Oct. 11, 1960 J. C. LILLY 2,956,102

TWISTED CONDUCTORS AND CABLES

Original Filed March 12, 1957

Fig. 1

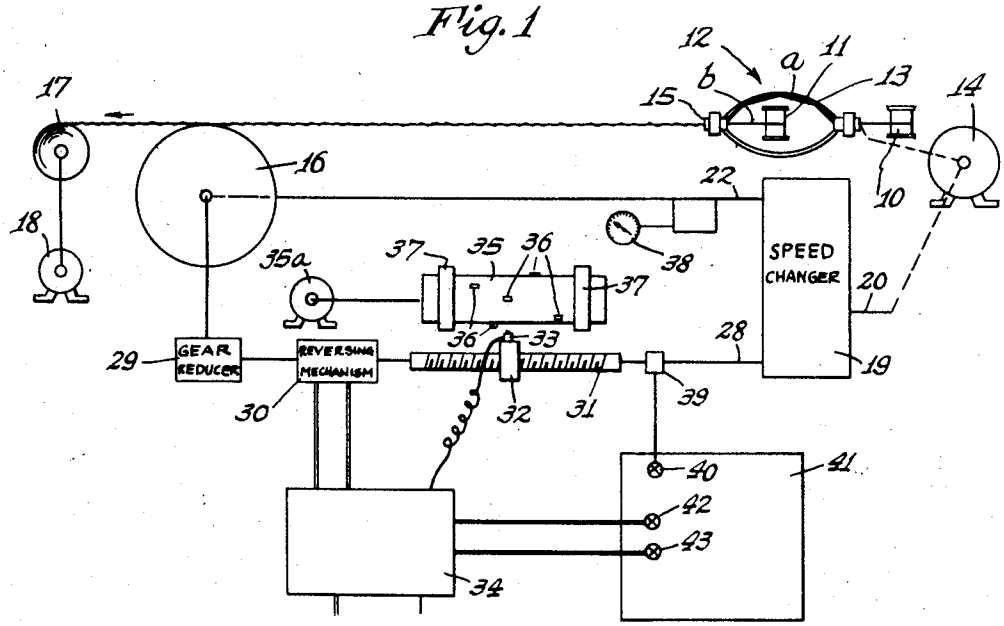


Fig. 2

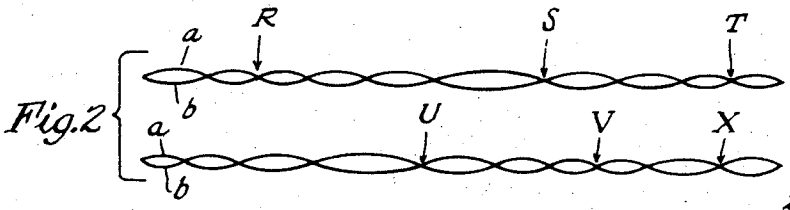


Fig. 3

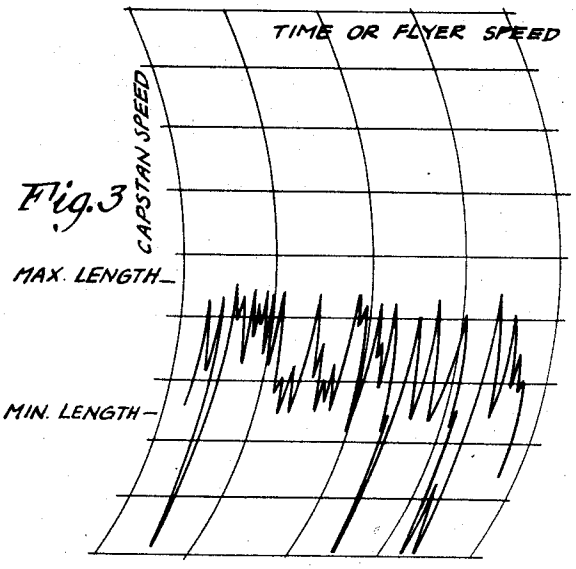
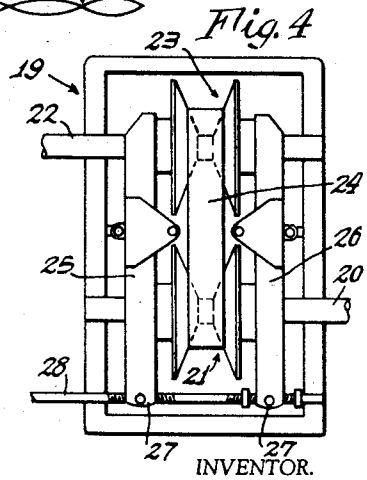


Fig. 4



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United States Patent Office 2,956,102
Patented Oct. 11, 1960

2,956,102

TWISTED CONDUCTORS AND CABLES

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Original application Mar. 12, 1957, Ser. No. 645,599, now Patent No. 2,869,316, dated Jan. 20, 1959. Divided and this application Sept. 11, 1958, Ser. No. 760,395

3 Claims. (Cl. 174—34)

This invention relates to electrical wires or conductors and cables made therefrom. More particularly, the present invention relates to an improved twisted pair circuit for use as an open wire or assembled into cables for the transmission of intelligible electric signals.

This application is a division of my copending application Serial No. 645,599, filed March 12, 1957, now Patent No. 2,869,316, granted January 20, 1959.

Heretofore, in producing cables, it has been the practice to produce twisted pairs which are distinct by reason of the fact that each has twists of predetermined fixed length. In use in cables, neighboring or juxtaposed pairs or subassemblies have different predetermined twist lengths so as to cause the members of one pair to be transposed with respect to those of another pair in order to reduce to a minimum inductive disturbances as, for example, cross-talk when the cable is used for telephone purposes. This, therefore, required a predetermined number of different and distinguishable subassemblies, each having a different rate of twist or twist length and that each pair be identified. It also required that the pairs be located in predetermined relation in the cable and their position maintained in the cable. This required the manufacture and storage of a number of different subassemblies and particular care in the selection and assembly of them into a cable, all of which adds to the cost of the cable.

The present invention overcomes these difficulties and disadvantages of the prior constructions by providing a single twisted pair having the lengths of the twists in the pair continuously varying throughout and preferably controlling the variation at random so that there is no fixed pattern in the twist variation whereby lengths of the one twisted pair can be placed adjacent one another in open circuits or in cables with a minimum of difficulty from inductive disturbances therebetween.

A feature of the present invention resides in the fact that but a single twisted pair need be produced which can be safely utilized in an open circuit or in a cable without the danger of electric disturbances being present between the twisted pairs therein, thus eliminating the necessity of making and storing a large number of different and distinguishable pairs or subassemblies.

Another feature of the invention resides in the fact that with the present invention the cable assembly and construction can be simplified.

Other features and advantages of the invention will be apparent from the specification and claims when considered in connection with the drawings in which:

Figure 1 shows a diagrammatic view of the apparatus for making the twisted pair of the present invention.

Fig. 2 shows two twisted pairs in side-by-side relation as they would appear in a cable.

Fig. 3 shows a speed time chart showing the variation of capstan speed.

Fig. 4 shows one form of speed-changing device.

As shown in the drawings, a pair of wires *a* and *b*, preferably insulated electrical conductors, are fed from reels **10, 11** through a conventional twisting device **12** which

includes a rotatable flyer **13** driven from a motor **14** or other source of power so as to carry the wire *a* around the wire *b* as it passes through the guide **15** and form a twist therewith as the wires are drawn therethrough by a capstan **16**. The twisted pairs are then fed to a takeup spool **17** which may be driven by a usual constant torque motor **18** or the like means. It will be apparent that the length of each twist depends upon the rate at which the wire is drawn by the capstan through the twisting device, i.e., the rate of speed of the capstan with respect to the rate of rotation of the flyer, so that by changing gears in the drive to the capstan a twisted pair having the twists of a predetermined length could be produced. The foregoing describes a standard machine now in use for forming twisted pairs having a uniform length of twist throughout.

In contradistinction to such a twisted pair, the present invention provides a novel twisted pair in which the length of successive twists therein is continuously changing. As shown in the top pair of the cable of Fig. 2, the length of the twist decreases to R, increases to S, decreases to T and then increases while in the lower pair the length of the twist increases to U, decreases to V, increases to X and decreases. It will be noted that the rate of change in length is constantly varying and the reversals thereof occur at random so that when two or more twisted pairs are put in juxtaposition in a cable the danger of cross-talk or the disturbances in the signal is substantially eliminated.

Since the length of twist in each pair is constantly varying, the present invention greatly simplifies the method and manufacture of novel cables because it is no longer necessary to maintain stocks of twisted pairs each having a predetermined different length of twist and it is no longer necessary to arrange the pairs having different length twists therein in predetermined position in the cable and to maintain them in said positional arrangement to prevent inductive disturbances in the cable.

While either the speed of the flyer or capstan can be varied, in the illustrated form of apparatus the capstan, as shown in Fig. 1, is driven from the motor **14** through a speed-changing device **19**.

Any suitable variable speed drive may be used. One such drive is shown in Fig. 4 wherein the input shaft **20** driven from motor **14** has an expansible pulley **21** thereon and the output shaft **22** has an expansible pulley **23** thereon. A belt **24** connects the pulleys. A pair of pivoted levers **25, 26** are connected to the sides of the pulleys to move the sides in opposite directions to increase the belt-engaging diameter of one pulley and decrease the belt-engaging diameter of the other pulley to vary the speed between the shafts **20** and **22**. The levers have their ends pivotally connected to nuts **27** threaded on the oppositely threaded portion of a rotatable adjusting shaft **28**. By controlling the rotation of shaft **28**, it will be seen that the relative speed of the capstan and the flyer can be regulated to control the length of twist.

In order to provide for a constantly varying length of twist in the wires, the present invention controls the rotatable member or shaft **28** of the variable speed drive. While the shaft 28 can be driven from the motor **14** or by a separate variable speed motor having suitable controls thereon, in the illustrated form of apparatus the rotating member **28** is driven from the capstan **16** through a gear reducer **29** so as to rotate the screw within the speed changer or variable speed drive so as to cause the levers **25, 26** to be pivoted about their pivots and move the side of the pulleys toward or away from one another to increase or decrease the effective diameter of the pulleys and change the speed of the capstan. Since the control member **28** is driven with the capstan which is being rotated at a variable speed, the change in speed of the speed-changing device will also be variable so

that the change of length of the twist in the pair is continuously varying.

In order to further modify the twist in the pair, the present invention provides a novel control means for controlling the rotating adjusting shaft of the speed changer. In the herein form of apparatus a reversing mechanism **30** is inserted in the drive for the shaft **28** and a control for the reversing mechanism is provided to periodically reverse the rotation of the shaft. While this control can take the form of a tape, cam or any other type of programming device capable of effecting random operation of the shaft, it is herein illustrated as comprising a rotatable screw **31** having a nut **32** thereon and driven with the rotating shaft **28**. The nut has a switch **33** thereon connected to the control box **34** housing the usual electrical relays and air control means (not shown) for controlling the usual fluid operated reversing clutch means (not shown) in the reversing mechanism so that by actuating the reversing switch the direction of rotation of the shaft **28** can be reversed.

The control of the switch can be carried out by any suitable programming device such as tape, cams, punch cards, photocells and the like devices capable of producing random reversal of the shaft **28**. In the illustrated form of apparatus it comprises a drum **35** having projecting at random from its surface a plurality of actuators **36**. The drum is positioned adjacent the screw and is rotated to cause the actuators to be moved into the path of movement of the reversing switch **33** to engage the same and operate the reversing means to cause a reversal of rotation of the shaft **28**. The drum can be driven in timed relation with the shaft **28** or by motor **14** but it is herein illustrated as being driven by a separate motor **35***a* which can be a single speed or variable speed motor as desired. Preferably, the drum is provided with continuous end projections **37** which form limit controls for actuating the switch and reversing the changing speed at predetermined points to define the maximum and minimum length of twist in the pair.

With this construction it will be seen that the rotation of the shaft **28** is continually varied between limits and reversed at random to cause the variable speed drive to continuously vary at random the speed of the capstan with respect to the flyer drive and hence the length of each twist in a twisted pair.

The speed-time chart shown in Fig. 3 is a section of a chart taken on an actual run of a machine forming a twisted pair of the present invention and graphically shows the variation in the speed of the capstan on a time basis, and, since the speed of the flyer is constant, the chart shows the variation between the speed of the capstan and flyer drives. The notations at the left in Fig. 3 indicate the speeds representing the maximum and minimum lengths of twist in the pair and the zigzag curve

having irregular reversals clearly show the continuous and random nature of the change in relative speeds and resulting increasing and decreasing lengths of twist. The portions of the curve below the minimum length line were produced during the starting and stopping of the machine.

The control means for producing twisted pairs of the present invention can be added to existing machines without substantial alteration thereto or can be built into the machine as original equipment.

Although the present machine is intended to produce twisted pairs having constantly varying lengths of twist, it can be adjusted to produce twisted pairs of fixed constant length of twist. This is accomplished by adjusting the capstan speed to the required speed as shown on the tachometer **38** on the output shaft **22** and then locking the adjusting shaft **28** against further adjustment by a suitable clamp **39** actuated by a handwheel **40** on the control panel **41**. Also, the clutch in the reversing mechanism can be rendered inoperative, by means of handwheels **42**, **43** on the control panel so that the connection will cease to drive the shaft **28** whereupon the capstan will be driven at a constant rate of speed to produce twists of constant length.

It will be seen, therefore, that the illustrated machine is very versatile in that it can produce twisted pairs having a fixed length of twist or a continuously varying length of twist as required.

Variations and modifications may be made within the scope of the claims and portions of the improvements may be used without others.

I claim:

1. An article of manufacture comprising a twisted pair of electrical conductors of indefinite length having the length of the succeeding twists therein continuously increasing and decreasing at random with no fixed pattern of twist variation.

2. A cable comprising a plurality of pairs of twisted electrical conductors of indefinite length, each pair having the twists therein of continuously varying random lengths with no fixed pattern of twist variation whereby the wires in the adjacent pairs are in transposed non-inductive relation.

3. A cable comprising a plurality of juxtaposed pairs of twisted electrical conductors of indefinite length, the length of the twists in each pair continuously increasing and decreasing at random with no fixed pattern of twist variation whereby the wires in the adjacent pairs are in non-inductive relation.

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