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Pokorny

[11] **3,825,671**

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[54] **TRANSMISSION LINE AUDIBLE NOISE AND CORONA REDUCING DEVICE**

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[52] **U.S. Cl.** ..... **174/40 R,** 174/42, 174/127, 174/DIG. 12

[51] **Int. Cl.** **H02g 7/00**

[58] **Field of Search** ..... 174/40 R, 42, 127, 128, 174/129 R, 130, 135, DIG. 12

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[57] **ABSTRACT**

A device for attachment to EHV and UHV transmission line conductors to reduce audible noise and other corona effects. A plurality of metallic rods each having a preformed shape are mounted on a conductor and form one or more cage-like generally elliptical structures. Each rod end portion has a helical shape, and the end portions of a complement of said rods form a cylindrical configuration having an inner diameter generally equal to the outer diameter of the conductor. The rod end portions have sufficient resiliency to wrap about and grip the conductor, eliminating the need of clamps, etc. to retain the elliptical cages thereon. The cages effectively increase the conductor diameter, modify the electrical field pattern about the conductor, and reduce the surface gradient to reduce audible noise and other corona effects.

8 Claims, 10 Drawing Figures

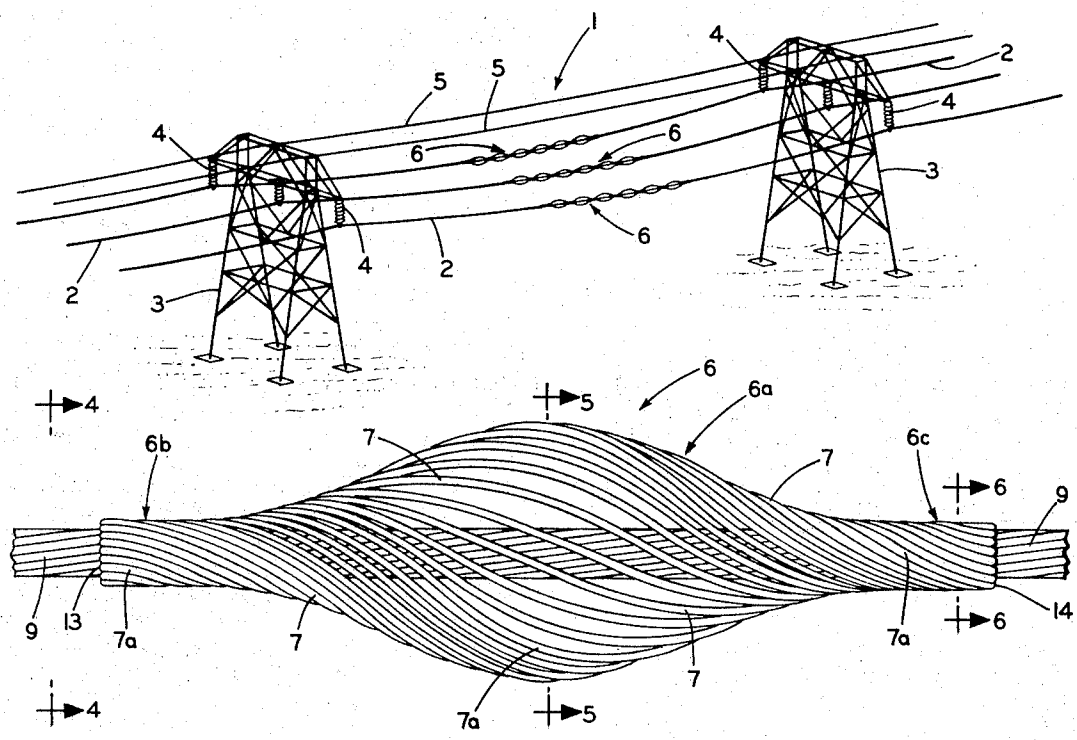
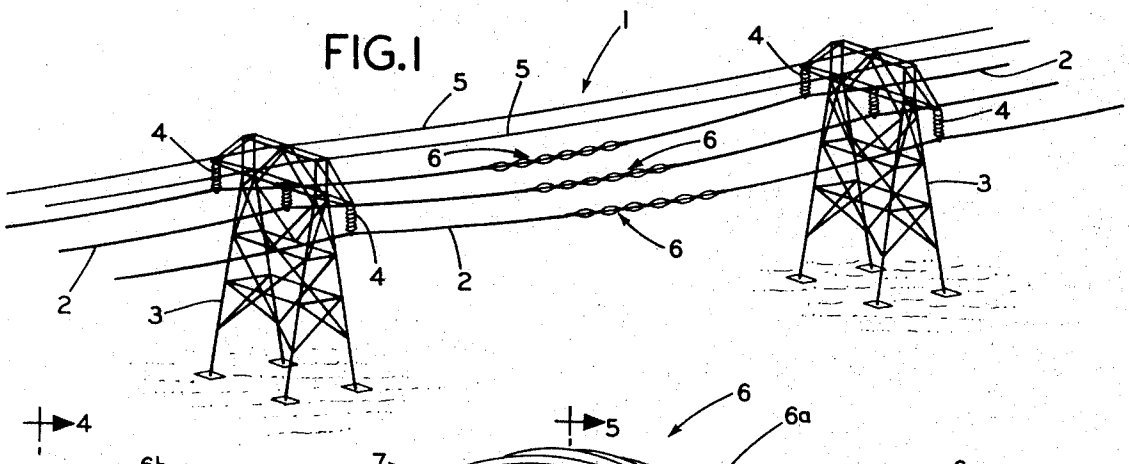


FIG. 1



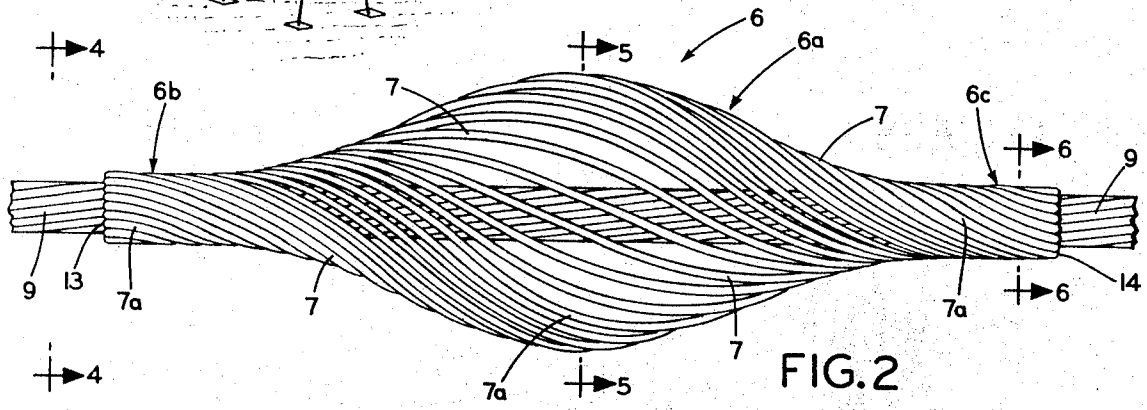


FIG. 2

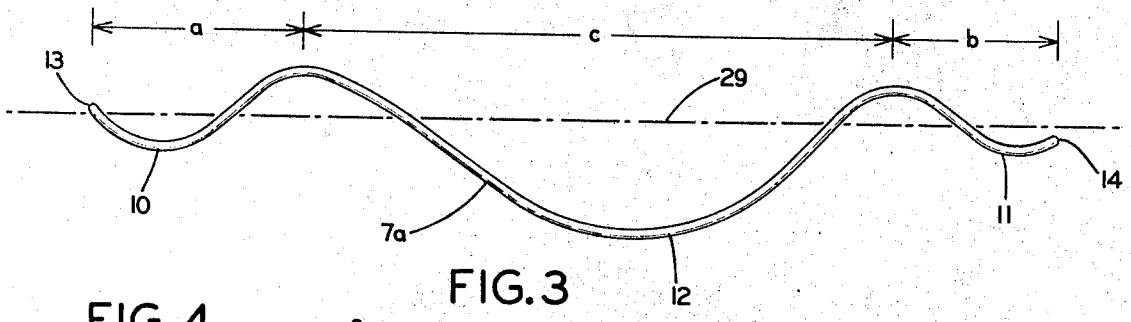


FIG. 3

FIG. 4

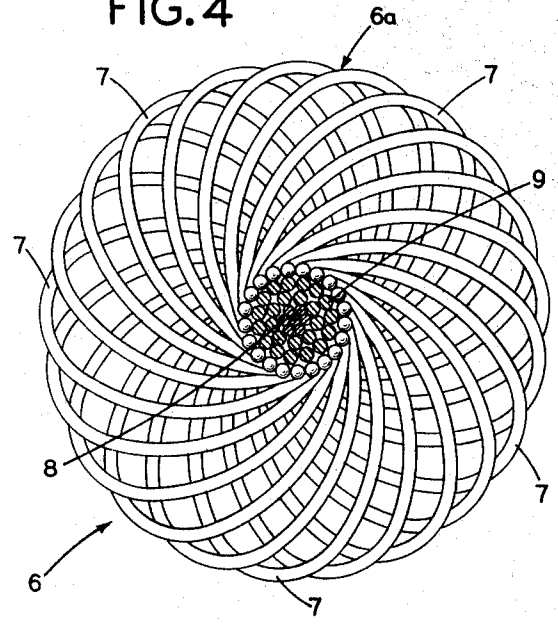
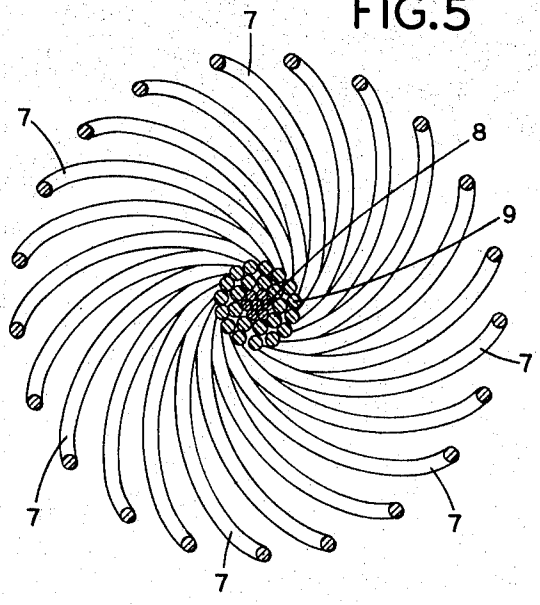


FIG. 5



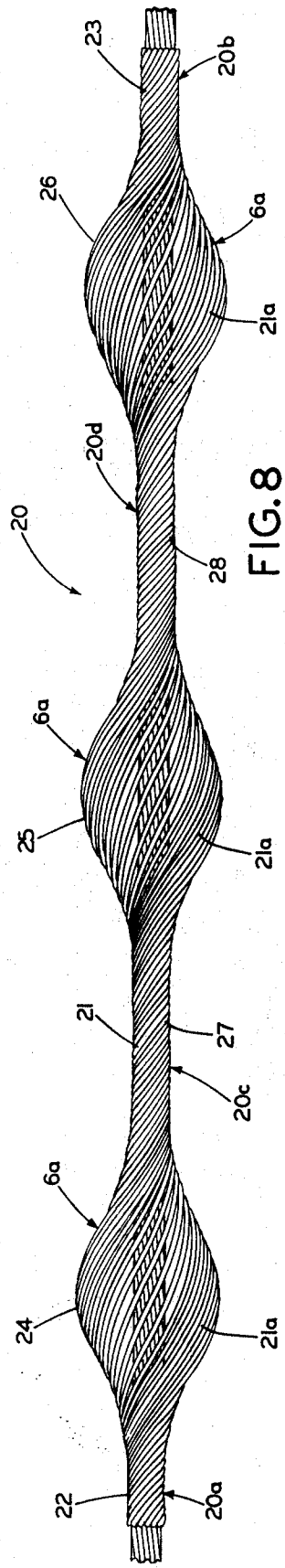


FIG.8

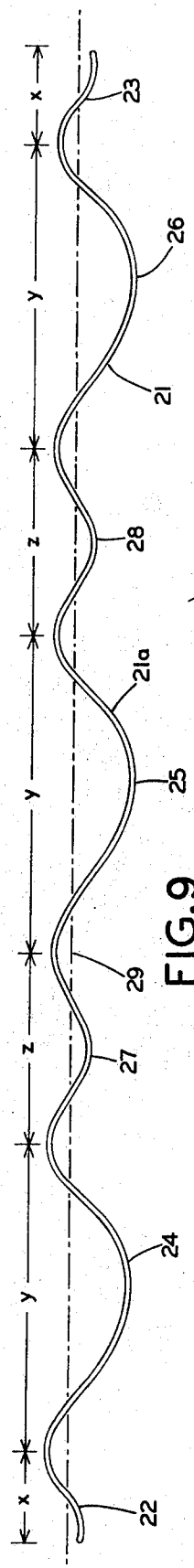


FIG.9

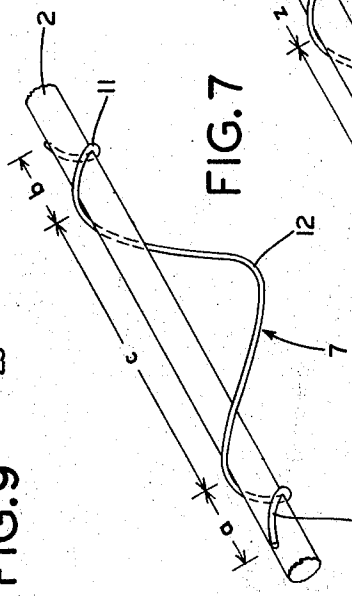


FIG.7

FIG.10

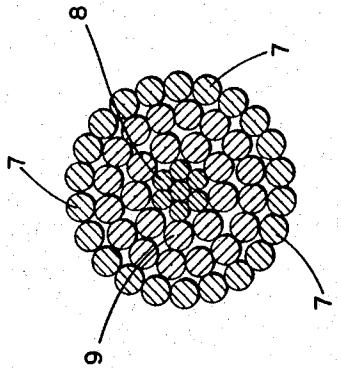


FIG.6

TRANSMISSION LINE AUDIBLE NOISE AND CORONA REDUCING DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to high voltage transmission line conductors and in particular to a device attached to such conductors to reduce audible noise and other corona effects. More particularly the invention relates to a cage-like structure formed on the conductors which has the effect of increasing the conductor diameter and modifying the electrical field pattern which reduces the surface gradient of the conductor. The cage-like structure has the additional effect of reducing wind induced conductor vibration.

2. Description of the Prior Art

The operating voltage of electrical transmission lines has increased considerably in recent years. Transmission lines with usual operating voltages in the range of 23 kv–138 kv have been used throughout the electrical industry until recent years when higher operating voltages in the range of 345 kv–500 kv have become standard. Such high voltages may result in increased corona effects, radio and T.V. interference and, with operating voltages in the range of 345 kv and greater, undesirable audible noise may result.

Transmission line conductor design is such that when conductors are energized at rated operating voltages, the voltage gradient at the surface of a clean and dry conductor is below the corona and audible noise starting level. However, when drops of water from rain, fog or dew adhere to the conductor, the corona starting level is reduced and audible noise may be generated at rated operating voltage.

The trend in transmission line construction is to higher and higher operating voltage in the range of 750 kv to possible future operating voltages as high as 2,000 kv. These UHV (ultrahigh voltages) can increase the problems of corona and audible noise.

Numerous devices have been used for suppression of corona effects, of power surges, and of radio and T.V. interference, such as disclosed in U.S. Pat. Nos. 1,288,751, 1,626,777, 1,691,329, 1,999,273, 2,009,854 and 3,179,740. Many of these prior devices perform satisfactorily for their intended purpose on transmission lines operating at heretofore nominal voltage levels.

The corona reducing devices such as shown in U.S. Pat. Nos. 1,626,777 and 1,999,273 require a specially manufactured conductor which is used throughout the transmission line, having outer layers of wire formed and wrapped about the main conductor. Such special conductors are expensive and greatly increase the cost of a transmission line.

Other devices mounted on transmission lines to reduce corona effects, such as shown in U.S. Pat. Nos. 1,691,329 and 2,009,854, use a helical conductor which is coaxial with and spaced from the transmission conductor. These devices require separate clamps and spacers to prevent the helical wire from contacting the conductors. The clamps and connectors are possible sources of problems and may result in the generation of radio, T.V. and audible noises of greater amounts then those suppressed by the device.

Other devices such as the voltage grading ring construction of U.S. Pat. No. 3,179,740, are used at the location where the conductor is suspended from a tower to grade the electrical field about an insulator suspension assembly.

The above discussed devices, as well as other known transmission line corona reducing devices, are not concerned particularly with audible noise, since such noise only becomes a serious problem at extremely high operating voltages, which voltage levels have not been used extensively for existing transmission lines.

Usually high voltage transmission lines in the range of 345 kv–2,000 kv when erected on strips of land having a sufficient right-of-way width, will have the transmission line located far enough from adjacent buildings, so that the audible noise will not become a problem to the inhabitants thereof. However, problems may occur in securing such right-of-way that the desired width may not be available, and the transmission line may be relatively close to inhabited dwellings where the audible noise produced may become a problem.

A need has arisen therefore, for a device which can be mounted on the conductors in a selected span or spans of a transmission line where audible noise and other corona effects may be a problem. Such devices must be inexpensive and easily attached to the conductor even when the conductor is energized, if necessary. Likewise, such devices must be lightweight, have low wind resistance and prevent the buildup of ice and snow thereon.

There is no transmission line device of which I am aware which has a generally elliptical cage-like configuration which can be mounted on a transmission line conductor without separate clamps or other attachment means, and which reduces the corona effects and audible noise produced thereby.

SUMMARY OF THE INVENTION

Objectives of the invention include providing a device attached to a transmission line for reducing corona effects and audible noise on EHV (extremely high voltage) and UHV transmission lines, which is inexpensive and which can be mounted easily on existing transmission line conductors without separate clamps and mounting means even when the conductors are energized; providing such device which has an elliptical cage-like configuration formed of a plurality of preformed electrical conducting metallic wires which have helical portions complementary to the transmission line conductor, whereby the preformed wires may be wrapped about the conductor to form and hold the cage-like structure on the conductor; providing such device having a cage-like configuration which has a minimum of wind resistance due to the spaced cage-forming wire strands and which has a minimum weight, and also which assists in reducing wind-induced conductor vibration; providing such device which can be preformed to provide a plurality of such cage-like structures in series along the conductor; providing such device which can be mounted on the conductor in a minimum of time and with a minimum of labor without removing the conductor from its suspended position on a transmission tower; and providing such device for reducing audible noise and other corona effects, which eliminates difficulties heretofore encountered, achieves the stated objectives simply and effectively, and solves problems and satisfies existing needs.

These objectives and advantages are obtained by the device for mounting on a transmission line conductor

for reducing corona and audible noise, the general nature of which may be stated as including a plurality of preformed electrically conductive members each having opposite end sections and an intermediate section; the opposite end sections each having a helical configuration with an internal diameter of the helix generally equal to the outer diameter of the transmission line conductor whereby the ends of the conductive members when applied to the conductor are held in tight-gripping relationship thereon; the intermediate section being arcuate and having a radius of curvature greater than the radius of the conductor and being spaced from the conductor when mounted thereon by the end sections; the end sections of the conductive members being disposed in surrounding circumferential relationship on the conductor; the radii of curvature of said intermediate sections being equal to each other and form a cage-like elliptical-shaped body coaxial with the transmission line conductor with the intermediate sections being spaced from each other and from the conductor; and alternatively the conductive members each including a plurality of intermediate sections having a helical section similar to the end sections located between each pair of intermediate sections.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention — illustrative of the best modes in which applicant has contemplated applying the principles — are set forth in the following description and shown in the drawings and are particularly and distinctly pointed out and set forth in the appended claims.

FIG. 1 is a perspective view of a transmission line having a plurality of the improved corona and audible noise reducing devices mounted on the conductors thereof;

FIG. 2 is an enlarged side elevation of one of the corona and noise reducing devices of FIG. 1;

FIG. 3 is a side elevation of one of the metallic strands, a plurality of which form the device of FIG. 2;

FIG. 4 is an enlarged sectional view taken on line 4—4, FIG. 2;

FIG. 5 is an enlarged sectional view taken on line 5—5, FIG. 2;

FIG. 6 is an enlarged sectional view taken on line 6—6, FIG. 2;

FIG. 7 is a fragmentary, diagrammatic perspective view of one metallic strand of the device mounted on a section of a conductor.

FIG. 8 is a side elevation similar to FIG. 2 showing a modification of the transmission line device having three of the cage-like structures integrally joined and mounted on a conductor;

FIG. 9 is a view similar to FIG. 3 showing a single strand of the device of FIG. 8; and

FIG. 10 is a fragmentary, diagrammatic perspective view similar to FIG. 7, showing a portion of a single strand of the device of FIG. 8, mounted on a section of a conductor.

Similar numerals refer to similar parts throughout the drawings.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

A portion of a usual three phase high voltage electrical transmission line is illustrated generally at 1 (FIG. 1), having three conductors 2 extending between and supported by a pair of spaced steel towers 3. Conductors 2 are suspended from towers 3 on a plurality of insulator discs 4. One or more static wires 5 extend between the tops of towers 3 to provide a lightning shield for conductors 2 and to function as the circuit ground conductors.

In accordance with the invention, a plurality of audible noise and corona reducing devices 6 are mounted on the conductors at one or more locations in the span between towers 3. Six such devices 6 are illustrated in FIG. 1 (exaggerated in size) as being mounted axially adjacent to each other on each conductor 2.

The components 6 may be mounted individually on conductors 2 and spaced some distance apart, or arranged in groups of two or more and may be axially adjacent to each other as shown in FIG. 1. The number and arrangement of devices 6 is determined by the amount of audible noise and corona reduction needed in a certain area. The amount of noise and corona produced on a transmission line to be reduced by device 6 is determined by a number of factors, such as weather conditions, conductor size and spacing, operating voltage level, etc.

Each device 6 includes a plurality of preformed, bare electrical conductive, rod-like strands of wire 7 (FIG. 3) formed of metal. Wire strands 7 are preformed so that when a complement of strands 7 are mounted on conductor 2, they form an intermediate cage-like structure 6*a* and a pair of cylindrical end portions 6*b* and 6*c*.

The particular metal of strands 7 must be compatible with the material of conductor 2 to prevent oxidation, corrosion, etc. Thus, for a usual transmission line conductor having a core formed of a plurality of steel strands 8 (FIGS. 4 and 6) surrounded by one or more layers of aluminum strands 9, strands 7 will be aluminum, aluminum coated steel, etc. Likewise, for copper conductors, strands 7 of device 6 will be formed of copper, copperweld, etc.

Strands 7 formed of aluminum coated steel are preferable for use on aluminum conductors 2. The steel provides sufficient resiliency for gripping conductor 2 when mounted thereon, and more than if strands 7 were formed completely of aluminum, and the aluminum coating provides the compatibility with the aluminum conductor strands.

An individual strand 7*a* for device 6 is shown in FIGS. 3 and 7. Each of the individual strands 7*a* of device 6 will have a similar shape and configuration and, therefore, only one strand 7*a* need be described in detail. Each strand 7*a* includes a pair of end sections 10 and 11 and an intermediate arcuate section 12. End sections 10 and 11 terminate in rounded tips 13 and 14, respectively, to eliminate any sharp projections or points which increases considerably the corona discharge and noise levels of a conductor.

Sections 10 and 11 have general helical shapes with the inner diameters of the helixes being approximately equal to the outer diameter of conductor 2, as can be seen in FIGS. 2 and 7. Thus, when a complement of such strands 7 are mounted on a conductor 2, end sections 10 and 11 form cylindrical end portions 6*b* and 6*c*, respectively, which have inner diameters generally equal to the outer diameter of the conductor.

The length of sections **10** and **11** of each strand **7** is indicated at "*a*" and "*b*," respectively, (FIGS. **3** and **7**) such that when strands **7** are applied to a conductor **2**, the end sections are wrapped sufficiently about and grip the conductor to mount strands **7** thereon. The small amount of resiliency inherent in such preformed sections of wire, together with matching diameters of conductor **2** and helical end sections **10** and **11**, and corresponding cylindrical portions **6***b* and **6***c*, enable strands **7** to be wrapped about and grip conductor **2** tightly, without additional clamping means being required.

Such preformed end sections **10** and **11** are somewhat similar to the formation of "preformed armor rods" and "preformed ties" used in the erection and maintenance of electrical transmission and distribution lines.

Intermediate section **12** is arcuate-shaped, preferably having a spiral configuration extending from one side of conductor **2** longitudinally axially along the conductor to a position on the opposite conductor side as seen in FIGS. **2, 4** and **7**. The length of sections **12** is indicated by "*c*" in FIGS. **3** and **7**. Intermediate section **12** extends through arc angle of approximately 180° about the axis **29** of conductor **2** as illustrated in FIG. **4**.

Strands **7** are installed easily and quickly on conductor **2** to form device **6** without tools, clamps, tape or other additional attaching means. Either end section **10** or **11** is placed on conductor **2** and strand **7** is rotated in a clockwise direction about conductor **2** when viewed from either end of the conductor in FIG. **7**. Sections **10** and **11** wrap tightly about the grip conductor **2** mounting strand **7** thereon.

Intermediate sections **12** of each strand **7** are spaced from conductor **2** and extend in a generally spiral direction about conductor **2** due to the preformed shape of strands **7** as sections **10** and **11** grip conductor **2**.

Each strand **7** is wrapped in succession individually on conductor **2** with sections **10** and **11** preferably being placed in abutting relationship, circumferentially about conductor **2**. Such a complement of strands **7** form a complete covering or strand layer over conductor **2** (FIGS. **2, 4** and **6**), indicated by cylindrical portions **6***b* and **6***c*.

Intermediate sections **12** form the elliptical cage-like structure **6***a* of devices **6**, as individual strands **7** are mounted successively on conductor **2**. Sections **12** are spaced equally apart from one another circumferentially about conductor **2** and are spaced radially from conductor **2** throughout their length, except for some contact which may occur with conductor **2** when merging with sections **10** and **11**.

Sections **12** are spaced apart automatically a predetermined distance as the strands are mounted on conductor **2** due to the circumferential advancement of sections **10** and **11** about conductor **2** when placed in circumferential abutting relationship with the end sections of the adjacent strands **7**. The amount of predetermined pitch with which intermediate sections **12** are formed also determines the spacing between sections **12**.

The formation of cage-like device **6** can be illustrated easily by the following example. A section of an outer strand layer of a conductor is cut circumferentially about the conductor with the end portions of the cut section being moved axially towards each other along the conductor. The strand sections between the ends will balloon outwardly forming a generally elliptical cage-like structure such as shown in FIG. **2**.

The diameter of such a formed cage-like structure is determined by the distance that the section ends are moved axially towards each other. Likewise, the greater the diameter of such a formed cage-like structure, greater will be the separation between the strands of the cage for a given length of wire.

Second Embodiment

A modified form of the invention is indicated generally at **20** and is illustrated in FIGS. **8, 9** and **10**. Modified device **20** includes three cages **6***a*, formed integrally with respect to each other and extending axially along conductor **2**.

Device **20** is formed of a plurality of individual metallic electrical conducting strands **21**, one of which, **21***a*, is shown in FIGS. **9** and **10**. Strands **21** have the same characteristics as to material, resiliency, etc. described above for strands **7**, except that the general configuration of strands **7** is repeated generally three times throughout the length of strands **21**.

Each strand **21** has helical end sections **22** and **23** similar to sections **10** and **11** of strands **7** for tightly gripping conductor **2** when strands **21** are mounted thereon. A plurality of intermediate arcuate sections **24, 25** and **26** are formed between end sections **22** and **23**, and are separated by intermediate helical sections **27** and **28**. Sections **10** and **11**, arcuate sections **24, 25** and **26**, and intermediate helical sections **27** and **28** extend axially along conductor **2**, distances "X", "Y" and "Z" as shown in FIGS. **9** and **10**.

Sections **27** and **28** are generally similar to helical end sections **22** and **23** with their inner diameters being equal to the diameter of conductor **2**.

Strands **21** of the modified device **20** are installed easily on a conductor **2** in the same manner as strands **7** of device **6**. Either end **22** or **23** is placed on the conductor. Strand **21** then is rotated in a clockwise direction about conductor **2**. Helical end sections **22** and **23**, and intermediate helical sections **27** and **28** wrap tightly about and grip conductor **2** mounting each strand **21** thereon. No tools or additional mounting means are required.

Each strand **21** is wrapped in succession, individually on conductor **2**, with end sections **22** and **23** and intermediate sections **27** and **28** of the adjacent strands preferably being placed in abutting relationship circumferentially about conductor **2** as shown in FIG. **8**. A complement of such strands **21** form a plurality of cages **6***a*, cylindrical end portions **20***a* and **20***b*, and cylindrical intermediate portions **20***c* and **20***d*. Arcuate strand sections **24, 25** and **26** form the elliptical-shaped cages **6***a* coaxial with the axis **29** of conductor **2** as do sections **12** of device **6**, and helical strand sections **22–23** and **27–28** form cylindrical portions **20***a*–**20***b* and **20***c*–**20***d*, respectively.

Each intermediate section **24, 25** and **26** of strands **21** will be spaced from each other and from conductor **2** as are sections **12** of device **6**, as shown in FIGS. **4** and **5**. Sections **24, 25** and **26** preferably extend in a spiral-like direction about conductor **2** as do sections **12** of strands **7**, in order to impart a generally elliptical shape to cages **6***a*.

IN GENERAL

The open cage-like construction of structure **6***a* of

devices 6 and 20 which are free of any intervening material between intermediate sections 12, 24, 25 and 26, and conductor 2 as shown in FIGS. 2 and 8, permits wind to flow freely through cages 6*a* and between strands 7 and 21 providing a minimum wind resistance. Likewise, the spaces between the individual strands in cages 6*a* reduces the formation of layers of ice and snow about the conductor which may cause excess weight on the conductor, and which may cause "dancing" and "galloping" conductors.

Cages 6*a*, in effect, increase the conductor diameter with a minimum of metal, thereby reducing the material and installation costs, and weight of the conductor, as compared with a usual integral layered conductor used to produce the same effective diameter. It is well known in the art that increasing the effective size of the conductor diameter, modifies the electrical field pattern about the conductor and reduces the surface gradient, thereby reducing audible noise and other corona effects.

The cages 6*a* need not be elliptically-shaped, as shown, in order to achieve the desired reduction in corona and audible noise. Cages 6*a* may have a more rounded or spherical shape. The elliptical shape, however, is preferable since it forms a smooth arcuate contour upon merging and joining with the conductor, and is preformed easily in the strands without sharp bends.

The particular arrangement of the three integral cages 6*a*, illustrated and described for device 20, is an example only of multiple cages, and there is no special significance to only three cages in the arrangement. In actual installations, individual strands of conductive material, such as strands 7 and 21, will be preformed to construct various numbers of such cages 6*a* which are axially joined. It is contemplated that as many as 5, 10, 15 or more cages 6*a* may be integrally formed. The main limitation of such multi-cage configurations is the length of the individual strands for forming such number of cages. If the length of the individual strands becomes too long, they are difficult to store, ship, handle, install, etc., especially since their installation may take place many feet in the air and with "hot stick equipment."

The formation of a device similar to device 20 having a plurality of cages 6*a* is more desirable in many situations than the single cage structure of device 6, in that device 20 provides considerably increased noise and corona reduction for the small amount of increase in material and installation time than required for device 6.

If desired, devices 6 and 20 and modifications thereof, may be installed adjacent to insulator discs 4 or at any location in a particular conductor span without removing the conductor from its supporting clamp or bracket.

A general guide in forming cages 6*a* of devices 6 and 20 is that the minor diameter of the cage is approximately five times the conductor diameter, with the cage length being approximately ten times the conductor diameter.

It has been discovered that devices 6 and 20 when applied to a conductor have the additional benefit of reducing wind induced conductor vibration. Devices 6 and 20, therefore, may be applied to particular conductors which have vibration problems, and function as a dampener therefor.

Devices 6 and 20 also may be applied to one or more subconductors of a transmission line having a bundled-conductor arrangement, in the same manner as described for a single conductor 2 for reducing corona and audible noise.

Accordingly, the transmission line device provides a simple, inexpensive structure for mounting on a transmission line conductor which is operating at voltages in the range of 345 kv to 2,000 kv to reduce audible noise and other corona effects, by effectively increasing the conductor diameter, by modifying the electrical field pattern, and by reducing the surface gradient; provides such device which can be mounted on existing or newly installed conductors, with the conductors being deenergized or energized; which device accomplishes the desired results with a minimum weight increase, minimum wind resistance, and without removing the conductor from its suspended position on a transmission structure; provides such device which is effective, safe, inexpensive, and efficient in assembly, operation and use, and which achieves all the enumerated objectives; and provides for eliminating difficulties encountered with prior devices, and solves problems and obtains new results in the art.

In the foregoing description, certain terms have been used for brevity, clearness and understanding, but no unnecessary limitations are to be implied therefrom beyond the requirements of the prior art, because such terms are used for descriptive purposes and are intended to be broadly construed.

Moreover, the description and illustration of the invention is by way of example, and the scope of the invention is not limited to the exact details of the construction shown or described.

Having now described the features, discoveries and principles of the invention, the manner in which the improved transmission line audible noise and corona reducing device is constructed, assembled and operated, the characteristics of the new construction, and the advantageous, new and useful results obtained; the new and useful structures, devices, elements, arrangements, parts, and combinations are set forth in the appended claims.

I claim:

1. In combination: an overhead high voltage transmission line conductor extending between spaced supports, and a device for reducing corona and audible noise mounted on said conductor, said device including a plurality of preformed electrically conductive members each having opposite end sections being mounted on the transmission line conductor at a location between and spaced from the supports, and each having a helical configuration with the internal diameter of the helix generally being equal to the outer diameter of the transmission line conductor with the ends of the conductive members being held in tight gripping relationship on the conductor; the intermediate section being arcuate and having a radius of curvature greater than the radius of the conductor and being spaced from the conductor; said intermediate section being integral with the end sections and extending generally longitudinally along the axis of the conductor between said end sections; the end sections of said conductive members being disposed at intervals in circumferential relationship on the conductor; the radii of curvature of said intermediate sections generally being equal to each other and forming an open cage-like body coaxial with

the conductor, with said intermediate sections being spaced from each other and from said conductor; and the cage-like body being free of any intervening material between said intermediate sections and the conductor thereby reducing the weight and wind resistance of the device.

2. The construction defined in claim **1** in which each of the intermediate arcuate sections has a spiral configuration; and in which said intermediate sections extend in a longitudinal direction along the axis of the conductor through approximately 180° about the axis of the conductor.

3. The construction defined in claim **2** in which the plurality of intermediate spiral sections form an elliptically-shaped open cage-like body; in which said cage-like body is coaxial with the conductor; and in which the major axis of said elliptical body coincides with the axis of the conductor.

4. The construction defined in claim **1** in which the end sections of a complement of the conductive members surround the conductor in circumferential abutting relationship and form cylindrical end portions completely encircling the conductor outer surface.

5. The construction defined in claim **4** in which the inner diameters of the cylindrical end portions generally are equal to the outer diameter of the conductor.

6. The construction defined in claim **1** in which the end sections of the conductive members terminate in rounded tip formations.

7. The construction defined in claim **1** in which the conductive members each includes a plurality of intermediate arcuate sections; and in which a helical section similar to the end sections is located between each pair of intermediate arcuate sections.

8. The construction defined in claim **7** in which the helical intermediate and helical end sections of a complement of said conductive members form intermediate and end cylindrical portions; and in which the inner diameters of said cylindrical portions generally are equal to the outer diameter of the transmission line conductor.

* * * * *