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Hetzel

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[54] **MAGNETIC PARTS AND METHOD OF MANUFACTURING SAME**

[75] Inventor: **Max Hetzel,** Biel, Switzerland

[73] Assignee: **Societe Suisse pour l'Industrie Horlogere Management Services S.A.,** Switzerland

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[52] **U.S. Cl.** **148/121;** 148/13; 148/13.1; 148/31.57; 148/108

[51] **Int. Cl.** **H01f 1/00**

[58] **Field of Search** 148/121, 103, 108, 31.57, 148/13, 13.1; 266/5; 126/19

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Primary Examiner—Walter R. Satterfield
Attorney, Agent, or Firm—Griffin, Branigan and Butler

[57] **ABSTRACT**

Extremely small parts are made free of rest magnetization by heating them in a gas oven at a first temperature above the Curie temperature. The parts are then cooled to a second temperature and maintained at the second temperature over a interval of time before being cooled to room temperature. The gas oven may include means for applying an alternating magnetic field of decreasing magnitude to the parts while the parts are at the first temperature. The method results in extremely small parts which are completely free of rest magnetization. The parts, which may be discs, may then be magnetized around their periphery with succeeding poles of opposite polarity to thus provide magnetic couplings or gears suitable for use in watches.

6 Claims, 6 Drawing Figures

PATENTED JUN 3 1975 3,887,401

Fig.1

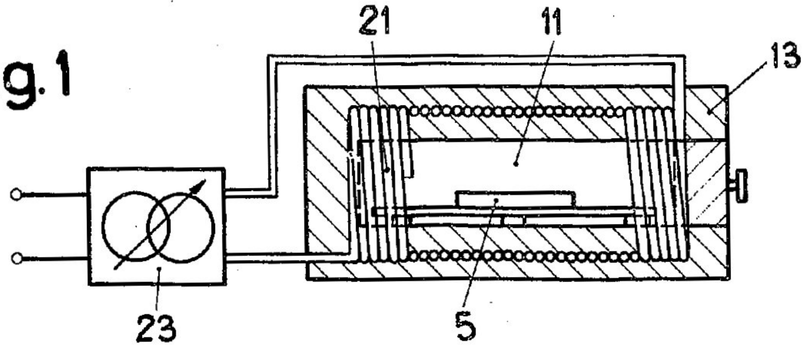
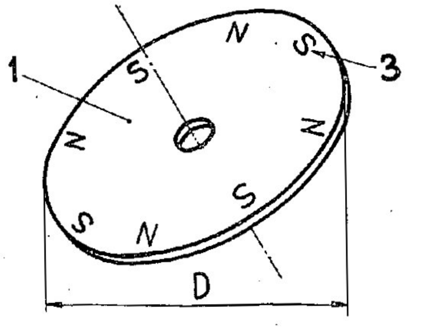


Fig.2



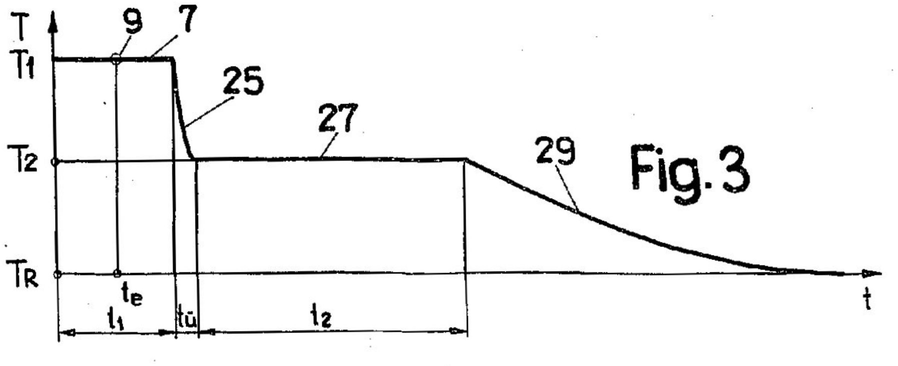
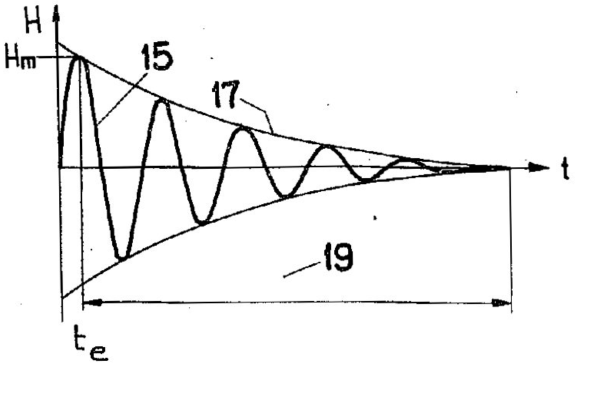


Fig.3

Fig.4



MAGNETIC PARTS AND METHOD OF MANUFACTURING SAME

BACKGROUND OF THE INVENTION

The invention refers to a method of manufacturing magnetic parts, particularly small magnetic coupling discs. The manufacture of some magnetic parts requires relatively complicated demagnetization procedures. Such a demagnetization is required if, for instance, the part must later on be provided with a certain specific magnetic pattern.

The problem is especially difficult where very small magnetic parts, which may be in the order of 0.3 to 5 mm, are required. Such parts are widely used in watch making and precision technology. Such small parts are very sensitive to external mechanical and magnetic influences. When subjected to influences such as those occurring during the manufacturing process, the material structure of the parts, which is of importance in determining the magnetic properties is easily changed.

The mechanical, chemical or electrochemical processes, such as stamping, cutting, rolling, electroerosion, etc. that are used in forming the magnetic parts cause in the magnetizable materials a rest (remanent) magnetization, or a certain material structure. When a subsequent magnetization is attempted, this rest magnetization can be a disadvantage or troublesome influence. The strength of the rest magnetization after forming is further dependent on the influences of foreign magnetic fields and is a function of the magnetic hardness of the material used. Accordingly, the problem of rest magnetization is closely related to the selection of the material and the respective manufacturing methods.

In practical manufacturing the creation of a rest magnetization during forming cannot be prevented. Accordingly, an undesirable existing magnetization must be eliminated after the forming of parts.

It is known that by heating a ferromagnetic alloy part above the Curie point the magnetization depending on the material structure can be so changed that the external magnetic moment becomes zero, so that the part can be considered as demagnetized. Thus, in the literature it has been suggested that the heat treatment be made in the presence of relatively large fields.

There exist electric ovens providing relatively small fields, whereby, when a maximum temperature has been reached, the oven can be slowly switched off. Such ovens have been used successfully for years for demagnetizing relatively small parts. However, there is a limit on how small the parts demagnetized in these ovens may be.

Experiments have shown that it is not possible to make extremely small magnetic parts, such as those used in the field of watch making by any of the prior art methods. It has heretofore been believed that the existing magnetizing methods by which, for instance, alternating north and south poles are generated at the periphery of a disc are not sufficiently precise to provide clearly defined areas of different polarity. Also the development of better methods did not substantially improve the results, so that finally the conclusion was drawn that the cause for the inability to space north and south poles only short distances apart would have to be sought in the particular characteristics of the microstructure of the material used. It must be remembered that the same material was perfectly suitable for

larger parts. Further investigations of the materials surprisingly showed that even very small magnetic fields occurring during a heat treatment have influences on the material, which influences are particularly disadvantageous on small parts because they make it difficult or prevent the creation of very small magnetized spots, whereas the creation of relatively large magnetized spots is practically not influenced.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a method of practically completely demagnetizing extremely small and sensitive parts made of ferromagnetic materials, particularly alloys. It is further an object of the invention to provide a means for carrying out the inventive method on small ductile magnetic parts.

According to the invention this is obtained by first forming the parts and then freeing them of their rest magnetization by a process including the steps of a first heat treatment at high temperature in a gas oven, then after a short intermediate phase, subjecting the parts to a second heat treatment at a lower temperature, and then slowly cooling the parts to room temperature, so that the demagnetized parts can be provided with a desired pattern of magnetization.

A gas oven to carry out said method is characterized in that the interior thereof is practically completely free of any magnetic fields and comprises a device for building up an alternating magnetic field of adjustable field strength. Said field strength is preferably on the order of approximately 50 Oersted at the upper limit.

The invention relates also to extremely small discs of ductile material manufactured according to said method and characterized in that they comprise at their periphery a number of small magnetic "teeth" of different directions of magnetization. That is, the discs have around their periphery small magnetic poles, adjacent poles being of alternate polarity.

The method, the means for carrying out the method, and the discs of ductile magnetizable material will be described with reference to the drawing wherein:

FIG. 1 shows schematically a gas oven;

FIG. 2 shows a typical magnetic part in highly enlarged scale;

FIG. 3 shows the sequence of the heat treatment in the form of a diagram;

FIG. 4 shows schematically the oscillogram of an external demagnetization field applied to the parts to be demagnetized.

DESCRIPTION OF PREFERRED EMBODIMENTS

Before the method is described in detail attention is drawn to the fact that this method is particularly suitable for very small magnetic parts. The description of an embodiment of the invention is therefore made with reference to a small magnetic disc **1** shown in FIG. **2.** The magnetic disc **1** is provided in the final stage of manufacturing with a plurality of north and south poles located alternatingly at the periphery of the disc to provide a kind of small magnetic teeth **3.** Such discs can be used as coupling gears for touchless couplings, where friction or sealing problems have to be considered in the transmission of forces. Particularly in the field of watch making such coupling discs have a wide field of application. For watch making purposes the discs 1 are very small and have a diameter D between approximately 0.3 mm and 5 mm.

Since it is contemplated that mechanical methods such as stamping or the like will be used to form the disc, the material used in the disc must be ductile. As a suitable alloy with respect to manufacturing and the magnetic properties, a platinum cobalt alloy may be used, preferably an alloy consisting of approximately 75 percent by weight platinum and 25 percent by weight cobalt.

The method basically comprises the following steps. After the discs 1 or other parts 5 (FIG. 1) are formed by any suitable method, they are freed from their still existing rest magnetism, or the rest magnetism caused by manufacturing or foreign fields. As FIG. 3 shows, this is accomplished by a first heat treatment 7 at a demagnetizing temperature T_1 substantially above the Curie point of the alloy. For the above-mentioned alloy the demagnetizing temperature T_1 is preferably 1150°C. The magnetic parts 5 are kept at the demagnetization temperature T_1 for a period of time t_1 of approximately 20 minutes.

It is of importance that the interior 11 of the oven used for heat treatment be practically free of any field. The own field of the oven should not exceed 5 Oersted, because otherwise this field is frozen into the magnetic parts. To avoid such an influencing of the magnetic parts an oven is used which is not electrically heated. Preferably an oven 13 is used, which is designed to meet the special requirements described. Such an oven will be described in detail later on.

At any time t_e during the first heat treatment 7 an additional demagnetization 9 can be applied. For this purpose the magnetic parts 5 in the interior 11 of the gas oven 13 are subjected to a subsiding magnetic alternating field 15 (FIG. 4). The field curve of the alternating field 15 can be of the form shown in FIG. 4. First the field strength H is brought to a maximum value Hm which causes a coercitive value in the magnetizable parts which is safely above the value of the expected rest magnetization. Preferably the field has a value of approximately 50 Oersted.

Subsequently the amplitude value of the alternating field is reduced slowly to zero as shown by the enveloping curve. The duration of the demagnetization 19 is preferably 2 to 5 seconds.

The alternating field 15 is generated in the gas oven 13 by the device schematically shown in FIG. 1. A coil 21 encloses the whole interior 11 of the gas oven 13 and is in electric connection with an alternating voltage control device 23 which may be simply a variable transformer (Variac) connected to the power mains. By setting the variable transformer any desirable amplitude value of the voltage and therefore any magnetic field of the coil 21 up to a maximum value (for instance H_m and corresponding voltage) can be selected to obtain the field curve shown in FIG. 4.

After completion of the first heat treatment 7, with or without the additional demagnetization 9, the temperature of the gas oven 13 is rapidly lowered during an intermediate phase 25 from the value T_1 to the value of the second heat treatment 27. This change of temperature must take place during a transit time t_u of approximately 3 minutes.

The annealing temperature T_2 is used for the following second heat treatment 27. In this second heat treatment 27 the magnetic characteristics (e.g., the form of the hysteresis loop) are set. The annealing temperature T_2 is above the Curie point. Preferably the annealing temperature T_2 is set for the described discs of platinum cobalt alloy at 650°C and maintained during the annealing time t_2 of approximately 1 hour.

After completion of the second heat treatment 27 follows the last phase of the method, namely the cooling down 29 to room temperature T_R. This cooling down 29 takes place slowly.

After this treatment the magnetic parts are in a magnetically virgin state with defined hysteresis characteristics and ready for further treatment. The parts 5 can now be magnetized by exposing them to suitable magnetic fields according to the requirements dictated by their intended use.

To provide the magnetic coupling discs of FIG. 2 with a magnetic pattern of different polarities, the discs 1 are located in special magnetic coils and are magnetized at their periphery according to the desired pattern by means of surge currents.

The magnetic discs 1 can have the form as discs or wheels provided with spokes. They may be flat at the periphery or may be provided with teeth. The discs may be used in magnetic couplings for very small torques or in small gear drives where they can also have the function of a gear.

The described method for manufacturing magnetic parts is based on a gas oven 13 which may be of known design, but must have an interior 11 that is practically completely free of any magnetic fields. This can be obtained by using suitable antimagnetic materials for the design of the oven, the location of the oven at a place free of magnetic fields, or by an effective shielding. Further, the gas oven 13 may be provided with a coil 21 with which the whole interior 11 of the oven can be provided with an uniform demagnetization field.

I claim:

1. A method of manufacturing small maagnetizable parts to eliminate rest magnetism therefrom, said parts being of the size range suitable for incorporation into wrist watches and like mechanical appliances, said method comprising the steps of:

heating the parts by combustion process during a first interval of time to a temperature substantially above the Curie point of the parts while maintaining said parts in a shielded heating environment free of any magnetic fields greater than about 5 Oersted;

rapidly cooling said parts to an annealing temperature above the Curie point while maintaining said shielded environment;

maintaining said parts at said annealing temperature over a second interval of time; and,

slowly cooling said parts to room temperature.

2. The method as claimed in claim 1 wherein said parts are subjected to a diminishing alternating magnetic field during said first interval of time, said field diminishing to zero before the end of said first interval.

3. The method as claimed in claim 1 wherein said small magnetic parts are maintained at a temperature above 1000°C for about 20 minutes during said first interval, said parts are rapidly cooled from above 1000°C to an annealing temperature of about 650°C in about 3 minutes, and are maintained at said annealing temperature for about one hour.

4. The method as claimed in claim **3** wherein said small parts consist essentially of a platinum-cobalt alloy.

5. The method as claimed in claim **2** wherein the maximum value of said diminishing alternating magnetic field is about 50 Oersted.

6. The method as claimed in claim **1** wherein said parts are not cooled below the Curie point between said first and second interval of time.

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