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CONTACT ALLOYS

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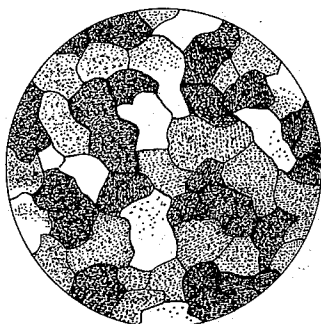


Fig. 1

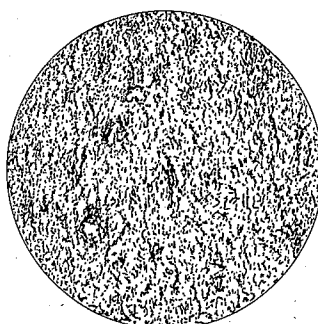


Fig. 2

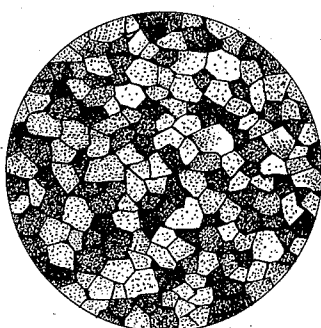


Fig. 3

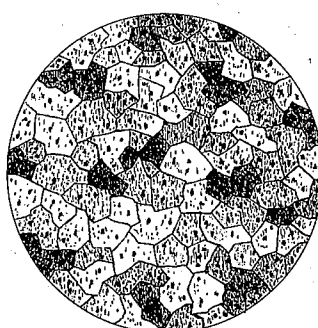


Fig. 4

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CONTACT ALLOYS

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9 Claims. (Cl. 75—176)

This invention relates to alloys and electrical contacts made therefrom and has for a general object the provision of electrical make-and-break contacts of novel composition, and of a novel method for making electrical make-and-break contacts.

In the art, the metal tungsten has been considered as possessing the physical, chemical and electrical properties required by or desired in electrical make-and-break contacts. Tungsten metal has been worked and treated by various methods, with the view of causing desired properties to become more or less pronounced, or of changing the nature of the metal itself to secure optimum performance. Tungsten contacts are, however, commonly made by a method involving sintering pressed tungsten powder at a relatively high temperature of the order of 3000° C., working the ingot thus formed, as by swaging or rolling, and either sawing contact discs from tungsten rods or punching them from rolled tungsten sheet. Securing such high sintering temperatures involves considerable expense, and the sawing and punching operations result in a scrap loss which, considering the production and material costs, is at least worth saving.

In view of the anticipated savings, numerous efforts have heretofore been made to eliminate the step of forming a relatively large body of tungsten by working, and the step of forming the contact from the said large body. It has been suggested that the expense of forming contact discs in the conventional fashion could be reduced by forming the discs directly from tungsten powder, sintering the pressed body in such manner as to produce a sintered pellet of substantially the desired final dimensions. Numerous efforts have been made to produce these pellets of substantially pure tungsten, but it has been found that unless the elevated temperature used in sintering tungsten bars is employed the grain growth necessary for electrically efficient performance is not obtained. Furthermore, this temperature is so high that the problem of finding suitable refractories for use in the furnaces employed in manipulating the tungsten, effectively offsets any advantage obtained. Consequently it is desirable to find some alloying element which will reduce the temperature within the range available in industrially available furnaces.

However, there is an immediate disadvantage resulting from the introduction of an alloying element into tungsten. The performance characteristics of tungsten alloys in contact service are for the most part undesirable. For example, it has been suggested that some relatively low boiling element, such as nickel, vanadium or gold, be employed to assist the grain growth of

the tungsten, and thereafter remove the alloying element by heating the otherwise finished contacts to a temperature sufficiently high to boil away the major part of the said alloying element. Two disadvantages attend the use of such element: first, the temperature required to boil the element away is relatively high—almost as high as the sintering temperature of pure tungsten. Hence little temperature advantage is obtained. In addition, the boiling away of the alloying element tends to leave some voids in the finished contact, which are also undesirable.

Recently, however, it has been learned that the addition of small amounts of nickel, say from one-half to 4 percent, when very evenly distributed through the tungsten mass, enables the tungsten-nickel alloy to be sintered at a temperature between 1400 and 1600° C. while maintaining the shape of pellet suitable for direct application as an electrical contact. The mechanism of this reaction is believed to be substantially as follows: From approximately 1 percent nickel and above there is evidently enough nickel present so that the resulting nickel-tungsten phase remains liquid, at least until extensive grain growth has occurred. The liquid nickel-tungsten phase is continuously rejected by the growing grains, so that finally it forms a more or less continuous envelope about the tungsten grains. On the other hand, if less amounts than 1 percent of nickel are employed, there is not enough of it to coat all of the grains, and consequently the nickel-tungsten alloy draws up into small globules by virtue of the forces of surface tension. These small globules probably become saturated with tungsten at an early stage, and hence freeze solid. Inasmuch as nickel per se does not materially improve the performance of tungsten as a contact material, and at times actually makes it less suitable, only a small amount of nickel is used. Using less than the amount necessary also tends to reduce performance characteristics. For example, one-half percent nickel pellets are deemed much less desirable than 1 percent pellets for contact purposes.

Another object of the invention is to produce an electrical make-and-break contact with substantially the same properties as commercial tungsten contacts, by a heat treatment at a relatively low temperature and by a method which eliminates or at least minimizes scrap loss.

A further object of the invention is to provide a composite contact of tungsten and nickel so intimately mixed therewith that not only is the sintering temperature reduced below that of tungsten, but in addition the intermixed tungsten and nickel result in a contact which has practically the same properties as a contact of tungsten without the nickel.

A still further object of the invention is to provide a new alloy of tungsten and nickel which, besides its properties as an electrical contact, also has numerous other uses, as will later appear.

Other objects of the invention will become apparent from the following description of an embodiment exemplifying some of the teachings of the invention.

In order to accomplish the foregoing objects, we provide a sintered composite make-and-break contact comprising tungsten as the principal contact material, in an amount predominating by weight in the contact, and nickel as the auxiliary contact material, or binder, in a significant but exceedingly minor percentage by weight.

The percentages of tungsten and nickel are dependent somewhat upon the contact use for which the resulting contact is intended. The percentage of nickel has hitherto also been considered significant from the point of view of the amount below which it was not thought possible to sinter the mixture at a relatively low temperature of the order of 1500° C. That amount has heretofore been considered to be of the order of one-half per cent. Furthermore, since the electrical properties of such contacts were definitely inferior to contacts containing 1 per cent nickel, it was heretofore not considered possible to produce an electrical contact of tungsten containing substantially less than one-half per cent nickel by sintering a pressed-to-shape contact body.

We have now found the surprising result that where it was formerly considered impossible to produce sintered-to-shape tungsten electrical contacts containing less than one-half per cent nickel, it is possible to produce such contacts containing 0.4 per cent nickel down to .02 per cent or less nickel, without employing temperatures any higher than 2000° C.

What is even more surprising, we find that the electrical properties of these alloys for contact purposes, are actually superior to those of higher percentage nickel alloys; so superior, in fact, that for some applications it is impossible to distinguish these contacts from those produced according to prior art methods by sawing or punching from processed tungsten bars.

The nickel may thus be varied between the limits just stated and the tungsten makes up the remainder of the novel electrical make-and-break contacts; and we have found that contacts of from about 0.1 per cent to about 0.25% by weight of nickel, the remainder being tungsten, are particularly suitable for use in the ignition control circuits of certain automobiles.

Briefly stated, the novel contact of the invention may be made by providing an intimate mixture of tungsten and nickel in the desired proportions, pressing the mixture into a pellet of the desired contact shape and substantially to the desired size, allowing for shrinkage during the ensuing heat treatment, and sintering the pellet.

Preferably the intimate mixture of the tungsten and nickel in the desired proportions is made by some method which promotes uniformity in the resulting product, and which provides a mixture of tungsten and nickel in a state of what we call "atomic dispersion", since the mixture seems so thorough and uniform that apparently the individual atoms of tungsten and nickel are distributed through the mass in the same proportions as would be obtained in a definite chem-

ical compound of the same formula. One such method of obtaining an intimate mixture is by reducing or otherwise treating a compound containing suitable proportions of tungsten and nickel to remove the undesirable constituents from the compound and to convert it into an intimate mixture of tungsten and nickel.

However, if the reduced tungsten particles are sufficiently small and a sufficiently low dilution of nickel salt is employed, we have found that reasonably satisfactory results may be obtained by dissolving any suitable nickel salt, as for example, nickel acetate, in water to produce a low dilution, and sprinkling the solution upon finely divided reduced tungsten powder in such fashion as to thoroughly distribute the nickel acetate molecules over the tungsten particles.

If contacts of disc shape are desired, dies are employed with diameters which allow for shrinkage due to sintering, so that the subsequent sintering of the pressed powder will result in contacts of the desired diameter. The thickness of each disc is controlled by the weight of the powder supplied to each die for pressing, and by the pressure employed. The powder mixture of tungsten and nickel is thus pressed into pellets at a forming pressure which permits handling the pressed pellets, and those pellets are heated in a neutral or reducing atmosphere or in a vacuum to a sintering temperature for a time from ten minutes to two or three hours, the sintering temperature being of the order of 1400 to 1800 or even 2000° C., depending upon the relative amounts of tungsten and nickel employed in the contacts, and depending also upon the time of sintering and the formation pressure.

Illustrative of our novel method, as described above, we add a soluble ammonia compound of nickel to a clear solution of tungstic acid in ammonium hydroxide, the while constantly stirring the mixture. One such soluble ammonia compound of nickel may be prepared from the chloride according to the formula, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$. An amount of that chloride providing the desired weight equivalent of nickel may be dissolved in water and ammonium hydroxide may then be added to that solution until the characteristic bluish-green precipitate which is formed at first is dissolved. For example, for a contact with 0.14 per cent of nickel, 1.8 grams of the nickel chloride as $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ (equivalent to .445 gram of metallic nickel) are employed in preparing the soluble ammonia compound of nickel already described. An amount of tungstic acid providing the desired weight equivalent of tungsten is dissolved in sufficient ammonia to form a clear solution known as ammonium tungstate. For example, to provide the above mentioned 0.14 per cent nickel contact, 433 grams of tungstic acid are dissolved in ammonia. While constantly stirring that solution, as already explained, the soluble ammonia compound of nickel described above is added thereto. If the ammonia is in sufficient excess no precipitate is obtained when the two solutions are thus mixed, but as the mixture is heated to expel the ammonia the greenish precipitate of green nickel tungstate, NiWO_4 , and tungstic acid is formed. The heating of the mixture is continued until the precipitate is dry.

The dried precipitate just described is heated to about 200° C. to expel excess ammonium salts, and the precipitate is reduced by heating it in hydrogen, in a well known manner, to yield a powder mixture of tungsten and nickel with the

proper grain or particle size for pressing into pellets and sintering as already described.

According to our alternative method, a suitable quantity of nickel salt, as for example, nickel acetate, 1.34 grams are dissolved in a large quantity of water. The solution is then sprinkled over 318 grams of finely powdered metallic tungsten in such manner as to thoroughly wet each particle. The mass is then dried and reduced in hydrogen at a relatively low temperature not exceeding 1000° C. This powder is then pressed into pellets and sintered, as previously described.

In order more clearly to differentiate our product from that of the prior art, photomicrographs of our product and that of the prior art are reproduced in the drawing, in which Fig. 1 shows a cross-section of commercially pure tungsten rod; Fig. 2 shows a cross-section of an 8 per cent nickel-tungsten alloy; Fig. 3 shows a cross section of a 1 per cent nickel-tungsten alloy; Fig. 4 shows a cross-section of a ¼ per cent nickel-tungsten alloy. Each of the figures is magnified 150 diameters, and in each case the etchant was H₂O₂.

It will be seen from Fig. 2 that the grain growth of the 8 per cent nickel alloy has not been great. Neither phase is continuous but the material is somewhat ductile which should be the case if the nickel phase were completely continuous. This material was sintered for 30 minutes, at 1400° C. Higher sintering temperatures deform the shape of the pellet.

It will be seen from Fig. 3 that the 1 per cent nickel alloy has greatly enhanced grain growth, with some interlocking grains. All of the nickel-tungsten alloy appears at the boundaries of the grains. This material was sintered for 30 minutes at 1500° C.

It will be seen from Fig. 4 that the material made according to our invention is distinctly similar to the prior art material of Fig. 1. Grains are large, well formed and interlocking. Practically no material appears at the grain boundaries, and only a small trace is found within the grains. The alloy containing ¼ per cent nickel has the same characteristic appearance, save that the material included within the grains is even less perceptible. This material was sintered for 45 minutes at 1525° C. A ⅛ per cent nickel alloy requires somewhat longer or higher-temperature sintering.

In order to show how contacts having various percentages of nickel compare with each other and with a standard grade of tungsten, distributor tests were run. The procedure in each test was as follows: The contacts were mounted in the distributors, the dwell and spring tension having been correctly adjusted and the contact resistance—symbolized by R_c—measured at 5 amperes by the voltmeter-ammeter method. The 8-lobe distributors were operated at about 390 R. P. M. and the 6-lobe distributors at about 525 R. P. M. The input voltage in all cases was set at 8.5 volts and circuit constants adjusted so that the peak break current, as measured on an oscillograph, was from 4 to 5 amperes. Then at every 25 hour interval thereafter, until a test run of 100 hours had been completed, R_c was measured and the point condition and amount of transfer noted.

At the conclusion of the test, the dwell, spring, tension, peak current, R_c, input voltage, point condition and amount of transfer at the points were noted and recorded.

The data are summarized in the following table,

data on a standard grade of tungsten discs being included for purposes of comparison:

Contact test data

Material	Av. duration of test (hours)	Av. final R _c (ohms)	Av. pitting grade*	Av. final point condition
Tungsten	100	0.001	1.1	Grey.
1% Ni-W	100	0.013	2.2	Dark.
0.5% Ni-W	100	0.154	1	Very black
0.25% Ni-W	100	0.019	2.2	Dark.
0.1% Ni-W	100	0.012	1.8	Grey.

*Pitting grade classification.

1. Flat or nearly so.
2. Smooth, shallow pit.
3. Deep, sharp edged pit.

It is to be understood that the invention is not to be limited to the improvements set forth in our specification above, which are solely for the purpose of illustration, but it is only to be restricted to the scope of the appended claims wherein we have set forth our invention.

1. An electrical make-and-break contact comprising a sintered-to-shape intimate mixture of from about 99.50 to 99.98 per cent by weight of tungsten and from about 0.50 to .02 per cent by weight of nickel, said contact closely approximating substantially pure tungsten in electrical characteristics.

2. An electrical make-and-break contact comprising a sintered-to-shape intimate mixture of from about 99.60 to 99.96 per cent by weight of tungsten and from about 0.4 to .04 per cent by weight of nickel, said contact closely approximating substantially pure tungsten in electrical characteristics.

3. An electrical make-and-break contact comprising a sintered-to-shape intimate mixture of about 99.75 per cent by weight of tungsten and about 0.25 per cent by weight of nickel, said contact closely approximating substantially pure tungsten in electrical characteristics.

4. An electrical make-and-break contact comprising a sintered-to-shape intimate mixture of about 99.9 per cent by weight of tungsten and about 0.1 per cent by weight of nickel, said contact closely approximating substantially pure tungsten in electrical characteristics.

5. An alloy consisting essentially of from about 99.50 to 99.98 per cent by weight of tungsten and from about 0.5 to .02 per cent by weight of nickel, said alloy being especially suitable for electrical contacts.

6. An alloy consisting essentially of from about 99.60 to 99.96 per cent by weight of tungsten and from about .4 to .04 per cent by weight of nickel, said alloy being especially suitable for electrical contacts.

7. An alloy consisting essentially of about 99.75 per cent by weight of tungsten and about 0.25 per cent by weight of nickel, said alloy being especially suitable for electrical contacts.

8. An alloy consisting essentially of about 99.9 per cent by weight of tungsten and about 0.1 per cent by weight of nickel, said alloy being especially suitable for electrical contacts.

9. An electric make-and-break contact formed of a metal composition composed of 99.50 to 99.98 per cent by weight of tungsten, and from about 0.5 to .02 per cent by weight of nickel.

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