Feb. 16, 1965 K. BUNGARDT ETAL 3,170,112

MAGNETIC CIRCUIT MEANS AND ALLOY COMPONENTS OF CONSTANT MAGNETIC PERMEABILITY THEREFOR

Filed Feb. 15, 1960 2 Sheets-Sheet 1

Fig. 1

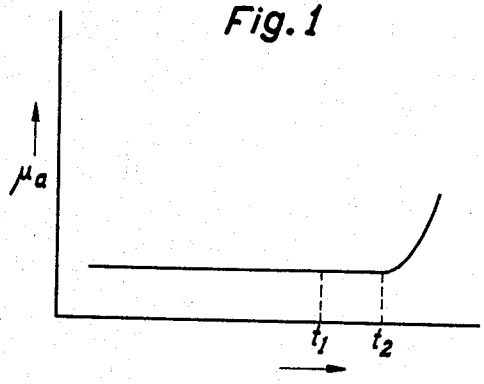
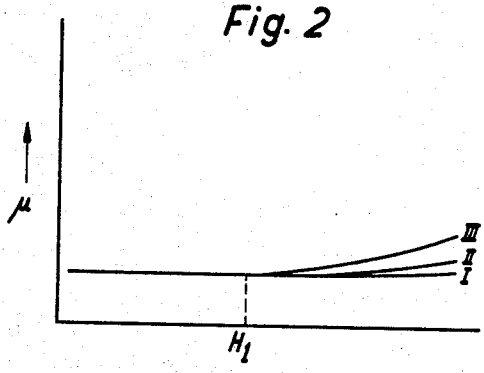


Fig. 2



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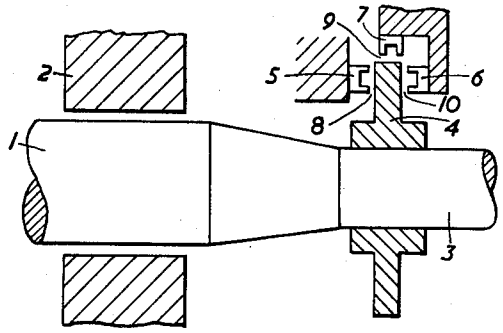


FIG. 3.

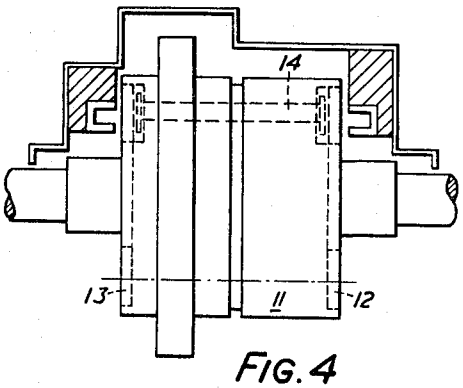


FIG. 4

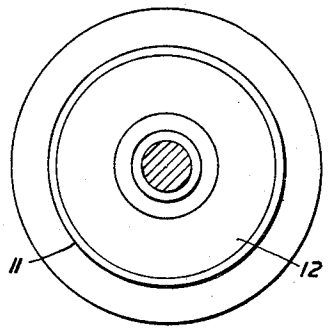
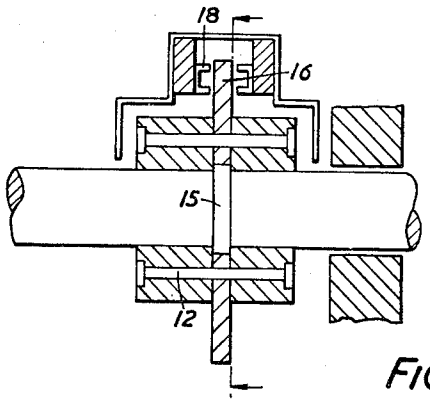


FIG. 4a.



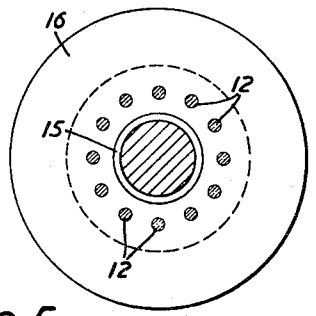


FIG. 5.

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MAGNETIC CIRCUIT MEANS AND ALLOY COMPONENTS OF CONSTANT MAGNETIC PERMEABILITY THEREFOR

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2 Claims. (Cl. 324—34)

The present invention relates to means wherein at least one alloy component forms part of a magnetic circuit and becomes heated during functioning of said means, e.g., where such a component co-operates with a magnetic monitoring means responsive to changes in form or movement of the said component or a part with which it is associated, and the invention is essentially concerned with alloys for the production of such components which shall have a magnetic permeability that does not change up to temperatures of at least 500° C. Components as aforesaid are required for instance in the determination of relative changes in length, eccentricities, and the like of shafts or other rotating parts in machines for example, steam or gas turbines, internal combustion engines, and so forth. In recent years the performance of such measurements has become a matter of increasing importance in the operational control of turbines. The measurements are based upon the determination of certain magnetic properties of materials built into the machines which it is desired to monitor. Consequently, the performance of such measurements depends upon the availability of a material which does not lose its magnetic properties at the elevated temperatures at which the measurements must be performed, and which at these temperature levels is non-scaling, heat-resistant, as well as corrosion-resistant.

In known methods of performing such measurements which have in the past been restricted to the low temperature range, not exceeding approximately 200° C., the material employed for the purpose in question has been an iron-nickel alloy containing 36% nickel. However, since the Curie point of this alloy is located at approximately 250° C. it cannot be used for measurements at more elevated temperatures. Moreover, this alloy is also unsuitable for use at higher temperatures because it tends to form scale.

Unexpectedly it has now been found that an iron-chrome alloy containing about 5–20%, preferably 7–15%, chromium 0.5 to 10%, preferably 1–7%, aluminium, 0.2 to 3%, preferably 0.5 to 2%, silicon, up to 0.2% carbon, remainder iron, with the usual impurities of manganese, sulphur, and phosphorus which arise in the melting process, is outstandingly suitable for application to the purpose in view. The alloy has a magnetic permeability of about 200 gauss/oersted and this remains substantially constant within the temperature range between 0 and 500° C. and it can be successfully used at temperatures above 250° C. Nor does this value change when the field strength increases, at least below 100 moe. Owing to its content of aluminium and silicon the proposed alloy forms no scale at the temperatures in question. As a result of its overall composition it is sufficiently heat-resistant and corrosion-resistant. An important property from the point of view of producing and working the alloy is that it possesses an adequate degree of hot and cold deformability.

In order further to improve the scale resistance and creep resistance of the alloy part or all of the aluminium may be replaced by corresponding quantities of molybdenum and/or tungsten. This substitution does not affect the characteristic magnetic properties of the alloy.

With a view to further extending the temperature range of constant permeability it is also proposed to add to the alloy, at the expense of its content of iron, and without changing its content of other constituents, a quantity of cobalt between 5 and 35%, preferably between 20 and 30%.

The presence of the alloying elements chromium, aluminium, silicon, and possibly molybdenum and/or tungsten, imparts favourable properties to the alloy in other respects, inasmuch as the resistivity of the alloy increases in proportion with the content of alloying elements. It is even possible by suitably adjusting the several constituents to produce alloys which exhibit maximum possible resistivity, and which nevertheless retain the desired favourable magnetic properties. This is a specially desirable result for the application of such alloys to the purposes taken in view because their resistivity reduces the generation of eddy currents.

The accompanying graphs FIGS. 1 and 2 schematically illustrate the permeability change as a function of temperature and of the field strength. FIG. 3 illustrates one way in which the alloy component attached to a shaft, co-operates with magnetic monitoring means. FIGS. 4 and 4*a* diagrammatically illustrate part of a turbine equipped with the alloy component and co-operative monitoring means and FIG. 5 shows another modification.

FIG. 1 represents the relationship between permeability and temperature of an alloy constituted as proposed by the present invention. It will be seen that this interdependence is approximately linear up to a point indicated by t_2. In order to give a rough idea of the actual location of this point the approximately 500° C. temperature level is shown at t_1.

FIG. 2 schematically represents permeability as a function of field strength H. At a point marked H_1 in the plot the field strength is about 100 moe. The graph further shows that the three illustrated curves practically coincide at field strengths below this point. The curves diverge slightly when H_1 is exceeded. The deviation from the desired linear relationship generally increases with increasing temperature. I is a curve plotted at a temperature of 20° C., whereas curve II is for 350° C., and curve III for 500° C.

FIG. 3 shows a shaft **1** running in bearings **2**. An extension **3** of reduced diameter of the shaft carries a disc **4**. This disc is of an alloy consisting of:

	Percent
Chromium	12.50
Aluminium	1.00
Silicon	0.95
Carbon	0.17

The remainder iron with the usual impurities of manganese, sulphur and phosphorus which arise in the melting process.

As will be readily understood from the figure, the disc revolves with the shaft and therefore participates in every oscillation or other movement performed by the shaft. At **5**, **6** and **7** are magnet cores schematically shown as of horseshoe shape. In each case a magnetic flux (alternating field) is generated by a coil, not shown. The magnetic circuits are closed through disc **4** across the air gaps **8**, **9** and **10**. The inductance of the magnet cores, which function as "transmitters," changes when the widths of gaps **8**, **9** and **10** change. This means that the changes in the inductance of the cores reflect oscillations, for example, of the revolving shaft **1**. Since the shaft, which may be the shaft of a turbine, runs in a steam atmosphere having a temperature of about 500° C. the material of disc **4** is likewise exposed to this temperature and to the corrosive attack occasioned thereby, but the disc made of

the said alloy, maintains its original permeability up to and including this temperature.

FIGS. 4 and 4*a* schematically represent a turbine which on its revolving components **11** carries the rings **12** and **13** which are of the aforesaid alloy. These rings are secured by screws **14** which engage the revolving components **11**.

In FIG. 5, two shafts are shown flanged together at **15**. The flange itself is used to hold a disc **16** by screw clamping means **17**, the disc being of the aforesaid alloy.

The rings or discs referred to magnetically serve as "armatures" of magnetic circuits.

By means of the invention the running of a turbine for example may be magnetically monitored continuously, a precaution which is especially necessary or desirable in modern high-speed and high-power turbines. The magnetic monitoring means may be associated with externally visual indicating means, but the magnetic means and the associated means form per se no part of the present invention and need be no further illustrated and may be of conventional pattern, the essence of this invention residing in the material of which the key component, whether it be a disc, ring or the like as specifically mentioned or other normal part of the machine, is produced.

Examples of other suitable alloys that will serve are:

(1)

	Percent
Chromium	12.00
Molybdenum	2.00
Silicon	1.00
Carbon	0.15

the rest being iron with impurities as aforesaid

(2)

	Percent
Chromium	13.00
Tungsten	3.00
Silicon	0.80
Carbon	0.12

the rest being iron with impurities as aforesaid.

(3)

	Percent
Chromium	12.50
Aluminium	1.05
Silicon	0.95
Carbon	0.02
Cobalt	22.00

the rest being iron with impurities as aforesaid.

What we claim is:

1. In a machine incorporating at least one component carried by a rotatable part of the said machine which becomes heated in the functioning of the machine and magnetic monitoring means co-operating with said component and responsive to changes in form or movement which take place in said part during its rotation, the improvement which consists in that the said component comprises an iron-chromium alloy consisting essentially of 5.0 to 20.0% chromium, 0.5 to 10.0% of aluminum, 0.2 to 3.0% silicon, 0 to 35% cobalt, up to 0.2% carbon, and the remainder iron, the said component having a permeability which remains constant up to a temperature of at least 500° C. and at field strengths up to at least 100 moe. and which is non-scale-forming at said temperatures.

2. In a machine incorporating at least one component carried by a rotatable part of the said machine which becomes heated in the functioning of the machine and magnetic monitoring means co-operating with said component and responsive to changes in form or movement which take place in said part during its rotation, the improvement which consists in that the said component comprises an iron-chromium alloy consisting essentially of 5.0 to 20.0% chromium, 0.5 to 10% in total of at least one of the elements selected from the group consisting of aluminum, molybdenum and tungsten, 0.2 to 3.0% silicon, 0 to 35% cobalt, up to 0.2% carbon, and the remainder iron, the said component having a permeability which remains constant up to a temperature of at least 500° C. and at field strength up to at least 100 moe. and which is non-scale-forming at said temperatures.

References Cited by the Examiner

UNITED STATES PATENTS

1,338,134	4/20	Honda.	
1,763,421	6/30	De Vries.	
2,864,997	12/58	Von Basel	324—34
2,932,568	4/60	Kegerise et al.	75—126 X

OTHER REFERENCES

"Aluminum in Iron and Steel," by Case and Van Horn, 1953.

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LLOYD McCOLLUM, SAMUEL BERNSTEIN, *Examiners.*