

[54] **CONTACTLESS GALVANO-MAGNETRO EFFECT APPARATUS**

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[51] Int. Cl. G05f 7/00

[58] Field of Search 338/12, 32 H, 32 R; 323/94 H; 324/45, 46; 307/309; 335/1, 2

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[57] **ABSTRACT**

A contactless galvano-magnetron effect apparatus comprised of a magneto resistance effect device which is provided with a plurality of electrodes, between which a plurality of resistance yokes are provided, at least one of the yokes being associated with a magnetic field applying means which is capable of varying the condition of magnetic field applied to the resistance yoke.

12 Claims, 17 Drawing Figures

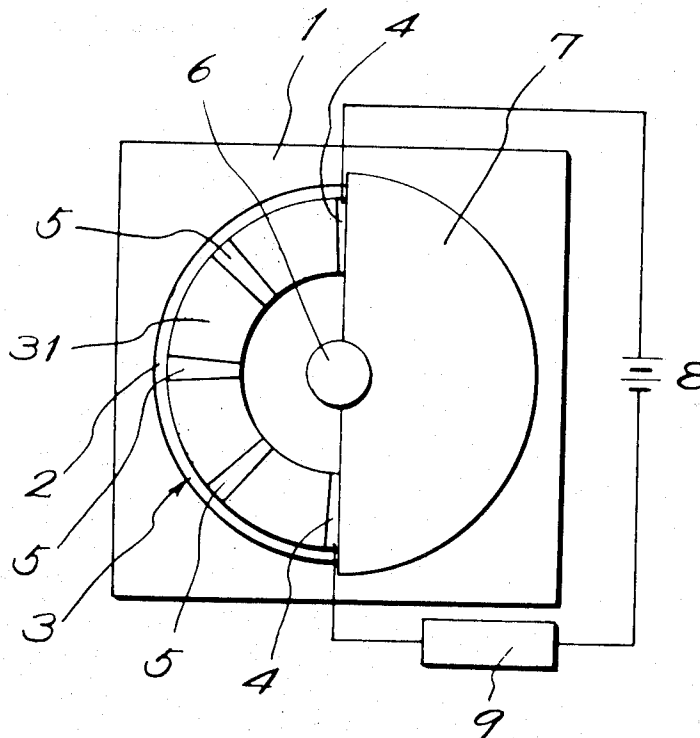


FIG. 1

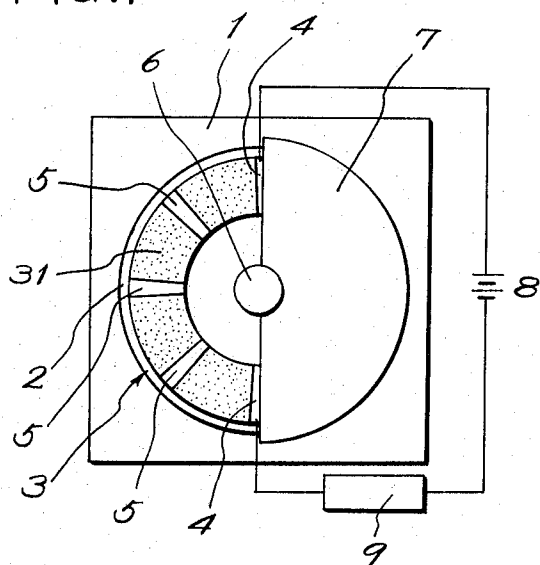


FIG.2

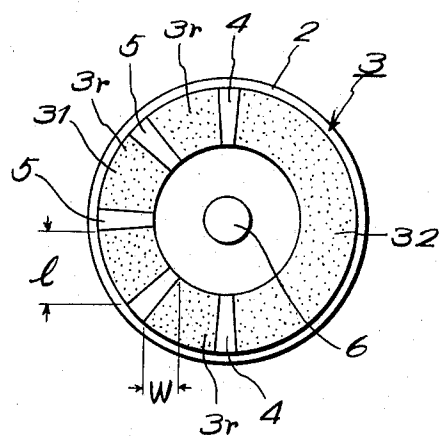


FIG. 3

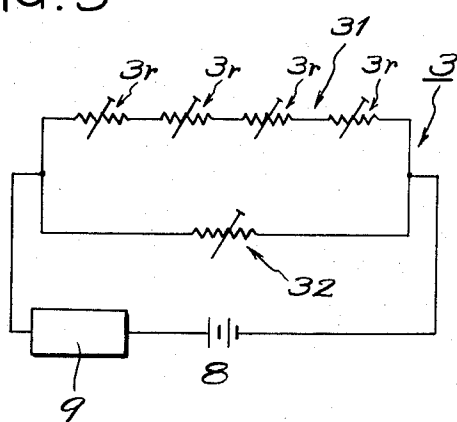


FIG. 4

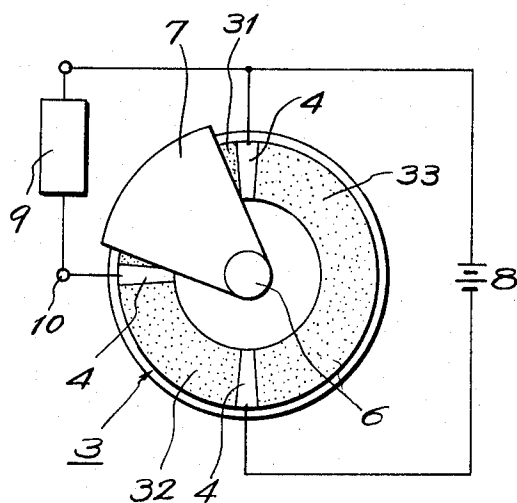


FIG.5

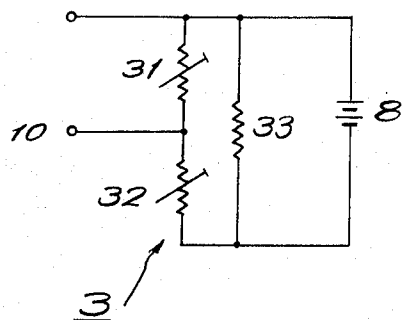


FIG. 6

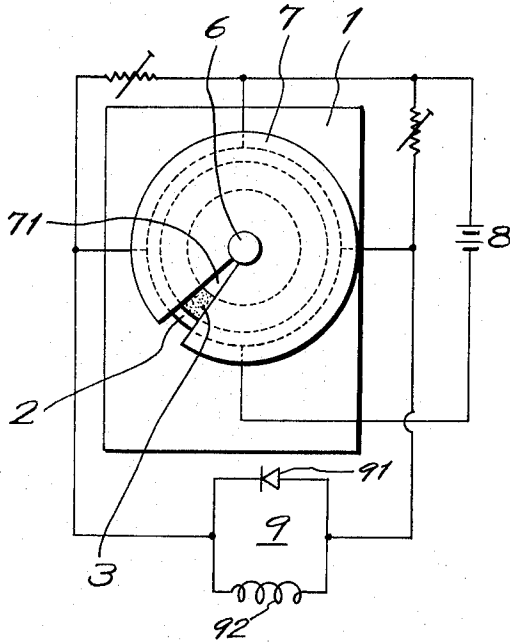


FIG. 7

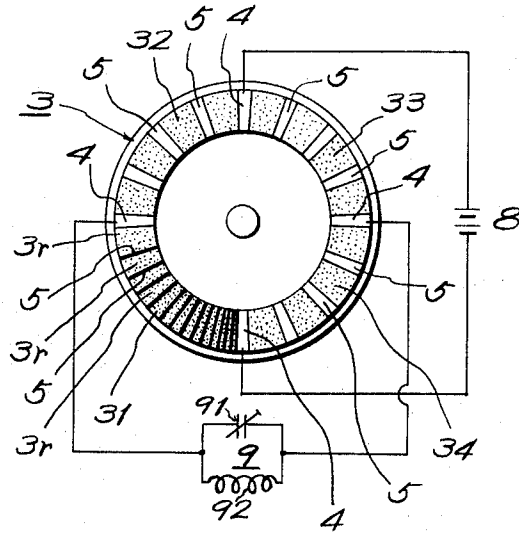


FIG. 8

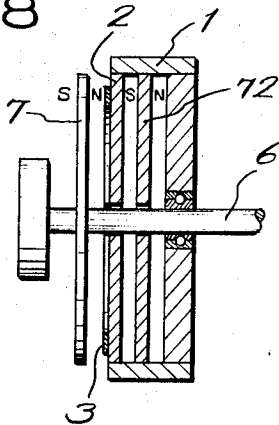


FIG. 9

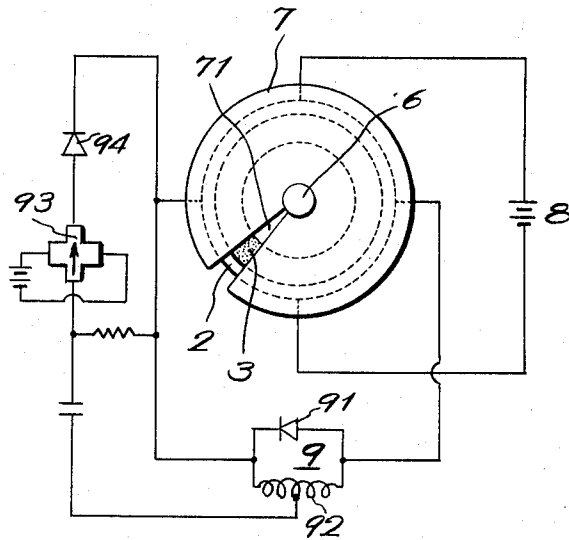


FIG. 10

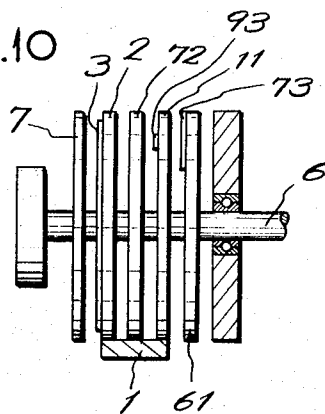


FIG.11a

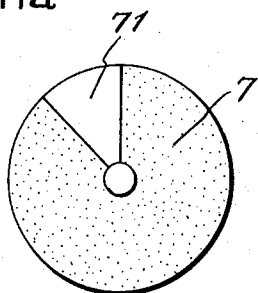


FIG.11b

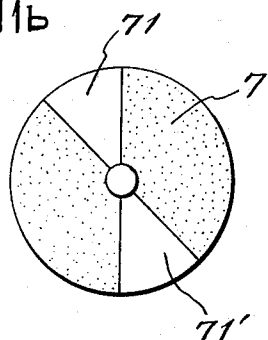


FIG.12

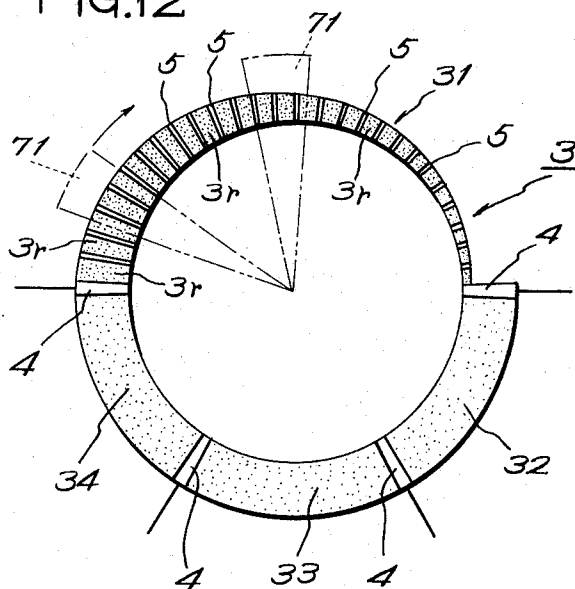
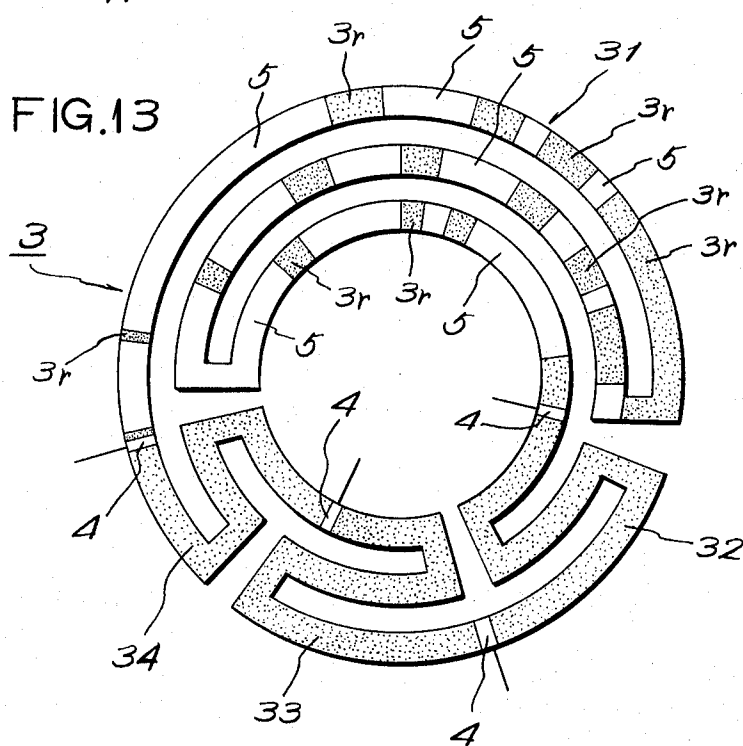


FIG.13



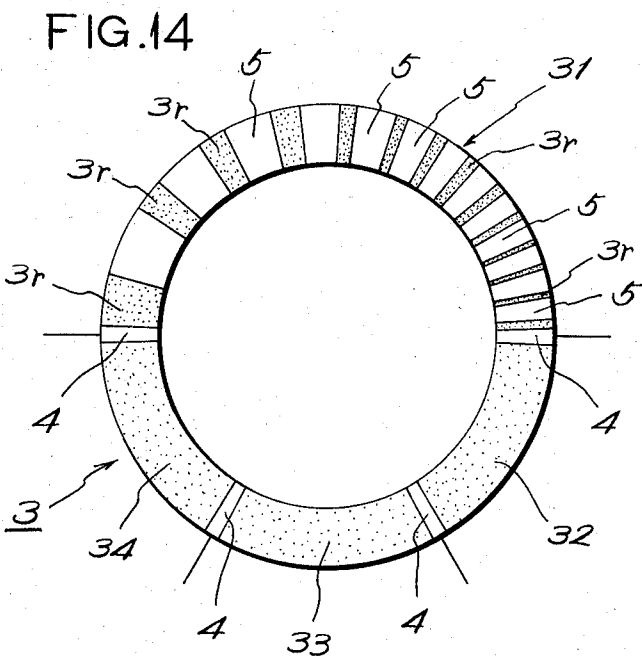


FIG.15

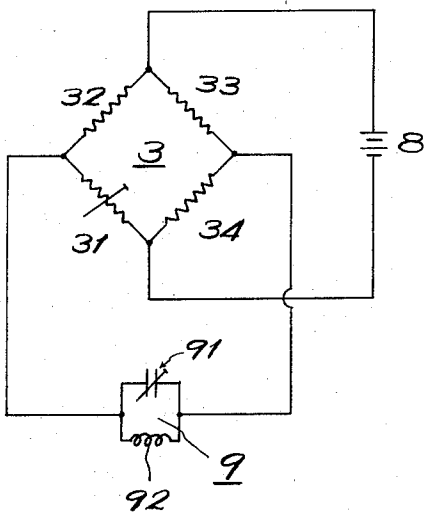
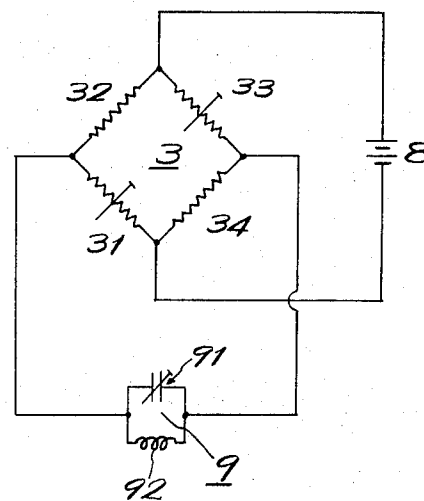


FIG.16



CONTACTLESS GALVANO-MAGNETRO EFFECT APPARATUS

BACKGROUND OF THE INVENTION

Conventional variable resistors and switching apparatus are constructed such that their contact pieces are forced to contact corresponding resistance portions and contacts. Consequently, such apparatus are disadvantageous because wear due to friction and noise, such as chattering, etc. are caused by repeated contact.

The present invention is intended to provide a contactless galvano-magnetro effect apparatus capable of eliminating these problems.

SUMMARY

The present invention provides a galvano-magnetro effect apparatus comprised of an endless circular type (including the polygonal type) magnetro resistance effect device, electrodes made of conductive material which are formed so that the electrodes cross at least two portions of the device to divide the device into at least two resistance yokes, a magnetic field applying means which is arranged to oppose to at least one resistance yoke so that the condition of the field being applied is varied, and external input power supply and load circuits which are connected to the electrodes.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated in detail by the accompanying drawings whereof:

FIG. 1 is a front view of a contactless galvano-magnetro effect apparatus of the present invention;

FIG. 2 is a front view of the magnetro resistance effect device used in the apparatus;

FIG. 3 is the circuit diagram of the apparatus illustrated in FIG. 1;

FIG. 4 is a front view of another embodiment of the apparatus of the present invention;

FIG. 5 is the circuit diagram of the apparatus illustrated in FIG. 4;

FIG. 6 is a front view of another embodiment of the apparatus of the present invention;

FIG. 7 is a front view of the galvano-magnetro effect device to be used in the apparatus shown in FIG. 6;

FIG. 8 is a cross-sectional side view of the apparatus shown in FIG. 6;

FIG. 9 is a front view of another embodiment of the apparatus of the present invention;

FIG. 10 is a side view of the apparatus shown in FIG. 9;

FIG. 11a and 11b are front views of embodiments of the magnetic field applying means which is used in the apparatus of the present invention;

FIGS. 12, 13 and 14 are front views of embodiments of the magnetro resistance effect device used in the apparatus of the present invention; and

FIGS. 15 and 16 are the circuit diagram of the apparatus shown in FIG. 6.

DETAILED DESCRIPTION

Referring to FIGS. 1 to 3, there is shown base plate 2 made of a magnetic or non-magnetic material which is fixed at chassis 1, magnetro resistance effect device 3 (hereinafter referred to as the "device") made of InAs, InSb, Ge, Si, etc. which is fixed in the form of an endless circle to the surface of base plate 2 by photo-etching, two electrodes 4 which are oppositely arranged in the radial direction of the device 3 so that the electrodes treated by means of metalization cross the surface of the device, a plurality of conductive segments 5 which are arranged at equal intervals on one of two resistance yokes 31 and 32, which are divided by two electrodes 4 and are formed so as to cross the surface of the device in the same manner as the electrodes, a semicircular magnet 7 which opposes the device 3 with a clearance separating the magnet and the

device, the magnet being forced to rotate by rotary shaft 6 while being energized in the direction of its thickness, and external input power supply 8 and external load 9, which are connected to the electrodes.

Conductive segments 5 need not always be provided. The apparatus as shown is, however, advantageous because, if conductive segments 5 are provided, the plurality of resistance surfaces 3r of the resistance yoke separated by the conductive segments operate as independent elements; therefore, the resistance yokes can be operated in the same manner as a number of magnetro-resistance effect devices which are series-connected.

The conductive segments can be provided at unequal intervals and can be arranged so that the intervals are gradually decreased. If thus arranged it is possible to make the resistance variation characteristics of each resistance surface 3r uneven by varying the ratio L/W (L is the length and W is the width of each resistance surface 3r) and, accordingly, the resistance variation characteristic of resistance yoke 31 can be set as desired.

The contactless galvano-magnetro effect apparatus as described above operates as follows: when magnet 7 is rotated, the areas of resistance yokes 31 and 32 of device 3 positioned opposite to magnet 7 vary, the resistance value of resistance yokes 31 and 32 vary, and the voltage to be applied to load 9 varies.

Hereupon, if conductive segments 5 are arranged on one of the resistance yokes 31 and 32 as shown, the apparatus operates advantageously because the resistance variation of resistance yoke 31 increases with the rotation of magnet 7 and it is possible to give linearity to the output voltage characteristic by selecting the distance between conductive segments 5 of resistance yoke 31.

FIGS. 4 and 5 illustrate the apparatus comprised of three resistance yokes 31, 32 and 33 which are made up by providing three electrodes 4 at device 3.

In this embodiment, magnet 7, which is used as the magnetic field applying means, is sector-shaped in accordance with the length of the resistance yoke so that the magnetic flux is alternately applied to two resistance yokes 31 and 32. Load 9 is connected to power supply 8 so that the load is parallel-connected to resistance yoke 31 of device 3.

The apparatus of this embodiment is constructed as mentioned above. If magnet 7 is alternatively positioned opposite to two resistance yokes 31 and 32, the voltage applied to load 9 varies.

Hereupon load 9 can be connected to power supply 8 so that the load is parallel-connected to resistance yoke 32. The magnet can be positioned so as not to alternatively oppose both resistance yokes 31 and 32 and can be arranged so that the magnetic flux is applied to only one of resistance yokes 31 and 32, one end of which is the electrode connected to intermediate output terminal 10.

In this case, the apparatus is constructed so that magnet 7 is forced to approach or depart from resistance yoke 31 or 32 to vary the density of magnetic flux applied to the resistance yoke.

Furthermore, it is desirable to provide conductive segments 5 on resistance yokes 31 and 32 which are opposite to magnet 7 as mentioned above. Thus, the resistance variation characteristic of the resistance yoke can be set according to its intended use.

The magnetic field applying means can be a means to increase the resistance value of a variable resistance yoke, for example, resistance yoke 31, to a value greater than that of other resistance yokes by applying the magnetic flux to resistance yoke 31 or alternatively, it can be a means to decrease the resistance value of the variable resistance yoke to a value lower than that of other resistance yokes.

FIGS. 6 to 8 illustrate the apparatus provided with four resistance yokes 31, 32, 33 and 34 which are obtained by dividing device 3 with four electrodes 4.

Each resistance yoke is designed so that its resistance value is equal to that of other resistance yokes. In this case, power supply 8 is connected to two electrodes which are oppositely arranged in the radial direction and load 9 is connected to the other two electrodes.

Accordingly, in this embodiment, resistance yokes 31, 32, 33 and 34 form a bridge circuit. In this embodiment, if the condition of the magnetic field, such as, for example, the magnetic flux density, which is applied to resistance yoke 31, varies, the resistance value of resistance yoke 31 varies and the voltage is applied to load 9.

The voltage applied to load 9 gradually increases and decreases if the resistance value of resistance yoke 31 is gradually increased or decreased. Accordingly, if load 9 is made as a resonance circuit consisting of variable capacity diode 91 such as, for example, a varactor diode, the capacity of which varies with the voltage, as shown in FIG. 6, the resonance frequency of the resonance circuit can be varied with the resistance variation of resistance yoke 31 and the apparatus of the present invention can be used as the tuner of a television set.

In this case, a method to change the condition of the magnetic field which is applied to resistance yoke 31 is optional. It is desirable to use the magnetic field applying means which is provided with disc-type magnet 7 which is energized in the direction of thickness, is rotatably supported by shaft 6 and is provided with non-energized portion 71 in the radial direction, as shown in FIGS. 6 and 8.

When using this magnet 7, it is necessary to vary the resistance value of resistance yoke 31 along with movement of non-energized portion 71 opposite to resistance yoke 31 and therefore it is necessary to arrange a number of conductive segments 5 on resistance yoke 31 so that the distances between conductive segments 5 becomes narrower as shown in FIG. 7.

When non-energized portion 71 of magnet 70 moves along resistance yoke 31, the total area of resistance surfaces 3r of the device which is opposite to non-energized portion 71 varies and accordingly, the resistance value of resistance yoke 31 gradually increases or decreases.

Hereupon conductive segments 5 can be provided on other resistance yokes 32, 33 and 34 of device 3 as desired. Thus, the resistance value of all resistance yokes can be even regardless of the length of resistance yoke under a special condition in which the magnetic flux density is being applied; for example, every resistance yoke is fixed. However, in this embodiment, magnet 7 has non-energized portion 71; therefore, the apparatus should be designed so that the bridge circuit is balanced when non-energized portion 71 is positioned at a specific idle position.

This can be achieved by widening electrode 4 and by arranging it so that the bridge circuit is balanced when non-energized portion 71 is forced to oppose to said electrode. In addition, it is possible to apply another method; that is, the idle point of non-energized portion 71 can be set at one of the resistance yokes 32, 33 and 34 (excepting resistance yoke 31) so that the resistance value of resistance yoke 31 is equal to that of other resistance yokes when the resistance yoke is opposed to non-energized portion 71.

Therefore, conductive segments 5 can be provided on every resistance yoke as shown FIG. 7 and the resistance value of a resistance yoke can be relatively set.

When arranging rotary magnet 7 to oppose to the device 3, it is desirable to fix plate magnet 72, which is energized in the direction of thickness at the rear surface of base plate 2 as shown in FIG. 8, so that the polarity of the device side of the plate magnet 72 is different from that of the device side of the rotary magnet 7. Thus, the magnetic field applied to device 3 can be even between both magnets 7 and 72.

The magnetic field applying means may be made so as to vary the magnetic flux density applied to a specified resistance yoke as mentioned above. However, when rotary magnet 7 as shown in FIG. 6 is used, this magnetic flux density applied to

resistance yoke 31 along which non-energized portion 71 moves while being kept opposite to the resistance yoke does not vary; accordingly, in this case, it is necessary to arrange a number of conductive segments 5 at different intervals so that the resistance value of resistance yoke 31 varies with movement of the magnetic field. In other words, the magnetic field applying means can vary the situation and strength of the magnetic field applied to specified resistance yoke 31.

Because the apparatus of this embodiment is constructed as described above, it can be used in various types of electric equipment. When using it as a tuner, as mentioned before, the resonance frequency is varied only with variation of the capacity of the diode; accordingly, the apparatus is disadvantageous because a substantially high voltage should be applied to the diode in the channel of the high frequency side.

FIGS. 9 and 10 illustrate a tuner which raises the resonance frequency by reducing the inductance of the resonance circuit.

In this embodiment, gate device 93, such as a Hall effect device, is connected to the intermediate portion of coil 92 of resonance circuit 9, and diode 94 for the gate, which has the characteristics of the Zener diode, is connected to gate device 93.

Gate device 93 is set so that it operates when the tuner selects the channel of the high frequency band and applies the operating voltage to the diode. Diode 94 for the gate is set so that it becomes conductive when the gate device 93 operates and the intermediate point of the coil 92 is short-circuited to electrode 4 at the output side of device 3.

The means to actuate gate device 93 is optional. A satisfactory operation of the apparatus can be obtained by fixing rotary plate 61 to shaft 6 so that it rotates together with magnet 7 as shown in FIG. 10, arranging magnetic material support plates 11 which are fixed at chassis 1 to be opposite in parallel on the rotary plate 61, fixing the Hall effect device at support plate 11 as gate device 93 and mounting magnet 73 on the part of rotary plate 61 so that the magnetic flux from magnet 73 is concentrated onto Hall effect device 93 when the tuner selects the channel of the high frequency band.

Thus, other galvano-magneto effect devices can be used as gate device 93; for example, the magneto-resistance effect device can be also used.

Hereupon, in the bridge circuit consisting of device 3, only resistance yoke 31 can be used as the variable resistance yoke as shown in FIG. 15. Depending on the intended use of the apparatus, resistance yokes 31 and 33 (or 32 and 34) in opposite positions can be used as the variable resistance yokes as shown in FIG. 16. Thus, it is advantageous because the bridge circuit can be greatly unbalanced.

Non-energized portion 71 of rotary magnet 7 can be made by notching magnet 7 as shown in FIG. 6 or by closely contacting the non-magnetic piece to the notched portion as shown in FIG. 11a.

If non-energized portion 7 is made by loosely contacting the non-magnetic piece to the notched portion, two or more non-energized portions 71 and 71' can be formed on one magnet 7. By this means a convenient rotary magnet to be used in the apparatus, for example, as shown in FIG. 16, can be made.

Hereupon resistance yoke 31, used as the variable resistance yoke, can be lengthened by providing conductive segments 5 on the resistance yoke.

FIGS. 12 to 14 illustrate device 3 in which resistance yoke 31 is made longer than other resistance yokes 32, 33 and 34.

The width of resistance yoke 31 of device 3 shown in FIG. 12 is gradually narrowed in the direction of the opposite electrode. Since the area and shape of resistance surfaces 3r of resistance yoke 31 are different from each other, even though the distances between conductive segments 5 of device 3 are fixed, the resistance value of resistance yoke varies with movement of non-energized portion 71 of rotary magnet 7 which is forced to oppose resistance yoke 31.

In this embodiment, the shape of resistance surfaces 3r of resistance yoke 31 can be freely changed with the distance

between conductive segments 5; for example, the sensitive characteristic to magnetic flux density of the wider resistance surface can be enlarged by setting ratio L/W of length L to width W to $1/4$, whereas the sensitive characteristic of the narrower resistance surface can be reduced by setting the ratio L/W to $1/4-n$.

According to this embodiment, because the resistance variation characteristic can be freely controlled depending on the shape variation resistance surface 3r, the output characteristic of the device can be determined to meet the intended use, for example, to have linearity.

In the device shown in FIGS. 13 and 14, resistance yoke 31 is made long in accordance with the length of conductive segments 5 or the area and distance. The devices of the above embodiment have the same advantages as said device shown in FIG. 12 and all resistance yokes 31, 32, 33 and 34 can be made in the same width; accordingly, the length of resistance yoke 31, which is used as the variable resistance yoke, can be freely determined and the device 3 in the same shape can be used for many purposes merely by changing the arrangement of the electrodes.

Since the apparatus of the invention does not require mechanical contacts, it is not subject to poor contact due to wear of the contacts or to generation of noise, such as chattering. Since resistance yokes 31, 32, 33 and 34 are made of the same material, the thermal characteristics of the resistance yokes are equal; accordingly, the bridge circuit will not be unbalanced because of a rise in temperature if device 3 forms a bridge circuit. Therefore, this type of the apparatus requires no separate temperature compensating means and there are no problems even if a material of low quality thermal characteristic is used. Thus, the cost of production can be reduced.

If conductive segments 5 are formed on a resistance yoke or yokes, the output characteristics of the device can be freely determined and the resistance yoke which is used as the variable resistance yoke can be long; for example, the moving stroke of non-energized portion 71 can be long when rotary magnet 7 as shown in FIG. 11a is used.

Since the resistance value and number of resistance yokes can be determined depending on the arrangement of a plurality of electrodes 4, a device with different patterns of uses and output characteristics can be easily made.

What is claimed is:

1. A contactless galvano-magnetro effect apparatus comprising of
 - a. a magneto-resistance effect device having an endless circular shape;
 - b. conductive electrodes which are arranged to cross the surface of the device at at least two positions so that the device is divided into at least two resistance yokes;
 - c. a magnetic field applying means which is positioned opposite to the device so that the flux density of the magnetic field applied to at least one resistance yoke can be varied; and
 - d. connections associated with the electrodes for an external input power supply and load, whereby the resistance value of the resistance yoke can be varied with the variation of the flux density of the magnetic field.
2. A contactless galvano-magnetro effect apparatus according to claim 1, wherein at least one conductive segment, which crosses the surface of at least one resistance yoke, is provided.
3. A contactless galvano-magnetro effect apparatus according to claim 2, wherein a plurality of conductive segments are arranged on the resistance yoke so that the distances between adjacent conductive segments are successively decreased from one electrode in the direction of the other electrode.

4. A contactless galvano-magnetro effect apparatus according to claim 1, wherein at least one resistance yoke, the width of which is gradually reduced from one electrode toward the other electrode, is provided.

5. A contactless galvano-magnetro effect apparatus according to claim 1, wherein a circular magnetro-resistance effect device is provided with three electrodes and is divided into three resistance yokes, two of the electrodes being connectable between the remaining intermediate electrode and the power supply, so as to be parallel with one of two resistance yokes which has the intermediate electrode at one end, and a magnetic field applying means which is positioned opposite to one of two resistance yokes divided by the intermediate electrode.

6. A contactless galvano-magnetro effect apparatus according to claim 5, wherein the flux density of the magnetic field applied to the two resistance yokes which are divided by the intermediate electrode is alternately varied.

7. A contactless galvano-magnetro effect apparatus according to claim 1, wherein a circular device is provided with four electrodes and is divided into four resistance yokes, the power supply being connected to two of the four electrodes which extend opposite from each other, the load being connected to the remaining two electrodes, and the resulting bridge circuit, which consists of the four resistance yokes, is unbalanced by varying the flux density of the magnetic field applied to one of the resistance yokes, and the voltage is applied to the load.

8. A contactless galvano-magnetro effect apparatus according to claim 7, wherein the flux density of the magnetic field applied to the two resistance yokes corresponding to the two opposite yokes of the bridge circuit is varied at the same time.

9. A contactless galvano-magnetro effect apparatus according to claim 7 wherein the load connected to the bridge circuit is a resonance circuit consisting of a variable capacity diode, which varies its capacity in accordance with voltage, and an inductance coil and the bridge circuit are controlled so that the output characteristics gradually increase or decrease with a variation of the flux density of the magnetic field.

10. A contactless galvano-magnetro effect apparatus according to claim 9, wherein a gate device and a diode for the gate with Zener characteristics are series-connected between the intermediate point of the coil of the resonance circuit and the output terminal of the bridge circuit, the gate device operating to cause the diode for the gate to be conductive and the intermediate point of the coil being short-circuited to the output terminal of the bridge circuit when the flux density of the magnetic field changes into a specified pattern.

11. A contactless galvano-magnetro effect apparatus according to claim 10, including a rotary shaft wherein a rotary magnet, energized in the direction of thickness, is provided with at least one non-energized portion in the radial direction and rotates in parallel with the device, a rotary plate, to which the magnet is fixed, is mounted to the same rotary shaft, and a fixed support plate is provided with at least one galvano-magnetro effect device as the gate device and is arranged opposite to the rotary plate, the magnetic flux from the magnet on the rotary plate being concentrated onto the gate device of the support plate when the non-energized portion of the rotary magnet comes to a position opposite to a specified position of a specific resistance yoke of the device.

12. A contactless galvano-magnetro effect apparatus according to claim 1, wherein a rotary magnet is energized in the direction of thickness and is provided with at least one non-energized portion in the radial direction so that the non-energized portion moves opposite to the resistance yoke of the device.

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