NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF:

March 31, 1971

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General
Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned
U.S. Patents in STAR

In accordance with the procedures contained in the Code GP to Code USI memorandum on this subject, dated June 8, 1970, the attached NASA-owned U.S. patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U.S. Patent No. : 3,417,298

Corporate Source : Electro-Optical Systems

Supplementary
Corporate Source :

NASA Patent Case No.: XNP-00952

Please note that this patent covers an invention made by an employee of a NASA contractor. Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of. . . ."

Gayle Parker

Enclosure:
Copy of Patent

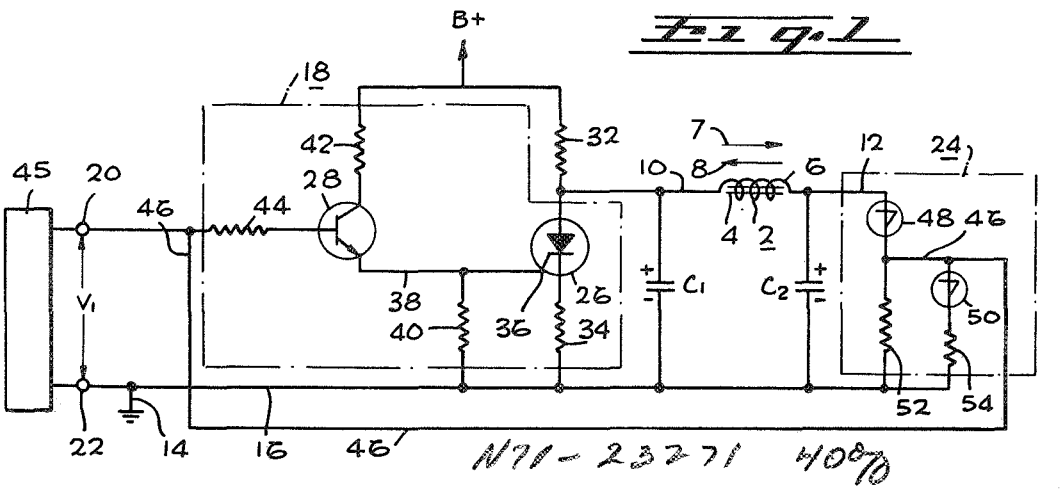
Dec. 17, 1968 HUGH L. DRYDEN 3,417,298

DEPUTY ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

POLARITY SENSITIVE CIRCUIT

Filed Aug. 11, 1964

Fig. 1



NII-23271 4080

Fig. 2

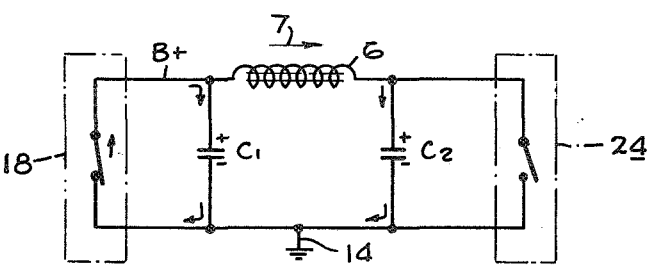
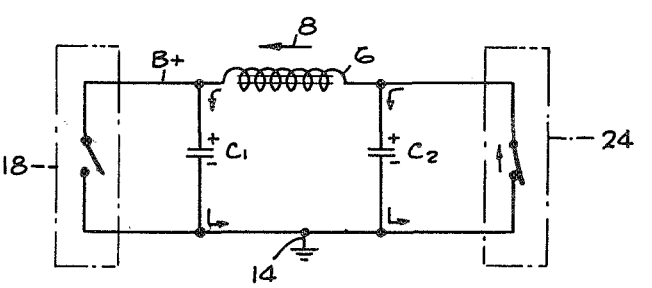


Fig. 3



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United States Patent Office 3,417,298 Patented Dec. 17, 1968

3,417,298

POLARITY SENSITIVE CIRCUIT

Hugh L. Dryden, Deputy Administrator of the National Aeronautics and Space Administration with respect to an invention of Lawrence S. Smith, Los Angeles, Calif.

Filed Aug. 11, 1964, Ser. No. 388,967
8 Claims. (Cl. 317—148.5)

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 U.S.C. 2457).

This invention relates to a switching circuit and more particularly to a circuit that can be selectively operated to reverse the direction of flow of a current.

One use of a circuit that can change the direction of flow of current is in the operation of a two way magnetic relay. A magnetic relay normally includes an inductance in the form of a solenoid coil and a magnetizable armature movably carried within the coil. When a pulse of current passes through the coil it creates a force that moves the armature. The direction of current flow through the coil determines the direction of armature movement.

There are many applications for a magnetic relay whose armature is capable of movements in opposite directions. Just as an example, such two-wave movement can be used to move a locking latch to a closed or to an open position. Or, such two-wave movement can be used to remotely control operation of various electrical circuits by making or breaking contacts.

There are a number of ways of accomplishing two-way movement of an armature of a magnetic relay in the prior art. For example one way has been to use two separate power supplies of opposite polarity. In broad terms with two power supplies, one power supply of one polarity is connected to cause current to move the armature in one direction. And, the other power supply of opposite polarity is connected to move the armature in the opposite direction.

One disadvantage of the above construction is that it is expensive to provide two power supplies. It is also expensive to supply the associated circuit components needed by two power supplies. In addition the more components that are used the greater the chance for some of them to fail. Also with two power supplies it is relatively difficult to control operation of the circuit.

Another example of a construction for providing two-way movement of an armature of a magnetic relay is to simply use two independent and separate circuits and two separate solenoid coils for the armature. In this construction, each coil is arranged to move the armature in one direction. That is, when current flows through one coil, it is energized and will move the armature in one direction. When the flow of current is through the other coil it in turn is energized and will move the armature in the opposite direction.

This construction also has disadvantages like the construction described above. It is expensive to provide two solenoid coils. It is also expensive to provide the associated circuit components needed to operate two solenoid coils independently. And it is also relatively difficult to control operation of these two independent circuits.

In general terms, this invention includes a circuit with one power supply connected to place equal charges on

two capacitances connected in parallel. The capacitances are connected to have a discharge path in a selected direction through a solenoid coil of a magnetic relay to provide bi-directional movement of the armature.

The direction in which a capacitance discharges through the coil is controlled by a first and second switch means. One switch means is closed only by a control signal voltage of positive polarity. The other switch means is closed only by a control signal voltage of negative polarity.

With the above construction, any voltage source capable of providing pulses of negative and positive polarity can control the bi-directional movement of the armature. That is, when a control voltage pulse of positive polarity is applied to the circuit, it will close one switch means, while the other switch means remains open. The closed switch means establishes a discharge path for a selected capacitance so that it discharges through the solenoid coil in one direction. If on the other hand, a control voltage pulse of negative polarity is applied to the circuit it will only close the other switch means. This switch means will establish a different discharge path for the other capacitance so that it discharges through the solenoid coil in the opposite direction.

It is therefore a principal object of this invention to provide a circuit that can be selectively operated to change the direction of flow of current.

Another object of this invention is to provide a circuit useable with a magnetic relay that provides bi-directional movement of the armature of the relay while using only one power supply and one solenoid coil.

Another object of this invention is to provide a circuit that can be controlled by one signal source to selectively shift the armature of a magnetic relay to provide bi-directioned operation.

Other objects and advantages will appear from the following detailed description considered in conjunction with the accompanying drawings, wherein:

FIG. 1 is a circuit diagram of a preferred embodiment of the invention;

FIG. 2 is a schematic showing of an equivalent circuit of FIG. 1 to illustrate the passage of current when one switch means is closed; and

FIG. 3 is similar to FIG. 2 showing the passage of the current when the other switch means is closed.

DESCRIPTION

For purposes of illustration, a preferred embodiment of the invention is shown in FIG. 1 with respect to its use in the bi-directional operation of a magnetic relay 2.

A magnetic relay broadly includes an armature 4 movably carried within a solenoid coil 6 and movable in the direction of arrows 7 and 8. The armature in turn may be provided with contacts (not shown) to make or break contacts of control circuits, as is well known in the art.

The circuitry shown in FIG. 1 can provide two-way movement of armature 4 of magnetic relay 2. In the explanation of the circuit, where current is referred to, it is electron flow that is meant.

Essentially the circuit includes a pi-network made up of two capacitances C1 and C2 having an inductance or solenoid coil 6 electrically connected between them. The capacitances C1 and C2 form the legs of the network and are connected to each end of coil 6 by conductors 10 and 12.

Capacitances C1 and C2 are charged by a source of direct current that may for example be a direct current bat-

tery B+ of 25 volts. The ground of the battery is indicated at 14 and it is connected to conductor 16.

Capacitances C1 and C2 have connected in parallel with them a first switch means indicated by dotted lines 18. This switch means is adapted to be closed by a control voltage pulse V1 of positive polarity applied at terminals 20 and 22. The capacitances also have connected in parallel with them a second switch means indicated by dotted lines 24. This switch means is adapted to be closed by a control voltage pulse V1 of negative polarity applied at terminals 20 and 22.

Switch means 18 includes a voltage controlled diode switch 26, more commonly referred to as a silicon controlled rectifier, and an NPN transistor 28. Transistor 28 passes a positive pulse signal V1 and in turn closes or opens diode switch 26 to the flow of current.

Diode switch 26 has its anode connected through resistance 32 to B+. The cathode of diode switch 26 is connected to resistance 34 and resistance 34 is in turn connected to ground 14 through conductor 16. Resistance 34 serves to limit current through diode switch 26.

Transistor 28 has its emitter connected to diode switch's gate 36 by conductor 38. Also connected to conductor 38 is resistance 40 whose other end is connected to conductor 16 and to terminal 22. Resistance 32 is made large to prevent either switch 18 or 24 from remaining on. Transistor 28 has its collector connected through resistance 42 to B+. The transistor's base is connected through resistance 44 to terminal 20.

Control voltage pulse V1 is applied to terminals 20 and 22. The control voltage pulse may be in the order of five volts positive or negative polarity where the solenoid coil requires 25 volts for operation. With respect to the control voltage, it is pointed out that any control voltage means indicated generally by numeral 45 which can selectively generate a positive and negative polarity voltage pulse in a random or selected order is suitable for use with the circuit. The control means to generate voltage pulses V1 is not part of the invention and its selection would depend primarily on the type of armature movement wanted. As an example a computer can be used for the source of voltage pulse.

Voltage pulse V1 in addition to being applied to transistor 28, is also applied through conductor 46 to the negative polarity controlled switch means 24. Diodes switch means 24 also controls operation of capacitances C1 and C2.

Switch means 24 includes voltage controlled diode switches 48 and 50, and current limiting resistors 52 and 54. Diode switches 48 and 50 are commonly known as Schockly or four layer diodes. Diode switch 48 is connected to resistance 52 and these are in shunt across capacitance C2. Diode switch 50 is connected to resistance 54 and these are in parallel to resistance 52.

Diode switch 48 has its cathode connected through conductor 46 to the anode of diode switch 50. Diode switch 48 is connected to conductor 12 which is connected to coil 6 and capacitance C2. Resistances 52 and 54 are connected through conductor 16 to ground 14.

Resistance 52 is made very large compared to transistor base resistance 44. This is to prevent the positive polarity signal current from by-passing transistor base resistance 44. That is, if resistance 52 were small compared to resistance 44, then on a positive polarity signal, the majority of current would flow from ground 14, through conductor 16, resistance 52, conductor 46, and then to terminal 20; instead of through transistor base resistance 44 where it is desired to develop a high voltage to turn transistor 28 on.

Resistance 52 is made 100 to 1000 times larger than resistance 54. The reason for this is to provide a low resistance path for the discharge of capacitances C1 and C2 when diode switch 48 is closed. This will be explained in greater detail in the summary of operation of the circuit to follow.

OPERATION

The circuit operates in the following manner:

CHARGING

Capacitances C1 and C2 are charged by direct current source B+. The path of the charging current in the case of capacitance C1 being from ground 14, through capacitance C1, resistance 32 and then to B+. In the case of capacitance C2 the path of the charging current is from ground 14, through capacitance C2, coil 6, resistance 32 and then to B+.

Resistance 32 in the charging circuit of capacitance C2 also functions to establish a time constant that will prevent capacitance C2 from charging too rapidly, otherwise the impulse of current passing through solenoid coil 6, while capacitance C2 is charging, might accidentally shift armature 4.

POSITIVE POLARITY PULSE

To move armature 4 in a first direction control signal means 45 is operated to provide a control voltage pulse V1 of positive polarity at input terminals 20–22. Current will flow through resistance 44 connected to the base of NPN transistor 28 to generate a positive voltage that in turn will turn the transistor on.

When transistor 28 is on, current flows from ground 14 through resistance 40, then through the emitter and collector of the transistor, through resistance 42 and then to B+.

The flow of current through resistance 40 in effect closes diode switch 26. The current makes the upper part of resistance 40 relatively more positive. This positive voltage is in turn applied by conductor 38 to gate 36 of diode switch 26 and will close this diode switch so it will conduct.

When switch 26 is closed, a discharge path is provided for capacitances C1 and C2. Capacitance C1 will quickly discharge through resistance 34, diode switch 26 and then back to the other plate of the capacitance an shown in FIG. 2 of the drawings.

Capacitance C2 will discharge more slowly than capacitance C1 since it has coil 6 in its discharge path. Capacitance C2 will discharge both through discharge diode switch 26 and also through capacitance C1, to provide a high impulse of current shown by arrow 7 in FIG. 2 through coil or impedance 6. This high current will in turn move armature 4, in a first direction.

NEGATIVE POLARITY PULSE

To move armature 4 in the opposite direction, control signal means 45 is operated to provide a control voltage pulse V1 of negative polarity at input terminals 20, 22. The negative polarity pulse is applied by conductor 46 to the cathode of diode switch 48. This pulse makes the annode if diode switch 48 more positive and biases the diode switch to conduction and in effect closes this switch.

When switch 48 is closed, a discharge path is opened for capacitances C1 and C2. Capacitance C2 will discharge through resistance 52, diode switch 48 and back to the other plate of the capacitance as shown in FIG. 3.

However since resistance 52 is very large it is desirable that the capacitances discharge through a small resistance so less power will be used. To accomplish this, diode switch 50 and small resistance 54, become operative. As current flows upward through resistance 52 it makes the top of the resistance more positive. This positive voltage is in turn applied to the annode of diode switch 50 and closes diode switch 50 so that it now conducts.

When diode switch 50 closes, it creates a rapid discharge path for the capacitance C2. The capacitance will discharge through very small resistance 54 which is 100 to 1000 times smaller than resistance 52, through diode switch 50, conductor 46, diode switch 48 and then back to the other plate of capacitance C2.

Capacitance C1 will discharge more slowly than capaci-

tance C2 since it now has coil 6 in its path. Capacitance C1 will discharge both through diode switch 50 and also through capacitance C2 to provide a high impulse of current shown by arrows 8 in FIG. 3, through coil 6. This high current will move armature 4 in a reverse direction.

It will be noted that when a positive polarity voltage pulse V1 is applied at terminals 20 and 22 the pulse is also applied by conductor 46 to the anode of diode switch 50. As a matter of design therefore, diode switch 50 must be selected with a high enough voltage rating so that it does not break down and conduct on the positive pulse.

With the above circuit construction it will be noted that there are a number of advantages:

First, only one power supply and only one solenoid coil 6 are required;

Second, it will be noted that the circuit uses very little power and is normally dormant. The circuit will use power only after the voltage pulses are applied. Until then only leakage current will flow in the circuit;

Third, the circuit is very simple and requires very few components;

Fourth, very low voltage pulses are required to switch the circuits, and

Fifth, as would be obvious to one skilled in the art, the sensitivity of the circuit can be increased by component selection and introducing gain stages at the input. Also, the polarity of the circuit could be reversed as is well known in the art.

It should be understood that it is not intended to limit this invention to the herein disclosed form, but that the invention should include such other forms or modifications as may be embraced by the scope of the appended claims.

What is claimed is:

1. In a circuit for providing impulses of current through an impedance in selected directions, the combination comprising:
   - an impedance;
   - first switch means having two input terminals, said switch means being connected to said impedance and operative in response only to a voltage pulse of positive polarity on said terminals to provide an impulse of current through said impedance in a first direction; and
   - second switch means having the same two input terminals, said second switch means also being connected to said impedance and being operative only in response to a voltage pulse of negative polarity on said terminals to provide an impulse of current through said impedance in a direction opposite to said first direction said first and second switch means being constructed to operate in random order depending on the sequence and polarity of the voltage pulses applied to said two input terminals.

2. In a circuit for providing impulses of current through an inductance in selected directions, the combination comprising:
   - an inductance;
   - a source of direct voltage;
   - first and second capacitances, said capacitances and said inductance being connected in the form of a pi-network, with said capacitances, being connected to said direct voltage source to become charged during the application of voltage from said source;
   - first switch means connected to said capacitances and to said inductance, said first switch means having input terminals, said first switch means being operative in response to a first signal applied to said input terminals to establish a discharge path through said inductance for one of said capacitances to provide an impulse of current in a first selected direction; and
   - second switch means connected to said capacitances and to said inductance, said second switch means being connected to the same input terminals as said first switch means, and being operative in response to a different signal than said first signal applied to said input terminals to establish a discharge path through said inductance in the reverse direction for the other of said capacitances to provide an impulse of current in a direction opposite to said first direction.

3. In a circuit for providing impulses of current through an inductance in selected directions, the combination comprising:
   - an inductance;
   - a source of direct voltage;
   - first and second capacitances, said capacitances and said inductance being connected in the form of a pi-network, said capacitances being coupled in parallel to said direct voltage source to become charged during the application of voltage from said source;
   - first switch means connected to said capacitances and to said inductance, said first switch means having input terminals and being operative in response to a voltage pulse of positive polarity applied to said input terminals to establish a discharge path through said inductance for one of said capacitances, to provide a high impulse of current in a first selected direction; and
   - second switch means connected to said capacitances and to said inductance, said second switch means, being connected to the same input terminals as said first switch means and being operative in response to a voltage pulse of negative polarity applied to said input terminals to establish a discharge path through said inductance for the other of said capacitances, to provide a high impulse of current in a direction opposite to said first direction.

4. In a circuit for providing impulses of current through an inductance in selected directions, the combination comprising:
   - an inductance;
   - a source of direct voltage;
   - first and second capacitances, said capacitances and said inductance being connected in the form of a pi-network said capacitances being coupled in parallel to said direct voltage source to become charged during the application of voltage from said source;
   - first switch means including a voltage controlled diode switch having its cathode connected to one plate of each of said capacitances and its anode connected to the other plate of said first capacitance, and its anode also connected to the other plate of said second capacitance through said inductance, said first switch means having input terminals and being operative in response to a voltage pulse of positive polarity applied to said input terminals to close said voltage controlled diode switch to establish a discharge path through said inductance for said second capacitance, to provide a high impulse of current in a first selected direction; and
   - second switch means including a voltage controlled diode switch having its cathode connected to one plate of each of said capacitances and its anode connected to the other plate of said second capacitance and its anode also connected to the other plate of said first capacitance through said inductance, said second switch means being connected to the same input terminals as said first switch means and being operative in response to a voltage pulse of negative polarity applied to said input terminals to close said voltage controlled diode switch to establish a discharge path through said inductance to provide a high impulse of current in a direction opposite to said first direction.

5. In a circuit for providing impulses of current through an inductance in selected directions, the combination comprising:
   - an inductance;

a source of direct voltage;

first and second capacitances, said capacitances and said inductance being connected in the form of pi-network, said capacitances being coupled in parallel to said direct voltage source to become charged during the application of voltage from said source;

first switch means including a first voltage controlled switch having one end connected to one plate of each of said capacitances and its other end connected to the other plate of said capacitance, and its other end also connected to the other plate of said second capacitance through said inductance, said first switch means having input terminals and being operative in response to a voltage pulse of positive polarity applied to said input terminals to close said first voltage controlled switch to establish a discharge path through said inductance for said second capacitance to provide a high impulse of current in a first selected direction; and

a second voltage controlled switch having one end connected to one plate of each of said capacitances through a resistance, and its other end connected to the other plate of said second capacitance, and said other end also being connected to the other plate of said first capacitance through said inductance, said resistance being connected to the same input terminals as said first switch means and being operative in response to a voltage pulse of negative polarity applied across said resistance by said input terminals to close said second voltage controlled switch to establish a discharge path through said inductance for said first capacitance to provide a high impulse of current in a direction opposite to said first direction.

6. In a circuit for providing impulses of current through an inductance in selected directions, the combination comprising:

an inductance;

a source of direct voltage;

first and second capacitances, said capacitances and said indutance being connected in the form of a pi-network, said capacitances being coupled in parallel to said direct voltages source to become charged during the application of voltage from said source;

first switch means including a first voltage controlled switch having one end connected to one plate of each of said capacitances and its other end connected to the other plate of said first capacitance, and its other end also connected to the other plate of said second capacitance through said inductance, said first switch means having input terminals and being operative in response to a voltage pulse of positive polarity applied to said input terminals to close said first voltage controlled switch to establish a discharge path through said inductance for said second capacitance and provide a high impulse of current in a first selected direction;

a second voltage controlled switch including a resistance, said second switch having its one end connected to one plate of each of said capacitances through a high resistance and its other end connected to the other plate of said second capacitance, and its other end also connected to the other plate of said first capacitance through said inductance, said high resistance being connected to the same input terminals as said first switch means and being operative in response to a voltage pulse of negative polarity applied across said high resistance by said input terminals to close said second voltage controlled switch; and

a third voltage controlled switch of low resistance in parallel with said high resistance, said third switch being operative to shunt sad high resistance in response to current flow through said high resistance, to establish a low resistance discharge path through said inductance for said first capacitance and provide a high impulse of current in a direction opposite to said first direction.

7. In a circuit for providing impulses of current through an inductance in selected directions, the combination comprising:

an inductance;

a source of direct voltage;

first and second capacitances, said capacitances and said inductance being connected in the form of a pi-network, said capacitances being coupled in parallel to said direct voltage source to become charged during the application of voltage from said source;

first switch means including a first voltage controlled diode switch having its cathode connected to one plate of each of said capacitances and its anode connected to the other plate of said first capacitance, and its anode also connected to the other plate of said second capacitance through said inductance, said first switch means having input terminals and being operative in response to a voltage pulse of positive polarity applied to said input terminals to close said diode switch to establish a discharge path through said inductance for said second capacitance and provide a high impulse of current in a first selected direction.

a second voltage controlled diode switch including a high resistance, said second switch having its cathode connected to one plate of each of said capacitances through said high resistance and its anode connected to the other plate of said second capacitance, and its anode also connected to the other plate of said first capacitance through said inductance, said high resistance being connected to the same input terminals as said first switch means and being operative in response to a voltage pulse of negative polarity applied across said high resistance by said input terminals to generate a voltage that closes said second voltage controlled diode switch; and

a third voltage controlled diode switch of low resistance in parallel with said high resistance, said third switch being operative in response to current flow through said high resistance to shunt said high resistance to establish a low resistance discharge path through said inductance for said first capacitance and provide a high impulse of current in a direction opposite to said first direction.

8. In a circuit for providing impulses of current through an inductance in selected directions, the combination comprising:

an inductance;

a source of direct voltage;

first and second capacitances, said capacitances and said inductance being connected in the form of a pi-network, said capacitances being coupled in parallel to said direct voltage source to become charged during the application of voltage from said source;

a first voltage controlled diode switch having its cathode connected to each of said capacitances and its anode connected to the first of said capacitances, and its anode also connected to said second capacitance through said inductance;

an NPN transistor having its emitter and collector connected in series with said source of direct current and in parallel with said first diode switch, the emitter and base of said transistor having input terminals and operative in response to a voltage pulse of positive polarity applied to said input terminals to turn said transistor on and close said first diode switch to establish a discharge path through said inductance for said second capacitance, and provide a high impulse of current in a first selected direction;

a second voltage controlled diode switch including a large resistance, said second switch having its cathode

connected to each of said capacitances through a large resistance and its anode connected to the second of said capacitances, and to its anode also connected to said first capacitance through said inductance, said high resistance being connected to the same input terminals as said transistor and being operative in response to a voltage of negative polarity applied across said high resistance by said input terminals to close said second voltage controlled diode switch; and

a third low resistance voltage controlled diode switch in parallel with said high resistance, and operative in response to current flow through said high resistance to shunt said high resistance, to establish a low

resistance discharge path through said inductance for said first capacitance and provide a high impulse of current in a direction opposite to said first direction.

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LEE T. HIX, *Primary Examiner.*

U.S. Cl. X.R.

317—150, 151