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ASTABLE MULTIVIBRATOR WITH SATURABLE CORE TIMING CIRCUIT

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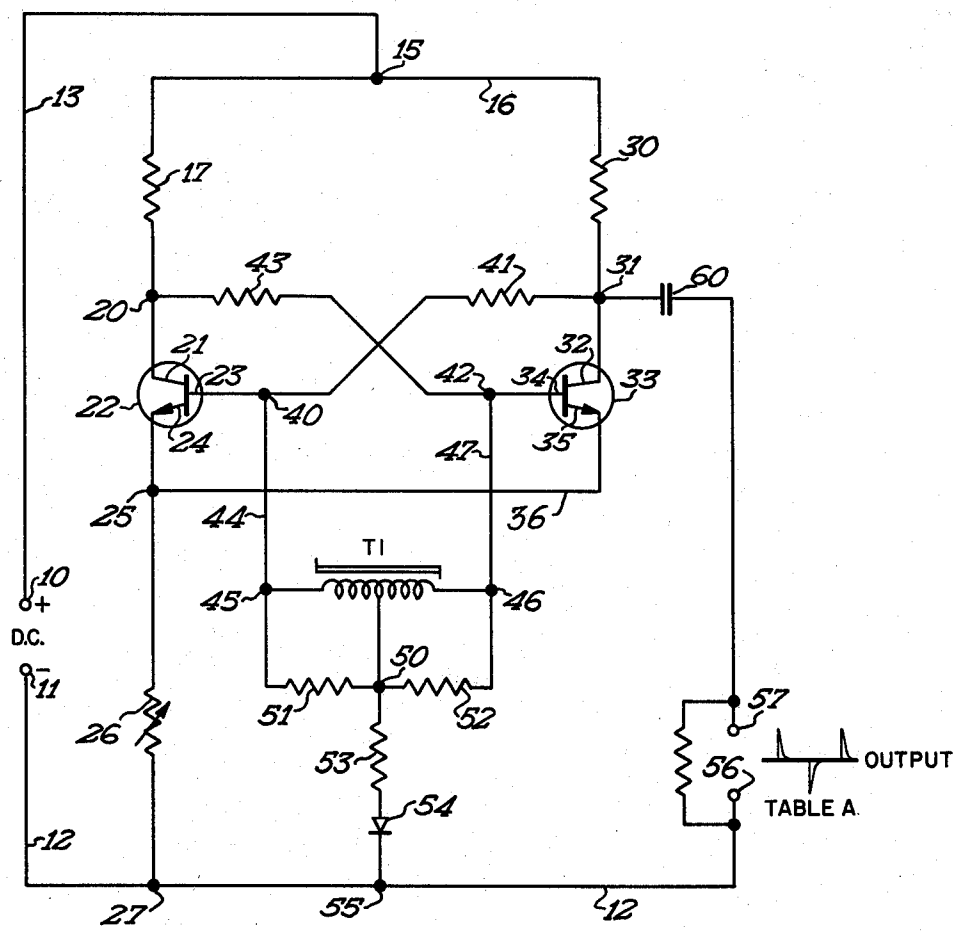

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ASTABLE MULTIVIBRATOR WITH SATURABLE CORE TIMING CIRCUIT

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This invention relates to a solid state precision timer oscillator and more specifically to a low frequency transistor-toroid timer oscillating circuit.

In prior art electronic timers using crystal time bases, the problem has always existed that the crystal may be destroyed by severe shock and prior art electronic timers using capacitive timing elements encounter drift when exposed to high temperatures and long shelf life. In the present invention a precision oscillator is obtained because of the use of a timing toroid which is unaffected by age, humidity or severe vibration and shock effects, and which does not store energy in its timing components whereby it will fail safe in the event of a power failure. This in contrast to capacitive timers that store energy in their timing elements and that often cause function prematurely in the event of a power failure. The solid state timer of this invention has no moving parts and being potted has withstood 4,000 G's. of shock without appreciable change in accuracy.

It is therefore an object of this invention to provide a precision solid state magnetic timing device oscillator adaptable for use at low frequencies.

This and other objects of the invention will become more apparent on a consideration of the specification, claim and drawing of which the single figure is a schematic diagram of a preferred embodiment of the invention.

Referring now to the drawing, a regulated direct current input is connected to a pair of terminals **10** and **11** with a terminal **10** being positive with respect to terminal **11**. Terminal **11** is connected to a common negative conductor **12** and terminal **10** is connected by a conductor **13** to a junction **15** on the conductor **16**. The conductor **16** is connected through a load resistor **17** and a junction **20** to a collector electrode **21** of a npn transistor **22**. Transistor **22** also includes a base electrode **23** and an emitter electrode **24**. The emitter electrode **24** is connected by a junction **25** and an emitter resistor **26** to a junction **27** on the negative conductor **12**.

Conductor **16** is also connected through a load resistor **30** and a junction **31** to a collector electrode **32** of a npn transistor **33**, which transistor also includes a base electrode **34** and an emitter electrode **35**. The emitter electrode **35** is connected by a conductor **36** to the junction **25**.

Base electrode **23** of transistor **22** is connected by a junction **40** and a cross coupling resistor **41** to the junction **31** and thereby to collector electrode **32**. Similarly, base electrode **34** of transistor **33** is connected by a junction **42** and a cross coupling resistor **43** to the junction **20** and thereby to collector electrode **21**.

A saturable core inductance or timing toroid, which has a substantially rectangular hysteresis loop, interconnects the base electrodes of the two transistors. The circuit may be traced from the junction **40** at base **23** through a conductor **44**, a junction **45**, through the timing toroid **T1** to a junction **46** and through a conductor **47** to the junction **42** at base **34**. A mid tap connection on the timing toroid **T1** connects to a junction **50**. Connected between the junctions **45** and **50** is a resistor **51** and similarly connected between the junction **46** and junction **50** is a resistor **52**. Junction **50** is connected

through a low impedance resistor **53** and a rectifying diode **54** to a junction **55** on the conductor **12**. A pair of output terminals **56** and **57** are connected respectively to the conductor **12** and **57** is connected through a coupling capacitor **60** to the junction **31**.

In considering the operation of the circuit generally, the time it takes the toroid **T1** to saturate serves as the time base. One cycle of operation of the circuit is explained below. Assuming initially that transistor **33** is conductive or "on" and transistor **22** is "off," one-half of the circuit conducts current from terminal **10** through conductors **13** and **16**, resistor **30**, transistor **33** from collector **32** to emitter **35**, and through common emitter resistor **26** to the negative conductor **12**.

During this time current also flows through resistors **17** and **43**, junction **42**, conductor **47**, from junction **46** through the toroid to the mid tap of toroid **T1** and through resistor **53** and diode **54** to conductor **12**. Little or substantially no current flows through the remaining portions of the toroid winding. The induced opposite phase voltage in the remaining portion of the winding opposes current flow therethrough and also aids in maintaining transistor **22** "off." The conduction through the right hand portion of toroid **T1** is small and slowly drives the toroid towards saturation. It will be noted that the right hand portion of the toroid and resistors **53** together with diode **54** are in parallel with the base-emitter circuit of "on" transistor **33** and provide base current potential therefor.

When the toroid core reaches flux saturation, the impedance of the toroid is reduced, reducing the base bias voltage of transistor **33**. The reduced bias of transistor **33** tends to cut off the conduction thereof and the resultant voltage increase at collector **32** and junction **31** provides a positive potential through resistor **41** to base **23** to render transistor **22** conductive. The cross coupling causes a switching action to occur very rapidly, thereby initiating the second half cycle of oscillation by turning transistor **22** on and **23** off.

A current path may now be traced from terminal **10** through conductors **13** and **16**, resistor **17**, transistor **22** from collector **21** to emitter **24** and to the common emitter resistor **26** to the negative conductor **12**. A further current path may be traced through the resistors **30** and **41**, junctions **40** and **45**, the left hand portion of the toroid and from the mid point thereof through resistor **53** and diode **54** to conductor **12**. Current now flows in the toroid in a reverse direction causing the flux to gradually change towards saturation in the opposite direction. When saturation is finally reached, another reversal is caused. The resistors **51** and **52** are high impedance shunts across the two halves of the toroid winding **T1** and each forms a voltage divider with resistor **53** to ground. The diode **54** is connected in the circuit to provide a degree of temperature-voltage compensation for the base emitter junction of the "on" transistor. Frequency modification and temperature compensation can be obtained in the choice of proper component values for resistors **26** and **53**.

This highly accurate circuit is adaptable to operate at very low frequencies in the order of five seconds per cycle and it may be adjusted to oscillate at a more rapid rate or more slowly by the means above described and the choice of a proper toroid.

In general, I have shown a specific embodiment of my invention, it is to be understood that this is for the purpose of illustration and that my invention is to be limited solely by the scope of the appended claim.

I claim:

Low frequency oscillator comprising: a first and a second input terminal for connection to a source of direct

current electric potential; a first and a second semiconductor current control means each having an input electrode, an output electrode, and a control electrode for varying the conductivity of a current flow path between the input and the output electrodes of respective current control means; direct current cross-coupling means, including impedance means, connecting the control electrode of each current control means to the input electrode of the other current control means; a first and a second impedance means respectively connecting the input electrodes of said first and said second current control means to said first input terminal; means connecting the output electrodes of said control means to said second input terminal; a saturable core timing means including a winding having a pair of end terminals and an intermediate tap, said end terminals being respectively connected to the control electrode of said first and second current control means and hence respectively connected through said impedance means of said direct current cross-coupling means to said input electrodes of said second and first current control means whereby the current flow through said saturable core timing means is substantially independent of the current flow through said semiconductor control means; and means connecting said intermediate tap of said saturable core means to said second input terminal.

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