

March 13, 1962

J. W. OLSON

3,025,340

FLEXIBLE POWER CABLE

Filed April 6, 1959

FIG. 1

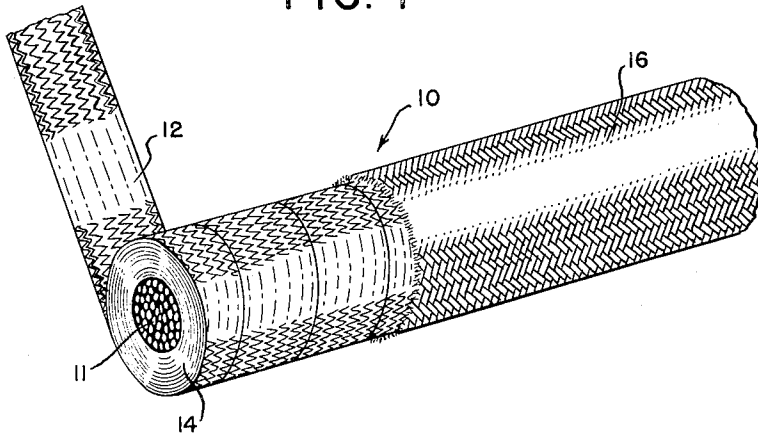


FIG. 2

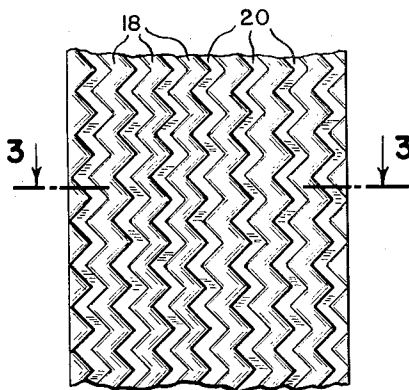
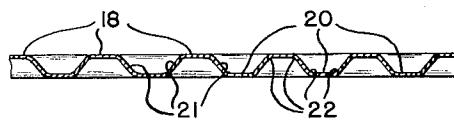


FIG. 3



INVENTOR

John W. Olson

BY

Pennie, Edmunds, Koster, Burruss & Taylor
ATTORNEYS

1

3,025,340

FLEXIBLE POWER CABLE

John W. Olson, Dobbs Ferry, N.Y., assigner to Anaconda Wire and Cable Company, a corporation of Delaware
Filed Apr. 6, 1959, Ser. No. 804,341
4 Claims. (Cl. 174-120)

This invention relates to flexible electric power cables of the type insulated with wrappings of paper tape. More particularly, the invention provides a paper-insulated flexible power cable which is characterized in that the paper tape of the insulation is embossed with a plurality of substantially regularly spaced non-rectilinear convexities.

Paper tape is often used as insulation on flexible electric cables and on power cable leads in transformers and the like, because it inherently has good dielectric strength and is inexpensive, easy to apply, and can be made to withstand the fixing and bending to which such cables and leads are often subjected. Also, a wrapping of paper can easily absorb a liquid dielectric if such is used, as in transformer leads which are submerged in oil in the transformer housing. To increase the flexibility of such paper-insulated electric cables, it has been proposed heretofore to form the paper wrappings from randomly crumpled paper or crepe paper tapes, rather than from tapes of ordinary flat paper, because the former are extensible and can stretch when the cable is flexed.

However, tapes of randomly crumpled or crepe paper have not proved entirely satisfactory for use as insulation on power cables. One of the prime disadvantages of both types of paper is that during their manufacture the individual fibers are deformed to such an extent that many are torn apart. For example, crepe paper is prepared by crowding a sheet of thin wetted paper on a roll so that the paper is folded into a multitude of acute pleats, and during the process fibers along the fold-lines of the pleats are severely damaged. Such damage to the fibers of a paper tape increases the susceptibility of insulating wrappings made from them to electrical and mechanical deterioration.

A further disadvantage of randomly crumpled and crepe papers is that such papers are necessarily of light weight and low density. As a result, they are less suitable for purposes of electrical insulation than harder and denser papers because the insulating ability of paper generally increases with its density. Also, crepe paper becomes permanently deformed when stretched perpendicular to its pleats. Hence, when a cable wrapped with such paper is bent and then bent back to its original form, the wrapping is permanently distorted and loosened.

It is the purpose of the present invention to provide a paper-insulated electric cable which does not suffer from any of these disadvantages and yet is exceptionally flexible. Broadly stated, the invention provides a flexible power cable comprising an electrical conductor, and a plurality of layers of paper tape wrapped about the conductor. Rather than being flat, crumpled, or creped, the paper of the tape in this new cable is embossed with a plurality of substantially regularly spaced convexities defined by a plurality of surfaces joined at rounded junctions without sharply folding the paper of the tape.

Paper of this type possesses many advantages over randomly crumpled or crepe papers. Not only is it substantially free from broken fibers as described above, but it is extensible both laterally and longitudinally. In the embossing of the paper used in the power cable of the invention, the convexities impressed in the paper are shaped without forming sharp, acute fold-lines. Thus, the individual fibers of the paper are not severely bent and are intact throughout the embossed tape. Moreover,

2

the paper tape of the present cable can be stretched resiliently in any direction without permanently deforming. Also, because the convexities of this tape are embossed in the paper, rather than being formed by wrinkling or crowding the paper on a roll, a much harder and denser paper can be employed.

Even when wrapped under tension, embossed paper of this type does not flatten out, so that each turn of the wrapped tape contacts only the raised surface of the previous turn. Hence, the tape forms a cushioning insulating layer about the conductor which yields easily to the internal radial forces imposed on it when the cable is bent, thereby improving the flexibility of the finished wrapping.

A preferred embodiment of the flexible power cable of the invention is described hereinbelow with reference to the accompanying drawing, wherein

FIG. 1 is a perspective showing a length of the new power cable;

FIG. 2 is a plan of a portion of one form of the embossed paper tape which may be used in the power cable of the invention; and

FIG. 3 is a cross section on an enlarged scale taken along the line 3-3 of FIG. 2.

Referring first to FIG. 1, a length of flexible cable 10 is shown provided with a stranded copper conductor 11. Wrapped helically about the conductor 11 are a plurality of turns of a paper tape 12 forming concentric layers of insulation 14. To protect the outermost turns of the tape, an outer braided jacket 16, preferably of cotton, is applied thereon.

Advantageously, the tape 12 is formed from a relatively hard calendered kraft paper because the higher density of such paper increases the dielectric properties of the wrapping, and its hardness facilitates retaining an embossed pattern. The paper can vary in thickness so long as it possesses sufficient strength to be helically wrapped under tension in the conventional manner about the conductor 11 and is sufficiently flexible for its particular application. If the surface of the paper possesses a smooth calendered finish the cable 10 is more flexible because the friction between layers in the wrapping 14 is then reduced and the adjoining layers of the tape 12 can slide more easily over one another when the cable is flexed.

According to the invention, the paper of the tape 12 is embossed with a plurality of regularly arranged spaced convexities, one form of which is shown in detail in FIGS. 2 and 3. Thus, a plurality of zigzagging ridges 18 are embossed parallel to one another along the length of the tape. The ridges 18 are spaced apart regularly on the surface of the tape so that a corresponding plurality of grooves 20 are defined therebetween.

The plateaus of the ridges 18 and the valleys of the grooves 20 are defined by substantially planar surfaces and are joined together by obtusely sloping surfaces 21 so that the included angles therebetween are always greater than 90°, and with the junction 22 between the sloping surfaces and the valleys rounded instead of being sharply folded. As a result, the fibers of the paper are not subjected to severe bending or creasing during the embossing of the ridges and grooves and are generally left intact throughout the paper after completion of the embossing operation. These ridges and grooves 18 and 20 may be formed by passing a calendered kraft paper through opposed rotating heated roller dies having mating zigzagging lands and grooves on their cylindrical surfaces which impress the paper into its embossed form.

The plateaus of the ridges 18 may be raised only between about 0.003 and 0.020 inch above the valleys of the grooves 20 though they may be higher. Such low height of the ridges 18 further insures that the fibers of

the paper are not torn or damaged during the embossing operation; yet even with such low height the zigzagging ridges 18 are sufficiently high to impart substantial extensibility, both lateral and longitudinal, to the tape and to provide a marked cushioning effect to the plurality of layers of tape superimposed upon one another in the wrapping.

When a tape 12 of the type shown in FIGS. 2 and 3 is wrapped about the conductor 11, the layer of insulation 14 which builds up is relatively spongy because of the embossed construction of the tape. Even under the tension imposed in helical wrapping operations, the ridges 18 do not completely flatten out. As a result, the internal radial compressive forces imposed on the tape when the cable is bent are readily absorbed, so that flexing of the cable is easy, and the wrapping is prevented from binding itself into an inflexible layer about the conductor. Also, the cushioning construction permits each turn of the finished wrapping to slide relative to the adjoining turns when the cable is bent so that the layers can easily re-orient to conform with the curve of the bend. In addition, a certain amount of both longitudinal and lateral resilient stretching of the tape 12 is permitted, as a result of the zigzagging form of the embossed ridges 18.

There are, of course, many other patterns of substantially regularly spaced convexities which may be embossed on the paper tape, such as patterns of raised triangles or hexagons, or of alternate octagons and squares, or of ridges and grooves which follow a course conforming to a succession of alternately inverted half-hexagons, rather than the zigzagging form shown, to give it the desired properties. In general, the important requirements of any pattern contemplated are that it should not involve any acute creasing of the paper which might cause injury to the fibers and also it should provide for resilient extensibility of the tape both longitudinally and laterally.

I claim:

1. A flexible power cable comprising an electrical conductor, and a plurality of layers of dense smooth-surfaced, embossed paper tape wrapped about said conductor, substantially the entire area of said embossed paper being formed with contiguous alternate concavities and convexities, said concavities and convexities merging directly into one another along rounded junctions without sharply folding the paper of said tape, said concavities and convexities being disposed in a non-rectilinear arrangement defining a pattern free of any straight line path lying in the paper and extending in a flat plane in any direction across the paper, said paper being in consequence of said arrangement of convexities and concavities extensible simultaneously in more than one direction without elongation of the paper itself.

2. A flexible power cable comprising an electrical conductor, and a plurality of layers of dense, smooth-surfaced, embossed paper tape wrapped about said conductor, substantially the entire area of said embossed paper being formed with contiguous alternate concavities

and convexities merging directly into one another along obtusely adjoining surfaces, said concavities and convexities being disposed in a non-rectilinear arrangement defining a pattern free of any straight line path lying in the paper and extending in a flat plane in any direction across the paper, said paper being in consequence of said arrangement of convexities and concavities extensible simultaneously in more than one direction without elongation of the paper itself.

3. A flexible power cable comprising an electrical conductor, and a plurality of layers of dense, smooth-surfaced, embossed paper tape wrapped under tension about said conductor, substantially the entire area of said embossed paper being formed with contiguous alternate ridges and grooves extending in a zig-zag path across the paper, said ridges and grooves merging directly into one another along obtusely adjoining surfaces, said ridges and grooves forming a non-rectilinear pattern free of any straight line path lying in the paper and extending in a flat plane in any direction across the paper, said paper being in consequence of said arrangement of ridges and grooves extensible simultaneously in more than one direction without elongation of the paper itself.

4. A flexible power cable comprising an electrical conductor, a plurality of layers of dense, smooth-surfaced embossed paper tape helically wrapped under tension about said conductor, and an outer protective braided jacket covering said layers of paper tape, substantially the entire area of said embossed paper being formed with contiguous zigzagging alternate ridges and grooves, said ridges and grooves merging directly into one another along obtusely adjoining substantially planar surfaces, said surfaces being joined at rounded junctions without sharply folding the paper of said tape, said zigzagging ridges and grooves defining a non-rectilinear pattern over the entire surface of said tape which is free of any straight line path lying in the paper and extending in a flat plane in any direction across the paper, said paper being in consequence of said pattern of ridges and grooves extensible simultaneously in more than one direction without elongation of the paper itself.

References Cited in the file of this patent

UNITED STATES PATENTS

463,107	Degenhardt	Nov. 10, 1891
1,939,264	Hill	Dec. 12, 1933
2,038,935	Hunter et al.	Apr. 28, 1936
2,233,592	Dunajeff	Mar. 4, 1941
2,607,822	Crandall	Aug. 19, 1952
2,607,824	Camilli et al.	Aug. 19, 1952

FOREIGN PATENTS

19,951	Great Britain	of 1900
--------	---------------	---------

OTHER REFERENCES

Fischer (German), printed App. S.N. S30,496, Mar. 29, 1956.