(51) International Patent Classification [6] :		(11) International Publication Number:	**WO 99/38247**
H02M 3/155	**A1**	(43) International Publication Date:	29 July 1999 (29.07.99)

(54) Title: HARNESSING A BACK EMF

To pulse generator
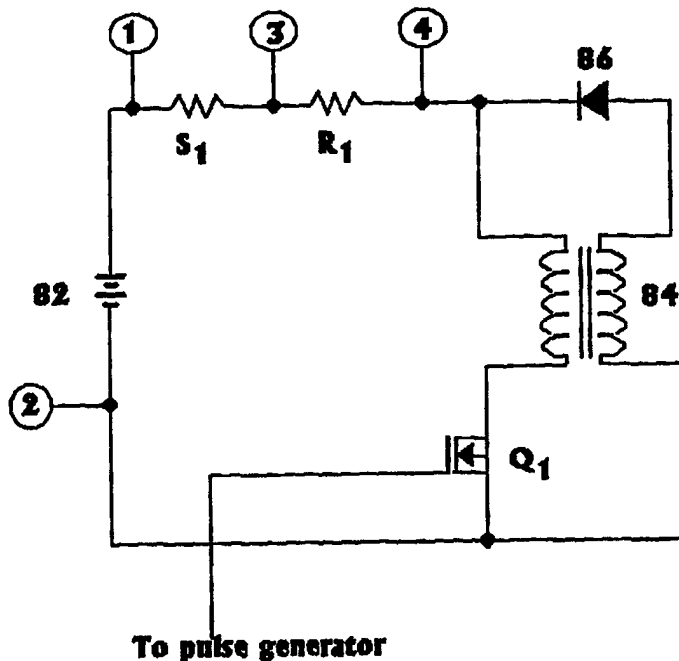
(57) Abstract

A method of achieving high efficiency of energy usage includes passing current through an inductor, causing the current to be repeatedly interrupted, thereby generating a back emf in the inductor and thereafter harnessing the back emf so generated to supply energy to an energy receiving or processing device. The frequency of interruptions should be 40 Hz or more and is achievable by applying rectifying means to the current. The invention extends to apparatus for harnessing such back–emf and energy generating means comprising an inductor and current interruption means connectable to an energy receiving device.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav	TM	Turkmenistan
BF	Burkina Faso	GR	Greece		Republic of Macedonia	TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's	NZ	New Zealand		
CM	Cameroon		Republic of Korea	PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

HARNESSING A BACK EMF

FIELD OF THE INVENTION

The invention relates to a method of harnessing back-emf for use in

powering a load or replenishing a depletable energy source and extends to

apparatus used in performing the method.

BACKGROUND OF THE INVENTION

5   Conventional switching circuits are well known in electrical energy

conversion technology and switch mode systems have been employed to

enhance energy utilization efficiencies. The concept of absorbing electrical

energy released by the collapse of autoelectronic emissions from a

discharge tube is disclosed in US5449989. This document discloses a

10   circuit that includes an output port connected to a current sink, which is

effective to absorb at least a substantial portion of such emissions. The

current sink may be an electric motor or a secondary battery.

The concept of applying a back-emf in electrical circuitry is also known. For

example, in US 5 521 476 is disclosed a control circuit for a disk drive motor

in which back-emf blocking circuitry is employed to prevent dissipation of a

back-emf through the power supply. By contrast Patent Co-operation Treaty

patent publication WO9613892 discloses the use of a back-emf to trigger a

response in a control system for a mechanical system so that driving pulses

5   are generated to accomplish a desired displacement motion.

In the present invention, to achieve high energy efficiencies, greater than

unity in relation to a conventional test circuit, a back-emf generated in an

inductor is harnessed, so as to return energy associated with such emf to a

depletable energy source supplying such circuit, or to a load included in the

10 same primary circuit as the energy source. It is envisaged that a wide

range of electrical power supply sources will derive benefit from the

invention disclosed hereunder.

According to a first aspect of the invention, a method of harnessing back-

emf on to an electrical circuit to increase the efficiency of energy usage to a

15 factor of 90% or more in comparison with a Resistor Temperature Versus

Wattage Calibration Circuit, comprises the steps of providing a circuit, said

circuit including an inductor and an energy receiving device and being

configured to operate the device, providing a source of electrical energy

capable of supplying an electrical current to the circuit, connecting the

20 source in operative configuration in series with the inductor, causing current

to pass from the source through the inductor, causing a back -emf to be

generated in the inductor, such back-emf having electrical energy

associated with it, thereby providing an additional source of potential difference to the circuit, said source of additional potential difference being sufficient to supply energy to such circuit and supplying the energy associated with the back-emf to the receiving device.

5 In a preferred form of the method, the step of causing the back-emf to be generated includes the step of interrupting the current. Preferably, the method includes interrupting and restoring the current repeatedly. Further, the interrupting and restoring of the current includes the step of applying rectifying means to the current. The frequency of interruptions is preferably

10 40Hz or more and more preferably should be at least 50Hz. The duty cycle of the interrupting means should preferably be 50% or more and further preferably be at least 60%.

In a further preferred form of the invention, the method includes generating a back-emf of sufficient magnitude to cause the comparative energy usage

15 efficiency to be at least unity. This may be achieved by setting and controlling a suitable value for a variable selected from one or more of the frequency of interruptions from the wave rectifier, the duty cycle, the thickness of the wiring in the circuit and efficiency of the core of the inductor, the value being set in accordance with operational requirements of

20 a desired end application.

In a yet further preferred form of the invention, the receiving device in the circuit is at least one of an energy consuming load and an energy storage

means. Preferably, the energy storage means is a replenishable source of electrical energy. Such energy source may be of alternating or direct current.

The method further preferably includes providing at least one inductive

5   load, the or each inductive load being operatively associated with the or each receiving device.

The inductor may be a transformer or other suitable inductive device.

According to a second aspect of the invention, a method of restoring electrical energy to a source comprises the steps of providing a closed

10   circuit including a source of electrical energy and an inductor configured to operate therein and receive electrical energy from the source; causing electric current to pass from the source to the inductor; causing the establishment of an extruded magnetic field associated with the inductor; causing a change in the orbital bias of the extruded magnetic field so that

15   the magnetic field collapses and a back-emf is generated, the back-emf having electrical energy associated with it; providing bias changing means, repeatedly changing the bias by such means, so that electrical energy associated with the back-emf is made available in the circuit; providing a receiving device capable of receiving such energy for utilization; and

20   operatively connecting the receiving device to receive the said energy.

In a preferred form of the invention according to this aspect, the method includes applying the energy associated with the back-emf to the source, thereby .to enhance energy usage efficiency in the circuit to a factor of 1 or more in comparison with a 'Resistor Temperature Versus Wattage Calibration Circuit.

The device may be an energy consuming load or a replenishable energy source.

In a further preferred form, the bias changing means comprises wave rectifier means and the method includes applying the wave rectifier means to interrupt the electric current.

Further preferably, the inductor used in performing the method has a core capable of inducing a magnetic moment associated with a collapsing magnetic field. In a preferred form of the method, the core is a solid core.

The inventive method preferably further includes the steps of selecting a value for a variable selected from the frequency of interruptions from the wave rectifier, the duty cycle, the thickness of the wiring in the circuit and efficiency of the core of the inductor so that the magnitude of the back-emf generated when the magnetic field collapses is in a predetermined range according to operational requirements of the receiving device, the value being set in accordance with operational requirements of a desired end application.

In a preferred form of the invention the inductor is a transformer means. The transformer has primary winding means of sufficient size to cause a voltage pressure to be established in use between it and the circuit, so that

5   energy associated with the back-emf generated is supplied to the circuit.

In a further preferred form of the invention, the interruption means comprises a current rectifier means. The rectifier means may be a diode or triac in the case of alternating current.

According to a further aspect of the invention, there is provided apparatus

10   for utilizing a back-emf, such apparatus comprising an inductor having a core suitable for generation of back-emf from collapsing magnetic fields, and an electrical circuit including said inductor, a replenishable energy source, an energy receiving device and means for changing orbital bias of a magnetic field set up in use and associated with said inductor, both such

15   source and such means being configured to operate the inductor, and variable selection means operable to set a variable, selected from the frequency of interruptions from the interruption means and duty cycle, so that, in use, by operation of the orbital bias changing means, such magnetic field associated with the inductor is caused repeatedly to collapse and be

20   restored, thereby generating electrical energy, the circuit being capable of conducting such energy so as to make it available to be used at said receiving device.

In a preferred form of the apparatus, the destination device is selected from at least one of a load to be powered and a replenishable energy source.

In a further preferred form, the orbital bias changing means comprises current interruption means, such a diode or a triac or similar suitable rectification means such as a wave rectifier.

In a yet further preferred form of the invention, the inductor has a core that is capable of inducing a magnetic moment associated with a collapsing magnetic field or back emf.

The invention extends to the use of apparatus as defined above for utilizing a back emf and making available to the destination device energy generated in use in the inductor of the apparatus.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 illustrates schematically a circuit according to which the invention may be applied.

Figure 2 illustrates an embodiment of an electrical generator apparatus that may be used in exercising the invention.

Figure 3 illustrates in A a control circuit described in Example 1 and in B a test circuit the performance of which was compared with the circuit in A.

Figure 4 illustrates a test circuit referred to in Example 2 below.

Figure 5 illustrates a circuit referred to in Example 3 below.

DETAILED DESCRIPTION OF INVENTION

By connecting an inductor means with a load-bearing circuit and causing a

5   back-emf to be established through the inductor, a voltage pressure may be

created sufficient to restore energy to the source and reduce its rate of

depletion, or the rate of consumption of energy therefrom. The voltage

pressure is represented by an additional potential difference provided

through the establishment of the back-emf. It is not contemplated that the

10   load itself should consume less energy than it would otherwise do, but that

a back-emf induced by means of the inductor is harnessed so as to cause

electrical charge to be directed from the inductor to wherever required, be it

source, load or other device.

The circuit may be supplied with electrical energy from either a direct or

15   alternating current source.

The inductor means may be any suitable such means known in the art.

Preferably it is a transformer. However, it may alternatively be a winding or

choke and should preferably have an inductive load associated with it. The

inductor preferably comprises a core capable of inducing a magnetic

20   moment associated with a collapsing magnetic field. The inductive load is

commonly an iron core located co-axially within the inductive device. However, it may alternatively be a suitable liquid or gaseous medium, or combinations thereof, including with solid material.

To generate a back-emf, the circuit is caused to be repeatedly closed and

5   opened, thus disrupting or interrupting electrical current flow through the inductor. This can be accomplished by use of any suitable interruption means. A preferred such means is a variable duty cycle chopper.

In the case where the energy source delivers alternating current, the interrupter means may comprise a wave rectifier means, preferably a diode,

10   triac or such like.

In the case of a direct current source, wave rectification and current interruption are achieved through the use of a current rectifying device such as an oscillator or a mos-fet or suitable equivalent wave rectifier means, such as would set up a fluctuating magnetic field in relation to the inductor.

15   The method of restoring, returning or recycling electrical energy to a device - be it a source, a means of storage or a processor, such as a consumer of such energy - that forms the substance of this invention, thus alternatively includes steps of (1) setting up an extruded magnetic field associated with an inductor that is configured to operate in a circuit that is itself operatively

20   configured to enable electrical energy to be passed to and from such inductor and (2) changing the orbital bias of the extruded magnetic field. By

"extruded magnetic field" is meant a magnetic field that is associated with an inductor, such as a solenoid, or is induced with the aid thereof and is in a state of distortion or imbalance.

It is believed that the changing orbit bias that is associated with the disruption of electrical current leads to the collapse of the magnetic fields and the change in current that is manifested in the back-emf. The changing bias recycles the current to render it reusable in the circuit at whichever point it is operationally required. During the period when the energy supply source is disrupted or disconnected due to the operation of an interruption device, an alternative circuit is used to promote the recylcling of this back-emf current. The use of an inductive load in the core of the solenoid enhances the efficiency of the apparatus. This load may be any substance or material, be it gaseous liquid or solid or a combination of one or more thereof, or even a vacuum. Such load should have properties rendering it capable of facilitating creation of a magnetic field of sufficient strength to enable a useful back emf to be generated. By "useful" is meant a back-emf that is suitable for supplying energy for a particular application or operational requirement. Preferred core materials are iron and other ferrous materials.

Thus, by repeatedly changing the bias, a disruptive or switching effect is achieved and resultant energy, detectable as an electric current is made available for use as desired by the operator or designer of the circuit.

Suitable bias changing means include wave rectifiers and other devices that interrupt current flow or change current direction. In this context, the word interrupt includes such changes. It has been found that interrupting or bias changing means should advantageously have a duty cycle of from 50% to

5   99% – i.e the "on" time when current is flowing should be in the range from 50% to 99% of the total "on" time plus "off" time. In a preferred embodiment of the invention, the duty cycle is in the range from 60% to 95%. Further preferably, the duty cycle should be in the range 75% to 95%.

The circuit need not be complex. It should, however, include means for

10   disrupting or reversing the current to the inductor, as described above.

The invention will be described further with reference to accompanying Figure 1, illustrating generally at 10 a portion of an electrical circuit in which the invention is applied.

15   Connected by means of suitable wiring in series with a primary inductor 12, is a wave rectifying diode 14, serving as an interrupter means for electrical current supplied to the circuit from a source (not shown).

When a full-wave AC or full square wave rectified DC waveform is applied to input 16, a wave rectified- or pulsing DC waveform is created in the

20   primary winding of the inductor 12. On interruption of each waveform cycle, the current change in the winding of the inductor 12 induces a magnetic field in the iron core 20 associated with it.

When the magnetic field collapses, it is thought that, due to the "blocking effect" of the interruption caused by the wave rectifier, a back-emf results. This induces a corresponding reverse waveform in the inductor, so that the waveform associated with the winding across the core 20 is a full sine wave

5   in the case of an alternating current source, and a full square wave in the case of a direct current source.

The inductor 12 may be connected with a load (not shown) in series or in parallel at any of the points 18.

Depending on the frequency of interruptions from the wave rectifier, the

10   duty cycle, the thickness of the wiring and efficiency of the core, the voltage across the inductor 12 may be conducted through a closed circuit to be used in powering the load and/or be returned to the power source according to requirements.   Desirably, but not essentially, the frequency of interruptions should not be less than 40Hz. Preferably it should be 50Hz or

15   more and more preferably 500Hz or more, but this will be largely dependent on the application.

A switch mode system may be utilised in performing the method of the invention. An example of a suitable closed circuit employing such a system includes a battery as DC energy source to power a lamp. A transformer

20   may be connected in series with the lamp and in turn connected with a variable duty cycle chopper.

In addition, the output from the transformer is preferably shunted through a diode to a suitably high value resistor and capacitor connected in series. When the circuit is closed by means of the chopper, current passes through the load and transformer. Repeated opening and closing of the circuit by

5   means of the chopper causes a back-emf and current to be induced in the inductor. A voltage pressure is established between the inductor and the low potential terminal of the source, so that the charge induced in the inductor is fed to the source, replenishing its drawn down energy. The net effect is that the workload exceeds the depletion rate of the source.

10   A further embodiment of a circuit used in the invention appears illustrated in figure 2, where a primary winding 30 having, for example 220 turns around a cylindrical core 32 of a ferrous metal such as iron or an iron alloy, is associated with a secondary winding 34 of a like number of turns. The secondary winding is wound round the core adjacent to or around the

15   primary winding 30. This configuration results in electromagnetic coupling between the windings via core 32.

The circuit input 36 is connected to an AC power source 38. This would be typically a 220V mains supply at 50Hz. The circuit output is taken at 40 from the secondary winding.

20   A diode 42 or other half-wave rectifier is connected in series with primary winding 30. On applying a full-wave AC waveform to the circuit input 36, a

half-wave rectified or pulsing direct current comes to exist in the primary winding 30.

On each positive-going half-cycle, the primary winding induces a corresponding current in the secondary winding 34. But, when due to the

5   diode's blocking effect, the magnetic field resulting from the current in the primary winding collapses, the back-emf that results in the primary winding induces a corresponding negative-going waveform in the secondary winding 34. Hence the output 40 from the secondary winding is a full-wave AC waveform.

10

Although the invention has been described above with reference to one inductor being employed at a time, it will be appreciated by those in the art that further inductors may be connected in operative configuration so as to achieve further enhancements of system performance. For example, two or

15   more primary windings may be connected in parallel, each having and independent magnetically susceptible core associated with it, with a rectifier connected in series with the parallel windings. In another example, respective primary and secondary windings may be coupled with a single core, with a rectifier connected in series with the primary winding.

20   The primary and secondary windings may be positioned end to end coaxially around the core or may overlap in annular fashion with the secondary, having greater diameter, being wound around the primary.

In an alternative configuration, two primary windings, having associated secondary windings, are connected in parallel, but placed around a common core. Wave rectifiers are connected in series with each primary winding.

5   The use in the method of the invention of the back-emf-generating apparatus above provides net energy savings opportunities to an energy consuming system in that the energy associated with the generated back-emf may be supplied to the energy processing device – be it an energy consumer or an energy source.

10   Applications of the back-emf generating apparatus of the invention include, without necessarily being limited to, switch mode systems, boost converters, battery operated systems, recharging of batteries, household electrical equipment, hybrid engines and heavy and light duty industrial equipment.

15   Other variations on and embodiments of circuits used in performing the method of the invention will be apparent. The non-limiting example that follows shows how the inventive method may be used in achieving an efficiency factor that reaches at least 90% and even exceeds unity.

20   **EXAMPLE 1**

Two tests were conducted on Phillips wire wound 10 watt resistors. The resistors

had identical surface areas. The thermally coupled device used was a standard

PC Platinum based probe linked to a thermal digital display device. Care was

taken to ensure that the thermal coupling of the thermometer probe to the resistor

5   was identical in both tests. The object of the test was to compare the rate at

which amperage was drawn by a standard 'Resistor Temperature Versus

Wattage Calibration Circuit' test, hereinafter referred to as the control test,

indicated in Figure 3A, and from a test using a switching device and an inductor,

indicated in Figure 3B. If the control test indicated that a greater current was

10   being supplied by the battery than was evident through the test which used the

device and yet the actual heating efficiency of the device was the same as that of

the control then the condition would be that the use of the device could enhance

heating efficiencies. The same battery was used in both tests. The amperage

draw down rate was deduced by an analysis of the voltage measured with an

15   oscilloscope probe placed across a low value resistor and the same sense

resistor was used in both tests in order to obviate any erroneous comparative

measurements. The positioning of the sense resistor is indicated on the circuit

drawings.

20   The control test (Figure 3A) had a thermocoupled 68Ω resistor 40 and a sense

resistor 42 placed in series with the battery terminals 44. All subsequent

measurements were taken when the temperature across the resistor 42 had

reached a maximum value. The digital thermometer indicated a heat of 95

degrees centigrade at its highest reading. At that time, the current delivered by the battery was evaluated from an analysis of voltage measured across the sense resistor. This was 0.0049 volts. In terms of Ohm's law, volts divided by the ohms value of the sense resistor, being 0.025 ohms, gives the current as 0.1960

5   amperes. The power delivered by the battery is calculated by multiplying the value of the loaded source battery voltage being 12.28V with the amperage value of 0.1960A, which gives a power of 2.406 watts.

The test circuit (Figure 3B) had the same thermocoupling on a 22 ohm resistor 52

10   placed in parallel to an inductor 54 before a switching device 56, in this example, a mos-fet. The same 0.025 ohm sense resistor 42 as was used in the control test was placed in series with the negative terminal of the battery 44 on the ground as indicated in Figure 3B . The duty cycle was adjusted until the digital thermometer (not shown) indicated a heat of 93°C on the load resistor 42 at its

15   highest reading. All measurements were taken subsequent to this.

The amperage draw down was deduced from an analysis of the square wave voltage measured across the sense resistor 42. The wave form observed was approximately a square wave with a slope during the on time from 0.0162 to

20   0.0217. These voltage values were added together and then divided by 2 to establish the average peak voltage during the on period being 0.01895 volts. In order to establish the average amperage as it related to the off and on time of the switched power supply source 44, it was necessary to analyse the period during

which the switched power supply was off compared to the period during which the switched power supply was on. The period per cycle was 0.2 milliseconds. The total length of the cycle was measured in 37.5 time divisions, of which 29 divisions represented the period during which the switch was off and 8.6 divisions

5   represented the period during which the switch was on. Therefore the average peak voltage of 0.01895 volts was divided by 37.5 and then multiplied by the one period of 8.5 to give an average of 0.043 volts. This voltage was then divided by 0.025, being the sense resistor's ohms value, which equals an average amperage of 0.1718A. In order to establish the power delivered by the battery

10 supply source, 0.1718A was multiplied by the loaded source battery voltage being 12.28V, which gives a power of 2.1097W.

Ambient temperatures in both tests were stable and the tests were conducted within one hour of each other. Values across the sense resistor were

15 standardised by the use of the same resistor in both tests, therefore obviating errors in the comparative voltage values.

Therefore the heat on the resistor in the control test was generated by a wattage dissipation of 2.406W from the source battery. Allowing for a 5 percent margin

20 for error on all measurements, it can be said that the heat on the resistor in the test circuit was generated by a wattage dissipation of 2.1097W plus 5 percent, or 2.21519W, indicating an efficiency of 8.6 percent in excess of a factor of 1.

In other words, it was found that at least 8.6% less current was required by the test circuit to produce effectively the same sensible temperature in the resistor there as was measured in the control circuit. This standard control circuit is accepted as the most efficient arrangement hitherto possible.

5

EXAMPLE 2

The following tests were conducted to prove that subject to specific circuit configurations an inductor is able to enhance energy efficiency to levels beyond

10   the standard capabilities of an electrical power supply source. The tests also indicate that in the event that a resistor is placed in series with a power supply source and an inductor as configured in the Test Circuit Test, the correct wattage analysis of that power may be calculated as the energy source voltage multiplied by the amperage or VI, as it is known and that i squared r (I^2R) analysis appears

15   to be erroneous as a base calculation of the wattage and power generated in this particular system.

THE CONTROL TEST ESTABLISHING TEST PARAMETERS

The control used here corresponds to the Resistor Temperature Versus Wattage

20   Calibration Circuit of the previous example.

- A 100 ohm, 10 watt, Phillips wire-wound resistor was placed in series with a six volt battery supply source. The source consisted of two 6V batteries used in parallel to each other. Their composite voltage was measured from the positive terminal of the first battery to the negative terminal of the second

battery. The voltage measured was 6.12 volts. In terms of Ohm's law, therefore:

6.12 (battery voltage) ÷ 100 Ω (resistive load) = 0.0612 amps

5   • To determine power dissipation, the current is multiplied by the voltage, i.e.

Power = 6.12V x 0.0612A = 0.374W.

• A PT platinum based probe was attached to the resistor which, in turn, was linked to a digital display device. Ambient room temperature was 22 degrees

10   centigrade. The heat measured from that resistor was 30 degrees centigrade. Therefore, in terms of classical scientific analysis and based on these specified test parameters, 0.374W correlates to 30 degrees centigrade. This test, hereafter, is referred to as the Control Test.

15   • It follows, therefore, that if an alternative test circuit could heat a resistor to 30°C and, provided that the new test used a load resistor which had the identical surface area and wattage to that 100 Ω resistor used in the Control Test, then that alternate test circuit would, in fact, be generating 0.374 watts - irrespective of any actual measurements evident on that circuit.

20   • However, in the event that the second test circuit was powered by the same battery supply source, being 6.12V, and if the amperage dissipated by that battery – and deduced from a measurement of the voltage across a sense resistor – was less than 0.0612 amps – per the Control Test – and yet the

heat was 30°C ,which level was consistent with 0.374W – then one may

deduce that something other than the existing power supply source had

contributed energy to the circuit to enhance its efficiency beyond the standard

capabilities of those 6.12V battery supply sources.

5

THE TEST CIRCUIT TEST

- With reference to figure 4, the Test Circuit 60 comprised a 47Ω, 10 watt,

10 Phillips wire-wound resistor 62 placed in series with a 6 volt battery supply

source comprising, as before, first and second 6V batteries, 64 and 66

respectively. An inductor 68, in turn, was placed in series with load resistor

62. A positively biased diode 72 was placed in parallel with the inductor 68

and above a switching device being an 'N' channel mos-fet 74. This wire was

then taken back to the positive terminal of the second battery which was

15 connected in parallel to the first battery. The battery voltage was 6.12V.

- Three sense resistors were used – one positioned directly behind the 47 ohm

resistive load and one each on both negative terminals of the two batteries.

Again, in terms of classical scientific analysis the assumption was made that

20 the sum of both currents evident at the negative terminal would be consistent

with the rate at which energy was dissipated by the batteries.

- The duty cycle of the switching device was adjusted to a 50:50 mark space ratio. Therefore the switch was off for a period consistent with the time during which the switch was on. The heat indicated on the thermocoupled digital display device was 30°C. Ambient room temperature was still 22°C.

5

- All wave forms for the three sense resistors SR1, SR2 and SR3 are indicated in figure 4 below the circuit 60:

  - **SR1** – the voltage wave form across the sense resistor placed in series with the load resistor 62, was roughly triangular in shape but followed an exponential rise and fall during the on and off periods of each cycle. Voltage did not cross ground. Peak voltage was positive 0.006V. In order to find an approximate rms voltage this value was divided by 2 giving 0.003 volts across the sense resistor. The amperage through the load resistor was calculated in terms of Ohm's law and was thus the sum of the 0.003 volts divided by the resistance value of the sense resistor (in ohms), being 0.05 ohms. The amperage thus equals 0.060A. In order to evaluate the power over the load resistor – also in terms of Ohm's Law, therefore:

    - $I^2R = 0.060$ amps x 0.060A x 47Ω

      = 0.169W

20

This value was not consistent with but less than the evident wattage indicated by the heat of the load resistor, which measured 30°C.

In terms of the Control Test, 30 degrees centigrade under these test

parameters corresponds to 0.375 watts. It would appear that the

phenomenon is only reconcilable if the mathematical formula applied is

based on the evident amperage multiplied by the battery source voltage.

5   Therefore:

$$0.06A \times 6.12V = 0.367W$$

This wattage value was precisely equivalent to the evident heat.

10   • **SR2** – the voltage wave form across the sense resistor placed in series

with Battery 1 (64) – was roughly triangular in form with some exponential

curvature as evidenced in the wave form over SR1. For the purposes of

calculating average current this was assumed to be triangular and all

measurements may be subject to an error not expected to exceed 10

15   percent. Their measurements were gauged as the sum of the off portion

of the cycle added to the sum of the on portion as both portions of the

cycle manifested above ground.

• In calculating the power delivered by the batteries, it was assumed that

20   since the battery voltage was constant during each cycle, it could be

calculated by taking an average of the battery current and multiplying this

by the battery voltage (P=VI). The voltage wave form evident during the

on portion of the cycle peaked at 0.0035 volts. Therefore: -

(0V + 0.0035V)/2 = 0.00175V

[the sum is divided by 2 - being the average of the on cycle].

5
- This sum is divided by 2 again - to allow for the 50% duty cycle – and this then gives a voltage value of 0.000875V. This is the average voltage, which, in terms of Ohm's Law is divided by the ohms value of the sense resistor, being 0.05Ω, to give the amperage of 0.0175A.

10
- The voltage wave form evident during the off period of the cycle peaked at 0.0015V. Therefore, as above

    (0V + 0.0015V)/ 2 (being the average of the off cycle) = 0.00075V

15
- This sum is divided by 2 to allow for the 50% duty cycle, thus giving a value of 0.000375V. This is the actual voltage, which, in terms of Ohm's Law, is divided by the ohms value of the sense resistor being 0.05Ω, thus giving an amperage of 0.0075 A.

- The sum of the amperage of both cycles therefore is :

    Amperage = 0.0075A + 0.0175A = 0.025A.

20
- Therefore, the actual rate of dissipation of wattage from Battery 1 is:

    - Amperage multipled by the evident battery voltage, or

    Dissipation rate = 0.025A x 6.12V = 0.153W

- **SR3** – The wave form evident from the voltage over the sense resistor placed in series with Battery 2 (66) indicated an equivalent above- and below-ground wave form. Both on and off periods of the cycle peaked at 0.0055V above and below the ground respectively. In as much as the on cycle crossed a little below ground, it is evident that no power was being lost from this battery but, in fact, there was a small margin of gain. The value is too small to represent a meaningful measurement and the entire cycle was therefore discounted as not representing any wattage loss but, in fact, some gain.

RESULTS AND CONCLUSIONS

- The wattage based on an I^2R analysis – being generated across the load resistor – is calculated at 0.169 watts. The actual wattage dissipated at the battery terminals is calculated at 0.153 watts. This only represents a 10% gain above unity – which may be evident mathematically and which, in any event is a marginal value and is consistent with the previous Resistor Temperature Versus Wattage Calibration Test. This marginal gain could, in effect, be further discounted by an adjustment to the amperage values to bring them in line with rms values, albeit that the consequent result would conflict with the evident heat apparent over the 47Ω load resistor.

- It has been very difficult to reconcile the difference between the calculated wattage and the heat dissipation of the load resistor. As mentioned the most accurate gauge appears to be if the average amperage is multiplied by the source battery voltage – although this is not in line with classical scientific

5   circuit analysis.

- Either way, the Control Test dissipated 0.0612 amps to achieve a temperature of 30 degrees centigrade over the load resistor and the Test Circuit Test dissipated 0.025 amps to achieve an equivalent temperature over its load

10   resistor. So, scientifically and correctly, the gain in efficiency is 100 percent greater than unity as represented in the Control Test.

- It must be noted that the two load resistors being the 100 ohm and the 47 ohm resistors used in the Control Test and the Test Circuit Tests respectively

15   both had the same surface area and care was taken to ensure that both resistors were strapped to the temperature probe in an identical manner. However, the calorific values of both tests were not accurately ascertained. Both tests were subject to fluctuations in room temperature but, as both were exposed to the same variations then their values may be considered to be

20   proportionate and, in any event fluctuations and variations in ambient room temperatures were not apparent. However, in the interests of conservative computations it is possibly advisable to discount the Test Circuit Test by a further 5 percent. But in view of the enormous gain in efficiency over the

Control Test this makes very little significant difference to the proof of

efficiency in the Test Circuit Test results will still remain at not less than 100

percent greater.than – unity being standardised by the Control Test.

5 The examples recorded above do not necessarily represent optimized values.

Further optimization may be attained by providing two or more inductors, two or

more energy sources or an energy storage means and appropriate switching

circuitry and selection means to facilitate balanced and efficient drawing and

replenishment.

10

EXAMPLE 3

A further set of tests was conducted to investigate the relationship between

power supplied by the battery 82 and power dissipated by a load resistor R_1 in

15 the circuit shown in figure 5 – i.e. efficiency of energy conversion – with variance

of the duty cycle of the FET switch Q_1. The circuit also included an inductor 84

comprising equal primary and secondary windings and a 350VA core, as well as

a positively biased diode 86 and further components mentioned below.

20 Duty cycle is expressed herein as the quotient of "on" time and "on" time plus

"off" time, multiplied by 100 to express it in percentage terms.

The tests were conducted by adjusting the duty cycle from 90% to 50% in steps

of 10%. At each such step value, simultaneous measurements were recorded of

battery voltage V_{1-2}, rms and average voltages across sense resistor ($V_{1-3\ rms}$ and

$V_{1-3\ av}$) and the rms voltage across resistor R1 ($V_{3-4\ rms}$). These measurements

5   are presented in Table 1 below. Measuring equipment used was as follows:

- For V_{1-2}: APPA True rms meter, Model No. 105

- $V_{1-3\ rms}$, $V_{1-3\ av}$ and $V_{3-4\ rms}$:   Fluke Scopemeter Model 123

- For calibration of S_1 Fluke Scopemeter Model 123 (voltage), Fluke 79 II

  ammeter

10

Care was taken to minimise interconnection resistances and inductances, so as

to reduce to negligible their possible effects on results.

Power supplied by the battery 82, of nominal voltage 12V, was calculated as the

15   product of battery voltage (V_{1-2}) and average current through switch S_1, on the

assumption that battery voltage remained constant during each cycle. The

resistance value of S_1 was 0.05 ohms and was assumed to have a negligible

effect on results.

20   Power dissipated by the load resistor R_1 (6R3 50W) was calculated as the

product of rms voltage across it and rms current through S_1. It was assumed

here that the load resistor had negligible inductance and that as a result, the

voltage across and current through it were in phase. Table 1 presents the

numerical results and the power products calculated therefrom. The final column

provides the quotient of load power delivered and battery power dissipated,

indicating results exceeding 0.95 and even above unity for duty cycles above

60%.

5

TABLE 1

Duty Cycle	V_{1-3} Av	Average Current I_{av}	V_{1-2} dc	Battery Power (P_{bat})	V_{1-3} rms	Rms Current I_{rms}	V_{3-4} rms	Load Power (P_{load})	$(P_{load})/$ (P_{bat})
%	[mV]	[A]	[V]	[W]	[mV]	[A]	[V]	[W]	
90	69.5	1.390	12.57	17.46	102.5	2.05	10.02	20.54	1.176
80	38.2	0.764	12.64	9.657	73.1	1.462	7.58	11.08	1.148
70	20.9	0.418	12.69	5.304	51.1	1.022	5.36	5.478	1.033
60	7.9	0.158	12.73	2.011	34.1	0.682	3.19	2.176	1.082
50	1.2	0.024	12.76	0.306	15.9	0.318	0.94	0.299	0.976

Claims

1   A method of harnessing back-emf on to an electrical circuit, comprising the steps of providing a circuit, said circuit including an inductor and an energy receiving device and being configured to operate the device, providing a source of electrical energy capable of supplying an electrical current to the circuit, connecting the source in operative configuration in series with the inductor, causing current to pass from the source through the inductor, generating a back -emf in the inductor, such back-emf having electrical energy associated with it and providing an additional source of potential difference to the circuit, and supplying the energy associated with the back-emf to the receiving device, so that the efficiency of energy usage in the circuit is increased to a factor of 90% or more in comparison with a Resistor Temperature Versus Wattage Calibration Circuit.

2   A method according to claim 1 wherein the step of generating the back-emf includes the step of interrupting the current.

3   A method according to claim 2 including the steps of interrupting and restoring the current repeatedly.

4   A method according to claim 3 in which the interrupting and restoring of the current includes the step of applying rectifying means to the current.

5   A method according to claim 4 including the steps of selecting a variable from one or more of the frequency of interruptions from the rectifying means, the duty cycle of such interruptions, the thickness of the wiring in the circuit and efficiency of the core of the inductor and setting a value for the variable in accordance with operational requirements of a desired end application for the circuit.

6   A method according to claim 5 including setting the frequency of interruptions to be at least 40Hz.

7   A method according to any one of claims 1 to 6 in which the receiving device is at least one of an energy consuming load and an energy storage means.

8   A method according to claim 7 wherein the energy storage means is a replenishable source of electrical energy.

9   A method according to claim 7 wherein the receiving device is a source of alternating current.

10   A method according to any one of claims 7 to 9 including the step of

providing at least one inductive load, the or each inductive load being

operatively associated with the or each receiving device.

11   A method according to any one of the preceding claims in which the

5   inductor is a transformer.

12   A method of restoring electrical energy to a source comprising the

steps of providing a closed circuit including a source of electrical

energy and an inductor configured to operate therein and receive

electrical energy from the source; causing electric current to pass from

10   the source to the inductor; causing the establishment of an extruded

magnetic field associated with the inductor; causing a change in the

orbital bias of the extruded magnetic field so that the magnetic field

collapses and a back-emf is generated, the back-emf having electrical

energy associated with it; providing bias changing means, repeatedly

15   changing the bias by such means, so that electrical energy associated

with the back-emf is made available in the circuit; providing a receiving

device capable of receiving such energy for utilization; and operatively

connecting the receiving device to receive the said energy.

13   A method according to claim 12, including applying the energy

20   associated with the back-emf to the source..

14   A method according to claim 12 or claim 13 wherein the bias changing

      means comprises wave rectifier means, the wave rectifier means

      being appliable to interrupt the electric current.

15   A method according to claim 14 including operating the bias changing

5   means at a duty cycle in the range from 50% to 99%.

16   A method according to any one of claims 12 to 15 wherein the inductor

      includes a core capable of inducing a magnetic moment associated

      with a collapsing magnetic field.

17   A method according to any one of claims 12 to 16 further including the

10   steps of selecting a variable from the frequency of interruptions from

      the wave rectifier, the duty cycle of such interruptions, the thickness of

      the wiring in the circuit and efficiency of the core of the inductor, and

      setting a value for such variable so that the magnitude of the back-emf

      generated when the magnetic field collapses is in a predetermined

15   range according to operational requirements of the receiving device.

18   Apparatus for utilizing a back-emf comprising an inductor, having a

      core suitable for generation of back-emf from collapsing magnetic

      fields and an electrical circuit including said inductor, a replenishable

      energy source, an energy receiving device and means for changing

20   orbital bias of a magnetic field set up in use and associated with said

      inductor, both such source and such means being configured to

operate the inductor, and variable selection means operable to set a variable, selected from the frequency of interruptions from the interruption means and its duty cycle, so that, in use, by operation of the orbital bias changing means, such magnetic field associated with the inductor is caused repeatedly to collapse and be restored, thereby generating electrical energy, the circuit being capable of conducting such energy so as to make it available to be used at said receiving device.

19   Apparatus according to claim 18 wherein the destination device is selected from at least one of a load to be powered and the replenishable energy source.

20   Apparatus according to claim 18 or claim 19 wherein the orbital bias changing means comprises current interruption means.

21   Apparatus according to claim 20 wherein the source is a source of alternating current and the current interruption means is a wave rectifier.

22   Apparatus according to claim 20 or claim 21 wherein the bias changing means is operable at a duty cycle in the range from 50% to 99%.

23   Electrical energy generating means comprising an inductor, bias

changing means operatively connectable with the inductor and

capable of acting on a current passing through it in use to generate a

back-emf therein, an energy receiving device and means for directing

5   electrical energy generated in the inductor to the receiving device.

24   Generating means according to claim 23 wherein the bias changing

means is operable at a duty cycle in the range from 50% to 99%.

25   Use of apparatus according to any one of claims 18 to 22 for utilizing a

back emf and making available to the destination device energy

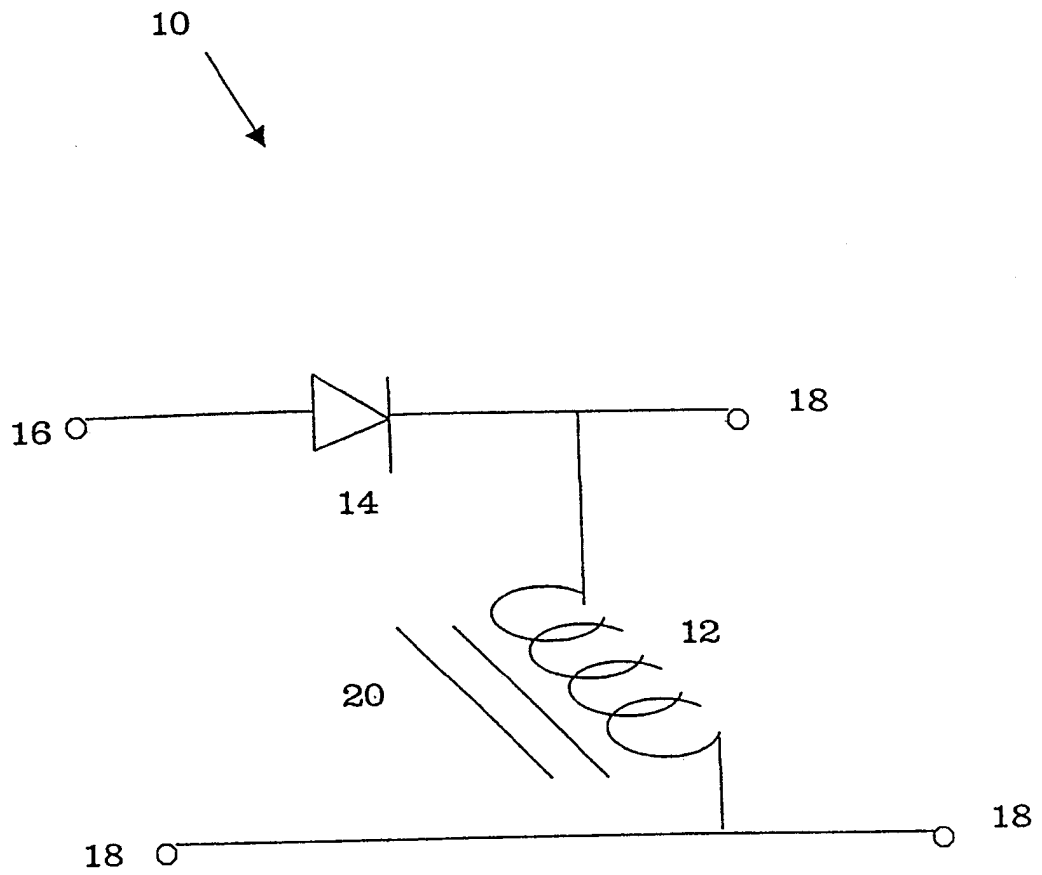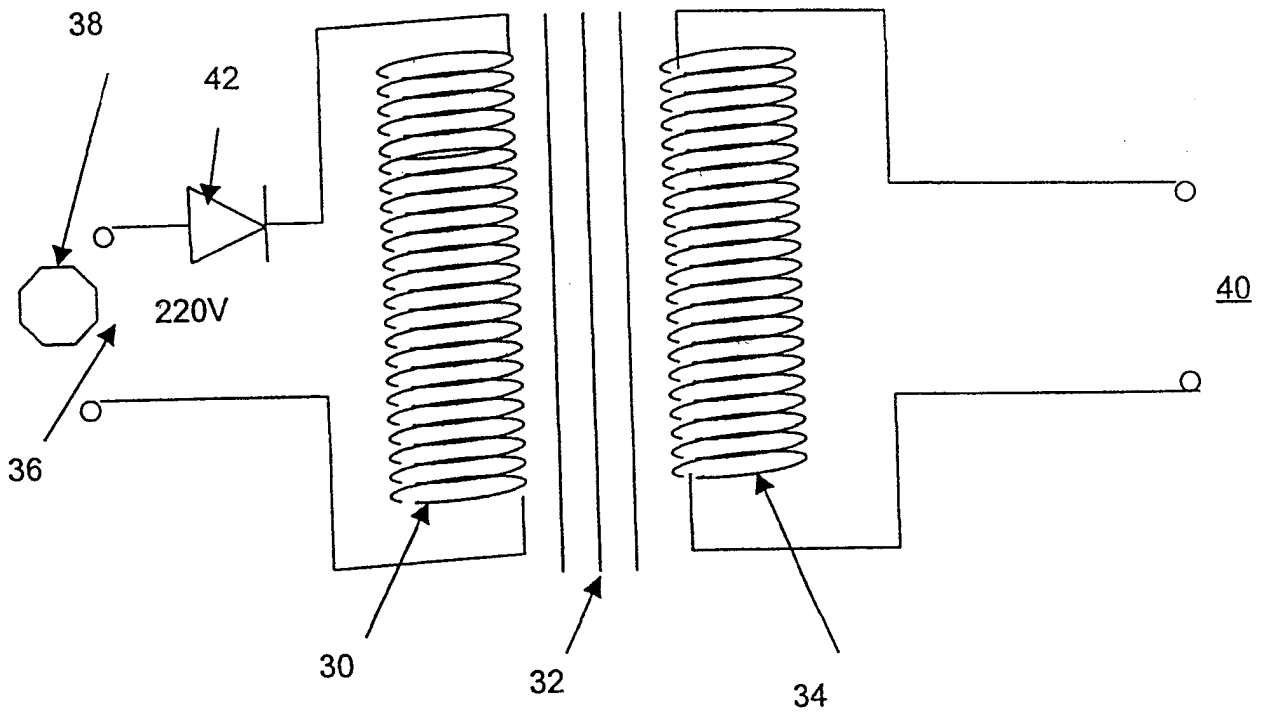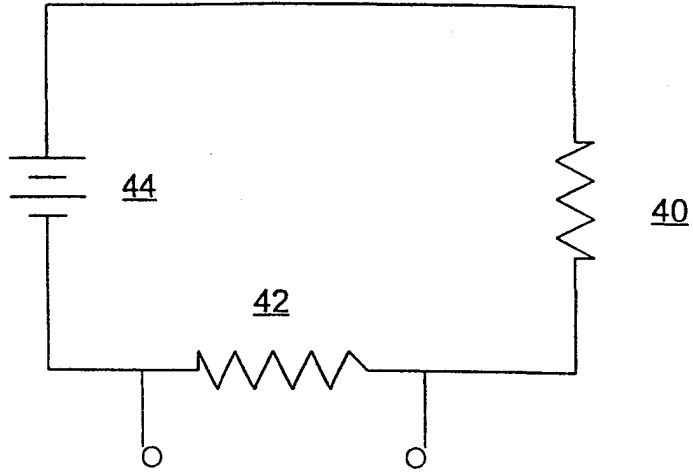10   generated in use in the inductor of the apparatus.

10

16 ○ ────▷|──── ○ 18

14

20

12

18 ○ ──────────── ○ 18

FIGURE 1

38

42

220V

36

30   32   34

40

FIGURE 2

FIGURE 3

A

B

Figure 4

To pulse generator
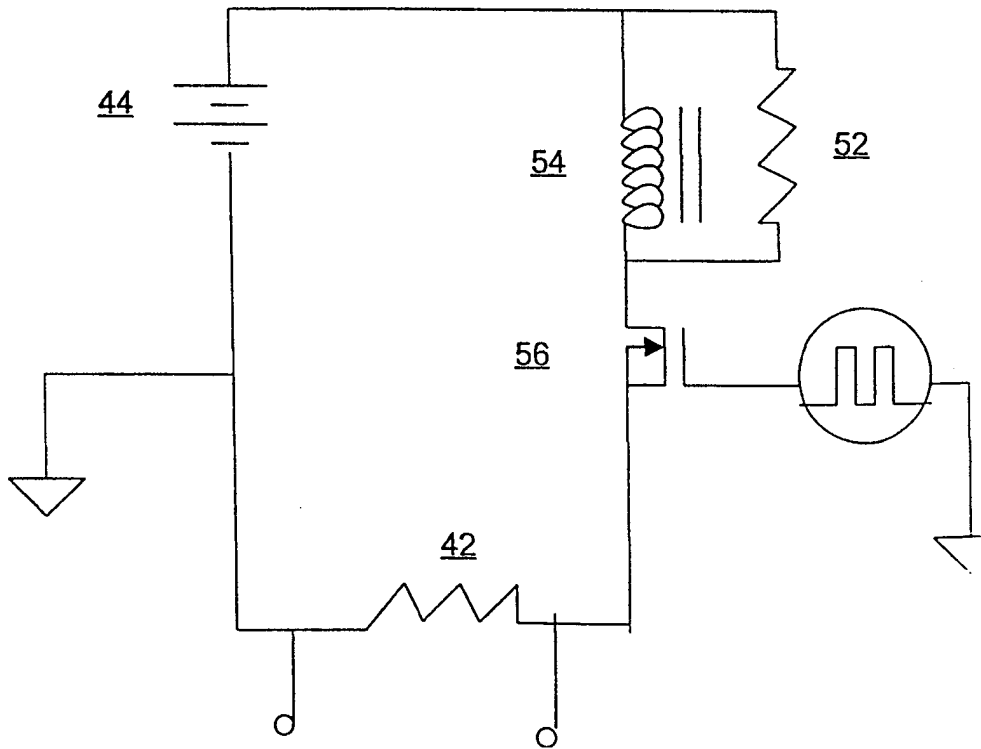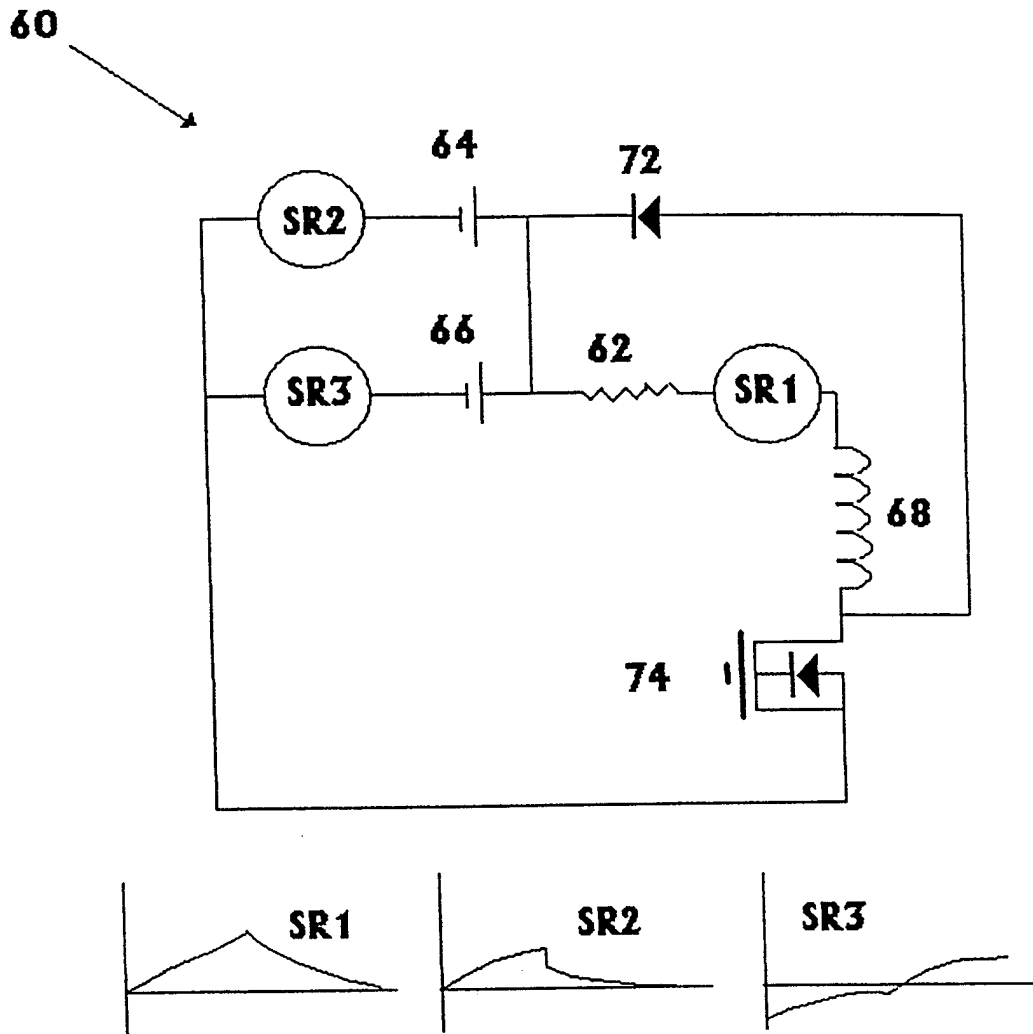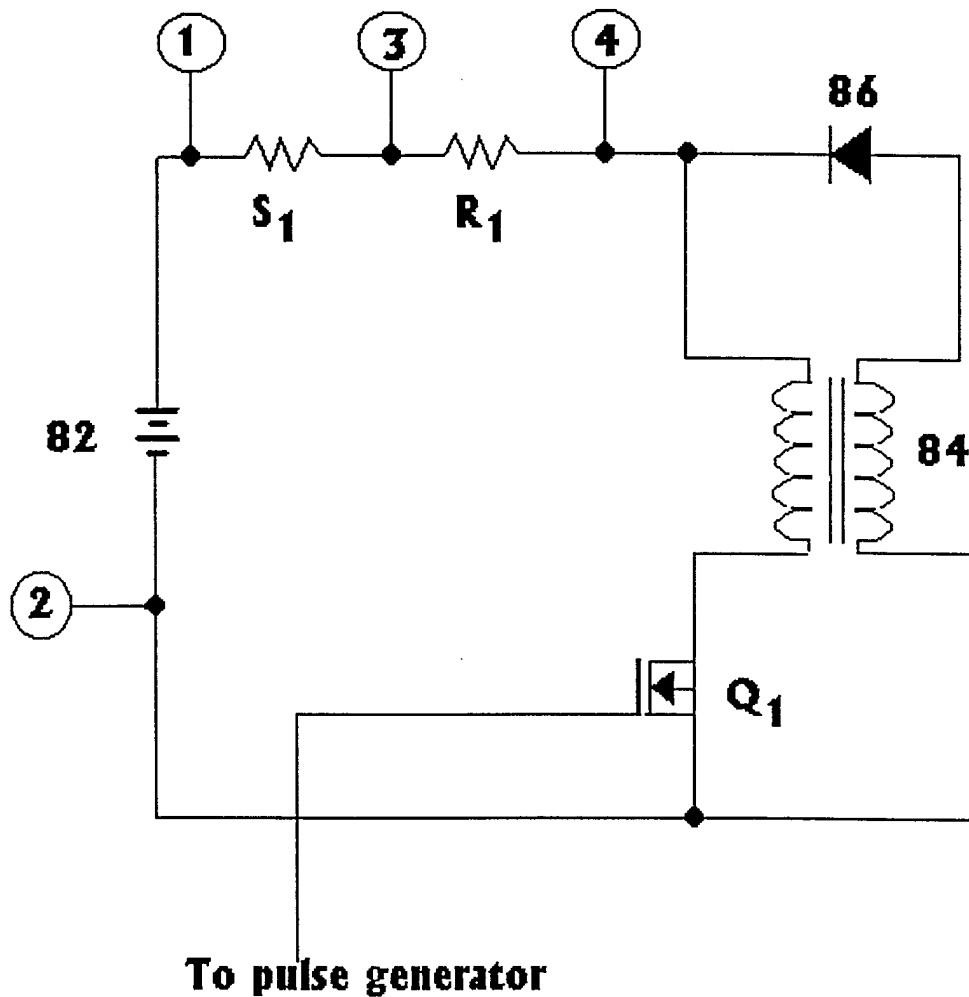
FIGURE 5

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   H02M3/155

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   H02M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 82 01627 A (UNITRON CORP) 13 May 1982 see the whole document	1-7, 11-14, 18-20, 23,25
X	EP 0 650 251 A (NICOTECH LTD) 26 April 1995 see column 3, line 52 - column 4, line 29; figure 1	1,2,12, 18,23
A	EP 0 151 199 A (ZETEX LTD) 14 August 1985 see abstract; figure 1	1,12,18, 23
A	EP 0 143 048 A (THOMSON CSF) 29 May 1985 see abstract; figure 1	1-23

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not
    considered to be of particular relevance

"E" earlier document but published on or after the international
    filing date

"L" document which may throw doubts on priority claim(s) or
    which is cited to establish the publication date of another
    citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or
    other means

"P" document published prior to the international filing date but
    later than the priority date claimed

"T" later document published after the international filing date
    or priority date and not in conflict with the application but
    cited to understand the principle or theory underlying the
    invention

"X" document of particular relevance; the claimed invention
    cannot be considered novel or cannot be considered to
    involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention
    cannot be considered to involve an inventive step when the
    document is combined with one or more other such docu-
    ments, such combination being obvious to a person skilled
    in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 April 1999	03/05/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gentili, L

1

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
WO 8201627	A	13-05-1982	AU	7297781 A	21-05-1982
EP 0650251	A	26-04-1995	GB	2283136 A	26-04-1995
EP 0151199	A	14-08-1985	NONE		
EP 0143048	A	29-05-1985	FR DE	2555375 A 3471410 A	24-05-1985 23-06-1988