Jan. 10, 1967 R. J. MULLIGAN ET AL 3,297,940

MEANS FOR REPRODUCING A PATTERN AS A D.C. OUTPUT

Filed June 1, 1962 2 Sheets-Sheet 1

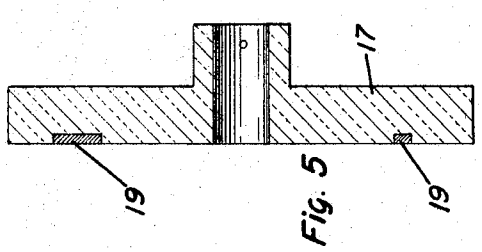


Fig. 5

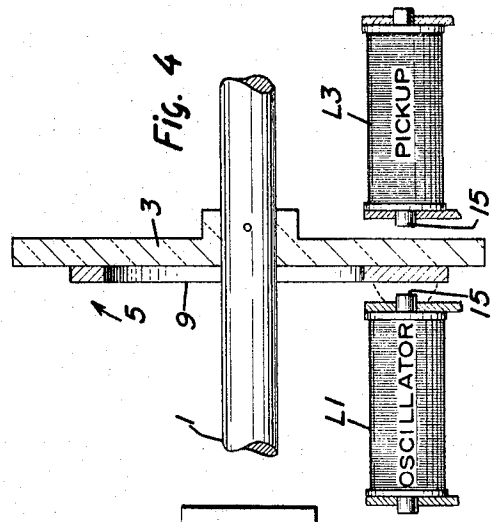


Fig. 4

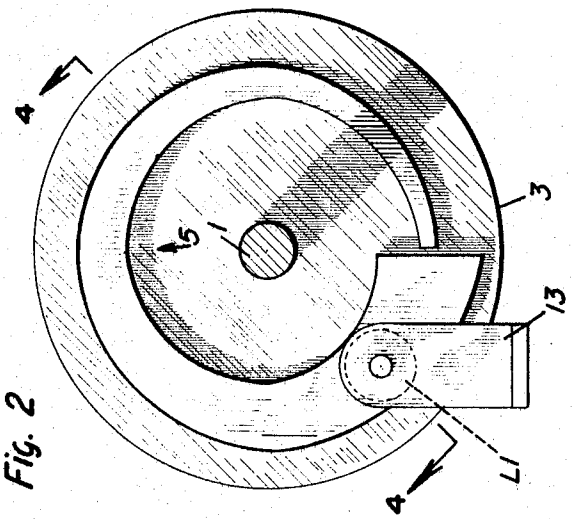


Fig. 2

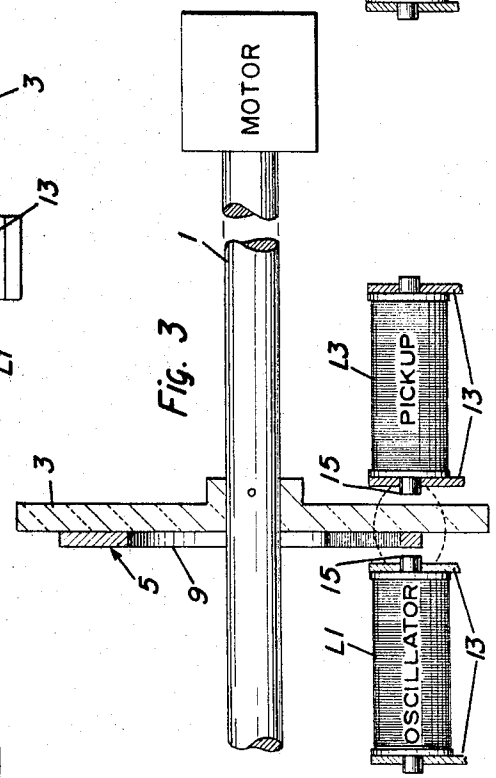


Fig. 3

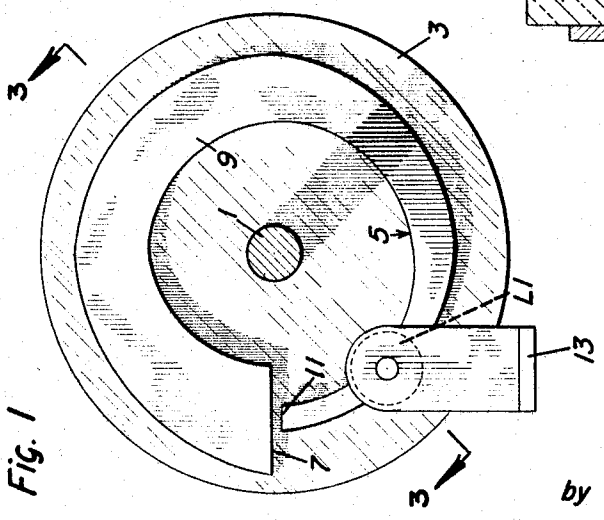


Fig. 1

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Jan. 10, 1967 R. J. MULLIGAN ET AL 3,297,940

MEANS FOR REPRODUCING A PATTERN AS A D.C. OUTPUT

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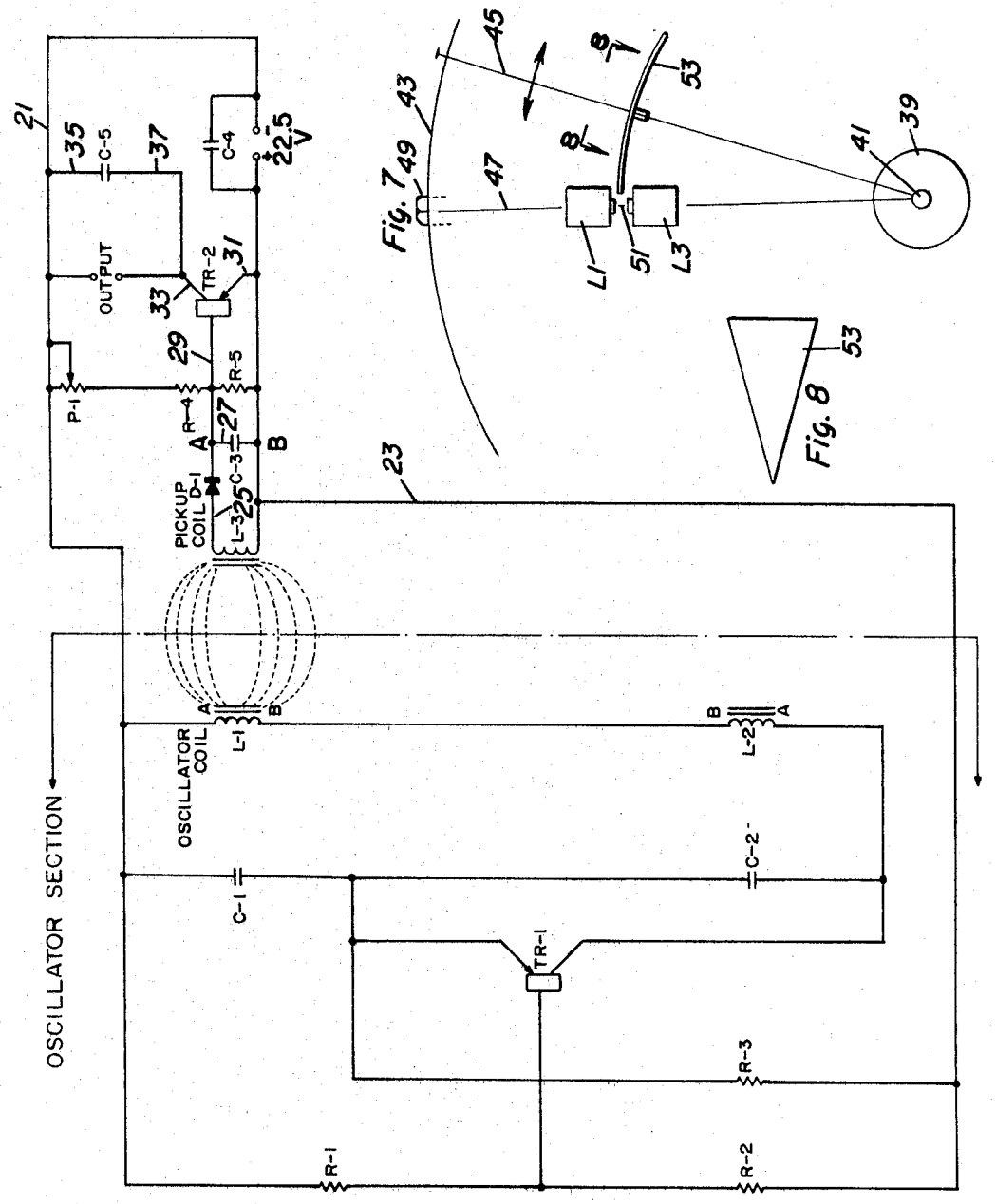


Fig. 6

Fig. 7

Fig. 8

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MEANS FOR REPRODUCING A PATTERN AS A D.C. OUTPUT

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This invention relates broadly to the potentiometer art, and in its more specific aspects it relates to a potentiometer which eliminates the need for a contact slider which moves across and in contact with the conventional turns of wire; and the nature and objects of the invention will be readily recognized and understood by those skilled in the art to which it relates in the light of the following explanation and detailed description of the accompanying drawings illustrating what we at present believe to be the preferred embodiment or mechanical expressions of our invention from among various other forms, arrangements, combinations and constructions, of which the invention is capable within the spirit and scope thereof.

The useful life and speed of conventional potentiometers are limited because of the mechanical action of the sliding contact which is customarily on a fixed mount and travels back and forth over and in engagement with the turns of wire. This sliding action of the contact slider, even though there exists only slight engaging pressures between the contact slider and the turns of wire, does cause wear which leads to malfunctioning of the device, and this is especially true in the case of a continually moving potentiometer where the potentiometer will turn out to be the weakest link in the system in which it is a component.

A further disadvantage flowing from the inherent design of conventional sliding contact potentiometers appears when a load is applied across the output terminals and the potentiometer ceases to be a linear device but becomes non-linear.

In potentiometers of the usual types of the prior art only the most basic types of output with shaft rotation are possible, such as straight line, slightly non-linear or the very costly sine-cosine types.

A further disadvantageous characteristic of sliding contact potentiometers is that in order to obtain infinite resolution it is necessary to use only one turn of wire and it will be recognized that this severely limits the number of ohms it is possible to attain.

We are aware that an attempt has heretofore been made to produce an apparatus of this character based on an entirely dissimilar operating concept than the one which we have developed. This prior device employed an optical-electronic wiper so that a movable light beam defined a highly conductive path between the resistive track and collector. The success of this device or its practical usefulness is doubtful since the light bulb has a questionable life and is the weak link in such a proposal. Also it should be noted that in this former development substantial difficulties are encountered in the process of manufacturing and preparing the semi-conductor substrate which will be optically sensitive.

Our invention overcomes and eliminates the above mentioned and other disadvantages of contact and other former types of potentiometers and has been designed to provide an apparatus based on unique principles involving the simplest manufacturing techniques with the resultant device endowed with a high life expectancy and with great versatility.

This invention does not employ a contact slider and is thus not subject to the undesirable and wearing contact action of the conventional contact slider form of potentiometer, nor does our potentiometer employ a light bulb which is of doubtful life expectance. Instead, we have devised an apparatus without contacting components or a light beam and one which operates generally on the principle of selective absorption of varying amounts of electromagnetic energy with the purpose in view of varying the amount of energy, or preventing entirely the passage of energy, from an oscillator coil to a spaced pick-up coil. These functions are obtained by providing the pair of spaced coils and a specially configured shield of non-magnetic metallic material which is placed between the coils and due to its shape and movement functions to prevent passage of energy from the oscillator coil to the pick-up coil, or, dependent upon its relative position with respect to the coils, permits transfer of energy in varying amounts from the oscillator coil to the pick-up coil. It is known that if a shield of non-magnetic metallic material is placed between two coils with hypernik cores and one coil is oscillating at, say, 85 kilocycles, the shielding effect of the non-magnetic metallic material will be to absorb the electromagnetic energy present in the form of eddy currents and prevent said energy from passing to the opposite core. When the shield is removed from position between the two coils, the energy will then pass and be transferred to the pick-up coil.

As we have mentioned above, the shield not only prevents the flow of energy from the oscillator coil to the pick-up coil, but by shaping the shield of non-magnetic metallic material in any desired configuration and moving it relative to the coils, varying amounts of energy are transferred from one coil to the opposite coil. The particularly shaped shield, comprising a pattern, in one form of our invention, is motor driven and revolves between the coils, thereby presenting all sections of the shaped shield in the critical area between the coils so that these different sections when in the critical area will determine the amount of electromagnetic energy passing from the oscillator coil to the pick-up coil.

Thus, all types of outputs may be obtained by our apparatus by changing the shape or configuration of the shield. For instance, we may configure a shield which will produce a linear output, and in this connection it should be noted that most potentiometers are limited to 330° travel in which case a linear output could be obtained by providing a stop at 330°. In our construction which is particularly well adapted for motor drive, no stop is required and the shield may continue its function revolution after revolution, clockwise or counterclockwise, with no mechanical restrictions or undesirable results from such mechanical restrictions. It will be understood that where our invention involves a continuously driven device, the contactless feature of the potentiometer is of substantial significance.

While our invention may be successfully and usefully used where the shield is mounted on a shaft and is continuously rotated, it is within our contemplation and clearly within the scope of this invention to arrange the shielding means on other movable elements which need not be rotating elements or shafts. For instance, the shielding means may be mounted on the moving coil element of a D'Arsonval meter for movement therewith between an oscillator and a pick-up coil. In such an organization a feeble input to the moving coil will result in a proportional output of much higher magnitude than the input signal. This would provide indication of the input signal and control by proportional output. This provides a highly desirable device which has not heretofore been available.

Our invention is simple and economical to produce, is endowed with long life expectancy characteristics. It eliminates contacts, is still linear regardless of load, is

capable of innumerable combinations of outputs versus shaft rotation and provides infinite resolution automatically by its design.

With the foregoing general objects, features and results in view, as well as certain others which will be apparent from the following explanation, the invention consists in certain novel features in design, construction, mounting and combination of elements, as will be more fully and particularly referred to and specified hereinafter.

Referring to the accompanying drawings:

FIG. 1 is a front elevational view of our apparatus with the shaft at one point in its revolution positioning a particular section of the shaped shield in the critical area between the coils.

FIG. 2 is a view similar to FIG. 1 but with shaft at a different point in its revolution positioning a further section of the shaped shield in the critical area between the coils.

FIG. 3 is a view taken on line 3—3 of FIG. 1.

FIG. 4 is a view taken on line 4—4 of FIG. 2.

FIG. 5 is a vertical sectional view of a further form of shielding means which we may use in our apparatus for reproducing a pattern as a D.C. output.

FIG. 6 is a diagram of a circuit which may be used with our apparatus.

FIG. 7 is a diagrammatic view of our structural concept incorporated in a D'Arsonval meter.

FIG. 8 is a view taken on line 8—8 of FIG. 7.

In the accompanying drawings, and particularly in FIGS. 1 through 4 thereof, we have illustrated a preferred form of our invention which includes a shaft **1** which is adapted to be motor driven, as shown in FIG. 3, to revolve continuously either clockwise or counterclockwise. Fixed in any suitable manner to the shaft **1** for rotation therewith is a disc **3** which is formed of an electrically transparent material such as glass melamine.

As will become apparent as this description proceeds, the shaped shielding means which we have discussed generally above is fixed to the disc **3** for rotation therewith. We have used the numeral **5** to designate in its entirety the shaped shield which is formed of a non-magnetic metallic material, and is fixed by any suitable means, such as by adhesive to the disc. In the example shown in the drawings merely for purposes of illustration, the shield is of curved configuration having what we shall term a wide end **7**, a body portion **9** and a narrow end **11**, the ends being slighlty spaced apart, and the shield forming substantially a full circle and constituting a continuous element from the wide end to the narrow end. The shield **5**, which is an example of one shape from among many which our shield may take, reduces uniformly in width from the wide end **7** to the narrow end **11** to provide a constantly decreasing width to the shielding body **9**.

We provide an oscillator coil L1 and a pick-up coil L3 which are mounted and supported in spaced relation by any suitable and convenient bracket arrangement **13**. As will be apparent from consideration of the drawings, the coils L1 and L3 include hypernik cores **15** which are directed toward each other since the coils L1 and L3 are co-planar. The shaft **1** is so mounted relative to the oscillator coil and the pick-up coil that the rotary disc **3** extends and rotates between said coils; and the shield **5** is so fixed on the disc that as the disc rotates, the shield, or some portion thereof, will extend between the coils, Thus, as the disc is revolved by rotation of the shaft, some portion of the shield will at all times be cutting through the projecting planes of the cores **15** of the coils L1 and L3. It will be understood from study of the drawings that the shield near the wider end **7** will absorb all of the electromagnetic energy emitted by the oscillator coil L1 so that none will be transferred to pick-up coil L3, while as the disc rotates and the shield becomes narrower, energy will be transferred to the pick-up coil in increasingly greater amounts. It will, of course, be appreciated that if the shaft is rotating in the opposite direction, energy will be transmitted from the oscillator coil to the pick-up coil in amounts which decrease uniformly.

This invention, it will now be recognized, accomplishes all that a conventional potentiometer achieves, yet it does not require a sliding contact or a light beam and revolves revolution after revolution without a stop as is normally required.

As we have pointed out, the shield **5** is formed of a non-magnetic metallic material which, when it is between the coils and completely shielding one coil from the other, absorbs the electromagnetic energy which is present into the form of eddy currents to thereby prevent the energy from passing to the opposite or pick-up coil. Now it is to be understood that it is our intention to permit varying amounts of energy to pass from the oscillator coil to the pick-up coil and this result we attain by the shape of the shield which is moved in the critical energy passing area between the spaced-apart opposed coils. The shape or configuration of the example shield **5** will provide a linear output. For instance, when the wide end of the shield is between the coils (see FIG. 4), no energy will be transferred, while as the disc and shield rotate to bring narrower portions of the shield into the critical area, some energy will pass and this amount of energy will be increased as the narrower sections of the shield move into the critical area between the coils.

While the example shield **5** disclosed in the drawings will provide a linear output regardless of load, it will now be clearly seen that all types of output will present themselves by merely changing the shape of the shield. For instance, if a series of shields are provided on the discs in our device, a type of square wave generator is provided which at slow speeds is practically impossible to accomplish by electronic means, and sine wave, pulse outputs, for example, may be produced with a minimum of effort.

In order to simplify manufacture and to provide uniformity it is within our contempltaion to use printed circuit discs instead of the shielding means which we have described above. By changing the art work of the printed circuit any variety of outputs are economically feasible.

In FIG. 5 of the drawings we have disclosed a disc **17** which is formed of an electrically transparent or dielectric material such as glass melamine and is adapted to be fixed to a shaft for rotation therewith in the manner of disc **3** previously described. The disc **17** is preferably, though not necessarily, grooved to receive therein a printed circuit type of shield **19** which may take any shape to provide a particular output. The printed circuit functions as a shield as does the shield **5** of FIGS. 1 through 4 and operates with the disc in the critical area between the oscillator coil and the pick-up coil, to prevent the passage of energy from one coil to the other or to permit the passage of varying amounts of electromagnetic energy to pass dependent upon the section of the printed circuit shield which is passing through the critical area.

In FIG. 6 of the drawings we have shown the electric circuit of the invention which we have devised which, in operation will require a 22½-volt power supply input. A load resistor, relay, etc. is placed across the output, and the current through the load will vary with the position of shaft **1** in view of the particular configuration of the shielding means **5**.

The oscillator section of the circuit is of the conventional Hartley oscillator type and supplies a constant 85 kilocycle frequency to coils L1 and L2, coil L2 being used only if more than one pick-up would be desirable. The oscillator circuit comprises resistors R_1, R_2, R_3, transistor TR1, condensers C_1 and C_2 and oscillator coils L1 and L2 which supply energy to the pick-up coils (one being shown in the drawings). Power is supplied to the oscillator circuit from input lines **21** and **23** which also power the circuit.

The control circuit is connected to the input leads **21**

and 23 and includes the pick-up coil L3 which is connected to rectifier D1 by conductor 25, the rectifier D1 being connected to capacitor C3 by conductor 27. Lead 29 connects a transistor TR2 between rectifier D1 and capacitor C3. Transistor TR2 is connected to input 23 by conductor 31 and to output by conductor 33. We provide a capacitor C5 which is connected by conductors 35 and 37 between transistor TR2 and input lead 21. Capacitor C4 which is connected across the input leads is employed as a by-pass. The circuit also includes a resistor network P1, R4 and R5 which is connected across input leads 21 and 23 and provides a negative bias to the transistor TR2 which puts the transistor in a highly conductive state. However, the positive potential at point A tends to counteract the negative bias and by means of P1 the transistor is set to a non-conducting state. When the shield 5 is placed between coils L1 and L3, the energy transferred to coil L3 is decreased and the positive potential available at point A decreases. The transistor now becomes negatively biased and the output increases in proportion to the amount of shielding between the coils. In other words, the proportionate increase in output is dependent upon the configuration of the shield and this proportion may be varied by changing the configuration of the shield.

It should be noted that to maintain proper linearity, the 22½-volt input should be regulated so that no change in input voltage will occur with increasing current in the output.

As we have stated above, this invention is not limited to potentiometers with shafts, but may be adapted for use with, for instance, a D'Arsonval meter.

In FIG. 7 we have diagrammatically disclosed one example of such an adaptation and have used the numeral 39 to designate a meter movement with 41 indicating the center thereof. The meter includes the usual scale 43 and the pointer 45, the end of which travels over the scale to give visual indications in the conventional manner. We provide a suitable set adjust arm 47, which is mounted to pivot about the center of the meter movement and at its outer end is provided with a knob or pointer 49 which extends over the scale and is accessible for manual adjustment to set the set adjust arm and the control area at the desired point.

Mounted on set adjust arm 47 are oscillator and pick-up coils L1 and L3, respectively, which are mounted in spaced relation forming a control area 51 therebetween.

We fixed to the pointer 45, in any suitable manner, for movement therewith a shaped shield 53 of non-magnetic metallic material, the shield being so positioned on the pointer that as the pointer swings, the shield will pass through the control area and its particular shape will control the amount of energy which will be transferred from the oscillator coil to the pick-up coil. Thus, the shield 53 functions in the manner of shield 5 in the form of my invention illustrated in FIGS. 1–4 of the drawings, so that the shape of the shield may be varied to vary the energy transfer.

It will now be appreciated that the invention disclosed herein provides a potentiometer which eliminates contacts and/or light beams, remains linear regardless of load, is capable of innumerable combinations of output versus

shaft rotation, and provides infinite resolution automatically by its design.

We claim:

1. Means for reproducing a pattern as a D.C. output, comprising an oscillator circuit including an oscillator coil, a pick-up coil positioned adjacent to said oscillator coil and linked thereto by an electromagnetic field, an electric circuit for said pick-up coil and a power source therefor, an elongated electromagnetic energy shielding means composed of a material absorbent to electromagnetic energy, a rotary shaft and means for continuously rotating said shaft, a disc fixed on said rotary shaft for rotation therewith in the area between said oscillator and pick-up coils, and said elongated electromagnetic energy shielding means being of varying widths and being fixed on said disc in position forming a generally circular outline thereon and in position to rotate through the area between the coils when said shaft is rotated, whereby varying amounts of electromagnetic energy will be transferred from the oscillator coil to the pick-up coil dependent upon the part of the elongated electromagnetic energy shielding means passing through the area between the coils.

2. Means for reproducing a pattern as a D.C. output, comprising in combination, an oscillator circuit including an oscillator coil, a pick-up coil positioned adjacent to said oscillator coil and linked thereto by an electromagnetic field, an electric circuit for said pick-up coil and a power source therefor, electromagnetic energy shielding means movable between said coils and being shaped for transfer of varying amounts of energy from the oscillator coil to the pick-up coil dependent upon the position of the shielding means relative to the coils, means for moving the shielding means between the coils, and said electric circuit for said pick-up coil including output control means, and said output control means comprising further means set to a non-conducting state changeable to a conducting state the output thereof increasing in proportion to the position of the shielding means relative to the coils.

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