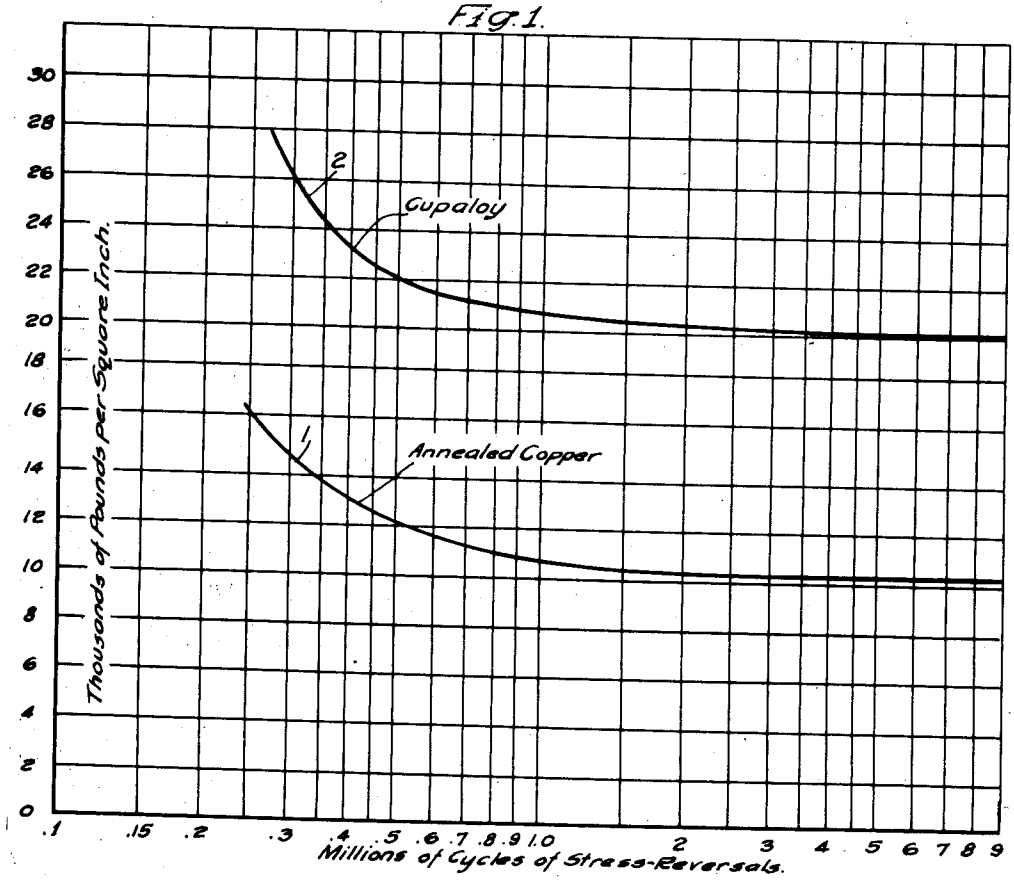
Feb. 12, 1935. F. W. McCLOSKEY 1,991,057

MEANS FOR PREVENTING BREAKAGE OF ARMATURE LEADS

Filed June 9, 1934

Fig. 1.



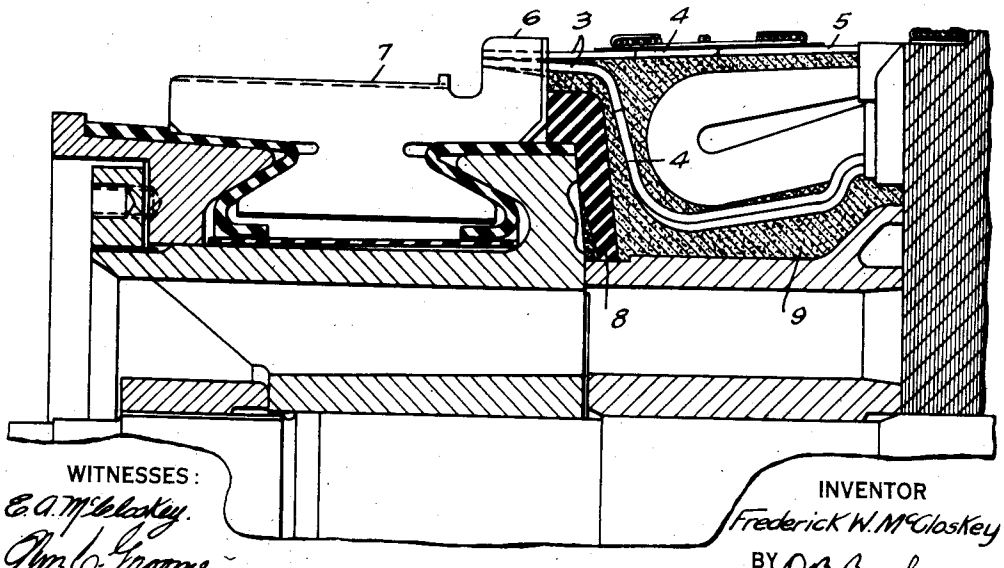


Fig. 2.

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MEANS FOR PREVENTING BREAKAGE OF ARMATURE LEADS

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22 Claims. (Cl. 171—320)

My invention relates to commutator-type motors, and particularly to commutator railway motors or other motors which are subjected to conditions of operation in which repeated stresses are set up in the armature leads.

A principal object of my invention is to provide means for preventing the breakage of the armature leads where the latter are soldered into the commutator neck. This breakage is caused by the fact that repeated movement takes place in the coil-ends and commutator-leads, and the stress developed by this movement is concentrated at the point where the leads enter the commutator neck. This movement stresses the copper leads beyond their fatigue or endurance limit, thus eventually causing breakage.

Heretofore, this problem of armature-lead breakage, particularly in railway motors, has been attacked by different expedients, but always utilizing ordinary annealed copper for the material of the leads. My present invention is designed to overcome continued difficulties in this respect, in spite of everything that has been done to control it heretofore.

In accordance with my invention, I utilize a material which is generally unsuitable for use in making the entire armature-coil, but I preferably, although not necessarily, in the broadest aspects of my invention, utilize only a short length of this material, which has a sufficiently high endurance limit to avoid breakage at the point where the lead enters the commutator neck, utilizing only enough of this material to make the connection with the commutator neck and to extend back about an inch behind the commutator neck, where it is joined onto the regular material of the copper armature coil.

With the foregoing and other objects in view, my invention consists in the apparatus, combinations, materials and methods hereinafter described and claimed, and illustrated in the accompanying drawing, wherein

Figure 1 is a curve diagram comparing the fatigue properties of annealed electrolytic tough-pitch copper, which is the usual material for armature coils, and cupaloy, which is one of the materials which I may utilize for making the connections with the commutator necks, and

Fig. 2 is a cross-sectional view of a portion of a motor armature, illustrating an application of my invention.

My invention has to do with a property of materials called the endurance limit or fatigue limit, which is the maximum stress which can be supported indefinitely when the material is tested with cycles of complete stress-reversal between the same values in tension and compression, for an infinite number of times. When a piece of material is subjected to a fatigue test consisting of a large number of such stress-reversals, it will not break if the stress is lower than the endurance limit, but it will eventually break, if the stress is above this limit.

The number of stress-reversals which the material will stand depends, of course, upon the amount by which the actual stress exceeds the endurance limit, and test-curves have been obtained such as those shown in Fig. 1, wherein curve 1 is the endurance curve for a particular sample of annealed copper, and curve 2 is a similar curve for a particular sample of cupaloy, which is one of the materials which I may utilize for making the connections with the commutator necks. The curves show the number of stress-reversals which these materials may be expected to stand, before failure, when subjected to different stresses, indicated in pounds per square inch. It will be noted that if the stress on annealed copper is more than about 11,000 pounds per square inch, the copper will fail at about 8,000,000 stress-reversals, and if larger stresses are utilized, the copper fails or breaks after a smaller number of stress-reversals. It is quite evident that the stresses applied to the copper, where it joins the commutator necks in railway motors as heretofore made, have fallen in the steep left-hand end of the curve, where failure occurs at less than 8,000,000 stress-reversals.

Various forms of hardened copper are known, which have a considerably higher endurance limit than the annealed copper which is substantially universally used for armature coils. Generally speaking, there are three principal hardening methods which may be utilized for increasing the endurance limit of copper. These may be briefly discussed as follows.

First, there is the cold-working method of hardening copper, which consists of drawing or rolling it so as to reduce its cross-section in successive stages. This results in a hardened copper which has a relatively high endurance limit, but which cannot be utilized for soldering to the commutator necks because it becomes softened, like annealed copper, when subjected to the temperature necessary for making the soldered connections. This soldering temperature is usually around 300 to 350° C. It is true that solders are known, which will melt at much lower temperatures, but it is obviously necessary, in motors, to utilize a solder which has a melting point suf-

ficiently higher than the maximum possible operating temperature of the soldered point to avoid any danger of softening of the solder, with an adequate margin of safety, so that soldering temperatures of 300 to 350° C. are desirable. Cold-worked copper would be of no advantage, therefore, in avoiding breakage at the commutator necks, because it would be weakened, by the solder, at the very point where breakage has previously been encountered.

A second hardening method for copper is that which utilizes what is known as a solid solution, the best example of which is an alloy containing about .1% of tin, or from .05% to .5% or even up to 1 or 2% of tin. Other elements may be utilized, besides tin, as the solid-solution element, as is well-known in the art. This hardening method, however, does not have much hardening effect, in the annealed condition, but it produces an alloy which can be hardened, by the proper amount of cold-working, so as to very materially increase the endurance limit over pure (or commercially pure) annealed copper.

In the case of the solid-solution copper alloys, however, the cold-working does not have the same disadvantage in regard to softening at the soldering temperature of 350° C., because the resulting product is able to withstand higher temperatures, for a short period of time, without becoming softened or annealed. The solid-solution element, such as tin, therefore, raises the permanent softening temperature of cold-worked copper. The permanent softening temperature is defined as the temperature at which there is a permanent drop of 50% in hardness after 15 minutes exposure to the temperature in question.

The usual commercial alloys of copper and tin contain more tin than is really desirable for my purpose, and I prefer to keep within the limits above stated for the amount of tin alloyed with the copper. The more tin that is added, the greater will be the reduction in conductivity of the resulting alloy, and it is obvious that the higher-conductivity solid-solution alloys should be chosen in preference to other alloys, provided that other considerations do not force a compromise. The conductivity of copper-tin alloys is about 80% of that of annealed copper, when the amount of tin present is of the order of .05%, and the conductivity falls to about 40% of that of annealed copper when the tin is present to the amount of about 2%.

In accordance with my invention, therefore, I may utilize a solid-solution hardened copper alloy, cold-worked to such a point that the permanent softening temperature is about 350° C., the amount of the solid-solution element being so small that the conductivity is at least 40% of that of annealed copper.

A third method of hardening copper is known as the precipitation-hardening method, in which the hardening element is precipitated out of the alloy. Three different types of precipitation-hardened copper alloys may be mentioned, to wit, cupaloy, containing something of the order of .4% chromium; beryllium copper, containing something like 2¼% berryllium; and tempaloy, which is a nickel-silicon copper-base alloy, one example of which contains 1% silicon and 4% nickel. Cupaloy has an endurance limit of about 20,000 pounds per square inch, or at least twice that of annealed copper, and it has a conductivity of at least 85% of the conductivity of annealed copper and some samples have up to 95% of the conductivity of annealed copper, depending upon the composition and treatment. Beryllium copper is still stronger, having an endurance limit of the order of 40,000 pounds per square inch, but it is very inferior in conductivity, a given sample, after treatment for maximum hardness, having a conductivity of only about 30% of that of annealed copper. Tempaloy has a conductivity and strength probably intermediate between cupaloy and beryllium copper.

According to my invention, I may utilize a precipitation-hardened copper alloy such as cupaloy or even tempaloy or beryllium copper, having an endurance limit which is sufficiently high to avoid failures under ordinary operating conditions, and specifically having an endurance limit of the order of 20,000 pounds per square inch or better.

Hardened copper of any form is usually considered undesirable in the manufacture of armature windings, because of the work which has to be done upon it in bending it into shape, which should obviously be accomplished without damaging the insulation which is necessarily applied thereto. If the hardening method produces a loss of 10 or 15% in conductivity, or even less, in the whole winding of the armature, it is usually quite out of the question to tolerate these additional losses in the motor, particularly in railway motors where the temperature is a controlling factor in the rating or size of the motor.

While it will not always be the case, it will be seen, therefore, that hardened copper alloys, having an endurance limit of about 20,000 pounds per square inch or better, are not generally suited as a material out of which armature windings can be made.

In accordance with my invention, I may utilize some of these strong hardened copper alloys, particularly those of the higher conductivities, to manufacture the whole armature winding, but I prefer, in my preferred constructions, to utilize only short lengths of these strong hardened copper alloys, as lead-extensions butt-welded or otherwise attached to the leads proper of the armature coils, thus providing a means of withstanding the concentrated stress at the junction with the commutator necks.

Thus, in Fig. 2, short lengths of one of these hardened copper alloys, as indicated at 3, are joined onto the ends of the leads 4 of the armature winding 5, and these short lengths or lead-extensions 3 are soldered into the necks 6 of the commutator-bars 7. Preferably the armature winding 5, except for the lead extensions 3, is made of annealed copper such as is customarily used in armature construction. In the particular motor which is illustrated in the drawing, the movement of the armature leads is partially restricted by a molded insulating ring or support 8, and a packing of cement as indicated at 9, although this particular refinement is not always necessary or desirable.

While I have illustrated my invention in a single form of construction, and while I have enumerated certain exemplary materials, it is obvious that certain departures from these details may be made by those skilled in the art without departing from the essential principles of the invention. I desire, therefore, that the appended claims shall be accorded the broadest construction commensurate with their language and the prior art.

I claim as my invention:

1. A commutator motor of a type having an armature winding and a multi-bar commutator

associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a copper alloy which will withstand said soldering and which has an endurance limit materially higher than annealed copper after soldering.

2. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a copper alloy which will withstand said soldering and which has an endurance limit, after soldering, at least about twice that of annealed copper.

3. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a copper alloy which will withstand said soldering and which has an endurance limit, after soldering, at least about twice that of annealed copper, said copper alloy having a conductivity of at least 85% of that of annealed copper.

4. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a copper alloy which will withstand said soldering and which has an endurance limit, after soldering, of at least about 20,000 pounds per square inch.

5. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a copper alloy which will withstand said soldering and which has an endurance limit, after soldering, of at least about 20,000 pounds per square inch, said copper alloy having a conductivity of at least 40% of that of annealed copper.

6. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a solid-solution hardened copper alloy cold-worked to such a point that the permanent softening temperature is above 350° C., the amount of the solid-solution element being so small that the conductivity is at least 40% of that of annealed copper.

7. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a solid-solution hardened copper-tin alloy, the amount of tin being between about .05% and about 2%.

8. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a solid-solution hardened copper-tin alloy, the amount of tin being of the order of .1%.

9. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a solid-solution hardened copper-tin alloy, the amount of tin being between about .05% and about .5%.

10. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a precipitation-hardened copper alloy.

11. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding having leads soldered into said necks, at least those parts of the armature winding which are soldered into the commutator necks being a precipitation-hardened copper-chromium alloy, the amount of chromium being of the order of .4%.

12. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a copper alloy which will withstand said soldering and which has an endurance limit materially higher than annealed copper after soldering.

13. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a copper alloy which will withstand said soldering and which has an endurance limit, after soldering, at least about twice that of annealed copper.

14. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a copper alloy which will withstand said soldering and which has an endurance limit, after soldering, at least about twice that of annealed copper, said copper alloy having a conductivity of at least 85% of that of annealed copper.

15. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a copper alloy which will withstand

said soldering and which has an endurance limit after soldering, of at least about 20,000 pounds per square inch.

16. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a copper alloy which will withstand said soldering and which has an endurance limit, after soldering, of at least about 20,000 pounds per square inch, said copper alloy having a conductivity of at least 40% of that of annealed copper.

17. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a solid-solution hardened copper alloy cold-worked to such a point that the permanent softening temperature is above 350° C., the amount of the solid-solution element being so small that the conductivity is at least 40% of that of annealed copper.

18. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a solid-solution hardened copper-tin alloy, the amount of tin being between about .05% and about 2%.

19. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a solid-solution hardened copper-tin alloy, the amount of tin being of the order of .1%.

20. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a solid-solution hardened copper-tin alloy, the amount of tin being between about .05% and about .5%.

21. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a precipitation-hardened copper alloy.

22. A commutator motor of a type having an armature winding and a multi-bar commutator associated therewith, the commutator bars having necks, the armature winding being mainly of annealed copper, but having lead-extensions of a different material, said lead-extensions being soldered into the commutator necks and being of a precipitation-hardened copper-chromium alloy, the amount of chromium being of the order of .4%.

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