

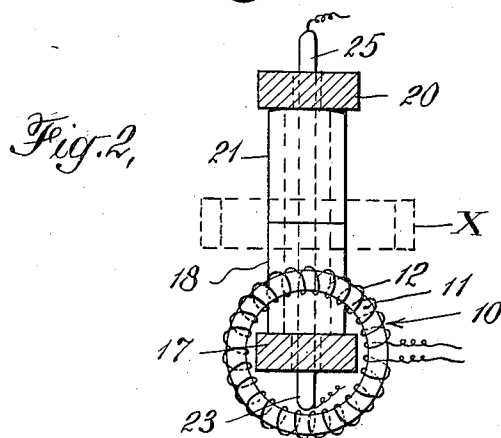
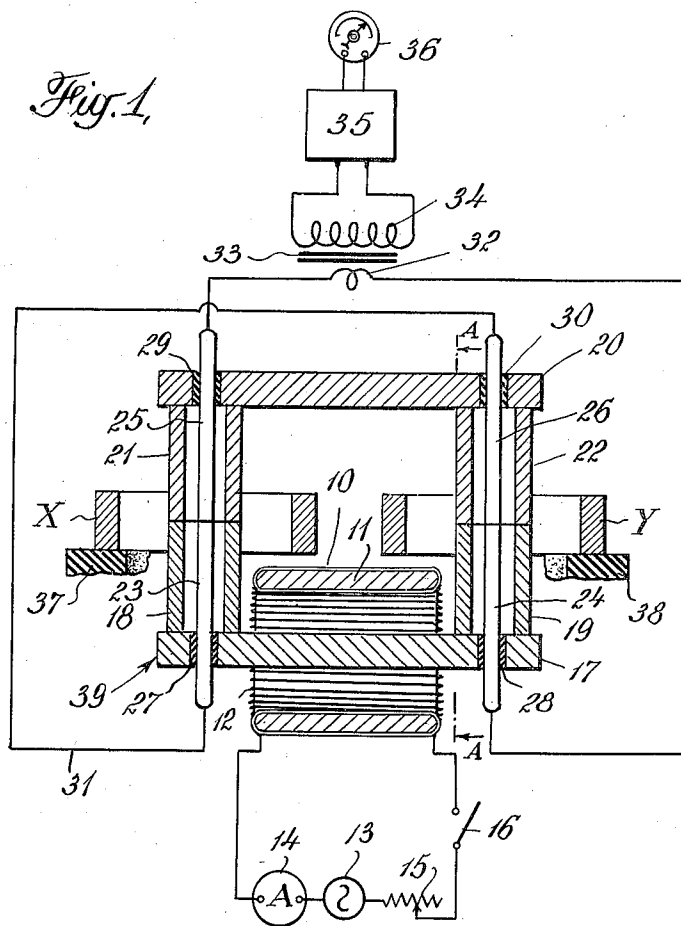
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MAGNETIC ANALYSIS

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MAGNETIC ANALYSIS

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10 Claims. (Cl. 175-183)

This invention is concerned with magnetic analysis and particularly with magnetic analysis of annular magnetizable bodies.

Differences in metallurgical and physical properties of steel and the like are manifested by differences in magnetism affecting properties. If identical magnetic fields are set up in two magnetizable bodies disposed respectively in inductive relationship with conductors, identical currents will be induced in these conductors only if the bodies are identical. If the two currents are opposed to each other no differential current will result unless the bodies are dissimilar. The principle has been employed heretofore to distinguish between magnetizable bodies, and to determine whether a magnetizable specimen of unknown characteristics conforms to a magnetizable standard of known and desirable physical and metallurgical character. Thus it is possible to detect specimens which are defective with respect to hardness, chemical analysis, flaws, metallographic characteristics or other properties.

When analyzing a relatively long magnetizable body of relatively uniform cross section it is customary to produce a magnetic field by passing the body through an electrically energized coil. The field thus set up is affected by and properly reflects the physical characteristics of the body, so that a current induced from the field is a proper index of these characteristics. However, when relatively short magnetizable bodies such as piston rings, ball-bearing ball races, etc., are treated as described hereinbefore for long bodies, the field does not properly reflect physical characteristics of the short bodies, probably due to the distortion of the field by so-called "end effect." The term "annular" is used herein to include not only closed rings but also annular bodies such as split rings and other bodies in which the annulus is not complete.

As a result of my investigations, I have discovered that magnetic fields may be caused to reflect correctly the physical and metallurgical characteristics of relatively short bodies, if these bodies are in annular form and the field is set up by a relatively powerful current passing through the annulus, and I have developed an apparatus which is especially adapted for the analysis of annular magnetizable objects such as ball-bearing races, rings and the like. In accordance with my invention, I produce a magnetic flux in an annular magnetizable object by disposing the object around and preferably concentric with a conductor carrying a heavy alternating current. The field thus produced preferably

is employed to induce a secondary current which is investigated, although it is possible to determine the physical properties of the annular objects by investigating the effect of the object's presence upon the primary current flowing in the conductor which creates the field. Preferably the conductor is the secondary of a transformer in the form of a short circuit ring of large current carrying capacity, the ring being divided into segments so that it can be passed through and in effect linked with the annular magnetizable object.

Accordingly, my invention contemplates the magnetic analysis of an annular magnetizable body by passing a conductor through and in inductive association with the body, passing an alternating current through the conductor to produce a magnetic flux in the magnetizable body, and determining the effect of the body upon current in said conductor or in a secondary conductor disposed in inductive relationship with the body. This is accomplished preferably in the apparatus illustrated in the accompanying drawing in which:

Figure 1 is a schematic elevation, partly in section, of a presently preferred form of magnetic analysis device of my invention; and

Figure 2 is a section taken through the apparatus of Figure 1, along the line A-A.

The presently preferred form of the apparatus of my invention includes a toroid transformer 10 having an annular core 11 with its axis set horizontally and with an insulated toroid winding 12 around the core. The core is of magnetizable material of low hysteresis such as iron and the winding has a low ohmic resistance. The two ends of the winding are connected to a source 13 of alternating current of commercial amplitude and frequency, for example a lighting circuit. An ammeter 14 or other current measuring device, an adjustable resistance 15, and a switch 16 are connected in series with the winding and the source.

A heavy lower conductor bar 17 (preferably copper) having a large cross section and high conductivity is disposed through the core of the transformer in a horizontal position and preferably concentric with the core. On the upper face and at each end of the bar are fastened lower cup or tubular contacts 18, 19, which may be made conveniently from short pieces of heavy gauge copper tubes. Good electrical contact between bar and tubes is necessary and may be assured by brasing or other means. The lower bar and the lower tubular contacts make up half

a short circuit ring 39, the other half of which is composed of an upper heavy bar 20, and a pair of upper cup or tubular contacts 21, 22, which in operation rest respectively on the lower tubular contacts. The short circuit ring is, in effect, the secondary of the transformer.

Within each of the four tubular contacts and concentric therewith are disposed respectively contact pins 23, 24, 25, 26, which are fastened into the respective bars with insulator bushings 27, 28, 29, 30. When the tubular contacts are seated against each other the pins within each pair abut and form good electrical contacts. The outside ends of each pin are connected in a secondary circuit 31 which is arranged so that current set up in the right hand pair of pins is in series opposition to the current in the other pair of pins.

Also connected in the secondary circuit is a primary coil 32 of a step-up transformer 33, the secondary 34 of which is connected through an amplifier 35 of any convenient type to a current indicating means 36 such as an A. C. galvanometer.

Means such as insulator shelves 37, 38 are provided for holding the magnetizable bodies to be compared in concentric relationship respectively with right and left halves of the short circuit ring. Thus a standard ring X, known to have desired metallurgical and physical properties is placed around one-half of the short circuit ring 39 and a specimen ring Y to be compared with the standard is placed around the other half of the short circuit ring.

The operation of the device is as follows:

With standard and specimen in position, the switch is closed and the toroid transformer is energized. The upper tubular contacts are then placed on the respective lower ones so as to couple the single turn short circuit ring composed of the tubular contacts and the bars. Due to the heavy construction and low resistance of the short circuit ring a heavy current flow is set up in it in an economical manner.

The heavy current set up in the short circuit ring creates a strong magnetic field which magnetizes the specimen and standard. The magnetic fluxes thus set up react upon the current flow in the short circuit ring and also react upon the current flow in the secondary series-opposition circuit. Because both right and left sides of the apparatus are electrically similar, the fluxes created in the specimen and standard tend to be equal, and if specimen and standard have equal magnetism affecting properties the two secondary currents set up in the secondary series-opposed circuit will equal and cancel each other. If, however, the specimen and standard are different metallurgically or physically, and hence have different magnetism affecting properties, the secondary currents opposed will not be equal and a differential current will be set up in the secondary circuit. The presence of this differential current indicates a lack of similarity between standard and specimen, and tells the operator to reject the specimen. Provided that the differential current or potential set up in the secondary series-opposed circuit is sufficiently great, it may be measured directly in this circuit. However, in order to detect differences which might escape such measurement, I prefer to step up the differential potential or amplify the differential current or both, and to determine the thus amplified differential with the indicator shown.

Instead of inducing a secondary current through a standard piece as described above, it

is possible to create by other means a so-called "artificial electrical standard," or in other words to introduce into the secondary circuit and oppose to the current induced through the specimen, a current such as would be induced through the specimen if it had the desired physical and metallurgical properties. The phase shifting amplitude controlling device shown in my copending application Serial No. 149,575, filed June 22, 1937, may be employed for creating the "artificial standard potential." However, for reasons of simplicity I prefer to employ the device as shown herein.

It should be noted that the secondary current flow set up by the fluxes in the specimen and standard is not directly linked with the flux set up in the iron core of the transformer, which is an advantage because the direct effect of the iron transformer core upon the wave form of the indicated current is eliminated.

I claim:

1. In an apparatus for analyzing an annular magnetizable body having means for creating a flux in said body, a circuit disposable in inductive relationship with the flux thus created, and means for determining the effect of the flux upon a current in said circuit, the improvement which comprises a transformer and a short circuit ring of relatively high conductivity disposed in inductive relationship with the transformer and constructed of a plurality of segments, so that it may be linked through said annular body.

2. In an apparatus for analyzing an annular magnetizable specimen having means for creating a flux in said specimen, means for creating a flux in a standard annular magnetizable body, conductors disposable respectively in inductive relationship with the fluxes thus created, a circuit for opposing currents in said conductors influenced by said flux to produce a differential current, and means for determining the presence of said differential current in the circuit, the improvement which comprises a transformer and a short circuit ring of relatively low resistance disposed in inductive relationship with the transformer and composed of a plurality of segments so that it may be linked through said specimen and through said standard body.

3. In an apparatus for analyzing an annular magnetizable body having means for creating an alternating magnetic flux in said body, a circuit disposable in inductive relationship with the flux thus created, and means for determining the effect of said flux upon a current in said circuit, the improvement which comprises a toroid transformer and a short circuit ring of relatively low resistance passing through said toroid transformer and composed of a plurality of segments so that it may be passed through and linked with said annular body.

4. A magnetic analysis apparatus for investigating an annular magnetizable body which comprises a toroid transformer, a U-shaped member passing through the toroid transformer and of relatively low electrical resistance, a second U-shaped member of relatively low electrical resistance adapted to form a contact with the first U-shaped member and make a short circuit ring, means for linking the annular body through said short circuit ring but out of contact therewith, a secondary circuit disposable in inductive relationship with said ring and said body, and current indicating means connected in said secondary circuit.

5. In a magnetic analysis apparatus for inves-

5 tigating an anular magnetizable body, the improvement which comprises a toroid transformer, a U-shaped conductor of relatively high conductivity passed through the toroid transformer and having a pair of tubular contacts on its ends, each tubular contact having a conductive pin disposed within it and insulated from the tubular contact and the bar, a second U-shaped conductor bar of relatively high conductivity
 10 having tubular conductors on its ends with conductive pins disposed within the tubular conductors and insulated from the conductors and the second bar, the tubular conductors and conductive pins on each bar being adapted to make contact with the respective tubular conductors and conductive pins on the other bar, a secondary circuit connected to the four pins and current indicating means connected to the secondary circuit.

20 6. An apparatus for analyzing an annular magnetizable specimen which comprises a transformer having a secondary in the form of a short circuit ring of relatively high current carrying capacity, means for linking said ring through
 25 the specimen and through an annular standard magnetizable body, a pair of conductors disposed within portions of the short circuit ring and disposable respectively in inductive relationship with the specimen and standard, a circuit connecting
 30 said conductors in series opposition, and means for indicating the presence of current in said circuit.

7. The method of subjecting an annular magnetizable body to magnetic analysis which comprises disposing said body and a standard annular magnetizable body respectively in inductive relationship with a closed conductor loop passing through both annular magnetizable bodies, energizing said conductor loop with an alternating power source disposed in inductive relationship with said loop, disposing two other conductors respectively in inductive relationship with said annular magnetizable bodies, opposing currents induced in said other conductors in a circuit and

noting the presence of a differential current in said circuit.

8. The method of subjecting an annular magnetizable body to a magnetic analysis which comprises disposing said body and a standard annular magnetizable body respectively in inductive relationship with a conductor loop passing through both annular magnetizable bodies, producing an alternating current in said conductor loop with an alternating current source disposed in inductive relationship with said loop, disposing two other conductors respectively in inductive relationship with said bodies but out of direct inductive relationship with said power source, opposing the currents induced respectively in said other conductors in a circuit, and noting the presence of differential current in said circuit.

9. An apparatus for analyzing an annular magnetizable specimen which comprises a short circuit ring of relatively high current carrying capacity having a tubular portion, a conductor disposed within the tubular portion and insulated from the short circuit ring, means for linking the specimen through the short circuit ring adjacent its tubular portion and out of contact but in inductive relationship therewith, means for energizing the short circuit ring with an alternating current, a secondary circuit connected to the conductor and current indicating means connected to the secondary circuit.

10. In an apparatus for subjecting an annular magnetizable body to magnetic analysis including means for producing a magnetic flux in said body, a conductor disposable in conductive relationship with said flux, and means for determining the effect of said flux on current in said conductor, the improvement which comprises a closed circuit of relatively high current-carrying capacity comprising a tubular U-shaped member disposed through said annular body in inductive relationship therewith, and a conductor connected to opposite sides of the U for closing it.

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