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NICKEL BASE ALLOY

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This invention relates to nickel base alloys particularly for use as an element of an electron emitting cathode of the oxide coated type which serves as an electrode in a discharge device.

oxide coated electron emitters and to eliminate peeling or flaking of the emitter coating in such emitters.

In accordance with the broad aspect of this invention, it was found that iron and cobalt when alloyed with nickel increased the strength and resistivity to a high degree and the incorporation of carbon in the alloy greatly enhances the electron emission of a core or base coated with active material and, furthermore, the operating life is greatly increased. Such an alloy consists primarily of nickel, cobalt, iron and carbon in which the nickel predominates. Suitable parameters for the constituents of the alloys of this invention are nickel 70 to 90 per cent, cobalt .1 to 15 per cent, iron .1 to 10 per cent and carbon 0.1 to 1.5 per cent. This general formula produces a group of efficient base materials having the required strength and specific resistance even when rolled or drawn to the cross-sectional dimensions usually employed for filaments consuming a minimum current. The alloy exhibits a complete absence of flaking or peeling when the alloy base is coated with thermionically active material due, no doubt, to the elimination of the deleterious metals mentioned above which tend to form an oxide interface between the base and the coating. This oxide interface is incapable of combining with the thermionic coating material and consequent inadhesion of the coating results. Furthermore, the high carbon content enhances the activity of the coating since it has been found that with continued operation the emission increases so that a materially longer operating life is obtained. The cobalt-iron content of the alloy also permits the retention of a greater amount of carbon than is possible with pure nickel and this carbon performs a progressive activation process during the operation of the emitter.

In accordance with one example of a more specific aspect of the invention, the nickel base alloy consists of a melt of 85 per cent nickel, about 7.25 per cent cobalt, about 7.25 per cent iron and substantially .5 per cent carbon. This composition of the alloy produces a strong filament having the required specific resistance even when reduced to diameters of the order of .001" and when coated with oxides of alkaline earth metals, such as barium and strontium, or other active materials, it is free from peeling and flaking so

In recent years, nickel has largely superseded the more expensive metals in the fabrication of cathodes for the emission of electrons in electron discharge devices, such as high vacuum tubes, gaseous discharge tubes and glow lamps. Usually, when nickel is the base or core of the emitting electrode, it has electron emitting material such as the oxides and metals of alkaline earth associated with it either combined with the core or coated on the core in an uncombined state.

Pure nickel, when used for these purposes, is deficient from the standpoint of versatility since operating conditions limit its use. For instance, in cathodes of the filamentary type the strength of the nickel is insufficient to withstand the tension necessary to maintain the filament in proper relation to other cooperating electrodes when it is heated to the proper temperature for thermionic emission. Similarly, the specific resistance of nickel is relatively low and this inherent drawback is particularly disadvantageous in filaments of low power since it necessitates a filament of smaller cross-sectional dimensions than would be required if the resistivity were high. Consequently, the disadvantages of inherent weakness and low resistivity almost preclude the use of nickel for filaments of low power.

This has been recognized heretofore and attempts have been made to remedy these defects by alloying other metals with nickel which increase the strength and resistivity. Nickel-silicon alloys and nickel-manganese alloys are examples of attempts to improve the characteristics of nickel. Although these alloys are stronger and have higher resistivity than ordinary nickel when used for small filaments, they exhibit a serious defect resulting in peeling or flaking of the active coating on the core. This peculiar effect is attributed to the presence of such deleterious metals as silicon, manganese, titanium, chromium, zirconium, molybdenum and vanadium which are ordinarily used to increase the strength and resistance of nickel alloys.

The principal object of this invention is to increase the strength and resistivity, to increase the thermionic efficiency and operating life of

that practically no difficulty is experienced from loss of emission over extended periods of operation. Furthermore, due to the high carbon content, the activity of such a filament or cathode is enhanced to a considerable degree and with increased life appears to improve, apparently, due to chemical reaction between the carbon in the core and the coating material applied thereon.

It should be understood that the above example is set forth to illustrate a physical concept of this invention but is not intended to limit the scope of the invention since other compositions of the quaternary type may be evolved from the parameters of the nickel base alloys set forth in the broad aspect of the invention.

In defining the above mentioned proportions of the group of alloys in accordance with this invention either the pure or commercial metals or substances may be employed. However, when commercial substances are used there will be varying quantities, mostly as impurities, of other metals present in the alloy. These impurities should not amount to more than .20 per cent of the total constituents of the alloy. For instance, among the impurities in commercial grades of nickel are manganese, silicon, copper, aluminum and lead. When these impurities are present in a total amount of not more than .20 per cent they produce a small oxide formation which, however, is not sufficient to affect the non-peeling properties of the alloy.

The primary requisites of the alloys of this invention, particularly with respect to serving as a base for an electron emitting coating, are thermionic activity, hot strength, adherence and specific resistance.

In order to attain these properties and still retain the economic properties of nickel, it is proposed to employ chemically pure nickel, varying between 70 to 90 per cent as the base of these alloys and add cobalt or cobalt and iron to the nickel to increase the strength and resistance but at the same time avoid the detrimental effects of the easily oxidizable deleterious metals. It has been found that by adding varying amounts of cobalt or cobalt and iron, in proportions of .5 to .15 per cent cobalt to .5 to 10 per cent iron, a definite series of alloys can be produced to satisfy a desirable range of temperature requirements for the commercial production of cathodes for discharge devices. It has also been found that carbon present in the alloy greatly enhances the activity of a thermionic coating on the alloy base, the amount of carbon varying from .1 to 1.5 per cent depending on the ability of the iron and cobalt to retain the carbon in the fabrication of the alloy.

The preferred parameters of the quaternary alloy are nickel about 85 per cent, iron 1 to 9.75 per cent, cobalt 4.75 to 13.5 per cent and .5 per cent carbon. The preferable composition of the ternary alloy is nickel about 85 per cent, cobalt 14.5 per cent and .5 per cent carbon. The latter alloy composition forms the subject-matter of a continuation-in-part application, Serial No. 87,220, filed June 25, 1936.

A typical alloy, highly efficient, particularly for a filament of low power consumption, such as a quarter-ampere filament having a cross-section of .00476" x .00128" and length of 3½" consists of a melt of 85 per cent nickel, 7.25 per cent iron, 7.25 per cent cobalt and .5 per cent carbon. This filament is coated with barium and strontium oxides and activated in vacuum. The hot strength of this filament was very satisfactory and the thermionic efficiency reasonably high.

The life test data on this filament is as follows: The filament was operated at 760° to 800° C. The power radiated per unit surface area of the filament at the operating temperature, based on the area of core, was 3.65 watts per square centimeter; it was about 2.77 watts per square centimeter, based on area of core and coating. The resistivity was approximately 71 microhms centimeter at the operating temperature. The thermionic efficiency increased continuously during the life test. At about 7000 hours the thermionic efficiency at the operating temperature was approximately 375 to 400 milliamperes per watt. This filament was entirely free from peeling or flaking.

Similarly, satisfactory results were obtained with alloy cores in which commercial nickel was used as the base of the alloy. However, in this instance, the grade of nickel employed should not have large amount of impurities such as manganese, silicon, copper or other deleterious metals. A suitable alloy of this form may consist of 85.43 per cent nickel, 7.47 per cent iron, 6.70 per cent cobalt, .20 per cent carbon, .07 per cent silicon, .05 per cent manganese and .08 per cent copper. This alloy when coated with barium and strontium oxides and activated in vacuum exhibits satisfactory characteristics of hot strength, resistivity, thermionic efficiency and adherence comparable with the nickel-cobalt-iron and carbon alloys described above.

It is apparent from the foregoing that tremendous changes can be made in filament characteristics by a systematic change in the filament core alloys to produce a series of alloys which will meet vacuum tube requirements in a definite range of operating temperatures which will have the added characteristic of coalescence or adherence of the active coating to the core and eliminate the faults heretofore encountered with nickel or nickel alloys that have been proposed heretofore to increase the strength and specific resistance of nickel.

While the main purpose of this invention is to set forth the characteristics of the nickel base alloys with respect to their operation as a core or base for an emitting coating which is maintained in the state of incandescence, it is apparent that the alloys may form the base for other cathodes, such as a cold cathode in a glow discharge device. Furthermore, the alloys of this invention may be suitable in other fields of application, such as resistance wire heaters or as other electrodes in a discharge device, such as the grid or anode.

What is claimed is:

1. An alloy consisting of nickel 85 per cent, iron between 1 to 9 per cent, cobalt approximately 6 per cent, and carbon about .5 per cent, the alloy having the characteristic of preventing the formation of an oxide interface when coated.
2. A nickel base alloy consisting of nickel from 70 to 90 per cent, iron from .1 to 10 per cent, cobalt from .1 to 15 per cent and carbon from 0.1 to 1.5 per cent.
3. A nickel base alloy consisting of 85 per cent nickel, .5 to 9.75 per cent iron, 4.75 to 13.5 per cent cobalt and .5 per cent carbon.
4. An alloy consisting of nickel, iron, cobalt and carbon in which the nickel content is between 70 and 90 per cent, the iron content .1 to 10 per cent, the cobalt range being from 4 to 15 per cent and carbon from .1 to 1.5 per cent.
5. A nickel base alloy consisting of cobalt 7.25 per cent, iron 7.25 per cent, carbon .50 per cent and nickel 85 per cent.

6. An electrode capable of retaining an electron emitting coating by avoiding peeling thereof and having a base consisting of an alloy of nickel 85 per cent, iron between 6 and 9 per cent, cobalt between 6 and 9 per cent, and carbon to the extent of .5 per cent.

7. An alloy core for an electron emitter consisting of nickel 85 per cent, iron between .1 to 6

per cent, cobalt between 1 to 15 per cent, and approximately .25 per cent carbon.

8. A nickel base alloy consisting of cobalt 1 to 15 per cent, iron from 1 to 10 per cent, carbon to the extent of about .25 per cent, and approximately 85 per cent nickel.

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