May 20, 1941. W. E. MANSFIELD 2,242,254

METHOD OF INCREASING THE HARDNESS OF FABRICATED DUCTILE METALS OF THE CHROMIUM GROUP

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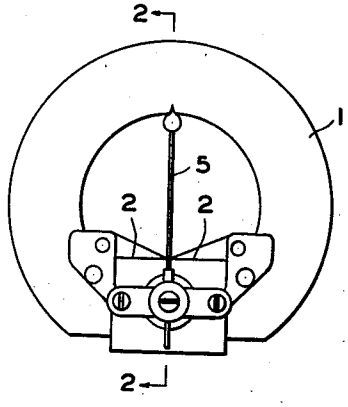


FIG.-1

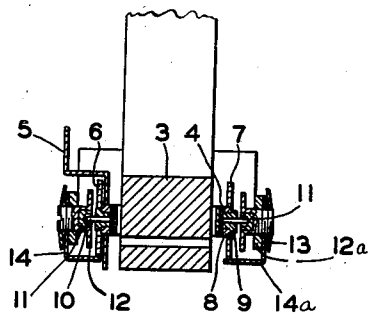


FIG.-2

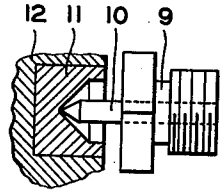


FIG.-3

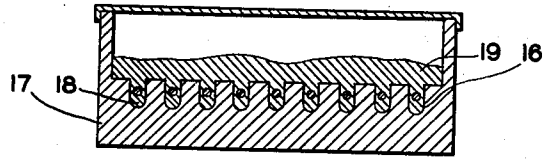


FIG.-4

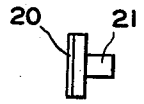


FIG.-5

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METHOD OF INCREASING THE HARDNESS OF FABRICATED DUCTILE METALS OF THE CHROMIUM GROUP

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7 Claims. (Cl. 148—13.1)

My invention relates to electrical instruments and more particularly to an improved pivot for such instruments. It also relates to an improved process of treating fabricated non-magnetic metals having a comparatively high melting point to increase their hardness without impairing their non-magnetic properties. My improved process is also particularly adapted for preparing electrical contacts having a comparatively high degree of hardness.

Electrical instruments are, as a rule, provided with oscillating or rotatable parts which are provided with pivots extending into stationary supported bearings or the moving parts are provided with bearings to receive pivots affixed to the stationary parts. It has formerly been the practice to utilize a jewel, such as a sapphire, as the bearing, and steel as the pivot. Steel, however, is magnetic, which has a tendency to disturb the magnetic properties of the instrument which affects its accuracy. This is particularly true in delicate electrical measuring instruments, such as light-indicating meters. Steel also has the tendency to oxidize and the oxide which is formed acts as an abrasive which corrodes the end of the pivot extending into the bearing, and since the specifications for such instruments are becoming increasingly severe, it is difficult to provide steel which is suitable for the purpose. For instance, in instruments utilized by the United States Government the specifications require that the pivot must be able to stand up under twenty-one hundred oscillations per minute for sixty hours, with instrument pivot off center and instrument on a 45° angle.

The desired requisites for pivots in electrical instruments are that the pivot shall be non-magnetic, harder than tool steel, and non-oxidizing at ordinary temperatures and climatic conditions. The pivot must also possess sufficient rigidity to support the coil or other moving part of the electrical instrument with which it is associated and should preferably have a fine grain structure so that it may be readily pointed. Cemented tungsten carbide which possesses the desired hardness, is not suitable because in preparing pivots it is necessary to utilize a magnetic material such as cobalt as a binder. It is also difficult to control the hardness of the tungsten carbide which as usually prepared may be harder than the sapphire bearing. Furthermore, the diameter of the pivots in many electrical instruments is necessarily small and it is difficult to prepare cemented tungsten carbide of the requisite diameter and finish. Tungsten itself is not suitable because it does not possess the desired rigidity and hardness.

I have made the discovery that certain non-ferrous metals having a comparatively high melting point, when treated in accordance with my improved process to further increase their hardness and improve their rigidity, possess the desired properties for use in preparing pivots for electrical instruments. My improved process, however, is also effective in increasing the hardness of such metals for any desired purpose and more particularly for use in preparing electrical contacts.

It is, therefore, an object of my invention to provide an electrical instrument in which the pivot associated with a moving part of the instrument is non-magnetic, has greater hardness than tool steel and sufficient rigidity to maintain the working parts of the instrument in the desired position.

Another object of my invention is to provide an improved process of hardening fabricated non-ferrous metals having a comparatively high melting point without causing the metal to become excessively brittle and preferably without materially increasing the size of the grain structure.

A further object of my invention is to provide an improved electrical contact formed of a non-ferrous metal having good conductivity and a comparatively high degree of hardness.

While my invention may be utilized in electrical instruments of all types requiring pivots, such as galvanometers, radio compasses, electrical clocks, gyroscopes, light-indicating meters and the like, for purposes of illustration an electrical measuring instrument, such as an ammeter or voltmeter, is shown in the accompanying drawing, in which

Fig. 1 is an elevational view of an electrical measuring instrument;

Fig. 2 is a cross sectional view on the line 2—2 of Fig. 1, showing parts broken away;

Fig. 3 is a detail view of my improved pivot, showing its supporting structure in elevation, and the bearing for the pivot in cross section;

Fig. 4 is a cross sectional view of a boat utilized in my improved process of preparing the pivot; and

Fig. 5 is a side view of an electrical contact prepared according to my improved process, the contact being shown welded or brazed to a suitable support.

As illustrated in the drawing, an electrical measuring instrument is shown comprising a per-

manent magnet 1 provided with poles 2 and a core 3. As is usual in instruments of this type, the coil 4 is pivotally mounted to oscillate about the core and to move a pointer 5 against the resilient action of springs 6 and 7 located above and below the core in accordance with the amount of current passing through the coil. To pivotally mount the coil, opposite sides of the coil are provided with bushings 8 in which is threaded a block 9 carrying the pivot 10, the pointed end of which is rotatably mounted in a jewelled bearing 11 supported in a bushing 12 which is threaded to a bridge 12a and is secured in place by means of a lock nut 13. As shown in the drawing, current from the line passes through conductor 14a, spring 7, coil 4, spring 6 and conductor 14. As current passes through the coil the pointer 5 is moved against the resilient action of springs 6 and 7, When a magnetic material, such as steel, is utilized, however, in such pivots, current is induced in the pivot, which disturbs the magnetic properties of the instrument and affects the accurate measurement of the current.

In forming the pivots a non-magnetic metal having a comparatively high melting point is provided, which is treated in a special manner and with certain treating material, to improve its hardness and rigidity. Specifically, I may utilize metals of the chromium group, such as chromium, tungsten or molybdenum. All of the metals specified have a melting point above 1600° C., and tungsten and molybdenum have a melting point above 2500° C. Chromium at present, however, is difficult to fabricate into wire form. I accordingly prefer to utilize metals of the tungsten group, such as tungsten or molybdenum. The metals specified, however, must be sufficiently ductile in their metallic state to be drawn into the form of a wire, or punched or otherwise fabricated in the form of a disk and must have a sufficiently high melting point to remain solid at the treating temperature. When the treated metal is utilized as a pivot for electrical instruments, it is also essential that it should not be sufficiently magnetic to affect the accuracy of the instrument, and when utilized as a contact it is essential that the metal should have a comparatively high conductivity.

In forming pivots in accordance with my process, the metal to be treated in wire form is placed in contact with a treating material, such as carbon, chromium, cobalt, silicon or a carbon-containing compound, such as carborumdum, or a mixture of two or more of such elements or compounds, and heated to a comparatively high temperature in a reducing or an inert atmosphere, such as hydrogen, nitrogen, carbon monoxide or carbon dioxide. When a reducing gas is employed, it is essential to provide a gas which does not react with the metal being treated to form a volatile compound and this is particularly true when fabricated ductile tungsten is being treated. I prefer to utilize powdered carbon although good results have been obtained when chromium, or a mixture of carbon and chromium, is employed. Satisfactory results have also been obtained when cobalt is used, since the amount of cobalt which penetrates the metal being treated is insufficient to materially affect its normally non-magnetic properties. When chromium is being treated, it is of course necessary to utilize one or more of the other treating materials. The treating material must be capable of increasing the hardness of the metal without adhering to the metal or rendering it excessively brittle.

The temperature at which the metal is treated and the time of heating are somewhat dependent upon each other, a longer period being required at lower temperatures. The temperature may range from approximately 900° to 1600° C., and the time from approximately one-half to four hours, although I do not desire to be limited in this respect as longer periods may often be employed, depending upon the metal being treated. The treatment should not be extended, however, to the point at which the metal becomes excessively brittle. The best results have been obtained at temperatures ranging from about 1200° to 1500° C. When a member of the tungsten group is being treated I prefer to treat the metal at a temperature of about 1200° to 1300° C. for a period of approximately two hours. When tungsten wire is treated by my process for the purpose of providing pivots for electrical instruments, care must be exercised in extending the time; otherwise the hardness of the metal will be increased to such an extent that it will become harder than the jewel bearing.

The following specific examples will serve to illustrate and explain my invention although it will be understood that I do desire to limit myself to the particular metals or the treatment specified.

Two tungsten wires having a diameter of .0265 of an inch and 4 inches in length, and one wire having a diameter of .040 of an inch, were placed in the grooves 16 of a carbon boat 17 as illustrated in Fig. 4 of the drawing, a layer 18 of powdered carbon being placed in the grooves below the tungsten wires which were then covered with additional powdered carbon as indicated by the numeral 19. The boat was covered with a carbon cover and placed in a furnace maintained at a temperature of about 1229° to 1295° C. in an atmosphere of hydrogen for a period of approximately two hours. At the end of this period the wires were sufficiently hard to scratch glass and had a fine grain structure. When pointed they were capable of being utilized as a pivot in electrical instruments. In the same boat were placed about 30 disks having a diameter of .156 of an inch and a thickness of .025 of an inch, which had been punched from a fabricated ductile tungsten strip. The disks, one of which is designated by the numeral 20 in Fig. 5 of the drawing, possessed a fine grain structure. The disks may be readily welded or brazed to a ferrous metal support 21, as illustrated, in the same manner as contactors formed of tungsten.

Another test was made in which a series of tungsten wires having a diameter of .0265 of an inch, were packed in chromium powder in the grooves of a tungsten boat and heated for 1 hour and fifteen minutes at a temperature of 1274° to 1295° C. in an atmosphere of hydrogen. The hardness of the tungsten wires was increased a sufficient amount to cut glass and while possessing sufficient rigidity to be utilized as a pivot the wires were not excessively brittle.

As another example in which a higher temperature was utilized, two pieces of tungsten wire .0265 of an inch in diameter and one piece having a diameter of .040 of an inch, were placed in the grooves of a carbon boat, powdered carbon being placed below the wires in the grooves which were then covered with additional carbon powder. The boat was covered with a carbon slab and heated at a temperature of 1410°

to 1460° C. in an atmosphere of hydrogen for approximately 2 hours, the temperature being maintained for the greater part of the period at a temperature range between 1418° to 1444° C. After the treatment the wires were capable of scratching glass and had a fine grain structure. In this experiment disks having a diameter of .156 of an inch and thickness of .025 of an inch were packed in the same manner, and the treated disks possessed a fine grain structure.

Similar experiments were conducted with molybdenum as the metal to be treated. Metal wires composed of molybdenum in a like manner were also treated with silicon, silicon carbide and a combination of chromium and carbon, and good results were obtained.

The particular reason for the increase in hardness of the wire is not definitely known. It is believed, however, that the treating material either combines with the surrounding gas to form a compound which penetrates the pores of the metal being treated, or that vapors from the treating material are carried into the pores of the metal by the surrounding gas.

What I claim is:

1. The method of increasing the hardness of a nonmagnetic fabricated ductile metal of the tungsten group which comprises embedding the metal in its fabricated ductile state in a solid material comprising cobalt, a carburizing substance, chromium and a substance containing silicon as a principal ingredient, each being present in substantial amounts more than incidental impurities, and treating the embedded metal in a nonoxidizing atmosphere at a temperature of 900° to 1600° C. for a sufficient time and with a sufficient amount of the cobalt, carburizing substance, chormium and silicon containing substance to increase the hardness of the metal to a sufficient extent to scratch glass.

2. The method of increasing the hardness of a nonmagnetic fabricated ductile metal of the chromium group which comprises embedding the metal in its fabricated ductile state in a solid material comprising cobalt, a carburizing substance and a substance containing silicon as the principal ingredient, each being present in substantial amounts more than incidental impurities, and treating the embedded metal in a nonoxidizing atmosphere at a temperature of 900° to 1600° C. for a sufficient time and with a sufficient amount of the cobalt, carburizing substance and silicon containing substance to harden the metal to a sufficient extent to scratch glass.

3. The method of increasing the hardness of a nonmagnetic fabricated metal of the chromium group which comprises embedding the metal in its fabricated ductile state in a solid material comprising cobalt in a substantial amount more than incidental impurities in a nonoxidizing atmosphere at a temperature of 900° to 1600° C. for a sufficient time and with a sufficient amount of cobalt to increase the hardness of the metal to a sufficient extent to scratch glass.

4. The method of increasing the hardness of fabricated ductile tungsten which comprises embedding the tungsten in its fabricated ductile state in a solid material comprising a carburizing substance in an amount substantially more than incidental impurities and treating the embedded tungsten in a nonoxidizing atmosphere at a temperature of 900° to 1600° C. with a sufficient amount of the carburizing substance and for a sufficient time to increase the hardness of the tungsten to a sufficient extent to scratch glass and to provide a comparatively fine grain structure in the tungsten, said atmosphere during the treating process being substantially free from vapor which reacts with tungsten to form a volatile tungsten compound.

5. The method of increasing the hardness of fabricated ductile tungsten which comprises embedding the metal in its fabricated ductile state in a solid material comprising a carburizing substance in an amount substantially more than incidental impurities and treating the embedded metal at a temperature of 1200° to 1600° C. in a nonoxidizing gas selected from a group of nonoxidizing gases consisting of hydrogen, nitrogen, carbon monoxide and carbon dioxide with a sufficient amount of the carburizing substance and for a sufficient time to increase the hardness of the tungsten to a sufficient extent to scratch glass and to provide a comparatively fine grain structure in the tungsten.

6. The method of increasing the hardness of fabricated ductile tungsten which comprises embedding the tungsten in its fabricated ductile state in a solid material comprising carbon in an amount substantially more than incidental impurities and treating the embedded tungsten in an atmosphere of hydrogen at a temperature of 900° to 1600° C. for a period of one-half to four hours depending upon the temperature and with a sufficient amount of carbon to harden the tungsten to a sufficient extent to scratch glass, said treatment being also effective in providing a comparatively fine grain structure in the tungsten.

7. The method of increasing the hardness of electrical contacts formed of fabricated ductile tungsten which comprises embedding the contact in its fabricated ductile state in a solid material comprising a carburizing substance in an amount substantially more than incidental impurities and treating the embedded contact at a temperature of approximately 900° to 1600° C. in a nonoxidizing atmosphere free from vapor which reacts with tungsten to form a volatile tungsten compound and with a sufficient amount of the carburizing substance and for sufficient time to harden the contact to a sufficient extent to scratch glass and to provide a comparatively fine grain structure in the tungsten.

WILLIAM E. MANSFIELD.