This invention relates to, and has as its principal object the provision of, new magnetic materials useful for the interconversion and control of various forms of energy.

Magnetic materials, inclusive of both ferro- and ferrimagnetic materials, are broadly old and many such compositions are known. Similarly, many energy transducer devices based thereon are also known. However, the previously known ferromagnetic compositions varied variously from one or more inferior properties, qualities, or behavior. For instance, many of the ferromagnetic compositions did not exhibit as high saturation magnetization values as was desired for many outlets, nor did they exhibit sufficient corrosion, oxidation, or high temperature resistance. While some of these ferro-, ferrimagnetic compositions did exhibit the rather peculiar property of an abrupt and large-scale increase in saturation magnetization with increasing temperature, those previously known either exhibited this so-called exchange inversion temperature at relatively low temperature and/or suffered from having too low a Curie temperature for successful application in many desired embodiments.

The iron/rhodium binary alloys of, for instance, Fallott, Revue Scientifique, 77, 498 (1939), and Kouvel et al., General Electric Research Report No. 61–RL–2870M, November 1961, also exhibited this abrupt increase in saturation magnetization with increasing temperature at a temperature of about 112 gauss cm. /g., i.e., 112 emu./g., as measured in a 5,000 oersteds (or conventionally a 5 kOe.) magnetic field, but at a temperature of only 350° K. (i.e., about 77° C.). Furthermore, the temperature at which the material suddenly changes from antiferromagnetic to ferromagnetic could not be widely varied without increasing greatly the ratio of residual magnetization to maximum magnetization.

There has now been discovered new ferri-ferrimagnetic materials which exhibit high-saturation magnetization values, high Curie temperature, and/or an exchange-induced inversion. The compositions are also outstanding in corrosion and oxidation resistance and thermal degradation, properties in which many or most of the presently known magnetic compositions are found wanting.

These new magnetic materials also exhibit a maximum saturation magnetization within a restricted temperature range and a very much smaller saturation magnetization at temperatures above and below this range. These magnetic compositions exhibit a relatively low saturation magnetization at low temperatures which abruptly increases with increasing temperature, at a specific temperature range for each composition, to a maximum saturation magnetization. The magnetic compositions exhibit many orders of magnitude greater than that exhibited at temperature below this critical temperature range. This maximum saturation magnetization slowly decreases with increasing temperature until the Curie temperature is reached. On being cooled, these compositions exhibit slowly increasing magnetization with decreasing temperature until a maximum saturation magnetization value is reached and then abruptly exhibit a large decrease in saturation magnetization, reaching ultimately a low remanence saturation magnetization. The maximum saturation magnetization is generally the same on decreasing temperature as that achieved on increasing temperature. However, the temperature at which the maximum value is exhibited is somewhat lower on a decreasing temperature cycle than an increasing temperature cycle, i.e., there is magnetization hysteresis as a function of cycling temperature.

Devices for the interconversion and control of various forms of energy based on this class of magnetic compositions comprise another portion of the present invention. Another preferred embodiment of the invention is directed to methods for preparing these magnetic products exhibiting these novel magnetic properties, and also to the preparation of energy transducers broadly based on such products.

The new and superior magnetic materials of the present invention are alloys containing both iron and rhodium in major amount and at least one other transition element from the second and third long transition periods of the Periodic Table in minor amount. More specifically, these new magnetic alloys consist essentially of iron and/or rhodium in major amounts and at least one element in minor amount of atomic number 39–48 and 57–80, inclusive, i.e., yttrium, zirconium, niobium, molybdenum, technetium, ruthenium, palladium, silver, cadmium, lanthanum, hafnium, tantalum, tungsten, rhenium, osmium, iridium, platinum, gold, and mercury, and must always be present, and there must also be one or more other transition metal from atomic number 39–48 and 57–80, inclusive, present. Iron and rhodium are normally present in substantially equiatomic amounts, but not necessarily and excesses of up to 20% of either can be present. These new magnetic products are thus representable by the formula

$$\text{Fe}_x\text{Rh}_{1-x}M_2$$

wherein M represents a transition metal of atomic number 39–48 and 57–80 inclusive, other than rhodium; x is an integer from one to six, generally from one to two; a and b, which can be alike or different, are numbers in the range 0.8–1.2; and c is a number in the range 0.01–0.20, and when x is greater than 1, the c parameters for the different metals M can be different but must still lie in this indicated range. The subscript numbers a, b, and c refer to the atom proportions of the respective elements in the products. M can be different within the same defined group when x is greater than 1.

The proportions of metals within the alloys of this invention can be expressed in somewhat different terminology as follows: iron, about 33.3–59.7 atom percent; rhodium, about 33.3–59.7 atom percent; and other transition element or elements of atomic number 39–48 or 57–80, i.e., of atomic number 39–44, 46–48, and 57–80, about 20.0–0.415 atom percent. It is to be distinctly understood that at least one of the transition elements of atomic number 39–48 or 57–80 other than rhodium is comprised within the designated 20.0–0.415 atom percent and that up to six of such elements can be present.

The following examples in which the parts given are by weight are submitted to illustrate the present invention further and not to limit it.

**EXAMPLE I**

An intimate mixture of 1.0853 parts of iron, 1.9998 parts of rhodium, and 0.1636 part of ruthenium, all in finely divided form, was placed in a die and pressed into a pellet. The pellet was dropped into an aluminum oxide crucible which was then placed inside the heating element of a carbon-resistance furnace. A bell jar was placed over the furnace which was then evacuated and heated to 840° C. Aragon gas was then admitted until the pressure in the furnace was 0.6 atmosphere. The temperature was increased until the charged metal had visibly melted (about 1600° C.). The mixed metal charge was held in the molten state for five minutes, and the furnace tem-
perature was gradually reduced over a period of 26 minutes, at which point the furnace temperature had been reduced to about 300°C. The furnace was then completely turned off and the crucible and charge then removed. The product was a metallic-appearing slug which was not visibly attracted by a magnet until it had been heated strongly.

To guarantee homogeneity, the slug was sealed in an evacuated silica tube and heated at 950°C for 70 hours, after which it was cooled slowly to room temperature over a period of 24 hours. After having been annealed, the slug appeared unchanged. It exhibited a saturation magnetization, $T_s$, (113 emu/g) indicating a 269°C to the lower ferromagnetic transition temperature thereof, viz., 172°C. On further heating, the saturation magnetization then rose rapidly to a maximum value of 79.7 emu/g. On continued heating, the saturation magnetization dropped as the Curie point (427°C) was approached. On cooling from above the Curie temperature, the sample exhibited the same Curie point and the saturation magnetization then increased as the temperature was dropped to reach the same maximum, i.e., 79.7 emu/g but at 167°C. On further cooling, the sample’s saturation magnetization dropped off slowly to its residual low value of 1.13 emu/g. The behavior of the iron/rhodium/ruthenium alloy as to saturation magnetization on the just-described heating/cooling cycle shows hysteresis phenomena. The saturation magnetization data were obtained using a magnetic field of 1575-1600 kOe. (i.e., kiloersteds or 15,750-16,000 oersteds).

For brevity, the following specific data on other illustrative examples of the new magnetic compositions of the present invention are presented in the following table. These compositions were prepared as described in full detail in Example I in the foregoing with the indicated variations in charge composition, preparation temperature, time required to reduce furnace temperature to permit removal of the charge, and, finally, the annealing time and the resultant different magnetic properties. As in Example I, in all instances the charge was held in the molten state at the indicated preparative temperature for five minutes. In this table the charged compositions are in the indicated atomic proportions. The annealing time was, in all instances, at 950°C, and the symbol $T_s$ refers to the temperature at which the indicated new magnetic composition undergoes the rapid and large-scale change in saturation magnetization. The column headed $T_c$ (cooling) lists the temperatures at which such a phenomenon occurs as the sample is raised from a lower temperature, and the column headed $T_s$ (cooling) indicates the temperature at which the sample undergoes the abrupt large-scale decrease in saturation magnetization on cooling from a higher temperature. The symbol $T_s$ is used to represent the Curie temperature. The symbol $T_m$ is used to indicate the residual saturation magnetization of the sample. The symbol $T_{max}$ is used to indicate the maximum saturation magnetization of the material, and the column headed $T_{max}$ indicates the temperature at which this maximum saturation magnetization value is attained. In all instances in all columns involving temperature the units are in °C.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Prep. Temp. degrees</th>
<th>Time to Reduce Temp.</th>
<th>Anneal Time, min.</th>
<th>$T_s$ °C</th>
<th>Cooling $T_s$ °C</th>
<th>$T_m$ °C</th>
<th>$T_{max}$ °C</th>
<th>$T_{Curie}$ °C</th>
<th>Temp. °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe/Rh/0.0033</td>
<td>1,400</td>
<td>20</td>
<td>70</td>
<td>182</td>
<td>177</td>
<td>385</td>
<td>0.7</td>
<td>85.7</td>
<td>108.3</td>
</tr>
<tr>
<td>Pd</td>
<td>1,690</td>
<td>22</td>
<td>10</td>
<td>150</td>
<td>146</td>
<td>167</td>
<td>0.8</td>
<td>108.3</td>
<td>106.5</td>
</tr>
<tr>
<td>Pt</td>
<td>1,605</td>
<td>15</td>
<td>20</td>
<td>203</td>
<td>200</td>
<td>410</td>
<td>0.1</td>
<td>61.2</td>
<td>110.0</td>
</tr>
<tr>
<td>Ag</td>
<td>1,892</td>
<td>15</td>
<td>20</td>
<td>205</td>
<td>200</td>
<td>415</td>
<td>0.1</td>
<td>61.2</td>
<td>110.0</td>
</tr>
<tr>
<td>Au</td>
<td>1,520</td>
<td>30</td>
<td>10</td>
<td>145</td>
<td>143</td>
<td>260</td>
<td>0.1</td>
<td>61.2</td>
<td>110.0</td>
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<tr>
<td>Re</td>
<td>1,630</td>
<td>19</td>
<td>19</td>
<td>145</td>
<td>143</td>
<td>260</td>
<td>0.1</td>
<td>61.2</td>
<td>110.0</td>
</tr>
<tr>
<td>Fe/Rh/0.0011</td>
<td>2.045</td>
<td>12</td>
<td>12</td>
<td>133</td>
<td>131</td>
<td>240</td>
<td>3.3</td>
<td>81.9</td>
<td>120.0</td>
</tr>
<tr>
<td>Fe/Rh/0.013</td>
<td>1,332</td>
<td>10</td>
<td>15</td>
<td>155</td>
<td>154</td>
<td>265</td>
<td>4.6</td>
<td>71.0</td>
<td>125.0</td>
</tr>
<tr>
<td>Fe/Rh/0.10</td>
<td>1,402</td>
<td>15</td>
<td>22</td>
<td>227</td>
<td>226</td>
<td>345</td>
<td>3.7</td>
<td>86.7</td>
<td>122.5</td>
</tr>
<tr>
<td>Fe/Rh/0.15</td>
<td>1,610</td>
<td>15</td>
<td>27</td>
<td>233</td>
<td>232</td>
<td>355</td>
<td>2.9</td>
<td>79.5</td>
<td>124.0</td>
</tr>
<tr>
<td>Fe/Rh/0.20</td>
<td>1,655</td>
<td>20</td>
<td>27</td>
<td>233</td>
<td>232</td>
<td>355</td>
<td>2.9</td>
<td>79.5</td>
<td>124.0</td>
</tr>
<tr>
<td>Fe/Rh/0.00 0.05</td>
<td>1,222</td>
<td>16</td>
<td>22</td>
<td>156</td>
<td>155</td>
<td>266</td>
<td>3.9</td>
<td>86.7</td>
<td>122.5</td>
</tr>
<tr>
<td>Fe/Rh/0.10 0.15</td>
<td>1,610</td>
<td>26</td>
<td>22</td>
<td>156</td>
<td>155</td>
<td>266</td>
<td>3.9</td>
<td>86.7</td>
<td>122.5</td>
</tr>
<tr>
<td>Fe/Rh/0.15 0.20</td>
<td>1,655</td>
<td>26</td>
<td>22</td>
<td>156</td>
<td>155</td>
<td>266</td>
<td>3.9</td>
<td>86.7</td>
<td>122.5</td>
</tr>
<tr>
<td>Fe/Rh/0.20 0.25</td>
<td>1,690</td>
<td>26</td>
<td>22</td>
<td>156</td>
<td>155</td>
<td>266</td>
<td>3.9</td>
<td>86.7</td>
<td>122.5</td>
</tr>
</tbody>
</table>

As stated previously, the present invention is generic to new magnetic compositions consisting essentially of Fe and Rh, always both present in major quantities, and minor amounts of at least one other transition metal from the second and third long transition periods of the Periodic Chart of the elements. Iron and rhodium must always be present in each of the compositions as must also at least one other transition metal from the second and third long transition periods of atomic number 38-48 and 57-80 inclusive. Specific such compositions include Fe₃₀/Rh₇₀/Y₅₂, Fe₃₀/Rh₇₀/Zr₃₀, Fe₃₀/Rh₇₀/Nb₀₅, Fe₃₀/Rh₇₀/Mo₁₅, Fe₃₀/Rh₇₀/Tc₀₅, Fe₃₀/Rh₇₀/Pd₀₅, Fe₃₀/Rh₇₀/Ag₀₅, Fe₃₀/Rh₇₀/H₂₅₀, Fe₃₀/Rh₇₀/Lₐ₀₅, Fe₃₀/Rh₇₀/Re₁₀₀, Fe₃₀/Rh₇₀/H₂₅₀, Fe₃₀/Rh₇₀/M₀₁₅, Fe₃₀/Rh₇₀/A₁₅, Fe₃₀/Rh₇₀/C₁₅, Fe₃₀/Rh₇₀/H₂₅₀, Fe₃₀/Rh₇₀/Sc₂₀₀, Fe₃₀/Rh₇₀/Y₉₀, Fe₃₀/Rh₇₀/H₂₅₀, Fe₃₀/Rh₇₀/C₁₅₀, Fe₃₀/Rh₇₀/H₂₅₀, Fe₃₀/Rh₇₀/C₁₅₀, Fe₃₀/Rh₇₀/H₂₅₀, and the like.

The invention is also generic to magnetic compositions consisting essentially of Fe and Rh in major amount and more than one other transition metal from the second and third long transition periods of the Periodic Chart of the elements. Thus, in addition to the necessary Fe and Rh and a transition metal of atomic number 38-48 and 57-80, there can be present in the new magnetic compositions of the present invention two, three, four, five, six, or more other transition metals of atomic number 39-48 and 57-80. Thus, to be specific, the present invention also includes the following multicomponent magnetic compositions:

Fe₃₀/Rh₇₀/Y₅₂/Zr₃₀, Fe₃₀/Rh₇₀/M₀₁₅/Tc₀₅, Fe₃₀/Rh₇₀/O₂₀₀/Pd₀₅, Fe₃₀/Rh₇₀/Ag₀₅/C₁₅₀, Fe₃₀/Rh₇₀/Lₐ₀₅/H₂₅₀, Fe₃₀/Rh₇₀/Re₁₀₀/Tc₀₅, Fe₃₀/Rh₇₀/H₂₅₀, Fe₃₀/Rh₇₀/Sc₂₀₀/Y₉₀/C₁₅₀, Fe₃₀/Rh₇₀/H₂₅₀, Fe₃₀/Rh₇₀/C₁₅₀/H₂₅₀, Fe₃₀/Rh₇₀/H₂₅₀.

While varying modifying amounts of the other transition elements of the second and third long periods can be present in these new alloys which have Fe and Rh in major amount and two or more of the said other trans-
tion elements, generally speaking there will be a total of no more than 0.2 to 0.4 atom proportion of said other modifying transition elements in any one alloy.

The novel compositions of the present invention exhibit maximum saturation magnetization at temperatures in the range 272°C to 278°C and Curie temperatures in the range 300°C to 500°C C. The magnetic compositions also exhibit increasing saturation magnetization with increasing temperature in a temperature range below the Curie point, and more specifically in the range -270°C to -300°C and preferably -170°C to -270°C C.

Such compositions are useful in devices operating at temperatures near room temperature and even at elevated temperature for those exhibiting maximum saturation magnetizations in the higher temperature ranges. These exhibiting maximum saturation magnetization at very low temperatures are especially useful in devices such as refrigerators and temperature-sensitive controls operating at temperatures near the boiling point of liquid helium and below. The manner in which saturation magnetization varies with temperatures can be controlled by modifying the composition of the ferromagnetic products. The most outstanding compositions exhibit a very low residual magnetism below the lower ferromagnetic transition temperature.

These novel magnetic compositions are prepared by heating mixtures of the elements or compounds of the elements materials. Particularly the mixtures are heated to temperatures ranging from 600 to 2000°C, or higher, as equipment and vapor pressure limitations dictate within the normal practice. Temperatures of 700 to 850°C and from 1200 to 1700°C are usually employed. Temperatures of at least 1550 to 1600°C are generally necessary if the compositions are to be melted. The time of heating is not critical but should be sufficient to permit complete reaction of the ingredients. Heating times ranging up to about 50 hours for the lower temperature ranges are necessary to effect appreciable solid state reaction. Longer times can be useful in some cases, particularly, for instance, if it is desired to prepare the composition in a crystal form. Generally speaking, the most efficient technique in the sense of obtaining the most complete reaction is to carry out the reaction in the melt for time periods of at least 5 to about 60 minutes or longer.

Heat treatment can be carried out at atmospheric pressure, or under a vacuum, or under pressure. For example, the reaction can be conducted as a highly evacuated vessel. It is also possible to employ superatmospheric pressure. The reaction can also be carried out in sealed vessels under the autogenous pressure developed by the reaction mixture at the reaction temperatures. Since the preferred techniques involve effecting reaction in the melt, it is normally preferred to carry out the reaction in an inert refractory material, such as a container, under reduced pressure or under a protective blanket of an inert gas.

The materials employed in preparing these new compositions can be the elements themselves or any of the binary or ternary combinations thereof as called for by the desired stoichiometry. Thus, to prepare Fe/Rh/Ru the three elements themselves can be charged or the necessary Fe/Rh binary can be separated previously and the requisite amount of Rh and Ru reaction effect to form the desired ternary composition. In any event, it is preferred that the materials be in powder or granular form and that they be well mixed before heating is commenced.

The starting materials are employed in such relative amounts that the resulting mixture contains the desired proportions of Fe/Rh and the requisite transition metal or metal. Thus, to prepare Fe₆₈₆/Rh₀₂₅/Nb₀₂₅/Mo₃₂ the respective components or their binaries or ternaries are charged in the indicated atomic portions.

After the desired preparative heating cycle has been completed, the reaction mixture is cooled and, if desired, subjected to purification, e.g., by extraction with acids or, after grinding, by magnetic separation. This first cooling cycle will be relatively rapid.

To assure the greatest homogeneity in the product and the maximum ferromagnetic transition behavior, it has been found that the products should preferably be annealed by holding for a relatively long time at an elevated temperature and slowly cooling to room temperature over a controlled temperature profile, e.g., by a suitably programmed or recorder driven furnace. Thus, it is preferred that the products of the present invention after the preparative heating and cooling cycle, whether or not any intervening mechanical, chemical, or magnetic purification is effected, be heated to an elevated temperature in the range 800 to 1000°C C. Higher or lower temperatures are not desirable. The preferred compositions of the present invention exhibit several magnetic characteristics which make them especially valuable for use in various specific applications. The novel lower ferromagnetic transition temperature is a distinguishing feature conferring unusual utility on these compositions. The relatively high saturation magnetization values exhibited by these compositions, as well as the high Curie temperature and good values of saturation magnetization exhibited at the maximum with increasing temperature below the Curie temperature. All the compositions are extremely resistant to corrosion, oxidation, and exhibit good magnetic behavior at elevated temperatures.

The preferred products are useful in devices for the interconversion and control of various forms of energy such as solar motors, temperature-sensitive inductors, thermally activated clutches, and temperature compensators in devices based on conventional magnetic materials where sagging of magnetic properties with increasing temperature is functionally deleterious. In their essential features all of these devices comprise at least three components, viz., the magnetic component described previously, suitable means for applying a field of energy to the magnetic component, and suitable means for utilizing the output from the magnetic component. For some applications, the devices of the present invention can include means for controlling magnetizing and demagnetizing the magnetic component. At temperatures within the ferromagnetic range, these compositions can be used in any of the conventional applications for ferromagnetic materials for which their properties render them suitable, e.g., electromagnets, high-frequency coil cores, information and memory storage elements, and the like.

In the preferred devices the elements which provide heat to or remove heat from the magnetic element, which magnetize and demagnetize the magnetic element, and which collect and detect the new form of energy produced are conventional in the art. For example, by introducing a pivotal element, with a magnetic component as just described, in a magnetic field and having means for magnetizing the magnetic component, the pivotal element can be caused to move in said field. In this way, mechanical work can be done. The pivotal element can be an armature, an oscillating arm, or a metering device.

The new magnetic compositions of the present invention are useful as the active component in forming temperature responsive electrical inductors comprising, usually in combination, a metallic core consisting at least in part of one of the present magnetic compositions with or without a second material exhibiting a magnetic permeability which is substantially invariant with temperature, and an electrical conductor wrapped around said core. These temperature responsive electrical (magnetic)
7 inductors are widely useful in any circuits in which inductance is a significant parameter. Thus, these inductors based on the present magnetic compositions can be employed as an element of the frequency-determining circuit of a single-phase oscillator or as a high-temperature safety device to reduce circuit current with increasing temperature or as a current-controlling device in which the control current flows through a heater winding on the temperature-sensitive inductor. In addition, these temperature-responsive inductors can be used in conjunction with a wide variety of conventional core materials, including both the metallic and oxide types, representative of which latter are, for example, the ferrites.

In view of the increasing saturation magnetization with increasing temperature below the Curie temperature, the new magnetic materials of the present invention are useful in forming temperature responsive magnetically operated rotary force coupleings comprising, in combination, a pair of relatively rotatable elements to be coupled disposed adjacent to one another in a common magnetic flux path, a permanent magnet, and one of the new magnetic compositions of the present invention which exhibits a changing permeability accompanying a reversible first order transition from a first solid state phase to a second solid state phase at a given temperature, both disposed in said common magnetic flux path, the permanent magnet and the magnetic composition of the present invention completing a magnetic flux circuit between the said elements of the pair coupling one of the elements with the other in that temperature range when the magnetic composition of the present invention exists in a first solid state phase and uncoupling the elements of the pair as the temperature decreases when the substance exists in a second solid state phase, and obviously the reverse and in cycles.

The new magnetic compositions of the present invention are also useful in thermomagnetic devices as the working substance therein, said devices being useful for effecting heat transfer, i.e., serving as heat pumps, e.g., a refrigerators. These new magnetic compositions of the present invention have value in devices in view of the first order solid phase to solid phase transition with changing temperature with accompanying relatively large change in internal energy content in going through the transition will function as the said working substance in said devices with allied the magnetic means for cyclically inducing said transition in a direction such to lower the temperature of the substance when one solid state phase is attained and to increase the temperature when the other solid state phase is attained along with an allied heat source and a thermal sink relative to one of the solid state phases individually adapted to effect heat transfer sequentially with respect to said substance.

With respect to the thermomagnetic working capability of the present magnetic compositions, they are of particular interest in the formation of gradient objects comprising the said magnetic materials varying in composition angularly about a point or axis or varied along one or more selected lines, which need not be straight, in the said gradient object such as to display the first order solid phase to solid phase transition at successively higher temperatures in a first path or a direction along or about said point or axis or said line, and at successively lower temperatures in an opposite path or direction achieved by varying the composition of the magnetic alloys. These gradient objects are particularly useful in many kinds of energy-converting devices, e.g., as temperature indicators, cores in temperature-sensitive inductors, transformers, elements in thermal switches, and the like, and are particularly outstanding because of the possible ready and precise adjustment of device operation achievable to suit particular environmental conditions obtained with the great control possible through the narrow compositional changes.

These new magnetic materials are also useful as the working substance in a method of information storage and retrieval wherein a recording member containing one of the new magnetic compositions of this invention substantially homogeneously distributed thereupon is exposed to a read-in beam, modulated patternwise in accordance with information to be stored from a temperature variation inducing component, thereby establishing in the said recording member regions of relatively higher and relatively lower intrinsic magnetization corresponding to said information, maintaining said element after said read-in at a temperature within the thermal hysteresis range, and reading out the stored information by exposing the element at said temperature to a low intensity electron beam whereby deviations in said beam corresponding to the stored information are produced and converted into electrical signals. Intrinsic magnetization is used here as defined by Cnack. "The Electrical and Magnetic Properties of Solids," Longmans-Green & Company, London, 1938, page 315.

The first order solid phase to solid phase transition accompanied by thermal hysteresis which is exhibited by the new magnetic materials is characterized by abrupt change not only in the magnetic properties, particularly in a number of the other physical properties of the materials and any of these properties can be employed in any sensing or read-out method. Thus, after modulated read-in, read-out can be based on the change in electrical resistance of the new magnetic compositions giving the working substance of said recording member simply by providing read-out means sensitive to changes in resistance. Alternately, read-out can be based upon changes in a linear dimension or in a volume of the working substance as desired.

Because of their outstanding magnetic properties coupled with good stability to temperature, atmosphere, corrosion, oxidation, and the like, and particularly because of the relatively high Curie temperatures that they possess, the preferred magnetic materials are broadly outstanding as the working substances in various devices whereby, generically, magnetic energy is changed controllably to mechanical, electrical, or thermal energies; mechanical energy is converted controllably into electrical, magnetic, or thermal energies; or thermal energy is controllably converted to mechanical, magnetic, or electrical energies.

More specifically, because of the present invention can serve as the working substances in magnetic switches, radiation-intensity meters, reciprocating engines, devices for maintaining constant temperature difference between two zones, magnetic balances, thermomagnetic generators, solar motors, temperature indicators, image-forming components, magnetic flasch, variable resistors, differential transformers, temperature responsive resonators, and the like.

Since obvious modifications and equivalents in the invention will be evident to those skilled in the chemical arts, I propose to be bound solely by the appended claims. The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An alloy in which (A) iron, (B) rhodium, and (C) at least one transition element of atomic number 39–44, 46–49, and 57–80 is present in the atom proportions of 0.8–1.2 of (A), 0.8–1.2 of (B), and 0.4–0.1 of (C).
2. An alloy of claim 1 in which (C) is ruthenium.
3. An alloy of claim 1 in which (C) is palladium.
4. An alloy of claim 1 in which (C) is iridium.
5. An alloy of claim 1 in which (C) is platinum.
6. An alloy of claim 1 in which (C) is silver.
7. An alloy of claim 1 in which (C) is sold.
8. An alloy of claim 1 in which (C) is rhodium.
9. An alloy of claim 1 in which (C) is iridium and palladium.

References Cited in the file of this patent:
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,140,941

July 14, 1964

Paul H. L. Walter

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, line 61, for "0.4-0.1" read -- 0.4-0.01 --.

Signed and sealed this 21st day of December 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents