Sept. 1, 1942. R. S. DEAN ET AL 2,294,389

ELECTRICAL RESISTANCE ALLOY

Filed Nov. 6, 1939 2 Sheets-Sheet 1

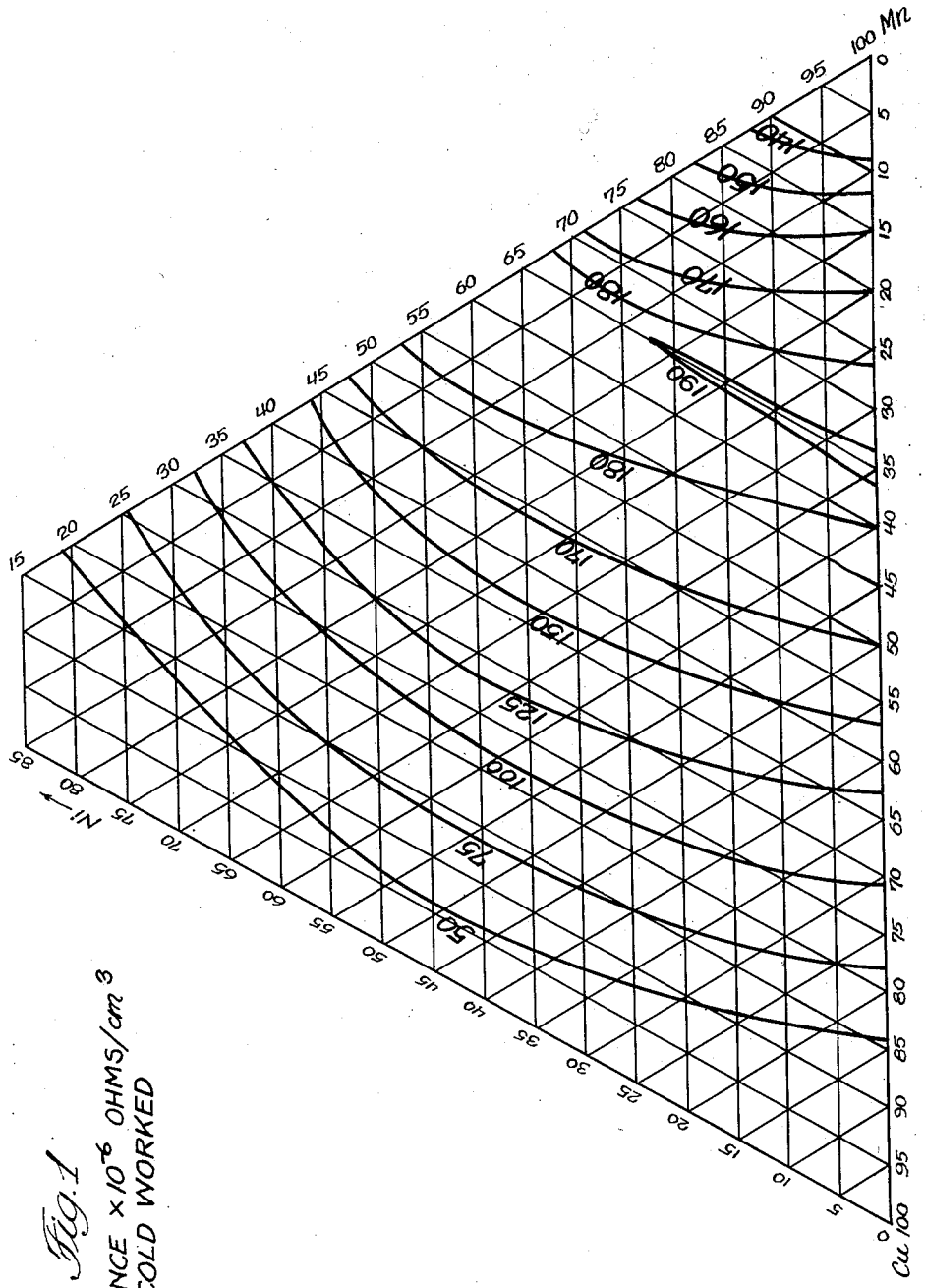


Fig. 1

RESISTANCE $\times 10^{-6}$ OHMS/cm 3
COLD WORKED

INVENTOR.
Reginald S. Dean
Clarence Travis Anderson
BY McLaughlin & Wallenstein
ATTORNEYS

Sept. 1, 1942. R. S. DEAN ET AL 2,294,389

ELECTRICAL RESISTANCE ALLOY

Filed Nov. 6, 1939 2 Sheets-Sheet 2

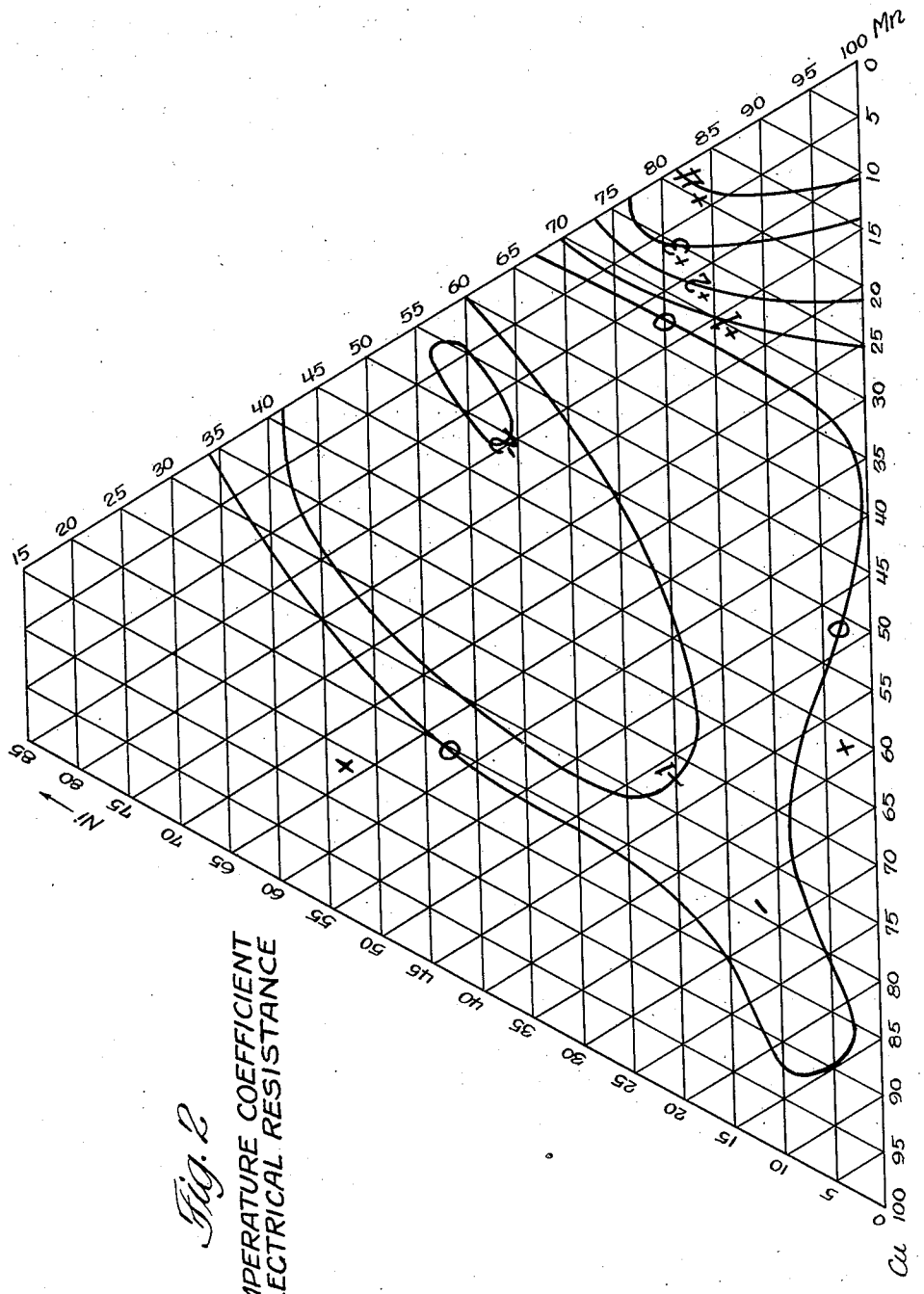


Fig. 2.

TEMPERATURE COEFFICIENT OF ELECTRICAL RESISTANCE

INVENTOR.
Reginald S. Dean
BY Clarence Travis Anderson
McLaughlin & Wallenstein
ATTORNEYS

Patented Sept. 1, 1942 2,294,389

UNITED STATES PATENT OFFICE

2,294,389

ELECTRICAL RESISTANCE ALLOY

Reginald S. Dean, Washington, D. C., and Clarence T. Anderson, Pittsburgh, Pa., assignors to Chicago Development Company, Chicago, Ill., a corporation of Illinois

Application November 6, 1939, Serial No. 303,008

7 Claims. (Cl. 201—76)

This invention relates to electrical resistance alloys having high electrical resistance and a low temperature coefficient of resistance. It relates more in particular to the alloys of manganese, nickel and copper which have these properties.

In the drawings accompanying the specification:

Fig. 1 is a ternary diagram of the manganese-nickel-copper system showing the relationship between composition and electrical resistance;

Fig. 2 is a similar diagram showing the temperature coefficient of electrical resistance as affected by the composition.

We have found that alloys of manganese, nickel and copper, within a certain composition range, possess electrical resistance of more than 170×10^{-6} ohm/cm.^{3} and a temperature coefficient of less than $\pm1.0\times10^{-4}$ ohms/ohm/deg. C. The relation between electrical resistance and composition in the ternary system manganese-nickel-copper appears clear from Fig. 1. The lines show equal electrical resistance as indicated. The unit of electrical resistance is 10^{-6} ohm/cm.^{3}. Thus, along the line marked **170**, the electrical resistance is 170×10^{-6} ohms/cm.^{3}.

Fig. 2 shows the relation between composition and temperature coefficient of electrical resistance in this same ternary system. The lines show equal temperature coefficient of electrical resistance in which the unit is 10^{-4} ohms/ohm/deg. C.

It will be clear that these results of our investigations disclose a range of compositions which have a high electrical resistance and a very low temperature coefficient. By noting where the lines of Figs. 1 and 2 bisect each other, a composition may be determined where the desired combination of properties are to be found.

We prefer to employ these alloys in the state produced by quenching from a temperature of about 900 degrees C. and cold working to suitable wire or other shape for practical use. The results from which Figs. 1 and 2 were plotted were obtained on alloys treated in this way. As to most of these alloys, when they are reheated to a temperature of approximately 450 degrees C., the very low temperature coefficient is no longer found in the alloys of high resistance. This is illustrated by the following examples:

Alloy composition			Resistance cold worked	Temperature coefficient	Resistance 450° C.	Temperature coefficient
Mn	Ni	Cu				
65	7½	27½	190.6	−0.8	168.1	+1.7
65	2½	32½	191.5	−0.3	150	+3.7

To secure the results desired, various quenching temperatures may be used. Good results may be obtained if this temperature is between 900 degrees C. and the melting point of the alloys.

The mechanical properties of the alloys encompassed within the range of high electrical resistance and low temperature coefficient are valuable. The following table illustrates tensile of the alloys in the cold worked condition:

Composition			Rockwell C	Tensile strength per square inch
Mn	Ni	Cu		
65	35	0	27	127,000
65	35	10	21	113,000
65	15	20	14	100,000
65	5	30	10	85,000
65	7½	27½	12	95,000
65	2½	32½	9	87,000

These alloys posses corrosion resisting properties which make them especially useful for electrical resistance purposes.

These alloys in the range up to 10% nickel possess unusually high vibration damping capacity. When measured at very low stresses, the damping capacity is of the order of 2%. The alloys of high resistance possess a coefficient of linear expansion of more than 20×10^{-6} cm./cm./deg. C.

Thus, it will be seen that in addition to unusual electrical properties, the alloys of our invention have desirable mechanical properties which make them eminently suitable for the production of electrical resistance elements of various types. Just as the combination of electrical properties desired may be determined by reference to composition, so the composition may be modified to meet mechanical requirements to a considerable extent, although it will be understood that as the number of properties considered is increased, there is less likelihood of obtaining the maximum of any particular characteristics, and some compromise may be necessary.

In addition to the selection of composition for determining properties, the treatment, particularly the heat treatment, of the alloys will have a bearing. The alloys of our present invention may be used as either low temperature or high temperature resistance alloys, particularly when they are employed in the soft condition.

A study of the ternary diagrams and an analysis of the properties as compared to composition, shows that with from about 45% and to 75% manganese, and substantially independently of the relative proportions of copper and nickel, the resistance value is 170 or above, with a particular valuable range occurring when the manganese is between about 55% and about 75%. So far as the relationship of copper to nickel is concerned, the manganese being constant, the relationship is fairly orderly as the shape of the lines in Fig. 1 illustrates.

The temperature coefficient of electrical resistance, except for the fairly orderly lines occurring where the manganese is 70% or above, seems to be affected appreciably by the relation between nickel and copper, the region of the lowest temperature cofficient being on opposite sides and quite well removed from the line coinciding with the pseudo-binary system Cu+MnNi. The comparatively small area where the lowest temperature coefficient is found, however, lies only on one side of the pseudo-binary line, that is, on the side where the manganese is greater than the nickel. Indeed, generally it may be stated that in the direction of increased manganese, the temperature coefficient of electrical resistance tends to be lower and the electrical resistance itself higher. The most valuable properties, therefore, are found in the relatively high manganese range previously discussed.

What we claim is new and desire to protect by Letters Patent of the United States is:

1. An electrical resistance element composed of an alloy of manganese, nickel and copper having more than 55% manganese and less than 75% manganese, from 2½% to 35% nickel, balance copper, said element having an electrical resistance of not less than 170×10^{-6} ohms/cm.^{3}, said alloy being quenched from a temperature between about 900 degrees C. and the melting point thereof and cold worked.

2. An electrical resistance element composed of an alloy of manganese, nickel and copper having a composition of between 55% manganese and 75% manganese having an electrical resistance of between 170 to 200×10^{-6} ohms/cm.^{3} and a temperature coefficient of electrical resistance not greater than 1.0×10^{-4} ohms/ohm/deg. C., said alloy falling within the region of low temperature coefficient of electrical resistance as identified in Fig. 2, and being quenched from a temperature between about 900 degrees C. and the melting point thereof and cold worked.

3. An electrical resistance element consisting of an alloy of manganese, nickel and copper, wherein the proportion of manganese is between about 25% and about 60%, and wherein the temperature coefficient of electrical resistance is less than 0×10^{-4} ohms/ohm/deg. C., said alloy falling within the region of low temperature coefficient of electrical resistance as identified in Fig. 2, and being quenched from a temperature between about 900 degrees C. and the melting point thereof and cold worked.

4. An electrical resistance element identified on the attached drawings falling substantially at the points where lines showing at least 150×10^{-6} ohms/cm.^{3} in Fig. 1 would cross lines on Fig. 2 showing a temperature coefficient of electrical resistance not greater than 1×10^{-4} ohms/ohm/deg. C., said resistance consisting of 45 to 75% manganese and at least one of the elements copper and nickel, said alloy being quenched from a temperature between about 900 degrees C. and the melting point thereof and cold worked.

5. A resistance element comprising an alloy of approximately 65% manganese, approximately 7½% nickel and approximately 27½% copper, said alloy being quenched from a temperature between about 900 degrees C. and the melting point thereof and cold worked.

6. A resistance element comprising an alloy consisting of approximately 65% manganese, and balance nickel and copper, the proportion of copper being greater than the proportion of nickel, the nickel constituting at least 2½% of the alloy, the resistance element having an electrical resistance of at least 170×10^{-6} ohms/cm.^{3} and a temperature coefficient of electrical resistance not greater than 1×10^{-4} ohms/ohm/cm.^{3}, said alloy being quenched from a temperature between about 900 degrees C. and the melting point thereof and cold worked.

7. An electrical resistance element, having a low temperature coefficient of electrical resistance, comprising an alloy quenched from a temperature of about 900 degrees C. and cold worked, said alloy consisting of about 60% to 75% manganese, the balance at least one of the metals nickel and copper.

REGINALD S. DEAN.
CLARENCE T. ANDERSON.