

UNITED STATES PATENT OFFICE

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MAGNETIC MATERIAL

No Drawing.

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The present invention relates to magnetic materials and to their application to electro-magnetic systems. They have a wide field of usefulness and are of special interest in all those cases in which the impressed magnetizing forces are small, such as in electric signaling systems.

Among the more important characteristics of the materials of this invention are high permeability, especially at low magnetizing forces, high degree of constancy of permeability over a considerable range of magnetizing forces, and high resistivity with consequent low eddy current losses.

In Elmen's applications, Serial Nos. 119,622 and 119,623, filed June 30, 1926, there are described and claimed magnetic compositions of iron, nickel, and cobalt which have been discovered to have, among other unusual properties, a very high degree of constancy of permeability over a wide range of magnetizing forces including the low range employed in loaded signaling conductors. The utility of such compositions may be increased, especially for loading speech frequency or other high frequency circuits, by increasing their resistivity, if this be done without excessively or at all impairing other desirable properties.

Brief mention is made in those specifications of the addition of fourth substances such as chromium to increase the resistivity. In this present specification, however, compositions of iron, nickel and cobalt, having the characteristic properties above specified and including chromium with or without still other elements, will be fully set forth and claimed. To the extent that the subject matter hereinafter claimed is disclosed in them, this application is a continuation of applications Serial No. 119,622 and Serial No. 119,623, both filed June 30, 1926, which have issued as Patents 1,715,646 and 1,715,647, granted June 4, 1929, also Serial No. 220,387, filed September 19, 1927, which has issued as Patent 1,715,541, granted June 4, 1929, Serial No. 256,657, filed February 24, 1928, Serial No. 287,017, filed June 20, 1928, which has issued as Patent 1,715,543, granted June 4, 1929 and Serial No. 289,050, filed June 28,

1928 which has issued as Patent 1,715,648, granted June 4, 1929.

An object of the present invention, therefore, is to increase the resistivity of magnetic materials having other desirable characteristics.

A further object is to reduce eddy current losses in magnetic materials of high initial permeability.

It has been found that by the addition of chromium in proper proportions, with or without other elements, and with appropriate heat treatments, compositions may be produced which have part or all of the desirable properties of the compositions described and claimed in application Serial No. 119,623 to a greater or lesser extent,—in some instances to the same extent as, or to a greater extent than without the added chromium,—and in addition, a greatly increased resistivity. The production of magnetic compositions having the magnetic and electrical characteristics above discussed and which are workable and otherwise suitable for use is of considerable technical importance. Chromium is cheaper than molybdenum, which has been specifically claimed as a fourth element for increasing the resistivity of such compositions in another application, and furthermore, in some compositions which are otherwise similar, gives a better combination of characteristics for certain purposes than does molybdenum.

Manganese may be added in addition to chromium to increase the workability or for other purposes in accordance with known metallurgical practice. Within the scope of the invention are included not only compositions of iron, nickel, and cobalt with chromium alone but also those including, in addition to chromium, molybdenum, tungsten, manganese, vanadium, tantalum, zirconium, chromium, copper and/or silicon.

The properties of compositions in accordance with the present invention may be varied over a wide range by the application of different heat treatments. A discussion of these heat treatments with the general rules for their application in order to develop particular characteristics, is given in Patent No.

1,715,541, dated June 4, 1929, and, therefore, is not repeated here.

A particular composition in accordance with the invention comprises 45% nickel, 27½% iron, 25% cobalt, and 2% chromium. When given a heat treatment designated I_b in Patent 1,715,541, adapted to develop a fairly constant, but not the greatest constancy of permeability, the initial permeability of 509 remains practically constant up to a value of H=about 1.7. The composition had a maximum permeability of 2350 at H=3.10; a hysteresis loss of 1120 at an induction of B=5100; an induction B of 13400 at H=50; a remanence of 3460; a coercive force of 1.08; a resistivity of 44.35; an H for 1% change in permeability of 1.75; and a percentage change in permeability for B=100 of .075. A heat treatment designed to develop a higher initial permeability gave a value thereof of 849 and a heat treatment designed to give a still higher value of initial permeability gave a value of 1077.

A composition composed of approximately 51% nickel, 21% iron, 24% cobalt, 3% chromium, and .4% manganese had an initial permeability of 451 and a resistivity of 43 microhm cms. when heat treated to develop a fairly constant value of initial permeability. Other heat treatments gave initial permeabilities of 941 and 849, respectively.

A virgin alloy composed approximately of 45% nickel, 27% iron, 25% cobalt, 3% chromium, and 0.33% manganese exhibited an initial permeability of about 500, a high degree of constancy of permeability up to H=1.10 and a maximum permeability of about 3110 after heat treatment designated I_b in Patent 1,715,541. The increase in permeability between H=1.4 and H=2.1 was striking.

Another composition tested and found to have desirable magnetic properties consisted approximately of 29% iron, 45% nickel, 25% cobalt, and 1% chromium. Still another consisted of 22% iron, 50% nickel, 25% cobalt, and 3% chromium. The initial permeability of the last mentioned composition was about 440 when heat treated to develop a fairly constant permeability up to H=1.

A composition composed approximately of 35% nickel, 27.5% iron, 35% cobalt, and 2.5% chromium, when heat treated in a manner adapted to develop constancy of permeability to a high but not the highest degree, had an initial permeability of 250 which was strikingly constant up to a magnetizing force of H=1.4. The hysteresis loss for a loop of which the maximum induction was about 5000 gauss was 1126 ergs per cubic centimeter per cycle. The remanence was 4490 gauss and the coercive force 1.25 gauss after an applied magnetizing force of H=76. The resistivity was 46 microhm cms.

Still another composition composed of 70% nickel, 12.5% iron, 15% cobalt, and 2.5%

chromium with a small amount of manganese when heat treated to develop a fairly constant permeability had an initial permeability over 900, a maximum permeability of about 3000 and a hysteresis loss for a loop of which the maximum induction was 5000 gauss of 607 ergs per cubic centimeter per cycle. The resistivity was 46.5 microhm cms. This composition was not particularly noteworthy for constancy of permeability as heat treated. The remanence was 3450 and the coercive force .62 after a high magnetization.

In general, the use of chromium in iron-nickel-cobalt magnetic compositions in an amount up to 10 or 12% enables one to produce a composition with a greatly increased resistivity, in combination with other desirable magnetic properties. A number of compositions show increased initial permeability with from 2 to 10% chromium as compared to similar compositions in which the chromium is replaced by iron.

These compositions disclose the characteristic properties of highly constant permeability over a range of flux densities from zero upward, small or negligible hysteresis loss over a range of flux densities from zero upward, initial permeability sufficiently high to make them desirable for use in the magnetic circuits of telephone, telegraph and cable conductors and apparatus, the peculiar wasp-waisted hysteresis loop characteristic of the compositions discussed in Patent No. 1,715,647, granted June 4, 1929, high resistivity, and workability in accordance with known methods.

In general, the nickel content may range from 10% to 80%, the cobalt content from 5% to 80%, the iron content from 9% to 50%, and the content of the chromium with or without still other elements up to about 10 or 12%.

Among the uses for which these materials are adapted are coil or lumped loading and continuous loading of carrier frequency signaling conductors in submarine and land line telegraphy and telephony, loading coils for composite telephone and telegraph systems, repeating coils or transformers, especially battery supply coils, wave filter coils, certain classes of relays, high frequency electromagnetic devices and magnetic circuits of electrical measuring instruments.

What is claimed is:

1. A magnetic material including nickel between 10% and 80%, cobalt between 5% and 80%, and iron between 9% and 50% of the entire nickel-iron-cobalt content, heat treated to have desirable magnetic properties with small magnetizing forces, and including from a substantial quantity up to 12% chromium.

2. A composition in accordance with the foregoing claim which, in addition to chromium, includes material selected to include at

least one of the following elements to a material extent; molybdenum, tungsten, manganese, vanadium, titanium, tantalum, zirconium, copper and silicon.

5 3. A composition in accordance with claim 1 heat treated to have an initial permeability above 200.

4. A composition in accordance with claim 1 heat treated to have an initial permeability
10 varying less than 1% up to magnetizing forces of .20 gauss.

5. A magnetic composition comprising between 30 and 60% nickel, between 10 and 40% iron, between 5 and 50% cobalt, and
15 between 1 and 10% chromium, not excluding small amounts of other elements, heat treated to have desirable magnetic properties at small magnetizing forces.

In witness whereof, I hereunto subscribe
20 my name this 29th day of May, 1929.

GUSTAF W. ELMEN.

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