GOVERNMENT OF INDIA : THE PATENT OFFICE, 214, ACHARYA JAGADISH BOSE ROAD, CALCUTTA-17.

Complete Specification No. 136487. Application No. 379/72 and Provisional Specification filed on 31st May, 1972. Complete Specification filed on 25th May, 1973. Acceptance advertised on 4th January, 1975.

Index at Acceptance—9D [XXXIII(1)], 48A3[LVIII(3)]

PROVISIONAL SPECIFICATION

"A PROCESS FOR THE PRODUCTION OF A NEW ALUMINIUM ALLOY FOR ELECTRICAL CONDUCTOR HAVING HIGH DUCTILITY."

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, RAFI MARG, NEW DELHI-1, INDIA, AN INDIAN REGISTERED BODY INCORPORATED UNDER THE REGISTRATION OF SOCIETIES ACT (ACT XXI OF 1860)

The following specification describes the nature of this invention.—

This is an invention by BALKUNJE ANANTHA SHENOI, Scientist, and VENKATARAMAN BALA SUBRAMANIN, Junior Scientific Assistant, both are Indian Nationals and are employed in the Central Electrochemical Research Institute, Karaikudi-3, India.

This invention relates to improvements in or relating to a new ductile aluminium alloy for electrical conductor having high ductility.

Hitherto it has been proposed to use EC grade aluminium as conductor material.

This is open to the objection that the existing aluminium alloy used for electrical conductors bare and insulated are not very ductile. Failure in service is common due to its brittleness. Fatigue failures under conditions of vibrations are common.

The object of this invention is to obviate these disadvantages by using the present aluminium alloy conductor which forms the subject matter of this specification.

To these ends, the invention broadly consists in using an aluminium alloy containing varying quantities of rare earth metals like misch metal (6% to 0 1%) and/or certain percentage of iron (2% to 0 1%) and silicon (0 1% max) in proper ratio In the case of aluminium alloy containing iron and silicon, addition of 0.06% to 0.6% of magnesium and/or 0.01% to 0.6% antimony is found to give better tensile strength and increased electrical conductivity. The aluminium alloy containing the above constituents is cast in the form of rods of any shape and dimension. This is drawn into wires of required diameter or gauge. After cold drawing the aluminium alloy in the form of wires, it is heat treated in a furnace between 250° and 450°C and cooled. The processed aluminium alloy conductor thus obtained is found to be extremely ductile and to possess good tensile strength and required electrical conductivity. Because of high ductility of the alloy now proposed, it is claimed that a real improvement is effected in the use of this alloy for the manufacture of wires and cables. By using these wires and cables, the failure in service due to the brittleness of the conductor material both under static conditions and under condition of vibration can be reduced.

The following typical examples are given to illustrate the invention :

Example 1

Aluminium alloy was prepared with the following composition :

Silicon : 0.07%
Iron : 0.5%
Rest aluminium.

This alloy was cast in the form of 3/4" dia rods and cold drawn in the form of wires of 1.4 mm dia and 1.8 mm dia. This was kept in a furnace at 350°C and anncaled for 3 hours. The alloy is possessing high ductility, tensile strength and electrical conductivity :

Tensile strength : 15,152 psi
Average number of bends to break : 25
Conductivity : 61.5% I Acs

The arc of bending radius is approximately 135°.

Example 2

Aluminium alloy rod 3/4" dia was cast with the following composition :

Silicon : 0.069%
Iron : 0.45%
Misch metal : 0.5%
Rest aluminium.

The alloy rod was cold drawn and annealed at 400°C for three hours. The tensile strength was found to be 15,500 psi and electrical conductivity of 61%. Average number of bends to break is 28. The arc of bending radius is approximately 135°.

Example 3

Aluminium alloy rod of 3/4" dia was cast with the following composition :

Silicon : 0.06%
Iron : 0.45%
Mangnesium : 0.3%
Rest aluminium.

The alloy was cold drawn in the form of wires and annealed at 350°C. The tensile strength was found to be 15,000 psi and electrical conductivity of 61%. It is giving 30 bends to break. The arc of bending radius is 135°.

Example 4

Aluminium alloy 1od of 3/4" dia was cast with the following composition :

Silicon :	0.6%
Iron :	0.45%
Magnesium :	0.3%
Antimony :	0.3%

The alloy was cold drawn in the form of wires and annealed at 350°C. The tensile strength was found to be 16,000 psi and electrical conductivity of 61.5%. It is giving 25 bends to break. The arc of bending radius is 135°.

The following are among the main advantages of the invention :

1. The aluminium alloy electrical conductor of the present invention possesses good ductility and hence can be best employed as an electrical conductor.

2. This aluminium alloy possesses more than the required electrical conductivity, viz. 61.5%.

3. This aluminium alloy electrical conductor can be used for winding transformers and other appliances which require aluminium conductors with good ductility, tensile strength and electrical conductivity after giving suitable insulation.

4. This alloy can also be used where aluminium is used for its ductility and lightness.

Dated this 3rd day of May, 1972.

Sd/-
R. BHASKARAN PAI
PATENTS OFFICER,
Council of Scientific & Industrial Research.

COMPLETE SPECIFICATION

"A PROCESS FOR THE PRODUCTION OF A NEW ALUMINIUM ALLOY FOR ELECTRICAL CONDUCTOR HAVING HIGH DUCTILITY"

COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, Rafi Marg, New Delhi.-1, India, an Indian Registered Body Incorporated under the Registration of Societies Act (Act XXI of 1860)

The following specification particularly describes and ascertains the nature of this invention and the manner in which it is to be performed:—

This is an invention by BALKUNJE ANANTHA SHENOI, Scientist and VENKATARAMAN BALASUBRAMANIAN, Junior Scientific Assistant, both are Indian Nationals and are employed in Central Electro-chemical Research Institute, Karaikudi-3, India.

This invention relates to improvements in or relating to a new aluminium alloy for electrical conductor having high ductility.

Hitherto it has been proposed to use Electrical Conductor grade aluminium alloy as electrical conductor.

This is open to the objection that the existing aluminium alloy used for electrical conductors are not very ductile. Failures in service are common due to its brittleness. Fatigue failures under conditions of vibration are common. Moreover, the Electrical Conductor grade conductors do not possess sufficient tensile strength at required percentage elongation and sufficient percentage elongation at required tensile strength. In other words, at a high percentage elongation, the tensile strength is low and when the tensile strength is good, the percentage elongation is poor.

The main object of the invention is to obviate these disadvantages by using the aluminium alloy compositions mentioned in this patent which possess good tensile strength and percentage elongation with an electrical conductivity of 61% International Annealed Copper Standard.

The main findings underlying the invention are as follows :

The aluminium is alloyed with iron 0.2 to 0.9% keeping the silicon content between 0.01 and 0.07%. The alloy is cast in the form of suitable wire rod for wire drawing to required gauges The cold drawn wire is subjected to annealing at 200°C to 450°C for two to three hours. These annealed wires are found to possess good yield strength and ductility without affecting the electrical conductivity.

In the present invention, it is also observed that when aluminium is alloyed with rare earth metal such as misch metal 0.15 to 1.5% with copper and/or magnesium 0.05 to 0.1% there is an increase in the tensile strength of aluminium without affecting the electrical conductivity.

It is also found that when aluminium is alloyed with iron 0.2 to 0.9% and silicon 0·01 to 0.07% containing trace amount of copper 0.05 to 0.1% and/or magnesium 0.05 to 0.1% the alloy is found to possess good electrical conductivity, yield strength and ductility.

The results of the new findings are as follows :

Aluminium is alloyed with iron and silicon with or without copper and/or magnesium in trace quantities. Also, aluminium is alloyed with misch metal (an alloy of cerium and iron with small percentage of other rare earth metals) and copper and or magnesium in trace quantities. These alloys are cast in the form of suitable wire rods and cold drawn in the form of wires of required gauge. The alloy wires are annealed in a furnace at 200—450°C for a period of 2 to 3 hours.

The processed aluminium alloy conductor thus obtained is found to be extremely ductile and to possess good tensile strength and required electrical conductivity (viz. 61% International Annealed Copper Standard). Because of the high ductility of the alloy now proposed, it is claimed that real improvement is effected in the use of this alloy for the manufacture of wires and cables. By using these wires and cables, the failure in service due to brittleness of the conductor material both under static and vibration conditions can be reduced.

According to the present invention there is provided a process for the production of a new aluminium alloy for electrical conductor having high ductility which consists in melting electrical grade aluminium, addition of alloying ingradients to molten aluminium, casting the wire rods, mechanical treatment, cold drawing the wire rods to the required gauge and subjecting it to thermal treatment, characterised in that alloying elements are added and the iron-silicon ratio is maintained preferably between 4:1 to 10:1 whereby the mechanical treatment and thermal treatment of the aluminium alloy wire imparts good tensile strength and ductility without affecting electrical conductivity of the aluminium alloy wire.

0.2 to 0.9% iron, silicon 0.01 to 0.07% misch metal (an alloy containing mostly cerium and iron 0.15% to 1.5%) are used, rest being aluminium.

Copper 0.05 to 0.1% or magnesium 0.05 to 0.1% is added whereby the electrical conductivity of the alloy is increased above 61% IACS (International Annealed Copper Standard).

The iron and silicon are present in the alloy in the ratio of 4:1 to 10:1 to possess the physical properties given in Tables I and II.

The alloy wire is annealed at 200—450° for two to three hours to have the electrical conductivity above 61% (IACS) and to have good tensile strength, percentage elongation and number of bends to break as shown in Tables I and II.

The invention provides a process for preparing aluminium alloy electrical conductor with high ductility, tensile strength and standard electrical conductivity by alloying aluminium with iron 0.2 to 0.9%, silicon 0.01 to 0.07% with or without copper and/or magnesium 0.05 to 0.1% or by alloying aluminium with rare earth metal like misch metal 0.15 to 1.5%, copper and/or magnesium 0.05 to 0.1%.

The iron silicon ratio in the alloy is kept at 2:1 or more but preferably at 8:1. The alloy thus obtained is cast in the form of suitable alloy wire rods. The alloy wire rods are cold drawn in the form of wires of required gauge and annealed at 200—450°C for two to three hours.

A comparative data of the inventive alloy with the conventional Electrical Conductor grade aluminium are given in the following table :

TABLE 1

Sl. No. of the alloy	Electrical Conductor grade alloy		Sl. No. of the alloy	Inventive alloy	
	Tensile strength in psi	Percentage ultimate elongation		Tensile strength in psi	Percentage ultimate elongation
1	14,200	11.5%	1	14,300	30%
2	15,500	8.0%	2	15,525	24%
3	13,500	14.0%	3	13,500	30.8%
4	16,500	3.5%	4	16,500	16.0%

TABLE 2

Sl. No. of the alloy	Electrical conductor grade alloy		Sl. No. of the alloy	Inventive alloy	
	Tensile strength	No. of bends to break		Tensile strength	Average no. of bends to break
1	13,480	21½	1	13,500	44
2	15,200	13	2	15,100	36
3	16,100	11	3	16,025	29
4	18,186	8	4	18,253	14

The alloy composition of Electrical Conductor grade alloy and inventive alloy are given below :

Composition of Electrical Conductor Grade alloy:

Aluminium content :	99.73%
Iron :	0.18%
Silicon :	0.059%

Composition of inventive alloy :

Aluminium content :	99.45%
Iron :	0.45%
Silicon :	0.056%

The following are the typical examples given to illustrate the invention and not to limit the scope of the invention :

Example 1

Aluminium alloy was prepared with the following composition :

Silicon :	0.07%
Iron :	0.5%
Rest aluminium	

The alloy was cast in the form of 3/4" dia rods and cold drawn in the form of wires of 1.4 mm dia and 1.8 mm dia. This was kept in a furnace at 350°C and annealed for 3 hours. The alloy is possessing high ductility, tensile strength and electrical conductivity :

Tensile strength :	15,152 psi
Average number of bends to break :	35
Conductivity :	61.5% International Annealed Copper Standard

The percentage elongation of the alloy is 25%.

Example 2

Aluminium alloy rod of 3/4" dia was cast with the following composition :

Silicon :	0.069%
Misch metal :	1.5% (Iron content in misch metal alloy is 10%)
Rest aluminium	

The alloy rod was cold drawn and annealed at 400°C for three hours. The tensile strength was found to be 15,500 psi and electrical conductivity was 61%. Average number of bends to break is 28. The percentage elongation of the alloy was found to be 24%.

Example 3

Aluminium alloy rod of 3/4" dia was cast with the following composition :

Silicon :	0.06%
Iron :	0.45%
Magnesium :	0 05%
Rest aluminium	

The alloy was cold drawn in the form of wires and annealed at 350°C or three hours. The tensile strength was found to be 16,000 psi and electrical conductivity of 61% It is giving 30 bends to break. The percentage elongation of the alloy was found to be 19%.

Example 4

Aluminium alloy rod of 3/4" dia was cast with the following composition :

Silicon :	0.06%
Iron :	0.45%
Magnesium	0.05%
Copper :	0.05%
Rest aluminium	

The alloy was cold drawn in the form of wires and annealed at 300°C for a period of three hours. The tensile strength was found to be 16,200 psi and electrical conductivity of 61.5%. It is giving 25 bends to break. The percentage elongation of the alloy was found to be 18%.

Example 5

Aluminium alloy rod of 3/4" dia was cast with the following composition :

Silicon :	0.064%
Iron :	0.45%
Misch metal :	0.5% (Iron percentage in misch metal is 10%)
Rest aluminium	

The alloy rod was cold drawn and annealed at 400°C for three hours. The tensile strength was found to be 15,500 psi and electrical conductivity of 16%. Average number of bends to break is 28. The percentage elongation of the alloy is found to be 23%.

The following are among the main advantages of the invention :

1. The aluminium alloy electrical conductor of the present invention possesses good ductility and hence can be employed as electrical conductor.

2. This aluminium alloy possesses electrical conductivity viz. 61% International Annealed Copper Standard which makes it suitable for use in electrical cables.

3. This aluminium alloy electrical conductor can be used for winding in electrical equipment which require aluminium conductors with good ductility, tensile strength and electrical conductivity after giving suitable insulation.

4. Since this alloy possesses good fatigue resistance electrical breakdown can be avoided by using this alloy.

WE CLAIM :

1. A process for the production of a new aluminium alloy for electrical conductor having high ductility which consists in melting electrical grade aluminium, addition of alloying ingredients to molten aluminium, casting the wire rods, mechanical treatment, cold drawing the wire rods to the required gauge and subjecting it to thermal treatment, characterised in that alloying elements are added and the iron-silicon ratio is maintained preferably between 4:1 to 10:1 whereby the mechanical treatment and thermal treatment of the aluminium alloy wire imparts good tensile strength and ductility without affecting electrical-conductivity of the aluminium alloy wire.

2. A process as claimed in claim 1 wherein are used 0.2 to 0.9% iron, silicon 0.01 to 0.07% misch metal (an alloy containing mostly cerium and iron 0.15% to 1.5%) and rest being aluminium.

3. A process as claimed in claim 1 wherein are added copper 0.05 to 0.1% or magnesium 0.05 to 0.1% or combination of copper and magnesium 0.05 to 0.1% whereby the electrical conductivity of the alloy is increased above 61% IACS (International Annealed Copper Standard).

4. A process as claimed in any of the preceding claims wherein the iron and silicon are present in the alloy in the ratio of 4:1 to 10:1 to possess the physical properties given in Tables I and II.

5. A process as claimed in any of the preceding claims wherein the alloy wire is annealed at 200—450°C for two to three hours to have the electrical conductivity above 61% (IACS) and to have good tensile strength, percentage elongation and number of bends to break as shown in Tables I and II.

Dated this 21st day of May, 1973.

Sd/
R. BHASKARAN PAI
PATENTS OFFICER,
Council of Scientific & Industrial Research.

GIPN—S7—64(5) CP&D Cal./74—7-4-76—150.