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Masuda

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[54] **GALVANO-MAGNETO EFFECT APPARATUS**

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[52] **U.S. Cl.** **307/309,** 333/75, 338/12, 307/254

[51] **Int. Cl.** **H01v 5/00**

[58] **Field of Search** 333/75; 330/109, 103, 86; 307/309; 338/12, 103

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Assistant Examiner—B. P. Davis
Attorney, Agent, or Firm—Armstrong & Wegner

[57] **ABSTRACT**

A galvano-magneto effect apparatus in which a parallel T circuit consisting of resistors and capacitors is employed as the positive feedback circuit of an active element. A magnetism sensing element the resistance of which varies with the intensity of a magnetic field applied is employed as the resistance component, and an AC signal is supplied from the AC signal generating source to the input side of said active element. The center frequency of said parallel T circuit is varied in reference to the frequency of said AC signal by varying the intensity of said magnetic field, and the output to be supplied to a load is increased or decreased by varying said center frequency.

7 Claims, 12 Drawing Figures

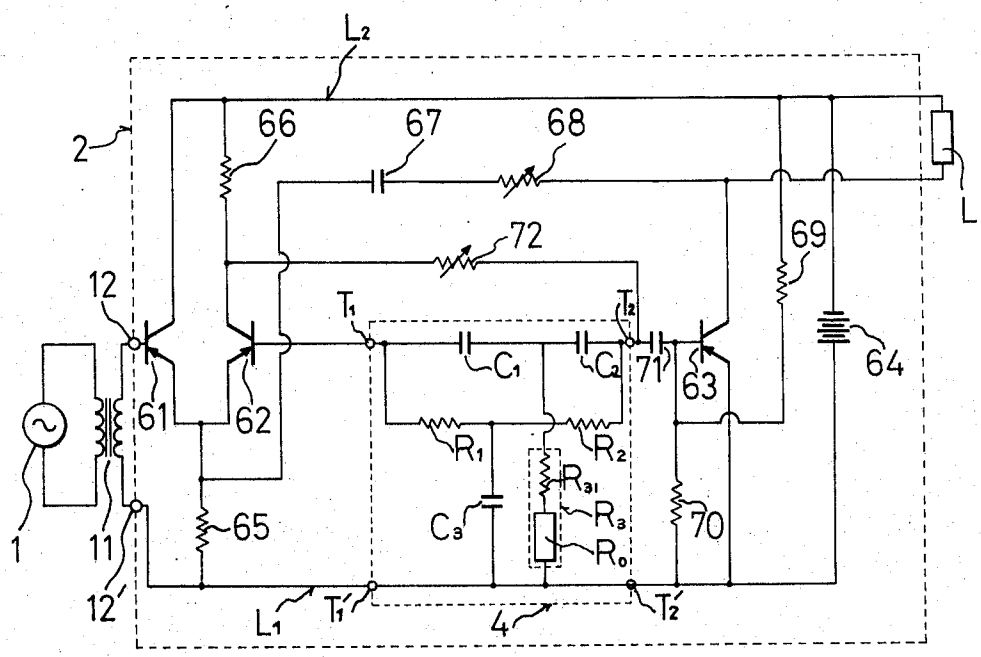


FIG1

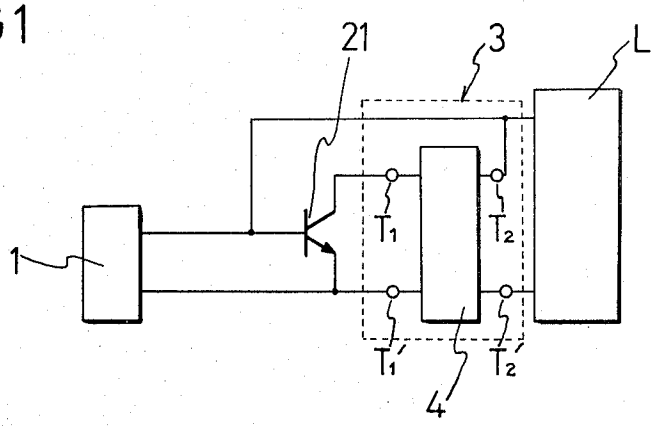


FIG2

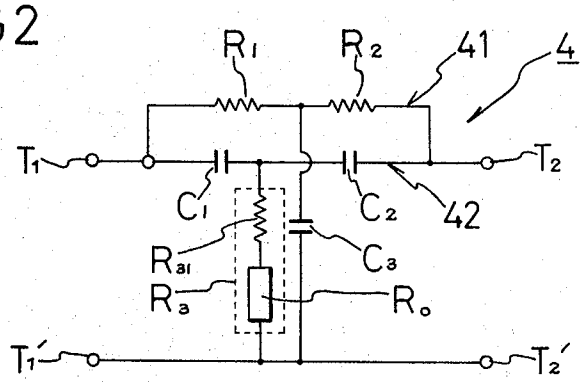


FIG6

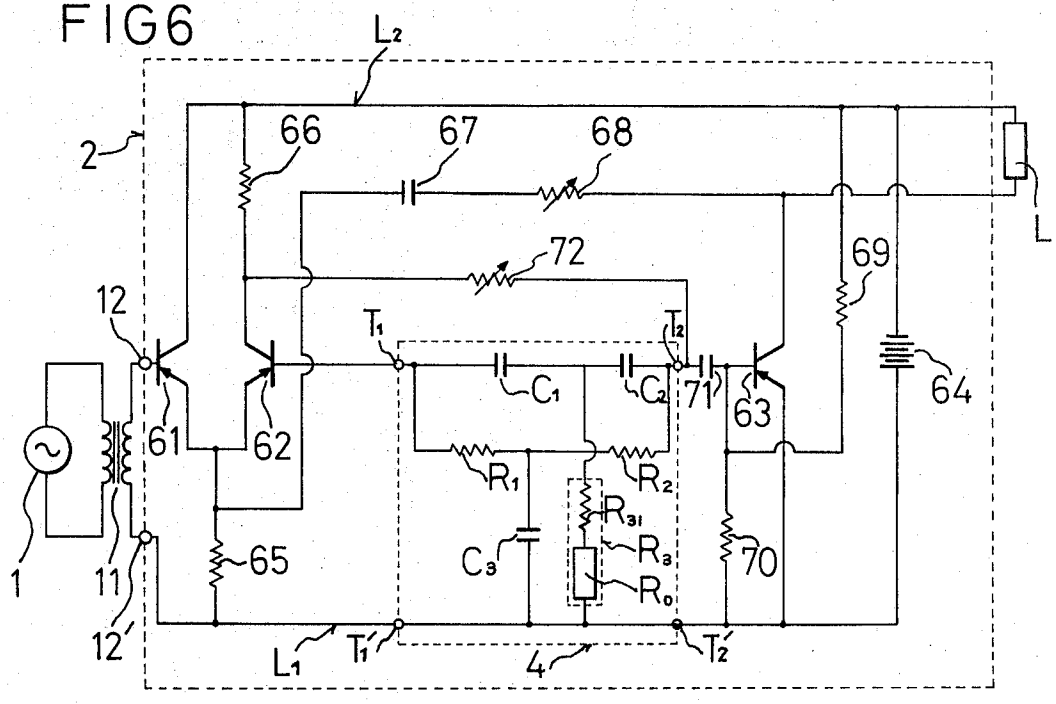


FIG3

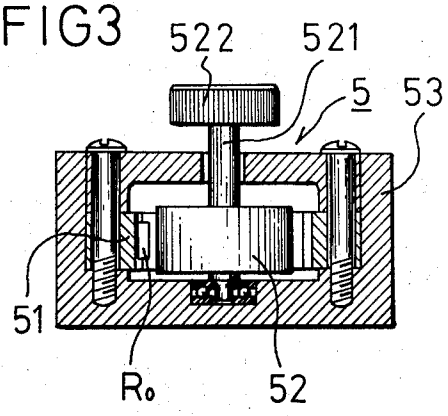


FIG7

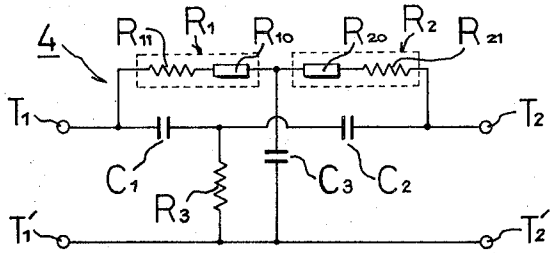


FIG4

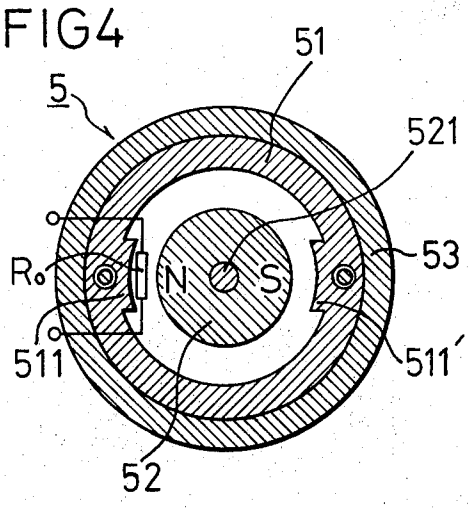


FIG8

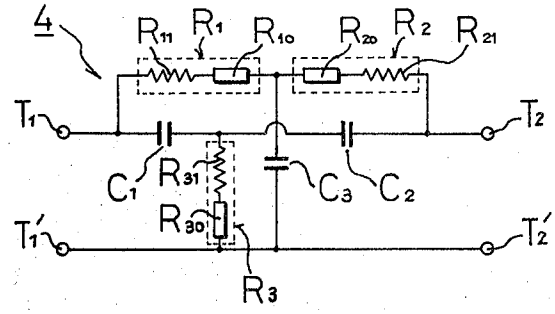


FIG5

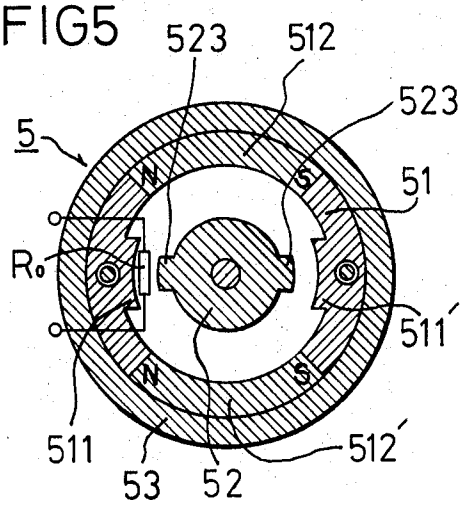


FIG9

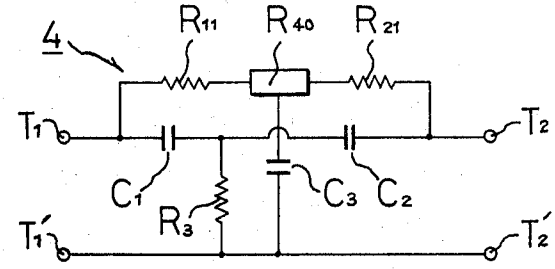


FIG10

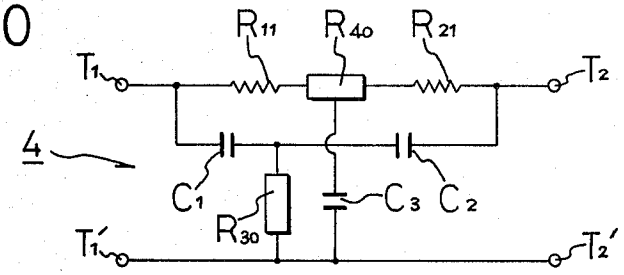


FIG11

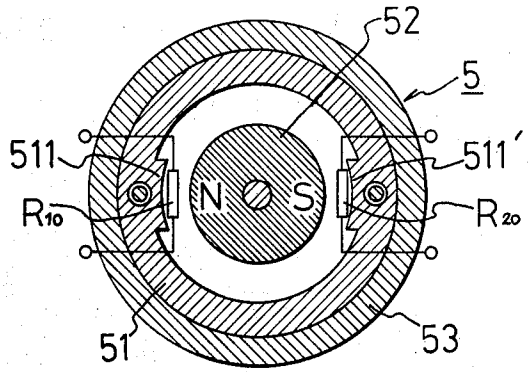
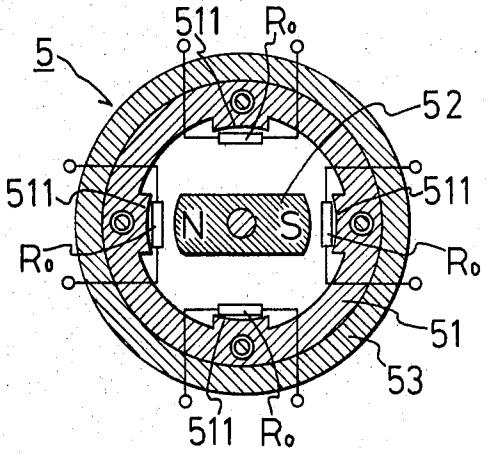


FIG12



GALVANO-MAGNETO EFFECT APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a galvano-magneto effect apparatus employing a galvano-magneto effect device the impedance of which varies with the intensity of a magnetic field to be applied.

Recently, various types of contactless switches have been developed as the galvano-magneto effect apparatus of this type. These switches employ said galvano-magneto effect device as the bias resistor of the switching element such as, for example, the transistor.

The present invention provides a galvano-magneto effect apparatus which can be employed as the switching apparatus, utilizing that the frequency response of the CR circuit varies with variation of the resistance value of the galvano-magneto effect device.

SUMMARY

A galvano-magneto effect apparatus (hereafter referred to as the "apparatus") comprises: a signal generating source which generates an AC signal; at least one active element such as, for example, a transistor to which said AC signal is supplied at its input side; a feedback circuit including of a parallel T circuit has a pair of input terminals and a pair of output terminals one of which is short-circuited to one of said input terminals, two resistors which are series-connected across the input terminal and output terminal which are not short-circuited, a capacitor which is connected between the connecting point of both resistors and said terminals which are short-circuited, two capacitors and which are series-connected so that these series-connected capacitors are connected in parallel with the series resistors and a third resistor, which is connected between the connecting point of the two capacitors and said terminals which are short-circuited at least one of said resistors is formed with a magnetism sensing element such as, for example, a magneto resistance effect device the resistance of which is varied with the intensity of the magnetic field to be applied. The output of said active element is supplied to the input terminal of said parallel T circuit and the output of the parallel T circuit is positive-fed back to the input side of the active element the apparatus further includes a magnetism applying means such as a mechanism which is provided with a rotary yoke made of a magnet and a fixed yoke made of a magnetic material at a position opposed to said rotary yoke so that the magnetic field is applied to said magnetism sensing element at a specified rotation angle of the rotary yoke, the center frequency of said parallel T circuit is varied by varying the intensity of the magnetic field applied to the magnetism sensing element and the output of the entire apparatus is increased or decreased by varying said center frequency.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated in detail by the accompanying drawings wherein.

FIG. **1** is a block diagram illustrating the outline of the apparatus according to the present invention,

FIG. **2** is a connection diagram illustrating the parallel T circuit to be employed in the apparatus of the present invention,

FIGS. **3** and **4** show an embodiment of a magnetism applying means to be employed in the apparatus, and FIG. **3** is a cross sectional front view as seen along line Y—Y in FIG. **4** and FIG. **4** is a cross sectional plan view as seen along line X—X in FIG. **3**.

FIGS. **5, 11** and **12** are respectively cross sectional plan views of another embodiment of said magnetism applying means,

FIG. **6** is a circuit connection diagram of the embodiment of the apparatus according to the present invention, and

FIGS. **7** to **10** are connection diagrams of another embodiment of parallel T circuit.

DETAILED DESCRIPTION

Referring to FIG. **1**, there is shown a block diagram of the apparatus according to the present invention.

Signal generator **1** generates an AC signal of a specified frequency and the output of this signal generator is supplied to the input side of the active element such as, for example, transistor **21.**

The output from the collector of said transistor is positively fed back to the base by feedback circuit **3.**

Said feedback circuit **3** comprises of parallel T circuit **4** consisting of resistors and capacitors and is provided with a pair of input terminals T_1 and T_1' and a pair of output terminals T_2 and T_2'. Input terminal T_1 of the parallel T circuit is connected to the collector of the transistor, input terminal T_1' to the emitter of the transistor, and output terminal T_2 to the base of the transistor.

Load L is connected to the output side, that is, output terminals T_2 and T_2' of the parallel T circuit **4.**

Referring to FIG. **2,** there is an embodiment of parallel T circuit **4.** Two T circuits, that is, T circuit **41** consisting of series-connected resistors R_1 and R_2 and capacitor C_3 series-connected to one of these resistors and T circuit **42** consisting of series-connected capacitors C_1 and C_2 and resistor R_3 series-connected to one of these capacitors are parallel-connected so that the circuit of series-connected resistors R_1 and R_2 and the circuit of series-connected capacitors C_1 and C_2 are parallel-connected, thus forming the parallel T circuit.

Resistor R_3 is made up by series-connecting fixed resistor R_{31} and a magnetism sensing element such as, for example, magneto resistance effect device R_0 the impedance of which varies with variation of the intensity of the magnetic field. Furthermore, resistance value r_3 of resistor R_3 is set so that it becomes equal to the sum of the resistance values of resistors R_1 and R_2 when a specified intensity of the magnetic field is applied to device R_0 by the magnetism applying means.

Magnetism applying means **5** is designed such that projections **511** and **511'** which are opposed each other are provided at the inside surface of circular fixed yoke **51** fixed in outer frame **53.** Device R_0 is provided at the surface of one of projections and moving yoke **52** which is formed as a disc and radially magnetized is housed in the space in fixed yoke **51** so that its poles S and N are respectively opposed to projections **511** and **511'**, as shown in FIGS. **3** and **4.**

Shaft **521** is fixed coaxially passing through moving yoke **52.** The lower end of shaft **521** is rotatably secured at the bottom of outer frame **53** which covers said fixed yoke and the upper end is projected outside fixed yoke **51** to form knob **522.** In the magnetism ap-

plying means thus constructed, magnet 52 is rotated by manually rotating knob 522, the positions of magnetic poles S and N vary in reference to projections 511 and 511' to open or close the magnetic path, thus varying the intensity of magnetic field applied to device R_0.

As shown in FIG. 5, both sides surrounding both projections 511 and 511' of fixed yoke 51 are formed with permanent magnets 512 and 512' the same magnetic poles of which are respectively opposed while moving yoke 52 is formed with a magnetic material which is not magnetized, and a plural number of projections 523 can be radially provided at the side edge of moving yoke 52 so that said projections are opposed to projections 511 and 511' of fixed yoke 51.

The closed magnetic path is formed when projection 523 of the moving yoke is opposed to projection 511 of the fixed yoke and a strong magnetic field is applied to device R_0.

As known, the center frequency of the parallel T circuit is determined by the resistance value of the resistors and the capacity value of capacitors. If the resistance value of resistor R_1 is r_1, that of resistor R_2 is r_2, that of resistor R_3 is r_3, the capacity value of capacity C_1 is c_1, that of capacitor C_2 is c_2 and that of capacitor C_3 is c_3, the filtering selectivity becomes highest in the relations denoted by $r_1=r_2=r_3/2$ and $c_1=c_2=2c_3$. In this case, center frequency fo is given below as known.

$$fo=1/2\pi r_1 c_1$$

According, if said capacitors and resistors are set to the values described above and an AC signal from signal generator 1 is not applied to transistor 21, transistor 21 the output of which is positively fed back by feedback circuit 3 having parallel T circuit 4 generates a signal of frequency fo. If resistance value r_0 of magneto resistance effect device R_0 is varied by varying the intensity of magnetic field applied to device R_0 and resistance value r_3 of resistor R_3 is consequently varied, the oscillation frequency varies, and thus the output attenuates.

Actually, signal S of frequency fs from signal generator 1 is applied to said transistor 21 and the output voltage and current to be supplied to load L become the maximum when frequency fs and oscillation frequency fo coincide, whereby the output voltage and current is greatly reduced when the center frequency fo is varied from the above condition. Accordingly, if the apparatus is set in advance so that the components of the parallel T circuit satisfy said relative equation and center frequency fo coincides with signal frequency fs of signal generator 1 when the specified intensity of magnetic field is applied to device R_0 by the magnetism applying means and the intensity of magnetic field is varied by operating magnetism applying means 5, the output voltage and current supplied to load L suddenly increase when the intensity of magnetic field reaches said specified level and suddenly decrease when the intensity of magnetic field varies from the specified level, thus performing the switching.

Referring to FIG. 6, there is shown the circuit diagram illustrating an embodiment of the apparatus of the present invention.

The output of AC signal generator 1 is applied to the primary coil of transformer 11 and the input side of oscillation circuit 2 is connected to secondary coil terminals 12 and 12' of transformer 11.

Oscillation circuit 2 corresponds to transistor 21 and feedback circuit 3 and is comprised of a pair of parallel-connected transistors 61 and 62, transistor 63, parallel T circuit 4 connected between the bases of both transistors 62 and 63, positive and negative feedback circuits from transistor 63 to transistor 62 and DC power supply 64.

Secondary terminal 12' of transformer 11 is connected to the positive electrode of DC power supply 64 by common line L_1 the other secondary terminal 12 is connected to the base of transistor 61, and the collector of transistor 61 is connected to the negative electrode of DC power supply 64 by common line L_2.

The emitters of transistors 61 and 62 are connected each other and are connected to common line L_1 through bias resistor 65 and the collector of transistor 62 is connected to common line L_2 through resistor 66. The emitters of mutually connected transistors 61 and 62 are connected to the collector of transistor 63 through the series circuit of variable resistor 68 and capacitor 67, whereby the series circuit forms the negative feedback circuit from transistor 63 to transistor 62. Furthermore, the base of transistor 63 is connected to common line L_2 through bias resistor 69 and to common line L_1 through bias resistor 70 and the emitter of transistor 63 is directly connected to common line L_1. The series circuit consisting of said parallel T circuit 4 and capacitor 71 are connected between the bases of transistors 62 and 63 and variable resistor 72 is connected between the connecting point of parallel T circuit 4 and capacitor 71 and the collector of transistor 62. Variable resistor 72 forms the positive feedback circuit from transistor 63 to transistor 62.

In this embodiment, parallel T circuit 4 is the same as shown in FIG. 2. Series capacitors C_1 and C_2 and series resistors R_1 and R_2 are parallel-connected between transistor 62 and capacitor 71. The sides of capacitor C_3 and resistor R_3 which are not connected to said both resistors and capacitors are connected to common line L_1.

As described above, resistor R_3 is the series resistor of magneto resistance effect device R_0 and fixed resistor R_{31} and device R_0 is built in magnetism applying means 5. In other words, the intensity of magnetic field is varied by rotating the moving yoke.

Load L is connected between common line L_2, at the negative pole side of the DC power supply; and the colllector of transistor 63.

The circuit of the embodiment shown in FIG. 6 functions as described below. When moving yoke 52 is in a position shown in FIG. 4, that is, a position where the magnetic pole of moving yoke 52 is opposed to device R_0, the maximum intensity of magnetic field is applied to device R_0 and therefore device R_0 provides a large resistance corresponding to the intensity of magnetic field.

It is assumed that the resistance value when the resistance of device R_0 is maximum is r_0, the sum of resistance value r_0 and resistance value r_{31} of fixed resistor R_{31}, that is, resistance value r_3 of resistor R_3 is set as $r_1=r_2=r_3/2$, the capacitors are set so as to satisfy the relations of $c_1=c_2=2c_3$ with respect to the capacity, and the components of parallel T circuit 4 are set so that center frequency fo is equal to signal frequency fs of signal generator 1.

If signal S is supplied from signal generator 1 to transformer 11, the alternating signal corresponding to sig-

nal S is applied to the base of transistor **61** through the secondary side of transformer **11.** When the base of transistor **61** is negatively biased by this alternating signal, transistor **61** turns on and the current from DC power supply **64** flows through resistor **65** and the emitter and collector of transistor **61.**

This current accompanies the voltage across both ends of resistor **65,** transistor **62** connected to resistor **65** turns off and, the collector potential drops, a negative voltage is applied to the base of transistor **63** and transistor **63** turns on. Furthermore, because the collector potential of transistor **63** rises, the voltage is applied to the emitter of transistor **62** through variable resistor **68** and capacitor **67,** thereby transistor **62** is turns on and transistor **61** permits a larger current to pass while the collector potential of transistor **62** is applied to the base of transistor **63.**

Under this condition, the positive voltage from signal generator **1** is applied to the base of transistor **61** and therefore transistor **61** turns on and transistor **62** turns on. When the positive potential occurs at the collector of transistor **62,** this potential is applied to the bases of transistors **62** and **63,** transistor **63** turns on the collector potential of transistor **63** drops. The drop of this collector potential causes the emitter potential of transistors **61** and **62** to drop and causes transistors **61** to turn on transistor **62** to turn off.

At this stage, the subsequent negative signal is applied to the base of transistor **61** and accordingly, the circuit repeats said functioning. Because load L is connected to the collector of transistor **63,** the current flows in the load when the negative voltage is applied to the base of transistor **61** and the value of this current is controlled by the parallel T circuit as the filter. In other words, the output current of oscillation circuit **2** is extremely large when the center frequency of the parallel T circuit between the base of transistor **62** and transistor **63,** that is, oscillation frequency *fo* of oscillation circuit **2** is synchronized with signal frequency *fs* of signal generator **1** and the current supplied to the base of transistor **63** is extremely low when center frequency *fo* is varied from signal frequency *fs.* Moreover, the resistance across the emitter and collector of transistor **63** approximates the maximum and the current flowing in load L through transistor **63** is extremely small.

If the intensity of magnetic field applied to device R_0 is reduced by turning moving yoke **52** from the position shown in FIG. **4,** the resistance of device R_0 is lowered, the center frequency is varied, the circuit constant is unbalanced and the output to input ratio of the filter is thereby reduced.

Accordingly, the current applied to load L is reduced and therefore the switching operation for load L can be performed. While the maximum intensity of magnetic field is applied to device R_0, the resistance value of device R_0 need not satisfy the balancing condition of the parallel T circuit. For example, the apparatus can be designed to satisfy the balancing condition of the parallel T circuit when the intensity of magnetic field applied to device R_0 is minimum, that is, device R_0 has the minimum resistance value.

Any one of resistors R_1, R_2 and R_3 of parallel T circuit **4** can be formed with device R_0 and a plural number of resistors can be formed with the devices.

As shown in FIG. **7,** for example, resistor R_1 can be formed with the series resistor consisting of devices R_{10} and fixed resistor R_{11} and resistor R_2 can be formed with the series resistor consisting of devices R_{20} and fixed resistor R_{21}. And a fixed resistor can be used as resistor R_3.

As shown in FIG. **8,** resistors R_1 and R_2 can be respectively formed with combination of the devices and fixed resistors and resistor R_3 can be formed with the series resistor consisting of device R_{30} and fixed resistor R_{31}.

As shown in FIG. **9,** resistors R_1 and R_2 are made using device R_{40} with three terminals and capacitor C_3 can be connected to intermediate terminal **81.** When device R_{40} with three terminals is employed, resistor R_3 can be formed with device R_{30} as shown in FIG. **10.**

Each resistor need not be combined with the fixed resistor and can be formed with a single device.

In cases described above, the component values of each resistor and capacitor are set so that the above-mentioned balancing condition is satisfied when the specified intensity of magnetic field is applied to the device.

As shown in FIG. **7,** if two devices are employed in the parallel T circuit, the devices can be provided at both end surfaces of both projections **511** and **511'** of fixed yoke **51** of magnetism applying means **5** as shown in FIG. **11.** When more than three devices are employed, the magnetism applying means can be constructed as described above.

Said magnetism applying means is made up by modifying the mechanism shown in FIG. **4.** As shown in FIG. **12,** many projections **511** are provided at the internal surface of fixed yoke **51** along the circumferential direction, each projection is provided with magnetism sensing device R_0 and each of devices is provided with respective circuit shown in FIG. **6.** Thus, the magnetism is applied to the devices in sequence along with rotation of moving yoke **52** and the output is applied to many loads in sequence; accordingly, one rotary switching mechanism can be employed as the mechanism which permits continuous switching.

The apparatus according to the present invention can be used as a contactless switching apparatus. It is useful for various types of electronic equipment.

What is claimed is:

1. A galvano-magneto effect apparatus comprising

a. a signal generating source which generates AC signals,

b. at least one active element coupled to said AC signal source,

c. a feedback circuit having a parallel T circuit comprising

1. a pair of input terminals,

2. a pair of output terminals one of which is short-circuited to one of said input terminals,

3. first and second resistors which are series-connected between the input terminal and output terminal which are not short-circuited,

4. a first capacitor which is connected between said short-circuited terminals and the connecting point between said first and second resistors,

5. second and third capacitors which are series-connected said series-connected capacitors being parallel-connected with said first and second resistors, and

6. resistance means connected between said second and third capacitors and said short-circuited terminals, said resistance means including a mag-

netism sensing means the resistance of which is varied in accordance with the intensity of a magnetic field applied thereto wherein the output of said active element is applied to the input terminal of said parallel T circuit and the output of said parallel T circuit is positively fed back to the input of said active element, and

d. a magnetism applying means for applying the magnetic field to said magnetism sensing means, wherein the magnetic field applied to said magnetism sensing means is varied by said magnetism applying means thereby varying the center frequency of the parallel T circuit whereby the output of the entire apparatus is varied.

2. An apparatus according to claim **1,** wherein said parallel T circuit is adjusted such that, when a predetermined magnetic field is applied to said magnetism sensing means, the resistance of said resistance means is equal to two times the resistance value of said first resistor, the capacity of said second and third capacitors are equal and the capacity of said first capacitor is equal to 1/2 the capacity of the second capacitor, and the center frequency of said parallel T circuit coincides with the signal frequency of the AC signal generating source, wherein said center frequency is varied in reference to the frequency of said AC signal by varying the intensity of the magnetic field applied to said magnetism sensing means thereby varying the output of the entire apparatus.

3. An apparatus according to claim **2,** wherein the center frequency of said parallel T circuit coincides with the frequency of a signal generated from said AC signal generating source when the intensity of magnetic field applied to said magnetism sensing means is maximum.

4. An apparatus according to claim **2,** wherein the center frequency of said parallel T circuit coincides with the frequency of a signal generated from said AC signal generating source when the intensity of magnetic field applied to said magnetism sensing means is minimum.

5. An apparatus according to claim **1,** wherein said magnetism applying means comprises a rotary yoke of a magnetic material and a fixed yoke opposite said rotary yoke, wherein at least one of said yokes is a magnet configured such that a magnetic path is formed between both said yokes when said rotary yoke is positioned at a specified rotation angle, wherein the magnetic flux applied to said magnetism sensing means is varied by rotating said rotary yoke.

6. An apparatus according to claim **5,** wherein said rotary yoke comprises a magnet.

7. An apparatus according to claim **5,** wherein said fixed yoke comprises a magnet.

* * * * *