

UNITED STATES PATENT OFFICE

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CONTACT ALLOY AND METHOD OF MAKING
SAME

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This invention relates to electrical make-and-break contacts and has for a general object the provision of an electrical make-and-break contact of novel composition and of a novel method for making electrical make-and-break contacts.

For so much of the subject matter as is common, we claim the priority of our application, Serial No. 73,300, filed April 8, 1936, of which this application is a continuation in part.

Prior to this invention the metal tungsten was considered as possessing the most nearly ideal physical, chemical and electrical properties by or desired in electrical make-and-break contacts. No other metal or alloy was known which even fairly approximated tungsten in these qualities.

Tungsten metal has been worked and treated by various methods with a view to causing these desired properties to become more or less pronounced or of changing the nature of the metal itself to secure optimum performance. Commercial tungsten contacts are, however, made by a method involving sintering pressed tungsten powder at a relatively high temperature, working the ingot thus formed, as by swaging or rolling, and either cutting contact discs from tungsten rods or punching them from rolled tungsten sheet. Securing the necessary high sintering temperatures involved considerable expense, and the cutting and punching operations result in a scrap loss which, taking into consideration the cost of production and material, is quite considerable. Up to the time of our invention no process eliminating any of these steps has to our knowledge been commercially successful.

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 materially 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.

Still another object of our invention is to produce an alloy of tungsten and nickel differing in composition and physical character from previously known alloys of these two metals.

Other objects of the invention will become apparent from the following description of an em-

bodiment exemplifying some of the features 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 predominat-
ing by weight in the contact, and nickel as the auxiliary contact material or binder in a significant but minor percentage by weight.

The percentages of the tungsten and nickel are dependent somewhat upon the contact for which the resulting contact is intended.

On the one hand, the lower limit of the nickel is—(1) that amount below which it has not been thought possible to sinter the mixture at a relatively low temperature of the order of 1500° C.; (2) even though sintering is possible with the percentage employed, the electrical properties of the finished product may not be desirable. The minimum useful amount, depending on either one or the other of these two factors, is found to be approximately ½ per cent.

On the other hand, the upper limit of the nickel is also necessarily a minor percentage by weight, since otherwise, due to the relative atomic weights the volumetric proportions may be such that the desirable resistance to migration or transfer of contact material contributed by the tungsten may be lowered to an objectionable amount. Ordinarily an upper limit for the nickel should rarely exceed 4% by weight of the contact and should never exceed 8 per cent by weight, since greater percentages have not been found to contribute any desirable properties to the contact.

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 contact, and we have found that contacts of from about one per cent to about two per cent by weight of nickel, the remainder being tungsten, are particularly suitable for use in the ignition control circuits of certain automobiles, although suitable contacts have been made with as little as one-half of one per cent nickel.

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 a 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 the tungsten and nickel are distributed throughout the mass in the same proportions as would obtain in a definite chemical compound of the same formula. Such an intimate mixture is obtained 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.

If contacts of disc shape are desired, dies are employed with diameters which allow for shrinkage due to a sintering, so that the subsequent sintering of the pressed powders will result in contacts of the desired diameters. 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 an atmosphere of hydrogen or other neutral or reducing atmospheres or in a vacuum to a sintering temperature for about one-half hour, the sintering temperature being in the order of 1500° C., depending upon the relative amounts of tungsten and nickel employed in the contacts.

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 again dissolved. For example, for a contact with 2 per cent of nickel, 25.3 grams of nickel chloride ($\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ (equivalent to 6.8 grams 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, for a contact with 98% of tungsten, 490 grams of tungstic acid are dissolved in the 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, a 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.

In carrying out our process we deliberately seek to obtain an alloy which is substantially

non-ductile. Also this procedure results in the production of an alloy which is relatively coarse-grained; that is to say, the grain size approximates that of the commercial grades of tungsten now used for contact purposes. This condition is brought about by maintaining the sintering time and temperature at sufficiently high values to secure the desired grain growth. For example, we prefer to sinter a 1 per cent nickel alloy for 40 minutes at 1500° C. in hydrogen. Another result of this method of procedure is to bring about the segregation of substantially all the nickel in the form of nickel-tungsten alloy at the grain boundaries. A typical structure resulting from the practice of our invention is illustrated at Fig. 3 of the drawings of an application of the inventor, Driggs, herein, and William H. Lenz, Serial Number 256,207 filed February 13, 1939.

In order to test the contact performance of our novel contact, a pair of such contacts was employed in a 110-volt A. C. lighting circuit in which two 60-watt lamps in parallel were lighted intermittently. The peak current amounted to approximately 1.1 amperes. At the end of 120 hours, about 1,296,000 contacts having meanwhile been made and broken by the pair of contacts, the contacts were removed and examined for oxidation and wear. The surfaces of the contacts were unusually clean and the contact surface wear of each contact was about 0.010 inches, although the contact surface radius of the test contacts was unusually small, about 0.5 inch, and therefore unfavorable to such good results as were obtained in the test.

After 100 hours of operation under the test conditions just described, a pair of commercial contacts consisting of tungsten had a contact resistance of 0.003 ohm as compared with the following potential drops of typical composite contacts having the indicated formulas and tested under the same conditions for the respective periods shown below:

Formulas in percent by weight	Time of test in hours	Contact resistance, ohms
Tungsten, 99½	100	0.15
Nickel, ½		
Tungsten, 99	100	.01
Nickel, 1		
Tungsten 98	100	.00
Nickel, 2		
Tungsten, 92	100	.02
Nickel, 8		
Tungsten, 87	100	.05
Nickel, 13		

Thus, the electrical durability of our composite contact compares favorably with well known commercial contacts of tungsten.

Likewise, the physical characteristics of our novel contact, as exemplified by the small amount of wear recited above, and as further shown by the following hardness comparisons indicate the utility of the invention. The hardness of the commercial tungsten contacts on the Rockwell A scale measured 66. On the same scale our contacts with 96% tungsten and 4% nickel were 65 hard; our contacts with 99½% tungsten and ½% nickel were 66 hard; our contacts with 99% tungsten and 1% nickel were 66 hard; our contacts with 98% tungsten and 2% nickel were 65 hard.

While we have described a preferred embodiment of our invention, many modifications may be made without departing from the spirit of

the invention, and we do not wish to be limited to the precise details of construction set forth, but desire to avail ourselves of all changes within the scope of the appended claims.

5 Having thus described our invention, what we claim as new and desire to secure by Letters Patent of the United States, is:

10 1. An alloy consisting essentially of from about 96 to 99½ per cent by weight of tungsten, and from about 4 to ½ per cent by weight of nickel, said alloy being characterized in the unworked condition, when sintered above 1500° C. for periods of the order of one-half hour and more by being for the most part made up of large well grown crystals, with the major portion of the nickel content segregated at the grain boundaries, said alloy being further characterized by substantially the non-ductile and electrical qualities of commercially pure tungsten contacts.

15 2. An alloy consisting essentially of from about 98 to 99 per cent by weight of tungsten, and from about 2 to 1 per cent by weight of nickel, said alloy being characterized in the unworked condition, when sintered above 1500° C. for periods of the order of one-half hour and more by being for the most part made up of large well grown crystals, with the major portion of the nickel content segregated at the grain boundaries, said alloy being further characterized by substantially the non-ductile and electrical qualities of commercially pure tungsten contacts.

20 3. An alloy consisting essentially of about 99 per cent by weight of tungsten, and about 1 per cent by weight of nickel, said alloy being characterized in the unworked condition, when sintered above 1500° C. for periods of the order of one-half hour and more by being for the most part made up of large well grown crystals, with the major portion of the nickel content segregated at the grain boundaries, said alloy being further characterized by substantially the non-ductile and electrical qualities of commercially pure tungsten contacts.

25 4. An alloy consisting of essentially of about 99½ per cent by weight of tungsten and about ½ per cent by weight of nickel, said alloy being characterized in the unworked condition, when sintered above 1500° C. for periods of the order

of one-half hour and more by being for the most part made up of large well grown crystals, with the major portion of the nickel content segregated at the grain boundaries, said alloy being further characterized by substantially the non-ductile and electrical qualities of commercially pure tungsten contacts.

5 5. An electrical make-and-break contact comprising an unworked, sintered-to-shape body consisting essentially of an alloy of from about 98 to 99 per cent by weight of tungsten and from about 2 to 1 per cent by weight of nickel, said alloy for the most part made up of large, well-grown crystals, produced by sintering above 1500° C. for a period of the order of one-half hour and longer the major portion of the nickel content being segregated at the grain boundaries, said alloy being further characterized by substantially the non-ductile and electrical qualities of commercially pure tungsten.

10 6. An electrical make-and-break contact comprising an unworked, sintered-to-shape body consisting essentially of an alloy of about 99 per cent by weight of tungsten and about 1 per cent by weight of nickel, said alloy for the most part made up of large, well-grown crystals, produced by sintering above 1500° C. for a period of the order of one-half hour and longer the major portion of the nickel content being segregated at the grain boundaries, said alloy being further characterized by substantially the non-ductile and electrical qualities of commercially pure tungsten.

15 7. A process of producing dense bodies made up largely of tungsten and suitable for substitution in place of tungsten in electrical contact applications, which comprises obtaining tungsten metal power admixed with from about ½ to 4 per cent by weight of nickel, pressing from the mixture a body of the desired shape and of sufficiently larger size to allow for subsequent shrinkage, and sintering the body at 1500° C. and upwards in a non-oxidizing atmosphere for sufficient time of the order of half an hour and upwards to produce the desired dense body having relatively large, well-grown grains.

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CERTIFICATE OF CORRECTION.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 1, first column, lines 8 and 9, strike out the comma and words ", of which application is a continuation in part"; same page, second column, after "contact" insert "--use--"; page 2, first column, line 17, before "entering" strike out the article "a"; line 30, for "1500 C." read "--1500 C."; line 74, for "our our" read "--out our--"; and that the said Letter Patent should be read with this correction therein that the same may be placed on the record of the case in the Patent Office.

Signed and sealed this 15th day of April, A. D. 1941.

(Seal)

Henry Van Arsda
Acting Commissioner of

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(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.