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(51) INT CL<sup>3</sup>

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**B519 B52Y B533 B535 B537 B549 B559 B610 B613**  
**B616 B619 B621 B624 B627 B62X B630 B635 B661**  
**B663 B665 B667 B669 B66X B670**  
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(56) Documents cited

**GB 1136741**

(58) Field of search

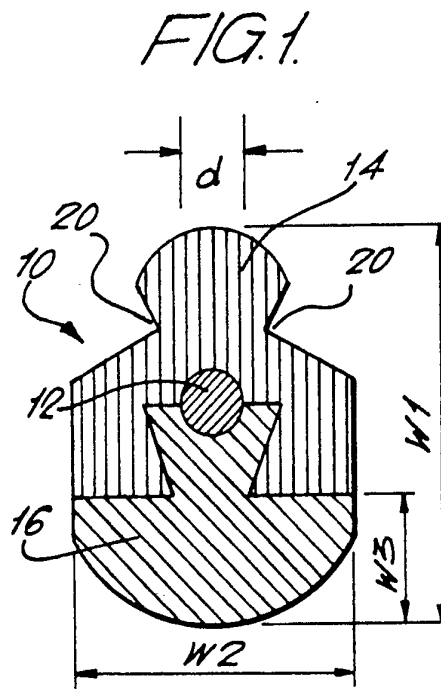
**B7L**

(54) **Overhead conductor for electric vehicles**

(57) An overhead conductor for supplying power to an electrically driven vehicle has a steel core 12 completely enclosed in an outer covering 14-16 which is of a wear-resistant aluminium alloy in the region of the contact surface 18 for the vehicle pick-up, the remainder of the covering being aluminium or aluminium alloy. The wear-resistant alloy preferably has dispersed fine hard particles of silicon and alpha-phase Al-Si-Ni-Ce and comprises:

	% by weight
silicon	0.10 to 4.0
nickel	0.05 to 2.0
cerium	0.01 to 1.0

the balance being aluminium and incidental impurities.



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FIG. 1.

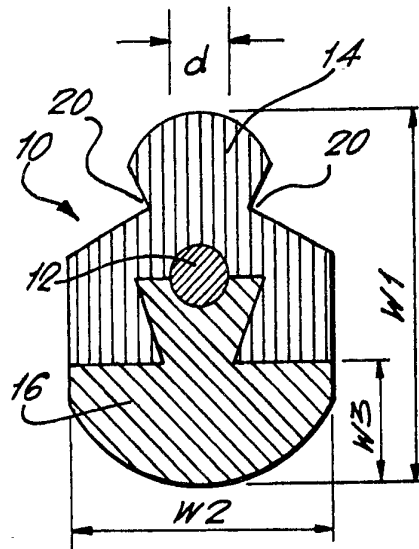


FIG. 2.

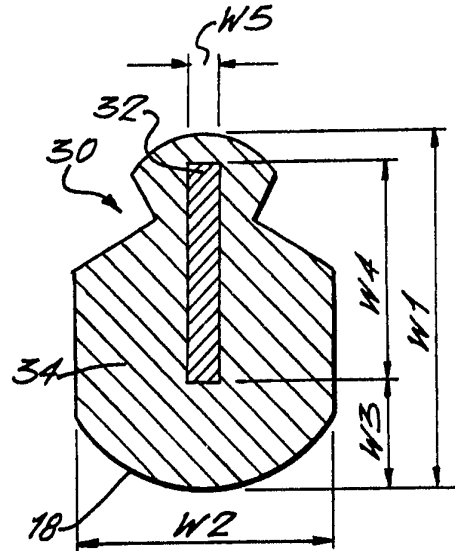


FIG. 3.



FIG. 4.



SPECIFICATION

Improvements in overhead contact conductors

5 This invention relates overhead contact conductors, otherwise known as contact wires, used to carry electrical power for electric trains, trams, trolley buses or the like and which are contacted by a carbon pick-up on a pantograph, arm or the like. 5

Previously copper or copper alloy conductors have been used for this purpose because of copper's high electrical conductivity and corrosion resistance. The high price of copper and the environmental pollution caused by the production of copper have promoted a search for alternative materials such as aluminium. 10

The strength and wear resistance of aluminium are relatively low and so overhead conductors have been suggested where a steel wire has been given a partial aluminium sheath. The steel wire gives strength and forms the contact surface for carbon pick-up whilst the aluminium sheath provides good electrical conductivity. 15

The major problem with such a composite conductor is that the steel contact surface is exposed to the atmosphere and so becomes corroded and roughened with pitting in its contact surface. Such a surface will cause arcing which in turn increases the damage to the surface. Therefore such conductors have a relatively short service life and in addition undesirable radio interference is given by the arcing. 20

It is not a solution to this problem to sheath the steel wire in aluminium since the aluminium surface contacted by the pick-up will wear away quite quickly and so again expose the steel wire.

The invention has been made with these points in mind and it is an object to provide an improved overhead contact conductor. 25

According to the inventor there is provided an overhead contact conductor having a steel core completely enclosed within an aluminium alloy or aluminium and aluminium alloy outer covering, at least the contact surface of the conductor having been formed of a wear-resistant aluminium alloy, preferably one containing dispersed fine hard particles of silicon and alpha-phase Al-Si-Ni-Ce for wear resistance. 30

Such a conductor has good conductivity provided by the aluminium alloy and/or aluminium, good wear resistance provided by the wear-resistant aluminium alloy and good strength provided by the steel core which is protected from problems of corrosion.

The wear-resistant aluminium alloy can comprise: 35

	% by weight		
	preferred	more preferred	
40 silicon .....	0.10 to 4.0	1.5 to 4.0	40
nickel .....	0.05 to 2.0	0.5 to 2.0	
45 cerium .....	0.01 to 1.0	0.05 to 0.5	45

the balance being aluminium and incidental impurities.

The thickness of the wear-resistant aluminium alloy covering the steel core in the region of the bearing surface determines the service life of the conductor before the core becomes exposed. Preferably therefore the steel core is positioned symmetrically relative the vertical axis of the conductor but assymmetrically relative the longitudinal axis of the conductor so as to give a relatively large thickness of the wear-resistant alloy. 50

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

55 Figure 1 is a section through one form of conductor according to the invention; 55

Figure 2 is a section through another form of conductor according to the invention;

Figure 3 is a micro-photograph of the microstructure of a wear-resistant aluminium alloy used in the conductors of the invention as cast; and

Figure 4 is a micro-photograph of the alloy after hot rolling.

60 The overhead contact conductor 10 shown in Fig. 1 has a circular steel core 12. This is enclosed by an upper part 14 which is either of aluminium or a corrosion-resistant aluminium alloy and a lower part 16 of wear-resistant aluminium alloy. It is this part 16 which provides the contact surface 18 which is touched by a carbon strip of a pantograph or the like. The upper part is shaped by having two opposed grooves 20 rolled in it so that it can be gripped by 65 hangers to suspend it. 65

The core 12 could be of other cross-section such as square or rectangular. Additionally the surface of the core is preferably rough so that it readily unites with the aluminium or aluminium alloy during hot or cold working and then the overall coefficient of expansion of the conductor is decreased.

5 The overhead contact conductor 30 shown in Fig. 2 is of the same overall outer shape as the conductor 10. However it has a rectangular-section steel core 32 and is sheathed completely by a wear-resisting aluminium alloy covering 34. 5

The dimension W3 determines the service life and stability of the conductors and in the conductors 10 and 30 this dimension W3 can be relatively large so ensuring the steel cores are not exposed to the atmosphere even when the surface 18 wears during use. 10

The conductor of the invention can be of any required length and formed by hot or cold working. 10

Examples of suitable dimensions in mm for the conductors 10 and 30 are set out in Table 1 below. 15

15

Table 1

<u>Conductor</u>	<u>W1</u>	<u>W2</u>	<u>W3</u>	<u>W4</u>	<u>W5</u>	<u>d</u>
20 10	16-20	14-19	5-7	-	-	2-6
30	16-20	14-19	5-7	9-12	2-4	-

25 A suitable example of a wear-resistant aluminium alloy for making the part 16 or the covering 34 is composed of 1.0% by weight of silicon, 0.50% by weight of nickel, 0.01% by weight of cerium, the balance being aluminium and incidental impurities. 25

Fig. 3 shows the microstructure of this alloy as cast (after etching by a mixture of acids) whilst Fig. 4 shows the microstructure after hot rolling. The alloy contains fine hard particles of silicon and alpha-phase Al-Si-Ni-Ce dispersed in a continuous aluminium matrix. This type of microstructure seems to promote the wear-resistance and so life of the conductor particularly when the carbon contact strip is somewhat harder than is normally used with a copper conductor. 30

It is found that when an overhead contact conductor has this type of microstructure according to the invention with hard particles dispersed in a softer matrix, the rubbing of the carbon strip of a pantograph against the contact surface 18 causes a thin graphite film to be left adhering to the surface. This thin film acts as a solid lubricant and decreases the coefficient of friction between the surface and the carbon strip of a pantograph or the like. The service life of both the conductor and carbon strip are therefore prolonged. 35

The conductor of the invention has good workability, its surface is bright and clean, it is straight and flexible and easy to join with other conductors, easy to suspend and suitable for mechanised construction. The conductor has an improved ability to transmit power to a contact strip without arcing and sparking. Its ability to transmit current resembles that of a copper conductor. The conductor of the invention can have a larger cross-section and so a reduced electrical resistance and a larger current carrying capacity. Electrical energy can be saved therefore and the potential power of the electric motor extended. 45

Examples of properties of a prior contact conductor of copper and a conductor according to the invention are listed in the following Table 2.

Table 2

Property	Copper wire, cross-sectional area (100mm <sup>2</sup> )	Contact conductor according to the invention, cross-sectional area (260mm <sup>2</sup> )
5		
10	Ultimate tensile force (Kg)	3500
10		4000
15	Weight per unit length (Kg/Km)	890
15		753
20	D.C. electric resistance at 25°C (ohm / Km)	0.17241
20		0.11653
	Allowable current (A)	550
		600
25	Construction property	good
25		better
	Price per Km	costly
		cheaper than copper by more than 30%
30	Atmospheric corrosion resistance	good
30		good
35	Environmental pollution during manufacture	serious
35		less
40	Service life	30-35 years
40		double that of the copper wire
45	Availability of natural resource	less year by year
45		abundant
50	The advantages of the contact conductor made according to the invention are more notable as compared with prior composite aluminium alloy/steel-reinforced contact conductors.	
50	The contact conductor of this invention can be used in all cases where overhead copper or copper alloy contact conductors were hung. If the hardness of the carbon contact strip, which contacts with the wire, is moderate, it is necessary only to change the old hanging units slightly to support a conductor according to the invention easily.	
55	Tests have shown that the service life of an overhead contact conductor according to the invention with a cross-sectional area 260mm <sup>2</sup> is similar or slightly greater than of a copper wire of cross-sectional area of 100mm <sup>2</sup> when the contact strip is relatively soft to match that used for the copper wire. If, however, a harder carbon contact strip is used it can be expected that the service life of the conductor according to the invention will be double that of the copper wire under the same conditions.	
60	CLAIMS	
60	1. An overhead contact conductor having a steel core completely enclosed within an aluminium alloy or aluminium and aluminium alloy outer covering, at least the contact surface of the conductor having been formed of a wear-resistant aluminium alloy.	
65	2. A conductor as claimed in Claim 1 in which the wear-resistant aluminium alloy comprising at least the contact surface of the conductor contains dispersed fine hard particles of silicon and alpha-phase Al-Si-Ni-Ce for wear resistance.	

3. A conductor as claimed in Claim 1 or Claim 2 in which the wear-resistant aluminium alloy comprises:

	% by weight	
5 silicon	.0.10 to 4.0	5
nickel	.0.05 to 2.0	
cerium	.0.01 to 1.0	

the balance being aluminium and incidental impurities, the alloy having been hot or cold worked. 10

4. A conductor as claimed in Claim 3 in which the aluminium alloy comprises:

	% by weight	
silicon	.1.5 to 4.0	
15 nickel	.0.5 to 2.0	15
cerium	.0.05 to 0.5	

the balance being aluminium and incidental impurities.

5. A conductor as claimed in Claim 3 in which the aluminium alloy contains about 0.50% by weight nickel, about 1.0% by weight of silicon, and about 0.01% by weight of cerium, the balance being aluminium and incidental impurities. 20

6. A conductor as claimed in any preceding claim in which the steel core is completely enclosed by a sheath of the wear-resistant aluminium alloy.

7. A conductor as claimed in any preceding claim in which the steel core is positioned 25 symmetrically in the conductor relative the vertical axis and assymmetrically relative the longitudinal axis so that there is a relatively large thickness of wear-resistant aluminium alloy between the steel core and the contact surface of the conductor. 25

8. An overhead contact conductor substantially as herein described with reference to the accompanying drawings.