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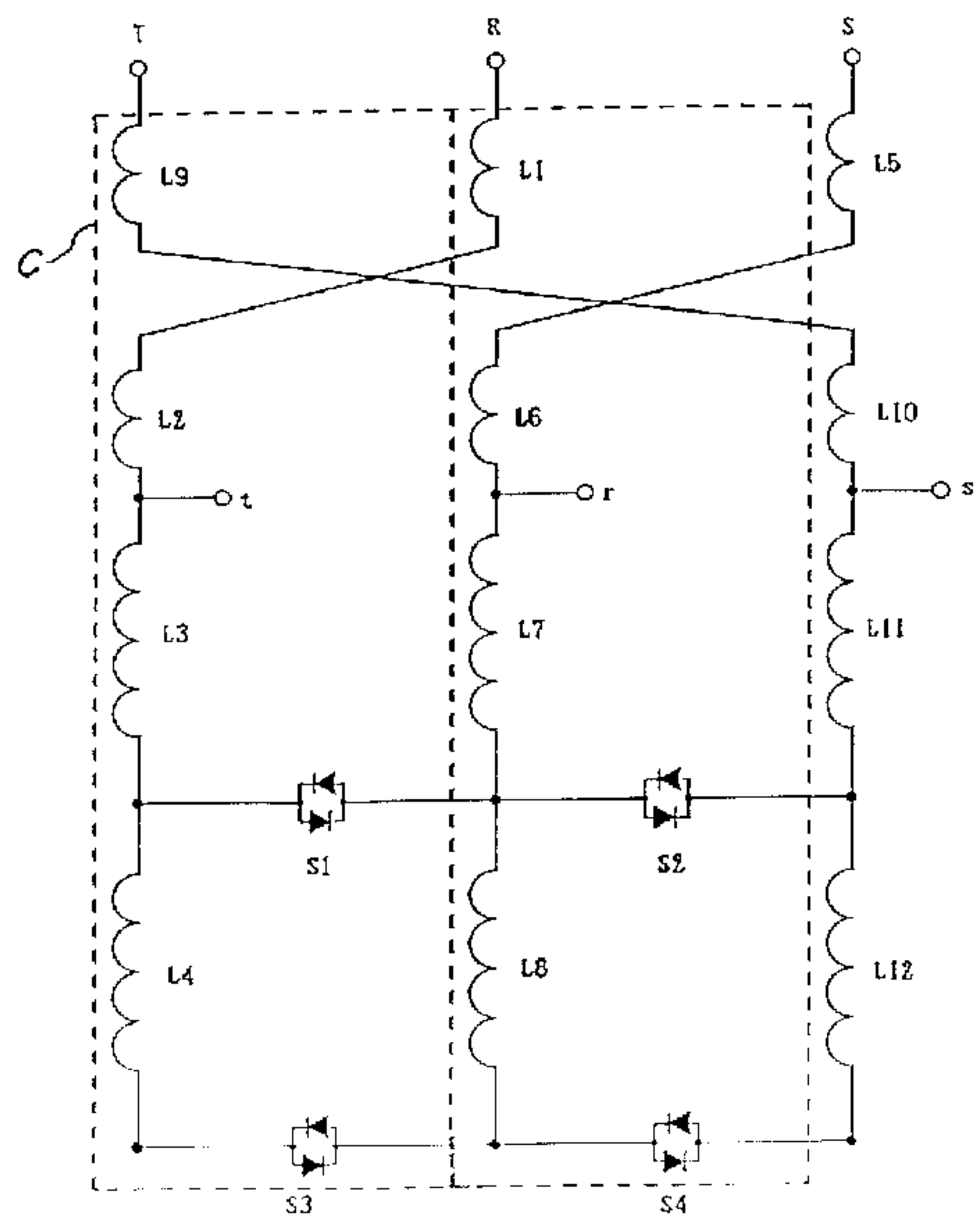
(54) Titre : METHODE ET DISPOSITIF DE REGULATION AUTOMATIQUE DE LA TENSION TRIPHASEE D'ALIMENTATION D'UN TRANSFORMATEUR ECONOMISEUR D'ENERGIE

(54) Title: METHOD OF AND DEVICE FOR AUTOMATICALLY REGULATING THREE-PHASE VOLTAGE FOR POWER SAVING TRANSFORMER



(57) Abrégé/Abstract:
In a three-phase three-wire or four-wire auto-transformer, one set or a plurality of sets of main coils connected to an input terminal are interwound around three-phase core type cores by three circuits and a plurality of sets of exciting coils, which are wound around the cores and connected in series with each other, are connected between the end sections of the main coils of individual circuits through a plurality of combination connections. At the same time, a plurality of sets of electronic switches which are turned on/off depending upon the voltage value of a voltage sensor connected to an input or output terminal are provided between the above-mentioned end sections are provided between the above-mentioned end sections and between individual exciting coils and one set or a plurality of sets of electronic switches between the end sections and between individual exciting coils are connected or disconnected by turning on/off the switches in steps for every same phase-to-phase potential or every same current of the switches so that the circuit can be switched to a circuit which uninterruptively regulates the output voltage of the transformer. Therefore, the output voltage of the transformer can be regulated to within a prescribed set range and the load of the transformer is not affected when the input voltage rises or drops, because the rise or drop is automatically detected and the circuit is switched.

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添付公開書類
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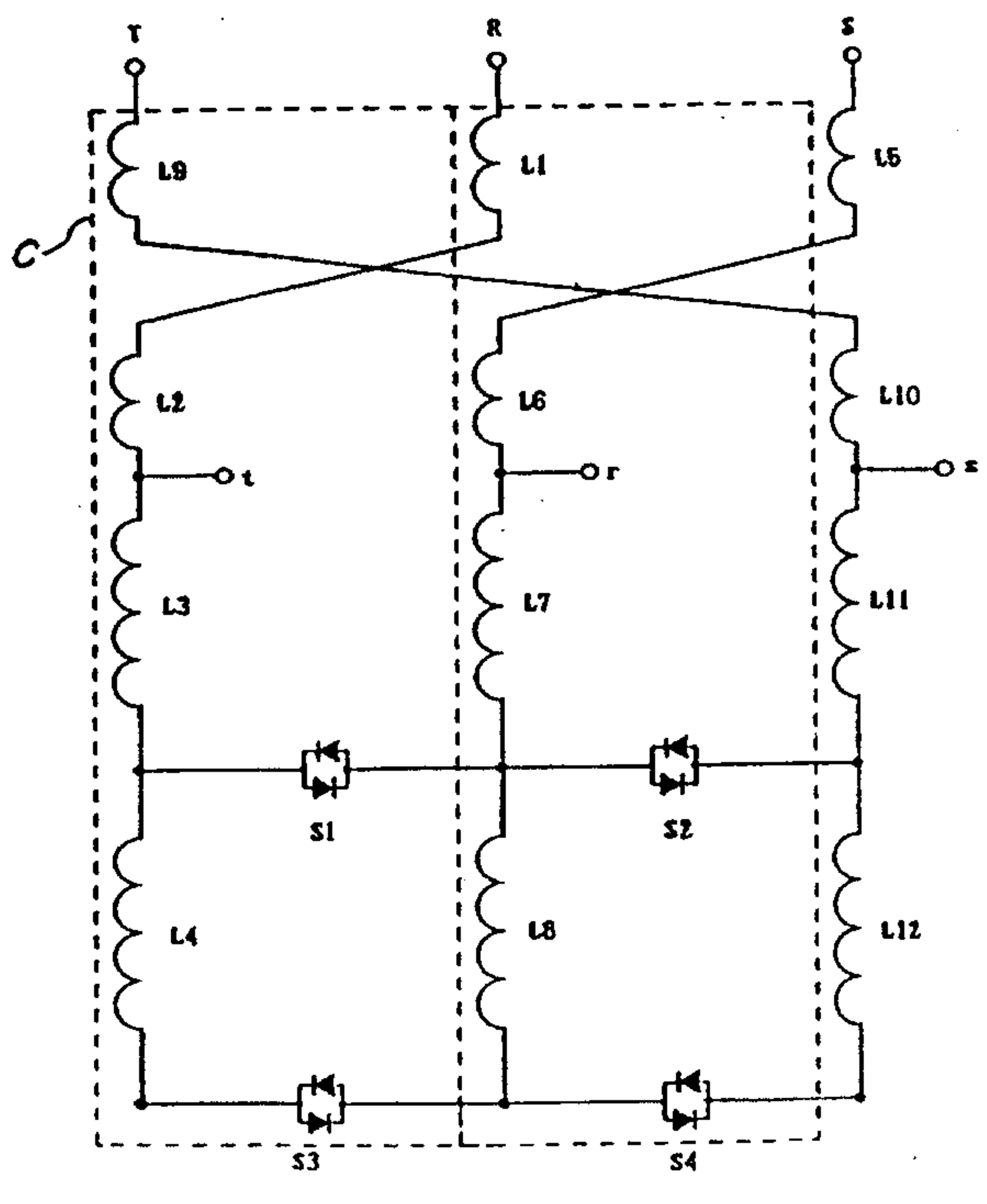
(54)Title: **METHOD AND DEVICE FOR AUTOMATICALLY SWITCHING THREE-PHASE VOLTAGE FOR POWER SAVING TRANSFORMER**

(54)発明の名称 省電力変圧器における3相式電圧自動切替方法及びその装置

(57) Abstract

In a three-phase three-wire or four-wire auto-transformer, one set or a plurality of sets of main coils connected to an input terminal are interwound around three-phase core type cores by three circuits and a plurality of sets of exciting coils, which are wound around the cores and connected in series with each other, are connected between the end sections of the main coils of individual circuits through a plurality of combination connections. At the same time, a plurality of sets of electronic switches which are turned on/off depending upon the voltage value of a voltage sensor connected to an input or output terminal are provided between the above-mentioned end sections are provided between the above-mentioned end sections and between individual exciting coils and one set or a plurality of sets of electronic switches between the end sections and between individual exciting coils are connected or disconnected by turning on/off the switches in steps for every same phase-to-phase potential or every same current of the switches so that the circuit can be switched to a circuit which uninterruptively regulates the output voltage of the transformer. Therefore, the output voltage of the transformer can be regulated to within a prescribed set range and the load of the transformer is not affected when the input voltage rises or drops, because the rise or drop is automatically detected and the circuit is switched.



METHOD OF AND DEVICE FOR AUTOMATICALLY REGULATING THREE-PHASE VOLTAGE FOR POWER SAVING TRANSFORMER

BACKGROUND OF THE INVENTION

The present invention relates to a device for automatically adjusting an output voltage within a prescribed range even when an input voltage rises or falls beyond its predetermined range in an electric power saving device, such as an autotransformer, so that an abnormal voltage is not supplied to a load.

One example of a conventional electric power saving apparatus is disclosed in a Japanese patent application filed by the same applicant, published in a Patent Abstract of Japan under publication number 08191542 A.

In a conventional electric power saving apparatus, as shown in Fig. 4, plural sets of exciting coils L3, L4, L7 and L8, which are wound on a single-phase core-type core in a mutually connected series, are connected between the ends of a plurality of sets of main coils L1, L2, L5 and L6 which are phase-wound on the core, in which the combinations of connection of the exciting coils L3, L4, L7 and L8 are controlled by thyristors 1, 2, 3, 4, 5, 6, 7, and 8 connected with a voltage sensor (not shown) provided at the input ends of the main coils L2 and L6, whereby an output voltage is prevented from an unnecessary increase and decrease.

For example, a circuit, on which the exciting coils are combined to cause the output voltage to drop by 6V for an input voltage of 100V, is automatically switched to another circuit which has a lower-voltage rate of 3V and then 0V when the input voltage falls. On the other hand, the circuit will be automatically switched to another circuit which has a upper-voltage rate of 3V or 6V when the input voltage is too low. Therefore, the output voltage is prevented from unnecessary increasing and decreasing so as to keep the effect on the load as little as possible.

However, conventional electric power saving transformers with automatic voltage regulating devices such as the aforementioned example are for single-phase current, and are restricted to autotransformers of single-phase three-wire or two-wire systems used for a power generator.

For the case of three-phase current systems, a simultaneous ON/OFF switching of voltages of the three phases is desired. Since the three phases of alternating current are not at the same voltage level and simultaneous turning OFF is impossible for thyristors when used as electric switches, the required control circuit is more complex and difficult to manage than for single-phase current. Accordingly, in three-phase current systems, manual voltage adjustments are performed conventionally instead of automatic voltage regulation.

SUMMARY OF THE INVENTION

To deal with the aforementioned disadvantages, the present invention provides, as will be described in the following, a method and an apparatus for automatically adjusting an output voltage within a prescribed range in an electric power saving device for three-phase current even when an input voltage rises or falls beyond its predetermined range.

In an autotransformer of a three-phase three-wire or four-wire system an electric power saving transformer for three-phase current with an automatic voltage switching device is characterized by phase-winding a single set or a plurality of sets of main coils which are connected to input terminals on a three-phase core-type core; connecting a plurality of sets of exciting coils mutually connected in series to wind the three-phase core-type core between the ends of the main coils by means of a plurality of connection configurations; connecting a plurality of electric switches between the ends of the main coils and the exciting coils which are turned ON or OFF depending upon the value detected by a voltage sensor connected to the input or output terminals; and connecting and disconnecting between the ends of the main coils and the exciting coils, by turning ON or OFF the electric switches stepwise on the same value of voltages or currents between the phases in order to automatically change output voltage correspondingly to input voltage onto voltage switching circuits in an uninterrupted manner.

According to the electric power saving device of the present invention, the instant the voltage sensor detects an increase or a decrease of the input voltage beyond the prescribed range, electric switches, which receive an output signal sent from the voltage sensor, control the combinations of connection of the aforementioned plural sets of the exciting coils so as to adjust the lower-voltage rate or the input voltage value in order to be able to constantly output the voltage within the prescribed range.

Furthermore, when the output voltage does not need to be decreased, the voltage may be output at the same value as the input voltage.

Hysteresis may be provided by difference between input voltage values in which a lower-voltage rate is changed, when the input voltage is being increased and decreased, so that an error made by the apparatus when the combinations of connection of the exciting coils are changed is prevented, and the coils and electric switches are facilitated without being overloaded.

The stepwise change of the lower-voltage rate according to the input voltage value is effective for electric power saving.

The lower-voltage rate of approximate 1% to 10% is useful.

According to the present invention as described so far, electric power is, a matter of course, saved by decreasing the output voltage to be above the minimum voltage necessary but within the prescribed range. Furthermore, the voltage is facilitated to adjust to automatically output the voltage value within a prescribed range, whereby the influence on a load for three-phase current wherein voltage stability is necessary may be minimized.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be seen in reference to the following descriptions taken in connection with the accompanying drawings in which:

Fig. 1 is a circuit diagram of the main part of an embodiment of an automatic three-phase voltage regulating apparatus according to the present invention;

Fig. 2 is a graph showing the relation between input voltage and output voltage in the apparatus according to the present invention;

Fig. 3 graphically profiles a three-phase current; and

Fig. 4 is a circuit diagram of the main part of an automatic voltage regulating apparatus according to conventional skills, wherein

L1, L2, L5, L6, L9 and L10 each stand for a main coil;
L3, L4, L7, L8, L11 and L12 each stand for an exciting coil;
R, S and T each stand for an input terminal; r, s and t each stand for an output terminal of transformer; S1, S2, S3 and S4 each stand for electric switches; and C stands for three-phase core-type core.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will be described below with reference to the drawings.

Fig. 1 shows a circuit diagram of the main part of an embodiment of an electric power saving apparatus according to the present invention, in which a plurality of main coils L1, L2; L5, L6; and L9, L10; connected to input terminals R, S and T of a transformer respectively, are phase-wound on a three-phase core-type core, and a plurality of sets of exciting coils L3, L7, L11 and L4, L8, L12, connected in series respectively to wind on the three-phase core-type core, are connected between the end sections of the main coils L2, L6 and L10 through a plurality of connecton configurations.

Further, an output terminal t of the transformer is connected between the main coil L2 and the exciting coil L3, and the other output terminals r and s are connected between the main coil L6 and the exciting coil L7 and between the main coil L10 and the exciting coil L11 respectively.

A voltage sensor (not shown) for detecting the input voltage is provided in a base plate (not shown), in which a terminal on the probe side is connected to the output terminals of, the main coils L2, L6, and L10, and another terminal on the signal output side is connected to electric switches S1, S2, S3 and S4 provided respectively between the exciting coils.

As shown in Fig. 1, the aforementioned electric switches S1, S2, S3 and S4 are respectively connected between the exciting coils; the electric switch S1 being connected between the exciting coils L3, L7, L4 and L8, the electric switch S2 being connected between the exciting coils L7, L11, L8 and L12, the electric switch S3 being connected between the exciting coils L4 and L8, and the electric switch S4 being connected between the exciting coils L8 and L12.

The electric switches are turned ON or OFF depending upon a voltage value detected by the voltage sensor, to control the connection configurations of the exciting coils L3, L4, L7, L8, L11 and L12 in the circuit, with the result that the output voltage is automatically adjusted. The function and effect of this embodiment of the present invention is explained below with reference to Fig. 2 which illustrates the relation between input voltage and output voltage.

In this embodiment, coils are designed to cause output voltage to drop by 4V(2%) or 8V(4%) for an input voltage at 200V under the condition that the prescribed lower voltage rate is defined as 2% or 4%, and the minimum voltage value necessary for a load is defined as 192V.

In this case, the circuit is initially connected to make the output voltage drop by 8V below the input voltage, and the input voltage is going to decrease. More specifically, in the circuit diagram of Fig. 1, through the control signal detected by the voltage sensor provided in the base plate, the electric switches S1 and S2 are switched to an ON state, and the other electric switches S3 and S4 are switched to an OFF state.

Here, for example, when an input voltage of 210V is applied, the main coils L1, L2; L5, L6; and L9, L10 are respectively dropped by 8V by the exciting coils L3, L7 and L11. Therefore, the voltage of 210-8=202V is provided at each output terminal r, s and t. As shown in Fig. 2, this lower-voltage circuit is used just before the input voltage reaches 200V, in which case the output voltage decreases below 192V when the input voltage falls by 8V.

When an input voltage reaches 200V, the circuit is switched to another configuration which drops by 4V in order to prevent decreasing the output voltage unnecessarily. The electric switches S3 and S4 are turned ON, and the other electric switches S1 and S2 are turned OFF in the circuit. The main coils L1, L2; L5, L6; and L9, L10 are respectively dropped by 4V by the exciting coils L3, L7 and L11. Therefore, the voltage of 200-4=196V is provided at each output terminal r, s and t. As shown in Fig. 2, this lower-voltage circuit is used just before the input voltage reaches 196V, in which case the output voltage decreases below 192V when the input voltage is dropped by 4V.

When the input voltage reaches 192V, the circuit is changed to another configuration, directly connecting input terminals R, S and T to output terminals r, s and t in order to prevent decreasing the output voltage unnecessarily.

Moreover hysteresis is provided in switching the connection configuration of the exciting coils so that errors made by the apparatus detecting an instantaneous change in the input voltage due to a sudden fluctuation or the like are eliminated, and thus an unnecessary loading on the electric switches and coils is prevented.

As shown in Fig. 2, the prescribed input voltage value for switching lower-voltage rate is different between the cases when the input voltage is falling or rising. When the input voltage is rising, the circuit for dropping by 4V is switched to that for dropping by 8V at an input voltage of 202V.

As seen, the apparatus according to the present invention adjusts the output voltage by means of the above circuit arrangement, and since it is for three-phase current, the timing of turning the electric switches ON or OFF is important.

Specifically, because each phase is relatively positioned at an angle of 120 degrees as shown in Fig. 3, the three phases are never of the same electric potential or the same electric current. Moreover, in electric switches like thyristors, the three phases may be turned ON at the same time but cannot be tured OFF at the same time. In switching ON/OFF of each phase, the exciting coils can become either short circuited or disconnected for a period of one-third or two-thirds of the cycle, resulting in that it is impossible to simultaneously change the voltage in each single phase.

Therefore, because there is a time when two of the three phases are at the same electric potential or the same electric current as shown in Fig. 3, the switches in the present invention operate at this particular time.

Namely, when the lower-voltage rate is 8V, electric switches S1 and S2 are ON, and S3 and S4 are OFF. As the lower-voltage rate is changed to 4V, S1 is switched from ON to OFF and S3 is switched from OFF to ON when phase T and phase R are of the same electric potential or the same electric current. During one third of the cycle till phase R and phase S become of the same electric potential or the same electric current, S2 is kept ON and S4 is kept OFF. Next, the moment phase R and phase S become of the same electric potential or the same electric current, S2 is switched from ON to OFF and S4 is switched from OFF to ON.

This way, voltage adjustment in a three-phase current system is made possible by operating the switches in two steps, and thus an electric power saving apparatus is provided.

Since the electric switches are switched stepwise, there may happen an instantaneous voltage unbalance in different phases depending on the characteristics of the electric switch used. However, this unbalance actually takes place for a short time so that security in operation is fully provided.

The electric power saving transformer for three-phase current with an automatic voltage regulating device according to the present invention can control the connection configuration of the plurality of sets of exciting coils in a stepwise manner on the two phases having the same electric potential or electric current with electric switches between the ends of main coils and exciting coils which are turned ON or OFF depending upon the input or output voltage level as detected by a voltage sensor. Accordingly, when an input or output voltage rises or falls so that it is no longer within the prescribed voltage range, the circuit is automatically switched to keep the output voltage to be higher than the prescribed minimum voltage value for a load.

Moreover hysteresis can be provided in changing the connection configuration of the exciting coils so that errors made by the apparatus detecting an instantaneous change in the input voltage due to a sudden fluctuation or the like are eliminated, and thus an unnecessary loading on the electric switches and coils is prevented.

The prescribed lower-voltage rate in the above embodiment is defined as 2% (4V) and 4% (8V) for an input voltage of 200V, however, it can be optionally modified in value and in number of steps, and further, although the minimum voltage value for load has been defined as 192V, the minimum voltage value for load can be optionally modified by a switch (not shown) provided in the apparatus.

While the invention has been particularly shown and described with reference to the preferred embodiment, it will be understood by those skilled in the art that the foregoing and other changes in form and details can be made without departing from the spirit and scope of the present invention.

CLAIMS:

1. A method of regulating three-phase voltage in an electric power saving transformer of a three-phase three-wire system or a three-phase four-wire system, comprising the steps of:

phase-winding at least one set of main coils being connected to input terminals on a three-phase core-type core in the transformer;

connecting a plurality of sets of exciting coils, mutually connected in series, to wind the core between the ends of the main coils by means of a plurality of connection configurations;

connecting a plurality of electric switches between the ends of the main coils and the exciting coils which are switched to ON/OFF based on the value detected by a voltage sensor connected to the input or output terminals of the transformer; and

connecting and disconnecting between the ends of the main coils and the exciting coils by switching ON/OFF the electric switches stepwise on the same value of voltages or currents between the phases in order to automatically change output voltage correspondingly to input voltage in an uninterrupted manner.

2. The method of changing three-phase voltage according to Claim 1, further comprising hysteresis provided by a difference between input voltage values in which a lower-voltage rate is changed when the input voltage is being increased and decreased.

3. The method of changing three-phase voltage according to Claim 2, wherein the lower-voltage rate is changed in plural steps.

4. The method of changing three-phase voltage according to Claim 3, wherein the lower-voltage rate is approximately 1% to 10%.

5. An electric power saving transformer of a three-phase three-wire system or a three-phase four-wire system for three-phase current, comprising:

one set or plural sets of main coils which are connected to input terminals to phase-wind on a three-phase core-type core in the transformer;

plural sets of exciting coils, mutually connected in series, to wind the core between the ends of the main coils by means of plural combinations of connections;

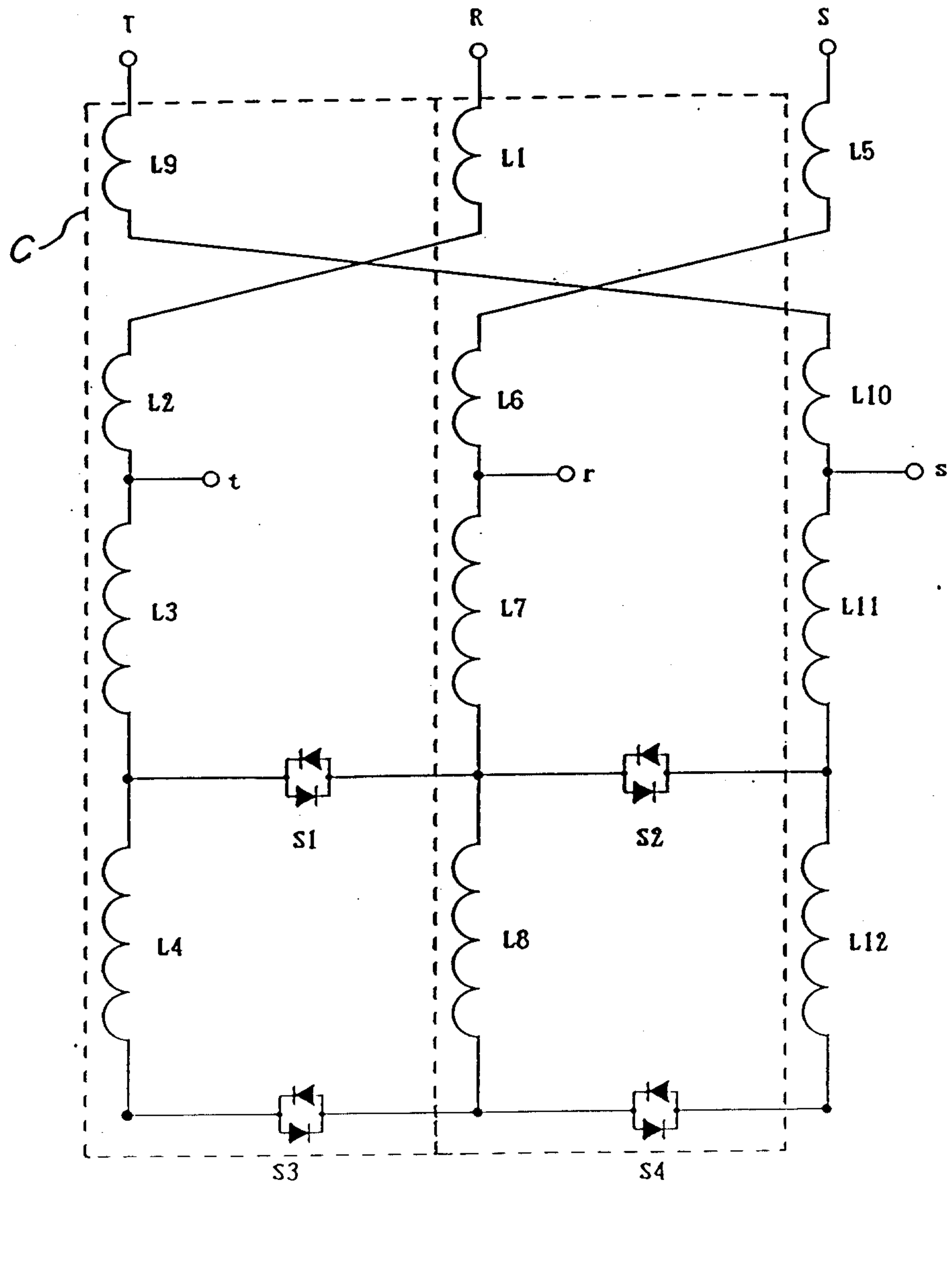
plural electric switches between the ends of the main coils and the exciting coils which are switched to ON/OFF based on the value detected by a voltage sensor connected to the input or output terminals of the transformer so that by connecting and disconnecting between the ends of the main coils and the exciting coils by switching ON/OFF of the electric switches stepwise on the same value of voltages or currents between the phases in order to automatically change output voltage correspondingly to input voltage in an uninterrupted manner.

6. The electric power saving transformer according to Claim 5, further comprising hysteresis provided by a difference between input voltage values in which a lower-voltage rate is changed when the input voltage is being increased and decreased.

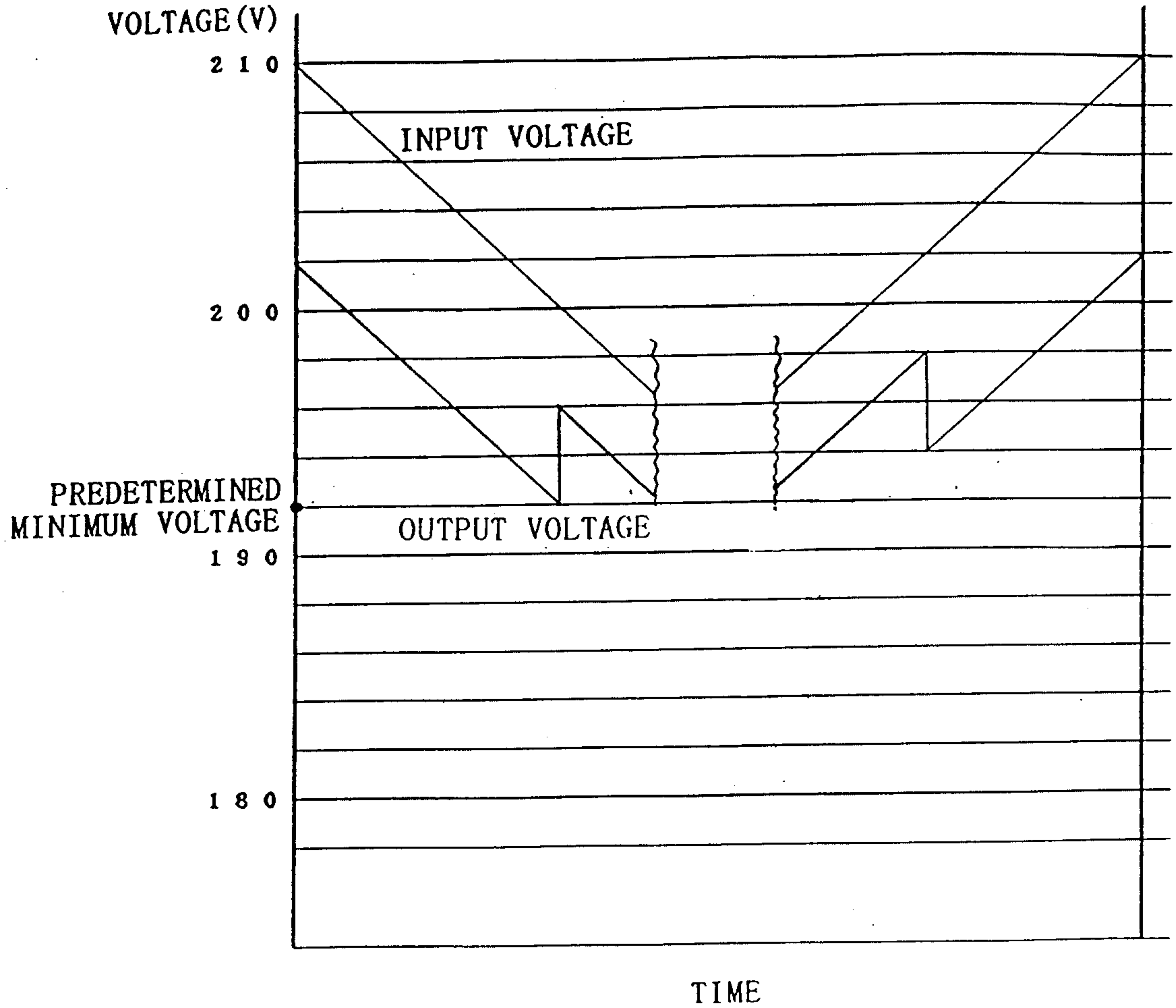
7. The electric power saving transformer according to Claim 6, wherein the lower-voltage rate is changed in plural steps.

8. The electric power saving transformer according to Claim 7, wherein the lower-voltage rate is approximately 1% to 10%.

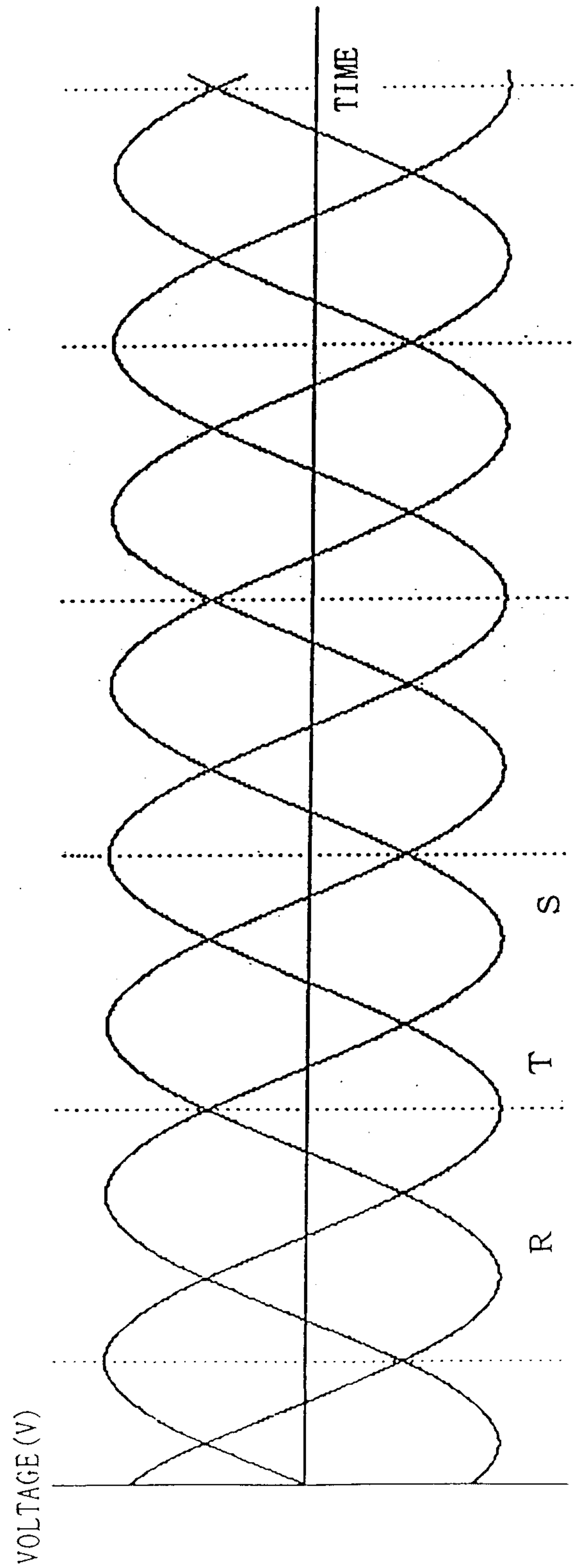
<FIG. 1>



<FIG. 2>

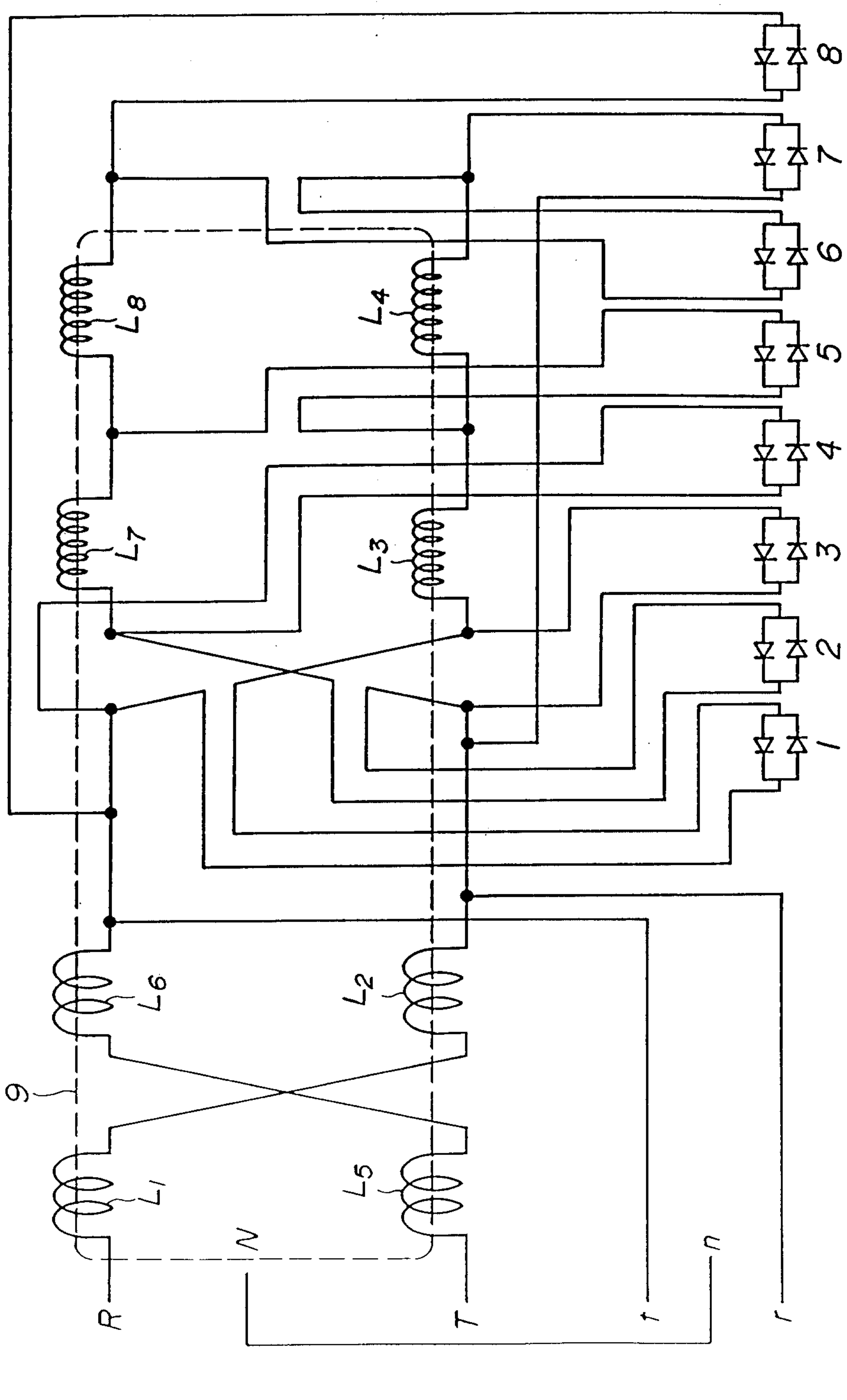

VOLTAGE (V)
210
200
190
180
INPUT VOLTAGE
PREDETERMINED MINIMUM VOLTAGE
OUTPUT VOLTAGE
TIME

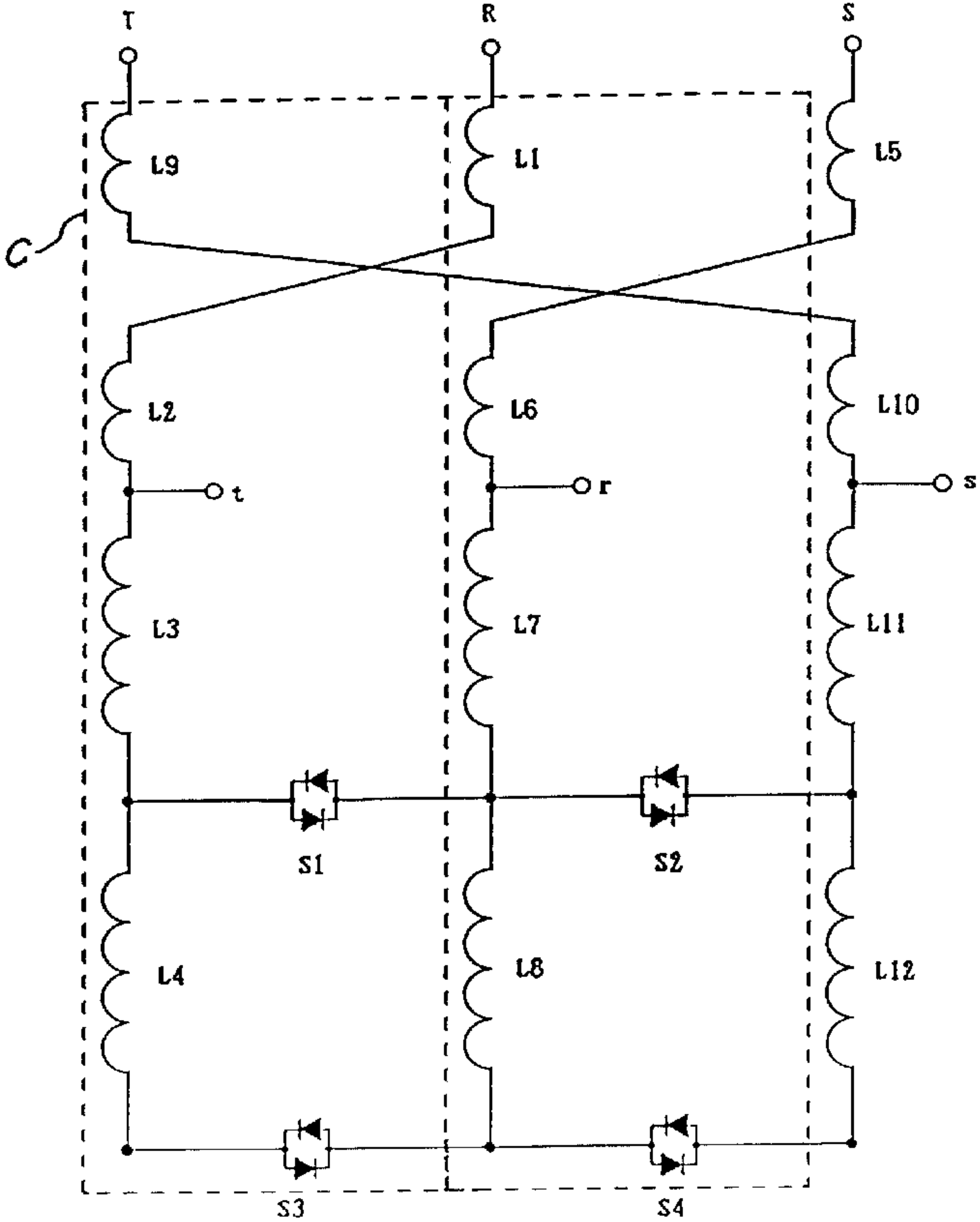
<FIG. 3>



<FIG. 4>

PRIOR ART

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