lead, tin, brass, aluminium or white metal, which may be used to hold the parts together (housings, bearings, etc.). Ferrous materials are normally soft ferromagnets, and for the purposes of this application the term "ferrous" will be used to describe the class of ferromagnetic materials comprising i.e. containing or consisting of iron (consistent with how it would normally be understood). Although non-ferrous ferromagnets, e.g. nickel and cobalt, also exist, most non-ferrous materials are paramagnetic or diamagnetic. Many non-ferrous materials only show a negligible paramagnetic or diamagnetic response to a magnetic field, and may essentially be classed as "non-magnetic".

The general principles behind metal detection using a magnetic field are well established, and the skilled person will understand that, and how, different metal particles may interact with an applied magnetic field. The basic concept is that an alternating magnetic field induces eddy currents in any conducting material, and will also be affected by the magnetic properties of the material. By detecting a resulting change in the magnetic field it is therefore possible to detect the presence of metals. Analysis of the signal may also allow classification of the material e.g. as ferromagnetic or non-ferromagnetic and/or a quantity of the material to be determined. The skilled person will also be aware of various established coil arrangements that can be used for measuring magnetic and conductive properties of metal particles within a test substance e.g. fluid.

Known coil arrangements fall into two main groups: either there are separate coils for transmitting and receiving a magnetic field, or the same coil effectively acts as both transmitter and receiver. An example of the latter arrangement is described in US patent no. 6,051,970 (HUTCHINGS). In US 6,051,970 a solenoidal coil is used to generate a magnetic field and a change in impedance of this coil in response to a sample being introduced into the field is monitored to detect the presence of metal particles. The development described in US 6,051,970 is the coaxial mounting of the solenoidal coil within a ferrite sleeve flux guide. As will be discussed further below the present inventors have recognised a number of problems associated with this sensor apparatus.

It is desired to provide an improved sensor apparatus, and in particular an improved coil arrangement for a sensor apparatus, for use in obtaining information relating to the presence of metal particles within a sample.

Accordingly, from a first aspect, the present invention provides a sensor apparatus for use in obtaining information relating to the presence of metal particles within a sample of a substance to be tested, the apparatus comprising:

a printed circuit board (PCB) defining a substrate comprising an aperture for receiving a sample of a substance to be tested;

magnetic field generating means for generating a magnetic field for application to a sample received in the aperture in use; and

sensing means for sensing the result of interaction between the generated magnetic field and a sample received in the aperture in use, the sensed result of the interaction being usable to determine a quantity of ferromagnetic e.g. ferrous particles in the sample;

Claims:

1. A sensor apparatus for use in obtaining information relating to the presence of metal particles within a sample of a substance to be tested, the apparatus comprising:

a printed circuit board (PCB) defining a substrate comprising an aperture for receiving a sample of a substance to be tested;

magnetic field generating means for generating a magnetic field for application to a sample received in the aperture in use; and

sensing means for sensing the result of interaction between the generated magnetic field and a sample received in the aperture in use, the sensed result of the interaction being usable to determine a quantity of ferromagnetic e.g. ferrous particles in the sample;

wherein the substrate includes an electrically conductive coil printed thereon that circumferentially surrounds said aperture for receiving the sample, the electrically conductive coil forming part of said sensing means.

2. The sensor apparatus of claim 1, wherein the quantity is a total content e.g. mass of the particles per unit volume.

3. The sensor apparatus of claim 1 or 2, wherein the sample is an extracted sample contained within a sample container, such as a test tube.

4. The sensor apparatus of claim 1 or 2, wherein the sample is a dynamic sample defined by a volume of fluid which flows through the aperture between first and second times.

5. The sensor apparatus of any of claims 1, 2 or 3 wherein the sensor apparatus forms part of a sensor unit, the sensor unit further comprising a housing, wherein said housing comprises an opening coaxial with said aperture of the sensor apparatus to enable a sample to be tested to be received within the aperture, optionally wherein the sensor unit is a portable unit.

6. The sensor apparatus of any preceding claim wherein at least the coil surrounding the aperture and forming part of the sensing means comprises multiple coil portions printed at different respective levels of the substrate; or wherein the substrate comprises multiple substrate layers, and wherein at least the coil surrounding the aperture and forming part of the sensing means comprises coil portions printed on more than one layer of the substrate, each coil portion being printed at a different respective level of the substrate.

7. The sensor apparatus as claimed in any preceding claim wherein at least the coil surrounding the aperture is a spiral coil and/or wherein the or each coil portion of at least the conductive coil surrounding the aperture is a spiral coil portion.

8. The sensor apparatus of any preceding claim wherein the printed circuit board (PCB) substrate comprises the magnetic field generating means.

9. The sensor apparatus as claimed in any preceding claim, wherein the printed conductive coil circumferentially surrounding said aperture that forms part of the sensing means also forms part of said magnetic field generating means.

10. The sensor apparatus as claimed in any preceding claim, wherein said sensing means is arranged to sense a change in impedance of the conductive coil resulting from said interaction between the sample fluid and the generated magnetic field.

11. The sensor apparatus of any preceding claim wherein the sensor apparatus comprises means for generating data indicative of the sensed result of the interaction between the sample and the generated magnetic field.

12. The sensor apparatus of claim 11 comprising means for providing the generated data indicative of the sensed result to one or more of; output means e.g. a display for outputting information to a user based on the data indicative of the sensed result, storage means for storing data based on the data indicative of the sensed result, and processing means for using the data indicative of the sensed result in obtaining information relating to the presence of metal particles within the sample.

13. The sensor apparatus of claim 12 wherein the sensor apparatus comprises any one or ones of said storage means, output or processing means and/or wherein any one or ones of the storage means, output or processing means are remote from the sensor apparatus, wherein the sensor apparatus further comprises means for transmitting the generated data indicative of the sensed result thereto.

14. The sensor apparatus of any preceding claim further comprising processing means for using the sensed result of said interaction to determine a quantity of ferromagnetic e.g. ferrous particles within the sample.

15. A system comprising the sensor apparatus of any one of claims 1 to 14 and processing means remote from the sensor apparatus for using the sensed result of said interaction to determine a quantity of ferromagnetic e.g. ferrous particles within the sample.

16. The apparatus or system as claimed in any preceding claim, further comprising a reference component for calibrating or balancing said sensing means, wherein

said reference component comprises a reference coil printed on the substrate, preferably wherein the reference coil is identical to the printed coil of the sensing means.

17. An apparatus or system as claimed in any preceding claim, further comprising electrostatic shielding disposed between the conductive coil of said sensing means and the aperture, preferably wherein said electrostatic shielding comprises an incomplete ring printed on said substrate.

18. A method of obtaining information relating to the presence of metal particles within a sample using the sensor apparatus or system of any preceding claim, optionally wherein the method comprises:

locating a sample of a substance to be tested such that it is received in said aperture;

using the magnetic field generating means to generate a magnetic field;

using the sensing means to sense the result of interaction between the sample and the applied magnetic field; and

using the sensed result of interaction between the sample and the generated magnetic field to determine a quantity of ferromagnetic e.g. ferrous particles in the sample.

19. The method of claim 18, wherein the method comprises determining a total content e.g. mass of the particles per unit volume.