

[54] **METHOD OF FORMING STEEL
SUPPORTED ALUMINUM OVERHEAD
CONDUCTORS**

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abandoned.

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174/102 R, 174/108

[51] Int. Cl. **H01b 13/26**

[58] Field of Search 156/47, 49, 50-56;
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474.1; 174/102 R, 102 C, 102 D, 103, 105 R,
106 R, 106 D, 108, 128, 13 D, 126 CP, 40,
42; 57/160, 161, 15, 3, 6, 9, 138, 139, 144,
145, 166

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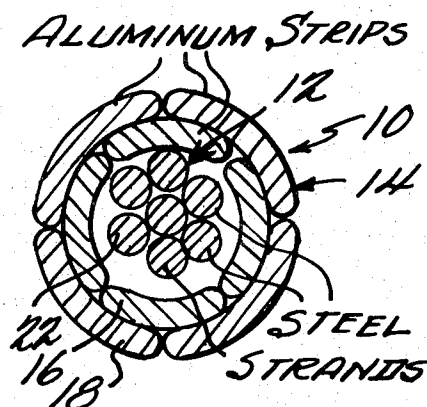
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Gibbs

[57] **ABSTRACT**

The conductors disclosed herein each comprise a hollow tube of aluminum supported on a steel cable received within the tube. The cable has a smaller outside diameter than the inside diameter of the aluminum tube. The latter need not be integral; it may be fabricated from flat strips, wires or rods, shaped or round. Strips, wires or rods are stranded over the cable; integral tubes are extruded over the cable or folded over the cable from a broad strip and longitudinally welded. Soft aluminum wires may be stranded radially between the steel cable and the hard-drawn aluminum conductor, then crushed by the application of radial pressure to provide internal space between the aluminum covered steel core and the hard-drawn aluminum conductor. Under operating conditions, substantially all mechanical tension on the steel supported aluminum overhead conductor is borne by the steel cable and the conductor is largely immune to hazards of galloping, aeolian vibration, loss of strength as a result of high operating temperatures, and creep at normal and high operating temperatures.

1 Claim, 11 Drawing Figures



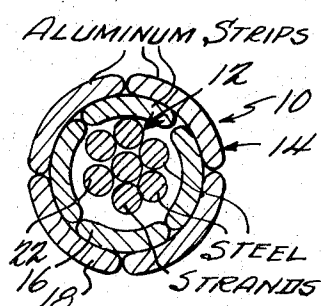


Fig. 1

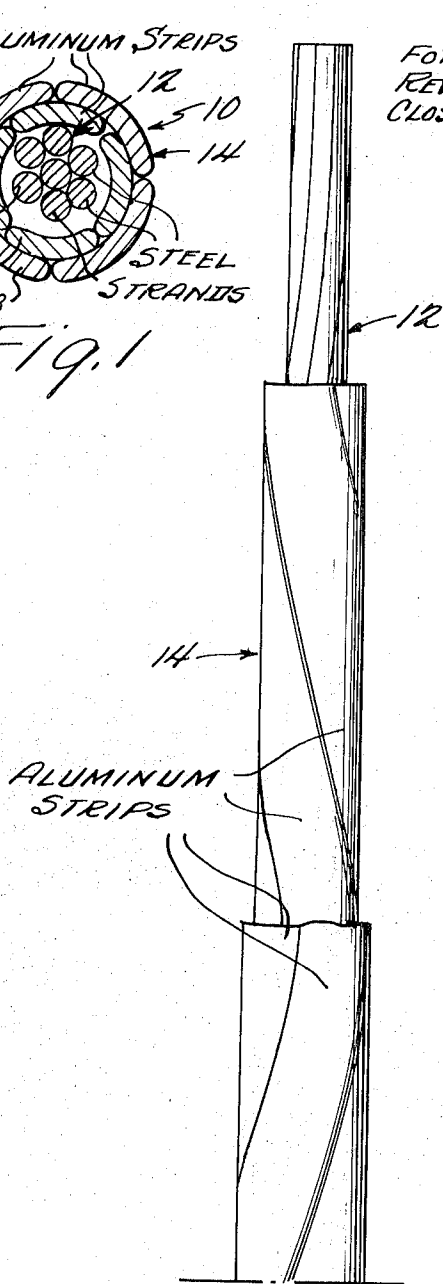


Fig. 2

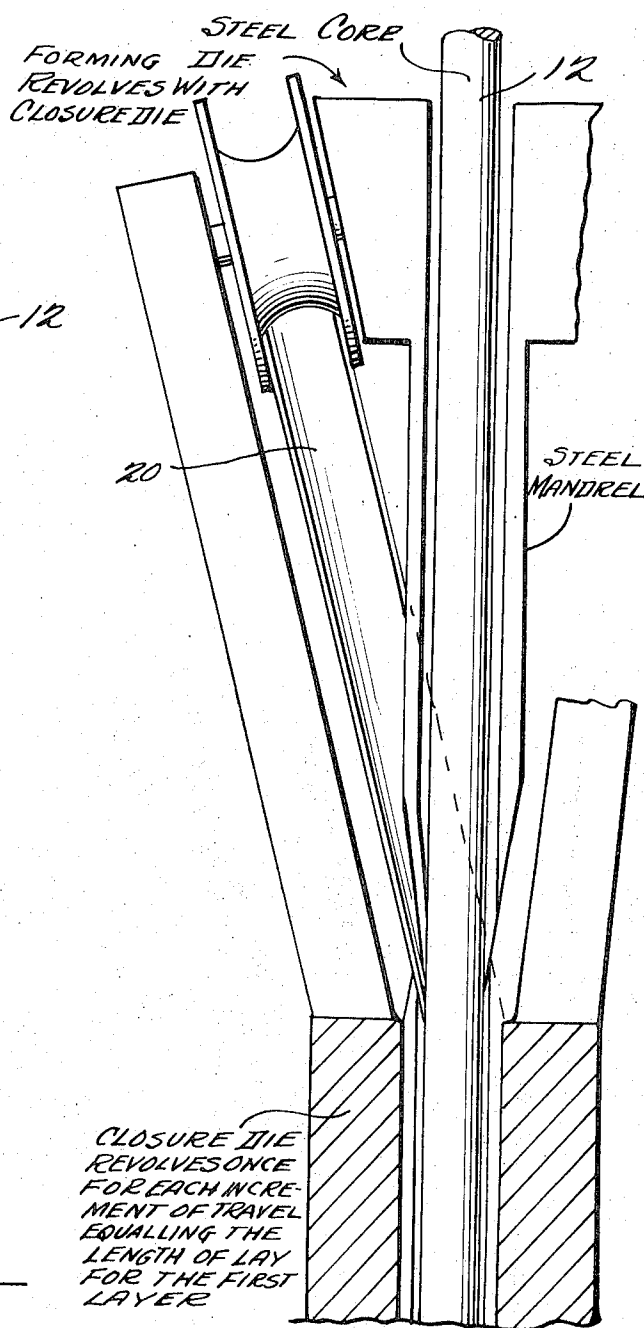


Fig. 4

Fig. 3

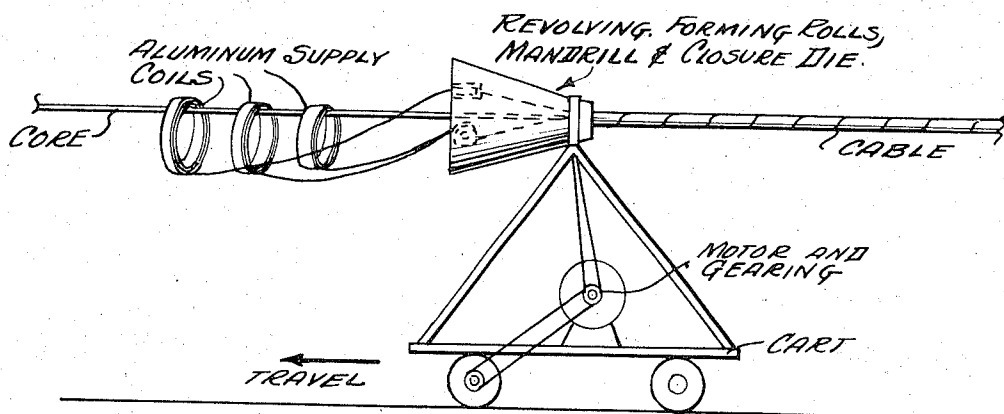
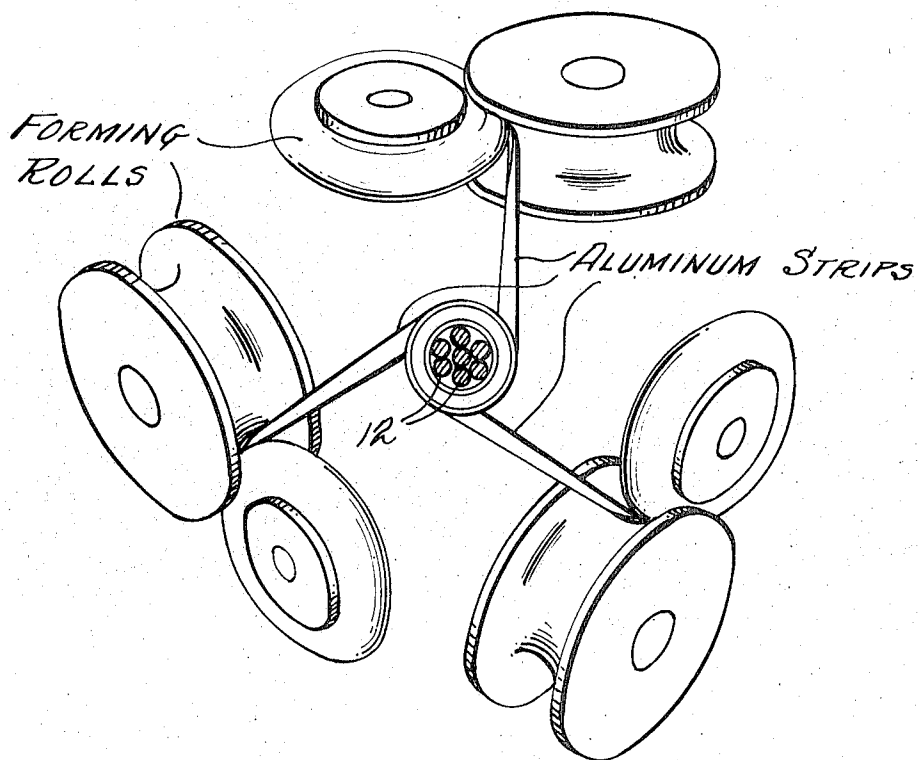


Fig. 5

Fig. 6

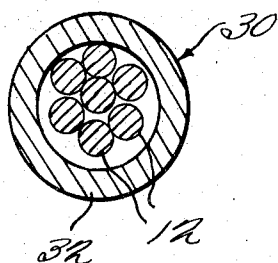


Fig. 7

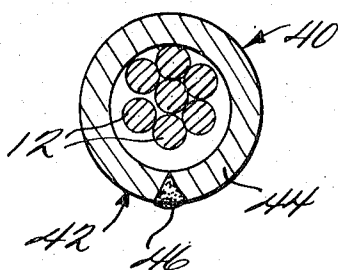


Fig. 8

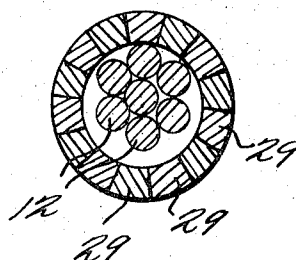


Fig. 9

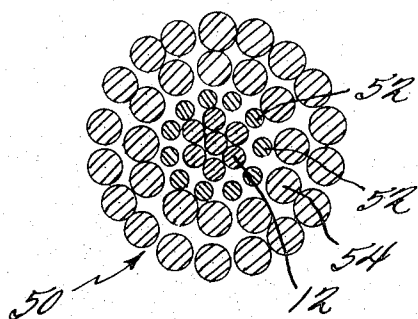


Fig. 10

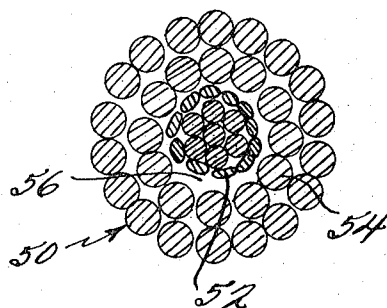
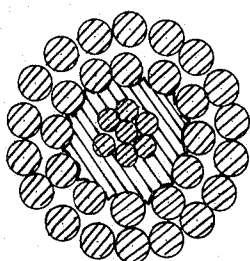


Fig. 11



METHOD OF FORMING STEEL SUPPORTED ALUMINUM OVERHEAD CONDUCTORS

This is a division, of application Ser. No. 51,128 filed June 30, 1970 and now abandoned.

BACKGROUND OF THE INVENTION

Conventional aluminum conductors employed in the construction of overhead lines are exposed in service to hazards which may cause different kinds of damage, the degrees of which are extremely difficult to predict. Among these hazards and the types of damage are:

1. Aeolian vibration which can result in fatigue breakage of aluminum wires. Tension limitations based upon aeolian vibration considerations are principal parameters in overhead line design. (Aeolian vibration is a relatively high frequency, low amplitude resonant oscillation that is normally caused by winds from about 3 to 15 miles per hour. Amplitudes of aeolian vibration are less than the conductor diameter. Galloping is a low frequency, large amplitude phenomena. Most usually it occurs when an ice formation on the conductor causes the overall cross section to assume the shape of an air foil, so there is an actual lift of the conductor by the wind. Amplitudes of galloping can be several feet.)

2. High operating temperatures resulting from heavy electrical loads which can result in the partial annealing of aluminum wires. High operating temperatures, especially during emergencies, become an increasingly important factor as system capacities are progressively enlarged.

3. Creep, or inelastic elongation, of aluminum wires that takes place over a relatively long period of time. The rate of creep is a function of time, temperature, stress, and of the amount of prior creep at any given point in time. Creep causes an increase in conductor sag and can result in problems with electrical clearances.

The principle of providing aluminum upon steel as an overhead conductor has been widely used in recognition of the current carrying capacity of the former and the strength of the latter. The designation by which this kind of conductor is usually known in technical and trade literature is "ACSR" for Aluminum Conductor, Steel Reinforced. However, with conventional steel reinforced conductors, tension is borne by the aluminum wires in all circumstances, except sometimes at high temperatures. The proportionate tension borne by aluminum and steel wires is primarily a function of temperature of operation (aluminum expands and contracts approximately twice as much as steel with changes in temperature) and of the amount of creep occurring in the aluminum. Sometimes conductors are prestressed during stringing to accelerate the creep of the aluminum wires, but this does not eliminate tension in them.

Conventional accessories such as dead ends, jumper terminals, splice connectors, armor rods, jumper filler rods, come alongs, socks, grading rings, suspension clamps, stringing sheaves and the like used in the stringing, cutting, sagging, terminating and splicing of ACSR and expanded ACSR conductors do not disturb the relative positions of the aluminum and steel strands of the conductors and so do not significantly affect the division of tension between the aluminum and steel portions of the conductors. When tension is applied to a long length of conventional steel reinforced alumi-

num conductor having such fittings on each end, both the aluminum and steel components are stretched equally and by an amount proportional to the average, or virtual modulus of elasticity. This, in turn, results in substantial stresses in both the aluminum and steel components of conventional conductors.

Some expanded ACSR conductors incorporate non-metallic filler or hollow metallic tubes between the central steel strand(s) and the radially distributed aluminum strands. Other expanded ACSR conductors employ aluminum wires stranded over a steel tube.

In expanded ACSR constructions which incorporate paper filler for expansion, there remains a need for conductor-metal contact throughout the diameter of the line. This is needed to preclude the development of voltage differentials that might result in arcing that could destroy the paper filler.

A feature common to all the expanded types of conductor, is that there is always a solid underlying base to support the radial pressures of overlying layers of wires. It is, therefore, impossible for the helices of the overlying wires to contract as they must to prevent the development of consequential tension in the wires.

SUMMARY OF THE INVENTION

The conductors disclosed herein each comprise a hollow tube of aluminum supported on a steel cable received within the tube. The steel cable has a smaller outside diameter than the inside diameter of the aluminum tube. The latter need not be integral; it may be fabricated from flat strips, wires or rods, shaped or round. Strips, wires or rods may be stranded over the steel cable; integral tubes may be extruded over the steel cable or folded over the cable from a broad strip and longitudinally welded. Soft aluminum wires may be stranded radially between the steel cable and overlaying hard-drawn aluminum conductor, then crushed by the application of radial pressure to provide internal space between the aluminum covered steel core and the hard-drawn aluminum conductor. Under operating conditions, substantially all mechanical tension on the steel supported aluminum overhead conductor is borne by the steel cable and the conductor is largely immune to hazards of galloping, aeolian vibration, loss of strength as a result of high operating temperatures, and creep at normal and high operating temperatures.

There are three reasons why this is so. First, relative to aluminum wires, steel wires are much more resistant to vibration damage, are not adversely affected by operating temperatures that cause partial annealing of aluminum wires, and have a very low creep rate throughout the operating temperature spectrum. Second, with little or no mechanical stress on the aluminum, fatigue of the aluminum is not likely to occur. Third, since there is no reliance on the strength of aluminum, creep would be of no consequence, and annealing of the aluminum would not cause any loss of rated strength.

For the aluminum to have substantially no stress, means must be provided for it to elongate with the stress but without picking up any consequential load. Ideally, the amount of elongation required would be that which would occur in the steel at about 50 percent of its rated strength plus the difference in length between steel and aluminum caused by a temperature change of about 60° F. The amounts are approximately:

Steel Stretch = $100,000 \text{ psi} / 27,000,000 = 0.0037$
inch/inch

Temp. Diff. = $(60) (0.0000128 - 0.000064) = 0.0004$
inch/inch

TOTAL = 0.0041 inch/inch

The need to compensate for this difference is illustrated by the fact that in a 10,000 foot length of conductor on a reel the total amount of differential elongation is about $10,000 \times 0.0041 = 41$ feet.

This necessary compensation can be provided for by designing the conductor so that an axial elongation of the helix of stranded aluminum wires or elements of whatever shape of 0.41 percent can take place without introducing consequential tension in the aluminum wires or elements. The relationship between the axial length of a stranded conductor and the length of an individual element in its helix is such that, unless the element itself is stretched, any lengthening of the helix must be accompanied by a reduction in the diameter of the helix. Means must be provided, therefore, for appropriate reduction in the diameters of the helices of aluminum wires or elements as the helices are lengthened.

Where the conductor is of multi-layer construction, alternate layers of the conductors are of opposite-sense pitch of counterbalance the torque in each layer that tends to unwind the helices when tension is applied, and to counterbalance internal magnetic effects caused by electrical current in each layer. This also simplifies manufacturing operations. The problem of torque is minimized by the conductor of the invention. Pitch angles for the helices may be critically established in relation to wire (round, keystone, flat or otherwise) dimensions so that wires do not crowd each other as the helices are stretched and their diameters reduced.

In order for consequential stresses not be transferred from the steel to the aluminum during changes in tension and temperature, the aluminum must not press tightly over the steel reinforcement. This can be accomplished by employing trapezoidally shaped aluminum wires for the innermost layer. With wires so shaped, the radial compressive force resulting from tension is carried by the "keystone" effect in a circumferential direction. The effect is, therefore, that of a tube which will not collapse and bear upon the underlying steel reinforcement. This tube, if made large enough, may serve as a means for producing an expanded, hollow (except for the steel reinforcing) conductor.

The shaped wires in the inner layer can also function to provide for the required reduction in diameter referred to above. This can be done by employing soft annealed wires for this layer, or by modifying the shape so that distortion takes place at a relatively low tension level. This will allow the inner layer to collapse to a smaller diameter as tension is applied, but not to such a degree that it will bear upon the steel.

Since there is no utilization of the strength of aluminum wires, there is no requirement for a hard temper for them. This may result in decreased cost of manufacturing and in an increase in conductivity when wires of a softer temper are used. It may also permit the use of trapezoidally shaped wires or round wires of larger diameter than conventionally employed.

To reduce any possibility of corrosion, the entire conductor may be impregnated with a suitable grease

to preclude the entry of moisture. The grease may be employed simply as a coating on individual wires or as a means to fill up the voids in the interstices and thus to preclude the entry of moisture. However, it is not necessary or possible to keep all of the internal voids filled with grease.

Another advantage of the conductor construction of the present invention is that aeolian vibration and galloping are inhibited. This is believed to be because the absence of consequential radial force permits the maximum amount of conductor self damping by interstrand friction at all frequencies and amplitudes.

Another advantage is that the full strength of the steel reinforcing wires can be utilized. Conventional conductors utilize only the strength of the steel at 1 percent extension because of the elongation limitations of hard drawn aluminum wires.

Another advantage is that computations of sags and tensions are greatly simplified by the elimination of factors such as stress distribution between different materials, differences in thermal coefficients of expansion, creep of aluminum, loss of strength due to elevated temperature, maximum operating temperature based upon possible conductor damage, tension limitations based upon aeolian vibration and galloping considerations. Such a conductor will permit the maximum tension limitation to be based solely on safety factors judged suitable under maximum ice and wind loading. Also the maximum operating temperature can be established as the temperature at which sags are the same as under maximum ice and wind loading.

The conductor of this invention can include a plastic filler, either metallic or nonmetallic, that would collapse, or could be caused to collapse, to provide the required tube to core spacing in the field, before the conductor is placed in service. Another reason for introducing the space during stringing rather than at the factor would be to avoid the possibility of traffic damage from chafing.

While it would be desirable to have zero stress in the aluminum conductor of the invention at all times, practical manufacturing the line construction considerations may dictate a minimal stress during initial installation and early periods of service. For example, it is desirable to joint successive lengths of conductor with fittings that rigidly connect both the steel and aluminum components.

In further summary, objects of the invention include:

1. Elimination of the possibility of aeolian vibration of fatigue damage.
2. Reduction of the possibilities of the occurrence of aeolian vibration and galloping.
3. Elimination of problems associated with creep of aluminum wires.
4. Elimination of the possibility of loss of strength due to partial annealing of aluminum wires at elevated temperatures.
5. Elimination of any need to limit the utilization of the strength of steel to its strength at 1 percent extension.
6. Simplification of sag and tension computations.
7. Allowance of maximum operating temperature to be limited by sag rather than by possibility of conductor damage.
8. Provision of a means for producing an improved expanded conductor.

To most effectively accomplish these objects, the tubular aluminum conductor desirably possesses the following characteristics:

1. Under all operating conditions, the inside diameter of the tube is larger than the outside diameter of the steel cable positioned inside of the tube.

2. The tube has sufficient radial stability to provide a base for overlying layers of wires, strips or rods during fabrication and during stringing.

3. The tube is capable of being elongated by approximately 0.50 percent at a very low level of longitudinal stress.

4. The length of lay of the helix is as long as practicable.

5. The reduction in diameter of the tube upon elongation is sufficient to allow overlying layers of helices to elongate an equal amount without developing consequential levels of stress.

6. The tube has an essentially round cross section, with no protruding irregularities either inside or outside. (Radius and smoothness of a surface is a factor that influences the voltage gradient in the air immediately surrounding a conductor. This, in turn, is a factor that influences corona discharges and associated radio interference. Any distortion will cause the radius at various positions around the periphery to vary, and possibly [but not necessarily] to introduce corona and radio interference phenomena. A small degree of distortion can be tolerated depending upon conductor size and voltage. If conductors are produced in a plant with the internal space between the core and tubular conductor, they may be distorted when placed on reels. If this distortion is all elastic in nature, however, it disappears when the conductor is strung. On the other hand, if internal space is introduced during stringing [for example, as by the use of pressure rolls as discussed below respecting FIGS. 9 and 10], this potential problem is eliminated.)

7. The tube must have sufficient flexibility to accommodate field stringing operations.

The principles of the invention will be further herein-after discussed with reference to the drawings wherein preferred embodiments are shown. The specifics illustrated in the drawings are intended to exemplify, rather than limit, aspects of the invention as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS IN THE DRAWINGS:

FIG. 1 is a transverse cross-sectional view of a steel supported aluminum overhead conductor incorporating aluminum strips;

FIG. 2 is a fragmentary elevational view of the conductor of FIG. 1 with layers progressively cut away to expose constructional details;

FIG. 3 is a schematic representation of equipment for manufacturing the conductor of FIGS. 1 and 2;

FIG. 4 is a fragmentary, partly cut away top plan view of the closure die region of the equipment of FIG. 3;

FIG. 5 is an end elevational view of a portion of the equipment of FIG. 3 showing the spatial relation of the forming rolls for the first aluminum strip layer to the conductor undergoing manufacture;

FIG. 6 is a transverse cross-sectional view of a steel supported aluminum overhead conductor incorporating an integral aluminum tube;

FIG. 7 is a transverse cross-sectional view of a steel supported aluminum overhead conductor incorporating an aluminum tube welded longitudinally from broad strip stock;

FIG. 8 is a transverse cross-sectional view of a steel supported aluminum overhead conductor incorporating stranded trapezoidally shaped aluminum wire;

FIG. 9 is a transverse cross-sectional view of a steel supported aluminum overhead conductor incorporating stranded aluminum wire over soft aluminum filler wires in an as-stranded condition;

FIG. 10 is a transverse cross-sectional view of the conductor of FIG. 9 after the soft aluminum filler has been crushed between the steel core and overlying hard aluminum wires; and

FIG. 11 is a transverse cross-sectional view of a steel supported aluminum overhead conductor similar to FIG. 10, but wherein the post stranding deformation is of a plastic filler.

DETAILED DESCRIPTION OF THE PRESENTLY PREFERRED EMBODIMENTS

Following a practice which is common in the industry, the entire article of the invention is referred to herein as a "conductor" even though the tubular aluminum portion thereof would in a strictly technical sense be more accurately designated the conductor. It is believed that this practice will cause no problem for those skilled in the art and familiar with its practices and vocabulary.

Unless otherwise indicated or obvious from the context, absolute values of dimensions given herein are for illustrative purposes only, to enable a more concise discussion of the preferred embodiments.

With reference to FIGS. 1-5 and especially FIGS. 1 and 2, there is depicted a steel supported aluminum overhead conductor 10 comprising a steel core 12 and a tubular aluminum conductor 14 received over the core 12. In the instance depicted, the tubular aluminum conductor is fabricated from two superimposed layers 16, 18 of helically wound layers of aluminum strip stock 20.

The steel core 12 is preferably made of stranded steel wires. They may be identical in composition and fabrication to the cores used in standard ACSR conductors, see ASTM specification B232 "Aluminum Conductors, Steel Reinforced, Concentric-Lay Stranded (ACSR)," ASTM specification B341 "Aluminum-Coated (Aluminized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR)," ASTM specification B502 "Aluminum-Clad Steel Core Wire for Aluminum Conductors, Aluminum-Clad Steel Reinforced (ACSR/AW)," and ASTM specification B498 "Zinc-Coated (Galvanized) Steel Core Wire for Aluminum Conductors, Steel Reinforced (ACSR)." They may also be of material having properties especially suitable to the disclosure, for example, higher strength than required by the ASTM specifications.

As illustrated, the steel core 12 consists of seven 0.1329 diameter steel strands 22 helically stranded to produce a core having an O.D. of 0.399 inches. (This is the same core as is found in 954 MCM 54/7 ACSR "Cardinal" conductor manufactured by Reynolds Metals Company of Richmond, Virginia.)

In this same example, the first, inner layer of the tubular aluminum conductor is provided by three helically stranded, rounded edged aluminum strips each

0.1 inch thick and 0.6 inch wide, this layer having an internal diameter of 0.50 inch, an external diameter of 0.70 inch and a pitch of 7.2 inches. The second, outer layer of the tubular aluminum conductor is helically stranded immediately upon the first, in an opposite helical sense, and consists of four, round edged aluminum strips each 0.1 inch thick and 0.6 inch wide, this layer having an internal diameter of 0.70 inch, an external diameter of 0.90 inch and a pitch of 9.6 inches. In each instance, the strips of aluminum are curved about the longitudinal axis of the tubular aluminum conductor so that each is arcuate as seen in transverse cross section.

in the core than in conventional constructions. Note that the elevated operating temperatures at which sag equals sag under maximum ice and wind loading are very high.

In the examples of Table II, the constructions in accordance with the invention utilize a solid aluminum jacket over the steel core for the conductor. The rated strengths were calculated on the basis of the strength of steel at 205,000 psi and of aluminum at 9,000 psi. This assumes that the stretch of the steel will be sufficient to cause load to be borne by the aluminum before break

TABLE II.—COMPARISON OF VARIOUS STEEL SUPPORTED CONDUCTORS

Property	Conductor size and type							
	7X.165	7X.165	477 MCM	7X.165	795 MCM	7X.165	1,272 MCM	7X.165
	0	.15	30/7 ACSR	.25	54/7 ACSR	.35	45/7 ACSR	.45
Steel area, sq. in.	.149	.149	.0616	.149	.0809	.149	.069	.149
Aluminum thickness	0	.15		.25		.35		.45
Aluminum area, MCM	0	443	477	796	795	1,220	1,272	1,760
Alum. area, percent of total	0	80	81	81	86	87	94	90
Rated strength	29,800	29,800	23,350	29,800	28,550	29,800	35,380	29,800
Conductor diameter, in.	.495	.795	.883	.995	1.092	1.195	1.345	1.395
Weight/M ft., bare	.502	.908	.747	1.235	1.024	1.622	1.434	2.122
Weight/M ft., H.L.		2,120		2,575		3,084		3,705
700 ft. span, 50% D.T.:								
0° Loaded:								
(a) Sag	6.5	9.45	10.8	10.7	10.6	12.9	10.5	15.7
(b) Tension	14,900	14,900	11,700	14,900	14,280	14,900	17,700	14,900
0° unloaded:								
(a) Sag		4.0	4.4	5.6	4.9	7.8	5.68	10.8
(b) Tension		13,600	9,890	13,200	11,050	12,750	15,400	12,300
120° final:								
(a) Sag		5.04		7.22	10.6	9.94	14.1	13.1
(b) Tension		10,650	4,620	10,500	6,000	10,300	6,300	10,100
Temp. for final sag to equal sag at 0°								
H.L.		(172° C.) 342° F.	(50° C.) 120° F.	(153° C.) 308° F.	(50° C.) 120° F.	(142° C.) 288° F.	(127° C.) 60° F.	(131° C.) 261° F.
								(0° C.) 30° F.

The strips 20 are preferably of EC-H19 aluminum, although other tempers and aluminum alloys, e.g. 5005 or 6201 could be employed.

The layer 16 could be formed from a greater or a lesser number of strips 20. To illustrate an alternative, the following table relates to a layer 16 consisting of two helically intertwined round edge strips of aluminum.

TABLE I

	As Fabricated	When Elongated 0.45%
Thickness of each strip	0.070 inch	0.070 inch
Inside diameter	0.5505 inch	0.500 inch
Inside circumference	1.729 inches	1.571 inches
Outside diameter	0.7105 inch	0.660 inch
Outside circumference	2.232 inches	2.073 inches
Lay factor	11.09 × I.D.	12 × O.D.
Pitch (length of lay)	7.88 inches	7.92 inches
Maximum strip width	0.832 inch	0.7598 inch
Recommended nominal strip width	0.750 inch	0.750 inch

The layer 16 of Table I may be stranded over the same 0.399 inch O.D. steel core as described above and an outer aluminum layer 18 of opposite helical sense may be laid directly on the layer 16 of this alternative example.

Although the conductors in the examples just described have overall outer diameters smaller than one inch, it is believed that the conductor of the invention has substantial and perhaps predominating usefulness in overall outer diameters in excess of one inch.

The properties and sag characteristics of several alternative constructions embodying the principles of the invention are contrasted with those of several ACSR constructions in the following table (Table II). For the constructions embodying principles of the invention approximately 5 to 10 percent more steel is shown used

actually occurs, and that the aluminum is annealed.

The representative equipment shown in FIGS. 3-5 for fabricating the steel supported aluminum overhead conductor of FIGS. 1 and 2 is provided with appropriate legends to enable those skilled in the art to rapidly grasp the salient features of its construction and manner of operation.

Rather than utilize rounded edge strips of aluminum to fabricate the layer(s) of the conductor 14, aluminum strands, of other cross-sectional shape may be employed. By way of illustration (FIG. 8), there may be used, upon a 7 × 0.1489 inch helically stranded steel core 12 having an outer diameter of 0.4467 inch, a tube of aluminum 27 having an inside diameter, when elongated 0.45 percent, of 0.4767 inch and consisting of 10 trapezoidally shaped wires 29 having a thickness of 0.20 inch. Other dimensions of the tube, assuming a stretch of 0.45 percent are as follows:

TABLE III

	As Stranded	When Stretched
Outside diameter	0.9498 inch	0.8767 inch
Length of Lay	14.7d = 13.97 inches	16d = 14.03 inch
Outside base (are line) of trapezoidal wires normal to length of wire	0.2916 inch	0.2702 inch
Required reduction in dimension of wire to permit stretching	—	7.5%

One problem in the design, the tube using trapezoidally shaped wires is ensuring that, when stranded, the

tube will be stable enough to provide a base for overlying layers of wires, and still be able to stretch without a particularly high tension. (Stretch for the overlying layers can be provided for by adjusting the pitch, number of wires, and wire diameters to the amount of diameter reduction expected in the tube.) It is obvious, however, that the reduction in wire dimension of 7.5 percent shown above cannot be achieved with ordinary wires by simply putting tension on the tube. However, the wires may be drawn about 10 percent undersize and every other wire given a zigzag shape with bends about every inch or two. This permits a reduction in the diameter of the tube by the forces that would tend to straighten out the zigzag.

Referring now to FIG. 6, there is shown a steel supported aluminum overhead conductor 30 which includes a steel core 12 as described above in relation to FIGS. 1 and 2, and a tubular aluminum conductor 32 extruded in an integral condition over the core. Exemplary values for the conductor 30 are provided in Table IV.

TABLE IV

	As Fabricated (inches)	When Crushed or Elongated 0.45% (inches)
Core outside diameter	0.450	0.450
Tube Thickness	0.1053	Approx. 0.1053
Tube inside diameter	0.500	Approx. 0.450
Tube outside diameter	0.7105	Approx. 0.6605
Tube outside circumference	2.232	Approx. 2.073

Referring now to FIG. 7, there is shown an alternative to the construction depicted in FIG. 6 in that tubular aluminum conductor 42 is provided for the steel supported aluminum overhead conductor 40 by wrapping a single broad strip 44 about the core 12 and welding its formerly laterally opposite edges to one another at 46 utilizing conventional welding equipment and techniques. Exemplary values for the conductor 40 are the same as in Table IV.

It is also possible to fabricate a steel supported aluminum overhead conductor 50 in accordance with the present invention utilizing round (e.g. cylindrical, oval, rounded edge flat strip) wires helically stranded upon the steel core. In order to do this, a special technique and means are employed to achieve the necessary spacing between the outside diameter of the core and the inside diameter of the tubular aluminum conductor. Very succinctly, with reference to FIG. 9, soft, annealed aluminum wires 52 are stranded directly upon the core 12. Then layer(s) of harder aluminum wires 54 are helically stranded upon the soft aluminum wire layer. The conductor 50 is shipped to where it is to be strung in this condition. Then, with reference to FIG. 10, the conductor 50 is run between pressure rolls applied to the exterior of the completely fabricated article. The harder wires 54 are elastically formed by the pressure rolls, but the softer underlying wires 52 are crushed into greater conformance, with interstitial spaces in the core 12 and in the hard aluminum wires 54. When the wires 54 spring back after passing the pressure rolls, the crushed wires 52 remain engaging the core 12 and the desired space 56 is provided between the composite core 12, 52 and the overlying tubular aluminum conductor 54.

The conductor 50 looks and behaves much like a conventional conductor in the plant and on shipping

reels. After pressure crushing, during stringing, the gap 56 allows sufficient space for attendant reduction in diameter of the helical layer(s) of wires 54. Exemplary characteristics of a steel supported aluminum overhead conductor constructed in accordance with the embodiment of FIGS. 9 and 10 are presented in Table VIII.

TABLE VIII

1. Size: 1,046,105 circular mils			
2. Stranding (Immediately after stranding):			
a. tubular aluminum conductor		30x0.1750"	EC-H19 aluminum
b. soft aluminum layer		11x0.1076"	EC-0 aluminum
c. core:		7x0.1329"	steel
3. Cross Section:			
a. Aluminum:	0.8216 sq. in.		
b. Steel:	0.0970 sq. in.		
c. Total:	0.9186 sq. in.		
4. Outside Diameter:			
a. As stranded:	1.3138"		
b. Under maximum load:	1.2250"		
5. Weight per 1,000 feet:			
a. Aluminum:	985.6 lb.		
b. Steel:	329.0 lb.		
c. Total:	1,314.6 lb.		
6. By weight:			
a. Aluminum:	75.0%		
b. Steel: 25.0%			
7. Rated strength (with Class A steel wire):			
a. As stranded: 36,096 lb.			
b. Aluminum fully annealed: 26,484 lb.			
8. Summary of Lay (as stranded):			
	Inner Layer	Outer Layer	Soft Layer
Maximum Length of Lay	11.318"	13.407"	7.95"
O. D. of Layer	.9638"	1.3138"	.6138"
Lay Factor	11.74	10.2	13.0

As should be apparent, integral or welded tubes, wire and strip may all alternatively be used in the fabrication of conductor in accordance with the invention disclosed in this document. The particular mode which would be preferable at any given point in time would be the one that could most economically be produced at that time or meet other considerations of design prejudice. One of the features of the conductor of the invention is that the basic requirement for conventional conductors that aluminum wires have the maximum possible strength has been eliminated. This makes possible the consideration of materials other than hard drawn round wires that may be produced by various processes. Combinations certainly are possible. For example, the soft aluminum wires referred to above in respect to FIGS. 9 and 10 could be replaced by an extruded, equally crushable jacket of soft aluminum.

In all of the disclosed embodiments, once the conductor has been strung, the top inside of the tubular aluminum conductor will definitely touch the top of the outside of the core and the core will not be precisely centered. This will result in some asymmetry of the magnetic fields caused by electric current. The degree of asymmetry should be quite small, however, and there should be no consequential problem. There is no significant sag to noncircular shape of the tubular aluminum conductor because of its resting on the core when the conductor is fabricated in accordance with the invention, as described hereinabove, and strung in accordance with sensible procedures.

It should now be apparent that the steel supported aluminum overhead conductors as described hereinabove possesses each of the attributes set forth in the specification under the heading "Summary of the Invention," hereinbefore. Because the steel supported

11

aluminum overhead conductors of the invention can be modified to some extent without departing from the principles of the invention as they have been outlined and explained in this specification, the present invention should be understood as encompassing all such modifications as are within the spirit and scope of the following claims.

I claim:

1. A method for manufacturing steel supported aluminum overhead conductor comprising providing a steel core, forming an intermediate layer of soft aluminum upon the steel core, fabricating a tubular aluminum conductor about said intermediate layer of soft

12

aluminum, applying circumferentially spaced radially inwardly directed forces upon the tubular aluminum conductor of sufficient magnitude to crush the intermediate layer into greater intimacy with the steel core and to thereby provide radial spacing between the exterior of the steel core and the interior of the tubular aluminum conductor that when the steel supported aluminum overhead conductor is strung overhead with consequent reduction in diameter of the steel core and the tubular aluminum conductor as both elongate, substantially all mechanical tension is borne by the steel core.

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