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TEMPERATURE COMPENSATOR

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This invention relates to a temperature-responsive magnetic alloy.

An object of the invention is the provision of an alloy having a new composition adapted primarily for use with magnetic measuring instruments to correct errors in their readings due to temperature changes.

Another object of the invention is an improvement in the process of production of such temperature-responsive compensating devices.

In magnetic measuring instruments, of which a vehicle speedometer is typical, there are employed permanent magnets, the magnetic lines of force of which are partly effective to influence the rotation of speed-indicating members, and partly passed through a shunt, the latter portion of the flux being ineffective upon the rotation of the speed-indicating member. The active lines of force have a lesser influence at higher temperatures because of the increasing electrical resistance of the speed-indicating member. It has therefore been proposed to increase the proportion of the magnetic flux which influences the speed-indicating member at high temperatures by introducing into the shunt an alloy which is less permeable at higher temperatures. Such devices are shown in patents to Wedin 1,848,068 and Davey 1,848,057. In this way the magnet is more effective upon the speed-indicating member with increasing temperature, as a larger proportion of its flux becomes available for the active field. An alloy of nickel and copper has been used for this purpose.

Such an alloy of nickel and copper has been frequently found somewhat unsatisfactory because of a lack of uniformity in its corrective influence throughout the range of temperature to which the instrument is subjected. It has been proposed also to use in addition to the nickel-copper alloy some other alloy, the two alloys, acting together, being intended to have a resultant compensation effect which shall render the readings accurate at all temperatures.

We have found if an alloy having the specified composition set forth below is employed and if the temperature-compensating devices are prepared as set forth herein, the desired correction to secure accurate readings may be had without resort to an additional alloy.

The alloy we propose to use has the following composition:

Ni	29.75 to 30.5%
C	.25 % maximum
Mn	.50 % maximum
S	.025% maximum
P	.025% maximum
Si	.25 % maximum
Fe	balance

In this alloy the nickel content is very important. Increasing the proportion of nickel increases the permeability and the slope of the temperature permeability curve. Small variations in the nickel content make great differences in the temperature-responsive characteristics. It is important that the percentages be kept within the specified limits. If the percentage rises above 30.5% the alloy has too high a permeability and too steep a slope for practical purposes. To insure the necessary permeability the nickel content should not be below 29.75%. Below a percentage somewhat less than 29.75% the alloy becomes very inefficient, and with percentages not much below the minimum limit specified the alloy has magnetic transformation points within the operating range (0–120° F.).

The percentage of carbon does not affect permeability nor the slope of the temperature permeability curve if kept below .25%. Carbon above .25% causes the permeability curve to become less regular.

The presence of manganese appears to have the effect of decreasing both the permeability and the slope of the temperature permeability curve. The curve also becomes more irregular with increasing percentages of manganese. .50% is the maximum allowable manganese content.

Silicon, sulphur, or phosphorus in the usual small amounts appear to have little or no effect upon the permeability of the alloy. They are added as necessary deoxidizers in the preparation of the alloy, following customary furnace procedure.

It is very difficult to make successive lots of metal having exactly the same composition, and the subsequent processes of rolling hot metal into strip form cannot be very accurately controlled. The resultant magnetic properties of the metal are greatly affected by slight variations in composition and by the rolling treatment. Even if the composition is held within much closer limits than is commercially practicable, the magnetic variation in the resultant material is so great that it would be necessary to change the size of the piece of metal used for the magnetic compensator with every new lot of metal that was used. Since the magnetic proportions are greatly affected by the rolling treatment which the metal receives and also by cold stamping and bending operations, it would not be practical to use material of this type for temperature compensation where thousands of instruments have to be built to the same standards of performance. In order to eliminate the variations due to chemical composition, hot rolling, and cold working, it has been discovered that a heat treatment may be employed which can be so adjusted as to eliminate these variables, and it becomes possible to produce temperature compensators of such uniform magnetic properties that they may be applied without correction as to size or location in the

magnetic field to any number of similar instruments with uniform results.

To that end, after holding the analysis within the above limits and obtaining an alloy with a permeability of between 30 and 60 at 75° F. having a permeability-temperature curve with a slope varying between .59% and .72%, the compensating articles are then formed by hot rolling and cold stamping as may be necessary. Since the processes of rolling and stamping affect the magnetic characteristics as explained above, the compensators are then heat treated.

In this subsequent heat treating the following facts are made use of:

1. Quenching the alloy in water from annealing temperatures between 850° F. and 1500° F. has a marked effect on the permeability. The permeability is decreased as the annealing temperature is increased. Above the temperature of 1500° F. there is no further effect on the permeability of the alloy.

2. Up to 1400° F. quenching from annealing temperatures has little or no effect upon the permeability-temperature curve of the alloy. Over 1400° F. causes the temperature-permeability curve to become less regular and to lose its linear characteristics.

3. Slow cooling of the alloy from the annealing temperature must be avoided. With slow cooling as in air, the permeability prior to heat treatment is restored. The alloy must be quickly cooled as by quenching in water for example.

4. The time of annealing is not an important factor in the heat treatment of this alloy.

The invention therefore involves a new composition which is of particular use in correcting inaccuracies in magnetic measuring instruments due to temperature changes. It also involves a heat treatment subsequent to such forming operations as hot rolling and cold stamping in order to produce uniform magnetic properties in the magnetic permeability and the relation of the variation of this permeability to temperature.

We claim:

1. A temperature-responsive compensator for magnetic measuring instruments formed from an alloy having the following composition:

Ni	29.75 to 30.5%
C	.25 % maximum
Mn	.50 % maximum
S	.025% maximum
P	.025% maximum
Si	.25 % maximum
Fe	balance

2. A temperature-responsive compensator for magnetic measuring instruments formed from an alloy containing between 29.75% and 30.5% nickel, carbon not in excess of .25%, manganese not in excess of .50% and the balance substantially all iron.

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