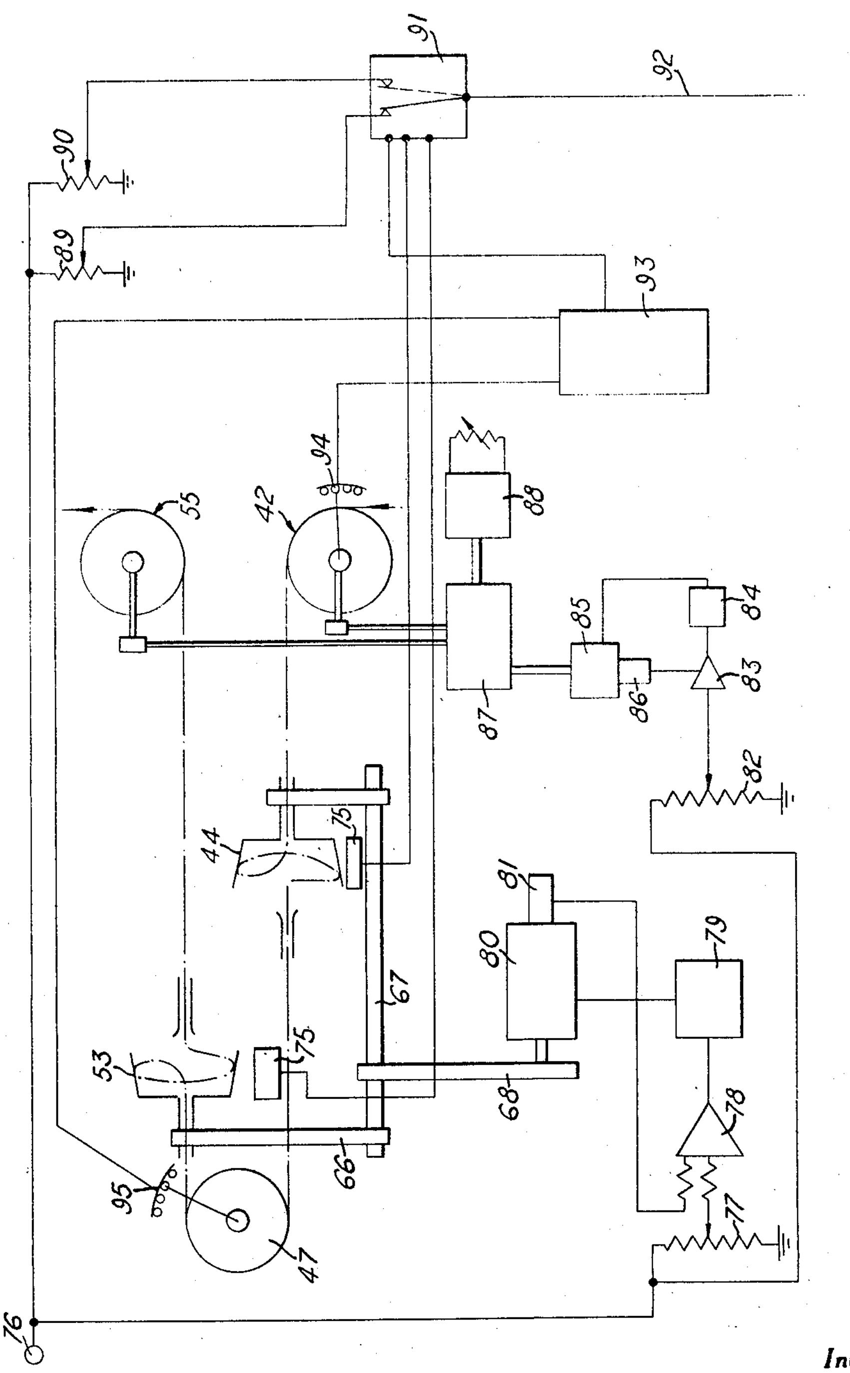

Fig. 3.

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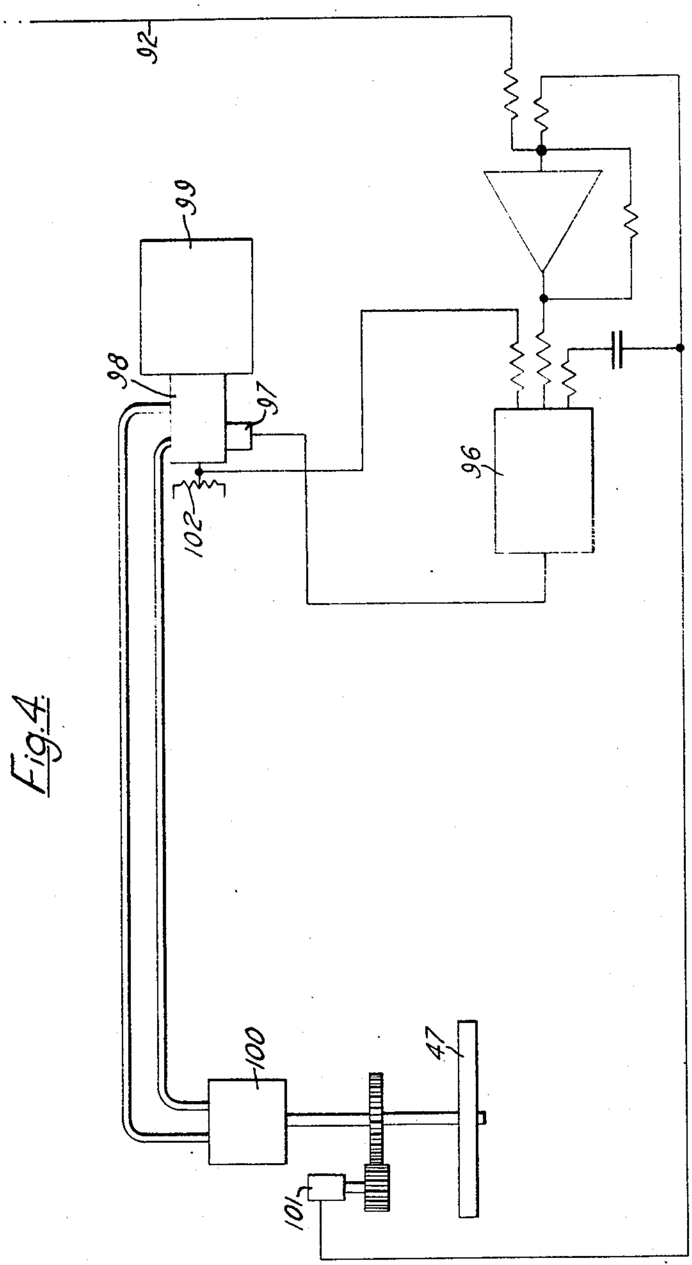

Fig. 4.

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METHOD AND APPARATUS FOR STRANDING FLEXIBLE MATERIALS

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U.S. Cl. 57—34 11 Claims

ABSTRACT OF THE DISCLOSURE

The invention provides a method of forming from a group of wires (e.g., a group of insulated conductors) a strand (e.g., a twin or quad for a telephone cable) in which the direction of lay is reversed at spaced intervals along the strand. The group of wires is fed into a first variable capacity accumulator which rotates unidirectionally about the axis of the group and twists the group of wires in one direction, and the strand thus formed is withdrawn from the accumulator in the same direction as the group of wires was fed into it whereby the strand is twisted in the opposite direction to its originally applied twist, and is fed into a second variable capacity accumulator which rotates unidirectionally about the strand axis in the direction opposite to that of the first accumulator. The speed at which the strand is withdrawn from the first accumulator and fed to the second is varied at intervals, so that the length of strand in each accumulator is varied, and a reversing lay is applied to the strand.

This invention relates to a method of and apparatus for forming from two or more elongated flexible members a strand of the kind in which the direction of lay is reversed at spaced positions along the length of the strand.

The principal object of the invention is to provide an improved method of and apparatus for manufacturing twins and quads for telephone cables consisting respectively of two and four insulated conductors laid up together with a lay that reverses in direction at spaced positions along the strand, not necessarily with a uniform rate of change of lay nor necessarily with the reversal points regularly spaced. It will be appreciated that the invention is however more widely applicable, for instance to the laying up or twisting together of other kinds of electrical conductor and of other elongated flexible elements whether metallic or nonmetallic. For convenience, the elements will nevertheless hereinafter be referred to generically as "wires."

A further object of the invention is to provide an apparatus for this purpose into which the wires to be stranded together can if desired be fed at a constant linear input speed and from which the strand can be made to emerge at a linear output speed which is constant and can be made essentially equal to the input speed (that is to say, equal apart from a small factor resulting from the slight change in length consequent upon the actual twisting of the strand).

One preferred method in accordance with the invention comprises feeding a group of wires into a first variable capacity accumulator which rotates unidirectionally about the axis of the group and twists the group of wires in one direction, withdrawing the strand thus formed from the first accumulator in the same diretcion as the group of wires was fed into it at a linear speed which is varied at intervals and feeding the strand at the same varying speed into a second variable capacity accumulator which rotates unidirectionally about the strand axis in a direction opposite to that of the first accumulator and twists the strand in the opposite direction to the twist initially applied to it as it entered the first accumulator, and withdrawing from the second accumulator in the same direction as the stand was fed into it a strand having a reversing lay.

It is preferable to control the linear speed of passage of the strand from the first accumulator to the second accumulator by applying a variable speed drive to the part of the strand passing from one accumulator to the other but this is not essential if the variable capacity accumulators are of a kind that can automatically, for example by internal means, positively vary the length of strand accumulated therein.

Although normally the wires of the group will be parallel to one another and not twisted together when fed into the first accumulator, it will be appreciated that the method can be applied to a pretwisted group of wires, in which case the function of the first accumulator is to vary the twist in one direction as the group enters the accumulator and in the other direction as the strand leaves the accumulator.

The preferred form of variable capacity accumulator for use in accordance with the present invention, especially in the manufacture of twins and quads for telephone cables, comprises a container which is rotated axially at a speed such that strand fed axially into the container is distributed in coils therein by centrifugal force. Such accumulators have been proposed for use as receivers and since they are often bucket shaped they are consequently known as (and will hereinafter be referred to as) "buckets." It will be understood however that they may be closed at both ends except for axial inlet and outlet apertures for the strand. As the individual wires, or a strand of two or more wires, enter one end of the bucket along its axis of rotation, the wires will be twisted together or the strand will be twisted about its axis, with a lay length dependent on the relationship between the longitudinal speed of the wires or strand and the speed of revolution of the bucket, and as the strand leaves the bucket it will be twisted in the opposite direction to an extent dependent on the relationship between the longitudinal speed of the wire and the speed of rotation of the bucket. Thus a strand or group of wires which enters the bucket at a speed greater than that at which it leaves the bucket will be given an overall twist in one direction and a strand or group of wires which enters the bucket at a speed less than that at which it leaves the bucket will be given an overall twist in the other direction.

The bucket type of accumulator may be of uniform diameter, though the amount of strand that can be accumulated is then relatively small as strand entering the bucket tends to overlie that already present with consequent tangling; or the diameter may increase uniformly from the inlet end towards the outlet end of the bucket, in which case capacity is limited either by the tendency of the accumulated strand slipping down the tapered wall to pile up against the end-wall at the outlet end of the bucket (or to escape from the bucket if there is no such end wall) or, if the angle of taper is reduced to avoid this tendency, by a liability to jerky movement of the accumulated strand resulting in its disengagement from the wall of the bucket. It has been found, however, that a bucket comprising a uniformly tapered part adjacent the inlet end merging into a part of uniform diameter adjacent the outlet end will satisfactorily accumulate a substantially greater length of strand, the limit in this case being set by the tendency of the strand to separate from the tapered part of the bucket when the amount of strand in the accumulator is being reduced and the axial slipping of the accumulated strand is consequently highest.

When the mechanical characteristics of the wire are such that the strand will not retain the reversing lay twist imparted to it by the method described it is necessary to apply to the strand continuously or at selected points (e.g., the points of lay reversal) a component that will restrain it from untwisting. For example a lapping of thread or tape, preferably in the form of an open turn helix may be applied to the strand at the output of the single bucket or the second bucket or alternatively an adhesive may be applied to the wires or to the strand continuously or at appropriately spaced intervals.

I prefer to rotate the two accumulators at the same constant speed in opposite directions and to vary the speed of the intermediate drive between the two accumulators regularly between the same fixed upper and lower limits. Lay reversals then occur at fixed intervals along the length of the strand. Alternatively it will be appreciated that many regular or random variations of lay can be obtained by suitable programming of the speeds of parts of the apparatus.

By using strand driving means of low inertia, e.g., two opposed light-weight pressure rollers or two opposed light-weight belts, rapid changes of strand speed with consequent sharp reversals of lay can be obtained. Slight over running at speed changes is not harmful and may result in a more abrupt lay-reversal. Variations in the lay pattern can also be obtained by varying the overall through-put speed and by varying the speed (but not the direction) of rotation of one or both buckets, in addition to or instead of by changing the programme of changes in the speed of the strand.

The invention further provides apparatus for carrying out the method above described.

A preferred type of apparatus comprises: two buckets with driving means which rotate them in opposite directions; means for guiding the wires axially into the first bucket; means for guiding the strand formed in the first bucket axially therefrom through a strand driving means which imparts a linear drive to the strand (without axial rotation of the strand) variable in speed between fixed or variable upper and lower limits; means for guiding the strand from the driving means axially into the second bucket; and means for guiding the strand axially from the second bucket towards take-up means for the strand.

In order that the invention may be more fully understood, it will be further described with reference to the accompanying drawings which show, by way of example, apparatus in accordance with the invention. In the drawings:

FIGURE 1 is a diagrammatic drawing of apparatus in accordance with the invention,

FIGURE 2 is a partly sectional elevation of a bucket type accumulator suitable for use in the construction of apparatus in accordance with the invention, and

FIGURES 3 and 4 together form a diagram showing in outline an arrangement suitable for the control of apparatus in accordance with FIGURE 1.

The apparatus shown in FIGURE 1 will be described in detail with reference to its use for twinning plastics insulated telephone conductors moving at a linear speed equal to the speed of extrusion of the installation on to the conductors.

The two insulated conductors **40** to form the twin are guided from the extruders **41** to a single input capstan **42**, in the form of a single capstan wheel of the belt type, rotating at a speed such that the input speed of the wires is equal to the extrusion speed, namely 20 metres per second (4,000 feet per minute). From the input capstan the two wires pass through a tubular guide **43** forming the axial inlet of a first bucket accumulator **44** of 90 cm. (3 ft.) circumference mounted in bearing **45** and driven at a constant speed of 6,000 revolutions per minute in a clockwise direction as seen from the approach direction of the wires. The two wires are thereby twisted together with a right hand lay of 3.8 turns per metre (1.16 turns per foot), and the strand thus formed is distributed helically within the bucket. Instead of using a single input capstan, the extruder capstans can be relied on to feed the wires towards the bucket and the centrifugal force in the bucket will pull the group of wires into the bucket but when this method is used the output speeds of the extruders must be very carefully matched.

At the open end of the bucket there is an axial outlet guide **46** through which the strand is withdrawn from the bucket by means of another capstan **47** (the intermediate capstan) driven by a programmed or manually controlled variable speed mechanism **48** in such a way as to give the strand a linear speed varying periodically between 40 metres per second (8,000 feet per minute) and 13.5 metres per second (2,666 feet per minute). The preferred form of intermediate capstan comprises a single capstan wheel **49** and a pressure belt **50**, with the axis of the wheel obliquely inclined to the plane of the strand engaging it. This enables the belt to engage the wheel over a large arc and, by passing under the strand (as seen in the drawing) to be guided by only two auxiliary pulleys **51**. Consequently the capstan has a relatively low inertia. When the capstan **47** drives the strand at the lower speed limit an anticlockwise twist equivalent to 6.25 turns per metre (1.91 turns per foot) will be induced in the strand so that, on entering the capstan it will consequently have a resultant left hand lay of 2.45 turns per metre (0.75 turn per foot). When the wire is travelling at its upper speed limit an anticlockwise twist of 1.35 turns per mitre (0.41 turn per foot) will be induced in the strand so that it will, on entering the capstan, have a resultant right hand lay of 2.45 turns per metre (0.75 turn per foot).

From the intermediate capstan the strand passes through the axial inlet guide **52** of a second bucket accumulator **53** which is driven at a constant speed of 6,000 revolutions per minute in an anticlockwise direction seen from the direction of approach. When the intermediate capstan **47** is driving the wire at the lower speed limit (and as already explained the strand has a left hand lay of 2.45 turns per metre (0.75 turn per foot) on leaving the capstan and entering the second bucket accumulator) it will be given a further left hand twist equivalent to a lay length of 6.25 turns per metre (1.91 turns per foot). When the strand leaves the capstan at the upper speed limit (and as explained has a right hand lay of 2.45 turns per metre (0.75 turn per foot)) it will on entering the bucket be twisted in such a way as would give it a left hand lay of 1.35 turns per metre (0.41 turn per foot). In other words the twist already given to it by the first bucket will be partly taken out of it as it enters the second bucket.

The strand is guided from the open end of the second bucket through an axial output guide **54** to an output capstan **55** similar to the input capstan **42** which drives it linearly at 20 metres per second (4,000 feet per minute) and withdrawal at this speed will induce in the strand a twist equivalent to a right hand lay of 3.8 turns per metre (1.16 turns per foot).

From the description given above it will be seen that when the intermediate capstan is driving the wire at its lower speed limit the resultant twist in the strand leaving the output capstan will be 4.9 turns per metre (1.5 turns per foot) left hand, or a left hand lay of 20 cm. (8 inches) but when the intermediate capstan is driving the strand at the upper speed limit the resultant twist in the wire will be 4.9 turns per metre (1.5 turns per foot) right hand, or a right hand lay of 20 cm. (8 inches).

The emergent twin conductor is taken up on a reel **57**.

It will be appreciated that the apparatus must be operated in such a way that each bucket will always contain a sufficient number of turns of strand to ensure that the strand or group of wires is twisted at the input and output ends of the bucket to an extent dependent on the relationship between the linear speed of the strand or group and the speed of rotation of the bucket. When the overall input and output speeds remain substantially constant, the aggregate content of the two buckets will remain substantially constant.

During the operation of the type of apparatus above described, the helical turns of strand contained in the bucket move progressively along the bucket in the general direction of strand movement and this movement will be ensured by appropriately relating the coefficient of friction between the wires and the bucket walls to the speed of rotation of the bucket and the linear speed of the wire and appropriately shaping the bucket wall as above described. In some cases lubrication of the walls may be necessary.

An inexpensive construction of bucket accumulator comprises a plain cylindrical metal rotor carrying a shaped wooded insert having a lining of polyvinyl chloride (PVC) which forms the strand-engaging wall of the bucket. The part of the wall adjacent the inlet is tapered, and merges smoothly with a part adjacent the outlet which part is of uniform diameter. A bucket of this construction having a maximum diameter of 30 cm. (11.75 inches) and a taper angle of 16 degrees operated at 4,000 revolutions per minute was found to have a capacity of about 75 metres (250 feet) of twinned cellular-polythene-insulated wire having a cross-section of 0.20 square mm. (6½ lbs. wire) or about 120 metres (400 feet) of twinned cellular-polythene insulated telephone wire having a cross-section of 0.073 square mm. (2½ lbs. wire). In each case the twin conductor is found to occupy about 4 cm. (1½ inches) of the part of uniform diameter and to build back up the tapered part about 2.5 cm. (1 inch). To avoid damage to the insulation, the wall of the bucket should be lubricated by a continuous fine spray of water.

An alternative and more durable form of bucket accumulator is shown, together with certain associated apparatus, in FIGURE 2. As a matter of convenience, this figure will be described in relation to the second bucket **53** of FIGURE 1; but bucket **44** may be of identical construction.

The bucket **53** is supported from the framework **65** of the machine in bearings **64** coaxially surrounding the inlet guide **52** and is driven by a belt **66** from the main shaft **67**, itself driven by a further belt **68** from an electric motor (not shown in this figure). The bucket is of polished steel and is similar in shape and size to that already described, except that, because of the different coefficient of friction, the taper angle α, is about 13 degrees. Bearing **64** is lubricated and cooled by oil circulating through pipes **69**. Water is introduced into the inlet guide **52** through valve **70** and, after serving to lubricate the walls of the bucket, escapes through apertures **71** to drain **72**. A guard **73** surrounds the rotating bucket, and the outlet guide tube **54** is mounted axially in the end-wall **74** of the guard, which is of transparent material. Light passing through the end-wall and through transparent inserts **105** activates a bank of photoelectric detectors **75** to give an indication of the amount of strand accumulated in the bucket.

Referring now to FIGURE 3, it is desirable, in order to synchronise the operation of the apparatus with the extruders or other wire supply apparatus, to derive a master control signal from the latter. This signal may be applied to the control circuit at **76**. A first manually preset potentiometer **77** supplies a proportion of this signal to a first servo amplifier **78** whose power stage **79** controls a first variable speed motor **80** driving the main shaft **67** and thus the buckets **44** and **53**. A tacho generator **81** provides feedback regulation.

A second manually preset potentiometer **82** similarly applies a proportion of the master control signal via a second servo amplifier **83, 84** to a second variable speed motor **85** with associated tachogenerator **86**. Motor **85** drives the input capstan **42** and output capstan **55** through a gear box **87** incorporating a differential to which a small manually controlled motor **88** is also coupled. A fine adjustment of the relative speed of the two capstans can be obtained by varying the speed of the motor **88**.

Third and fourth preset potentiometers **89, 90** in conjunction with an electronic switching device **91** provide at **92** alternative signals proportioned to the master control signal which are utilised to control the speed of the transfer capstan in a manner to be described, one of these signals corresponding to the desired high transfer speed, and the other to the low transfer speed. Switching between these two alternative signals is normally effected by an arithmetic device **93** which computes the length of strand contained in the first accumulator **44** from the output of electronic revolution counters **94** and **95** associated with the input capstan and with the transfer capstan. This control may be overridden if one of the banks of photoelectric detectors **75** indicates that its associated accumulator contains an amount of strand outside a predetermined range.

Turning now to FIGURE 4, the signal appearing at **92** is fed to a servo amplifier **96** controlling a servo valve **97** which controls the swash plate position of a variable-capacity hydraulic pump **98** driven by constant speed electric motor **99** and supplying hydraulic motor **100** which drives the transfer capstan **47**. Tacho generator **101** feeds back to the servo amplifier **96** signals representing the position and angular velocity and angular acceleration of the transfer capstan, while a detector **102** supplies a signal indicating the swash-plate position.

The procedure for starting up the apparatus of FIGURES 1, 3 and 4 is as follows:

The extruders must be started up first, as the bucket type of accumulator will not operate at very low speeds. The wires to be twisted together are then threaded through the apparatus with the input and output capstans in inoperative positions, so that the transfer capstan acts as a haul-off. When a sufficient speed has been reached, the input capstan is made operative and the speed of the transfer capstan reduced to form a loop in the first accumulator and gradually to fill it. The output capstan is then made operative and the transfer capstan is speeded up, transferring the accumulated strand to the second accumulator. The apparatus may then be run up to full speed under the control of the master control signal from the extruders, though it will usually be preferable for the speed of the transfer capstan to be manually controlled during the first few cycles.

As mentioned above, a lapping head or an adhesive applicator may be provided if required.

Although the only form of variable capacity accumulator capable of rotating about the strand axis so far described is the bucket type accumulator, other types of rotating variable capacity accumulator can be used, for example the type of accumulator in which the capacity is varied by moving two pulleys or groups of pulleys about which the strand is looped towards and away from each other. When this form of accumulator is rotated, it is preferable that the relative movement of the pulleys or pulley groups should be along the strand axis.

What I claim as my invention is:

1. A method of forming from a group of wires a strand in which the direction of lay is reversed at spaced intervals along the strand, comprising feeding the group of wires into a first variable capacity accumulator which rotates unidirectionally about the axis of the group and twists the group of wires in one direction, withdrawing the strand thus formed from the first accumulator in the same direction as the group of wires was fed into it at a linear speed which is varied at intervals and feeding the strand at the same varying speed into a second variable capacity accumulator which rotates unidirectionally about the strand axis in a direction opposite to that of the first accumulator and twists the strand in the opposite direction to the twist initially applied to it as it entered the first accumulator, and withdrawing from the second ac-

cumulator in the same direction as the strand was fed into it a strand having a reversing lay.

2. A method as claimed in claim **1**, wherein the wires of the group are insulated electric conductors.

3. A method as claimed in claim **1**, in which the linear speed at which the wires or conductors are fed into the apparatus and the linear speed at which the strand is withdrawn from the apparatus are both substantially constant and are essentially equal.

4. A method as claimed in claim **1**, in which the group of wires is fed into the first accumulator at a constant speed, the strand is withdrawn from the second accumulator at essentially the same constant speed, and the speed at which the strand is withdrawn from the first accumulator and fed into the second accumulator varies periodically between fixed upper and lower limits, whereby there is obtained strand having a lay which reverses at regular intervals.

5. A method as claimed in claim **1**, in which at least one of the accumulators used is of the bucket type, comprising lubricating the strand-engaging wall of the bucket.

6. Apparatus for forming from at least two wires a strand of the kind in which the direction of lay is reversed at spaced intervals along the strand, comprising two variable capacity accumulators, means for unidirectionally rotating the first accumulator about an axis, means for feeding a group of wires axially into the first variable capacity accumulator and for withdrawing the strand thus formed from the first accumulator in the same direction as the group of wires was fed into it at a linear speed which is varied at intervals and feeding the strand at the same varying speed axially into the second variable capacity accumulator, means for rotating the second variable capacity accumulator in such a direction that it rotates unidirectionally with respect to the strand in a direction opposite to that of the first accumulator, and means for withdrawing the strand from the second accumulator in the same direction as it was fed into it.

7. Apparatus as claimed in claim **6**, wherein the means for feeding the group of wires axially into the first variable capacity accumulator comprises an input capstan; the means for withdrawing the strand from the first accumulator and for feeding it axially into the second accumulator comprises a transfer capstan; and the means for withdrawing the strand from the second accumulator comprises an output capstan; and wherein there is provided means for driving the input and output capstans at essentially the same linear speed and means for driving the transfer capstan at a linear speed that can be varied at intervals between values higher and lower than the speed of the input and output capstans.

8. Apparatus as claimed in claim **6** in which each accumulator is of the bucket type.

9. Apparatus as claimed in claim **6**, wherein the means for withdrawing the strand from the first accumulator and for feeding it axially into the second accumulator comprises a transfer capstan driven by a hydraulic motor itself driven by a variable-capacity swash-plate pump and wherein switching means is provided for varying the capacity of the pump at intervals.

10. Apparatus as claimed in claim **6**, wherein the means for feeding the group of wires axially into the first accumulator comprises an input capstan and the means for withdrawing the strand from the first accumulator and for feeding it axially into the second accumulator comprises a transfer capstan driven by a hydraulic motor itself driven by a variable-capacity swash-plate pump and wherein there is provided for varying the capacity of the pump at intervals switching means controlled by a programmed arithmetic device which computes the length of strand contained in the first variable capacity accumulator from signals received from electronic revolution counters associated with the input capstan and with the transfer capstan.

11. Apparatus as claimed in claim **6**, in which each accumulator is of the bucket type, comprising means for supplying lubricant to the strand-engaging wall of each bucket.

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