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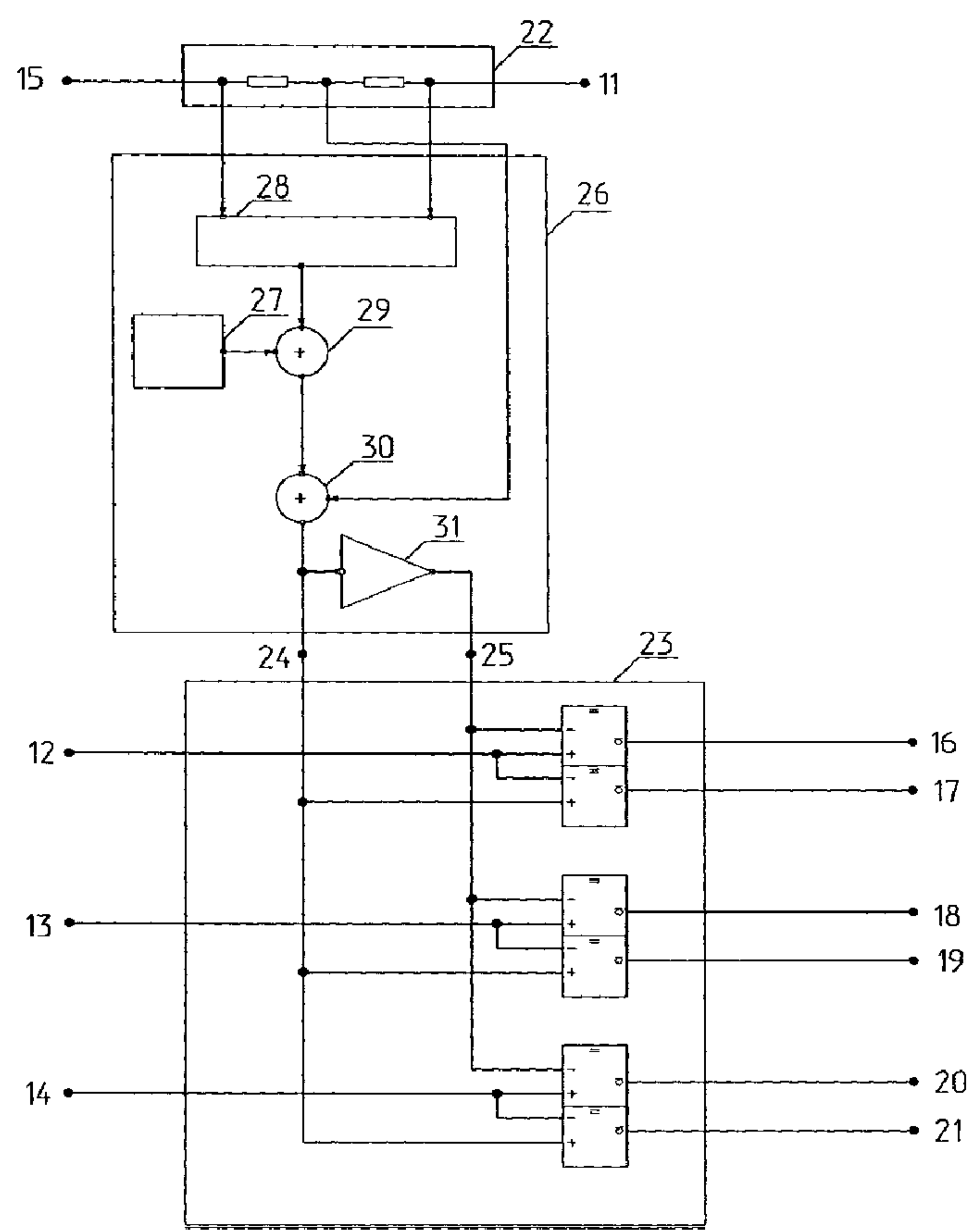
(54) Titre : PROCEDE DE COMMANDE D'UN MOTEUR C.A. ELECTRONIQUE ET DISPOSITIF DE SA MISE EN OEUVRE
(54) Title: METHOD FOR CONTROLLING AN AC ELECTRONIC MOTOR AND DEVICE FOR CARRYING OUT SAID METHOD



(57) Abrégé/Abstract:
The invention relates to electric engineering, in particular to methods for controlling an ac electronic motor . The inventive control method consists in starting and rotating a rotor upon EMF signals in current-free sections of an armature winding, in converting the

(57) Abrégé(suite)/Abstract(continued):
EMF signals into discrete logical level signals by a normaliser, in detecting switching points by means of a microcontroller and in displacing said points according to a load current quantity, the rotor speed of rotation and the inductance of the armature winding sections, wherein the switching points are calculated and displaced with respect to bridging times of the free sections EMF whose voltage levels are different from zero. The inventive device is characterised in that it comprises a reference level displacing unit (26), which is arranged in the normaliser between a divider 22 and a comparator unit (23) and which consists of a current sensor (27), a voltage sensor (27), two adders (29, 30) and an inverter (31).

(12) МЕЖДУНАРОДНАЯ ЗАЯВКА, ОПУБЛИКОВАННАЯ В СООТВЕТСТВИИ С ДОГОВОРОМ О ПАТЕНТНОЙ КООПЕРАЦИИ (РСТ)

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(71) Заявитель *(для всех указанных государств, кроме US)*: **ЦЕНТР РАЗРАБОТКИ НЕФТЕДОБЫВАЮЩЕГО ОБОРУДОВАНИЯ (OILFIELD EQUIPMENT DEVELOPMENT CENTER LIMITED COMPANY)** [SC/SC]; Тринити Хаус, 1-й этаж, Альберт стрит, Маэ, Виктория, Victoria (SC).

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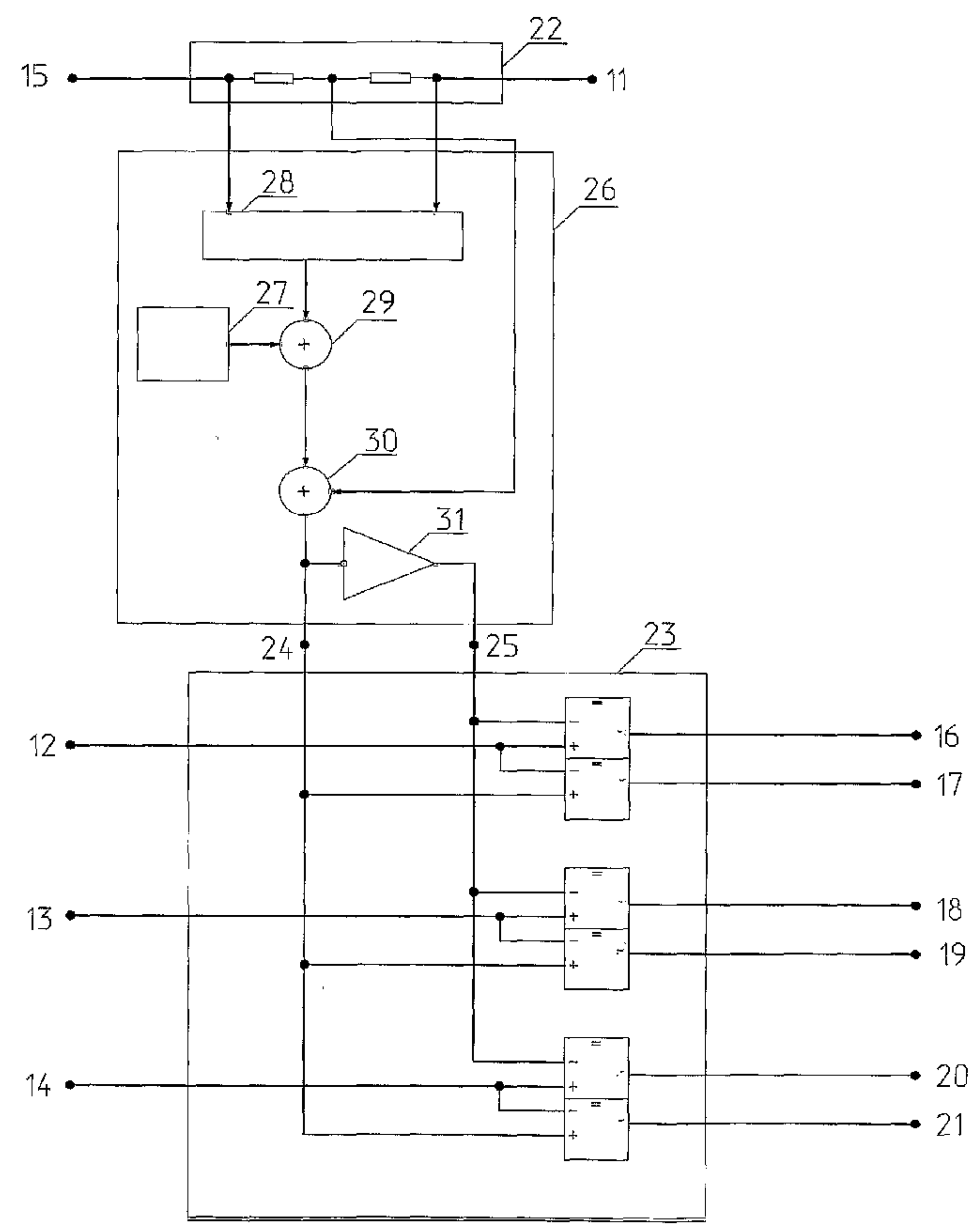
(54) Title: METHOD FOR CONTROLLING AN AC ELECTRONIC MOTOR AND DEVICE FOR CARRYING OUT SAID METHOD

(54) Название изобретения: СПОСОБ УПРАВЛЕНИЯ ВЕНТИЛЬНЫМ ЭЛЕКТРОДВИГАТЕЛЕМ И УСТРОЙСТВО ДЛЯ ЕГО ОСУЩЕСТВЛЕНИЯ



(57) Abstract: The invention relates to electric engineering, in particular to methods for controlling an ac electronic motor . The inventive control method consists in starting and rotating a rotor upon EMF signals in current-free sections of an armature winding, in converting the EMF signals into discrete logical level signals by a normaliser, in detecting switching points by means of a microcontroller and in displacing said points according to a load current quantity, the rotor speed of rotation and the inductance of the armature winding sections, wherein the switching points are calculated and displaced with respect to bridging times of the free sections EMF whose voltage levels are different from zero. The inventive device is characterised in that it comprises a reference level displacing unit (26), which is arranged in the normaliser between a divider 22 and a comparator unit (23) and which consists of a current sensor (27), a voltage sensor (27), two adders (29, 30) and an inverter (31).

(57) Реферат: Изобретение относится к области электротехники, а именно к способам управления вентильным электродвигателем. Способ управления включает пуск и вращение ротора по сигналам ЭДС в свободных от тока секциях обмотки якоря, преобразование сигналов ЭДС нормализатором в дискретные сигналы логического уровня, определение микроконтроллером моментов коммутации и их смещение в зависимости от величин тока нагрузки, скорости вращения ротора и индуктивности секций якорной обмотки, при этом моменты коммутации вычисляют и

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В отношении двубуквенных кодов, кодов языков и других сокращений см. "Пояснения к кодам и сокращениям", публикуемые в начале каждого очередного выпуска Бюллетеня PCT.

смещают относительно моментов перехода ЭДС свободных секций уровней напряжения, отличных от нуля. Особенностью устройства является наличие блока смещения опорного уровня (26), установленного в нормализаторе между делителем (22) и блоком компараторов (23), и состоящего из датчика тока (27), датчика напряжения (28), двух сумматоров (29), (30) и инвертора (31).

Method of AC Converter-Fed Motor Control and its Application

Pertinent Art

This invention relates to the field of electrical engineering, and more particularly to methods of AC converter-fed motor control applicable particularly for use in a submersible AC converter-fed motor as a submersible pump drive commonly used in the petroleum industry.

Prior Knowledge

A method of control of an AC converter-fed motor, including such functions as electric motor synchronous start-up and rotary valve rotation to be actuated by EMF signals transmitted over current-free armature coil, was investigated in the previous invention (Certificate of authorship: USSR 1774455, кл. H 02 P 6/02, 1992).

The above method suffers from low accuracy of determination of power key switching time resulting in loss of electric motor running performance and service life.

Also, a method of AC converter-fed motor control is known using a "star" armature coil connected to full-wave frequency converter outputs constructed as a three-phase reverse diode bridge, including such functions as start-up and rotary rotation actuated by EMF signals transmitted over a current-free armature coil, conditioning of EMF signals by means of a normalizer and their transformation to logical level discrete signals, delivery of discrete signals to microcontroller inputs, determination by means of a microcontroller of a certain type of electrical motor mathematical model consisting of the armature coil switching time with respect to signals passing over the current-free coil EMF zero (Radim Visinka, Leos Chalupa, Ivan Skalka. "Operation of MOTOROLA microcontroller controlled electric motors ", magazine “CHIP NEWS: Microdrive Digital Control”, No.1, 1999, p. 14-16).

The above method suffers from the unavailability of switch time correction depending on the rate of load current, motor speed and cabled motor inductance and thus the impossibility of AC converter-fed motor control by reason of increased rate of coil inductance.

As per the combination of essential features and the results attained, the method considered to be the most closest to the claimed invention is the method of AC converter-fed motor control using “star” armature coils connected to full-wave frequency converter outputs constructed as a three-phase reverse diode bridge including such functions as start-up and rotary rotation actuated by EMF signals transmitted over a current-free armature coil, conditioning of EMF signals by means of a normalizer and their transformation to logical level discrete signals, delivery of discrete signals to microcontroller inputs, determination by means of a microcontroller of a certain type of electrical motor mathematical model consisting of the armature coil switching time with respect to signals passing over the current-free coil EMF zero with respect to the parameters with EMF zero passing over the current-free coil and shift of switching time with respect to the parameters with the EMF zero value passing over the current-free coil depending on the rates of current load, rotor speed and armature coil inductance, where the timing of the current coming over the three-phase bridge reverse diode is used for the integral estimation of the load current, the rotor speed and the armature coil inductance existing values. For the purpose of this method, a full-wave frequency converter constructed as a three-phase reverse diode bridge, as well as a microcontroller and normalizer consisting of divider and comparator units with two reference inputs, are used in the device (see Patent RU2207700C2 publ. 27.06.2003, МПК^7 H02P6/00, H02P6/18, H02K29/00, H02K29/06).

The above method suffers from limited shifting of the switching time parameters under the influence of the time specified for the EMF passing its zero free phase at the rate of 30 electrical degrees, but, taking into account the rate of normalizer filter delay and the period specified for the switching time parameters estimated upon the EMF free zero phase transition at the rate of 10-15 electric degrees (depending on speed), the rate of 15-20 electric degrees may be considered as an accessible value to be estimated for the shifting of the switching time parameters.

As a result, the AC converter-fed motor efficiency is decreased and, due to the large coefficients of electric field distortion and shifting of switching times by more than 20 electric degrees, the AC converter-fed motor becomes of control.

Disclosure of Invention

The object of this invention is to, provide a method that is efficient enough for operation of different AC converter-fed motors.

The technical result attained makes it possible to increase the AC converter-fed motor efficiency and to control the AC converter-fed motor functions with considerably distorted electric field coefficients.

The technical result specified is attained at the expense of the method of the AC converter-fed motor control with “star” armature coils connected to full-wave frequency converter outputs constructed as a three-phase reverse diode bridge including such functions as start-up and rotary rotation actuated by EMF signals transmitted over a current-free armature coil, conditioning of EMF signals by means of a normalizer and their transformation to logical level discrete signals, delivery of discrete signals to microcontroller inputs, determination by means of a microcontroller of a certain type of electrical motor mathematical model consisting of the armature coil switching time with respect to the parameters with EMF zero passing over the current-free coil and shift of switching time with respect to the parameters with EMF zero value passing over the current-free coil depending on the rates of current load, rotor speed and armature coil inductance, where timing of current coming over the three-phase bridge reverse diode is used for the integral estimation of the load current, the rotor speed and the armature coil inductance existing values. The switching time parameters are subject to estimation and shifting with respect to the parameters with the EMF passing over the voltage level free coil sections different from zero and compliant to the rotor angle specified for this kind of motor.

This device consists of a full-wave frequency converter constructed as a three-phase reverse diode bridge, microcontroller and normalizer comprising two reference inputs and is differed by the reference level shift block installed between the divider and comparator block and comprising a current sensor, a voltage sensor, two adders and an inverter, in which case the first adder inputs are connected to the current and voltage sensors, the second adder inputs are connected to the first adder output and to the divider midpoint and the second adder output is connected to first reference level input directly and to the second reference level input over the inverter.

The reference level shifting block in the device makes it possible to calculate and shift switching time parameters with respect to the parameters with the EMF passing over the voltage level free coil sections different from zero, thus obtaining large angles of switching time shifting, increasing the motor efficiency and improving the operation of the various AC converter-fed motors including those with large coefficients of electric field distortion.

This invention is illustrated by the following drawings:

Fig.1 – Functional diagram of AC converter-fed motor control;

Fig.2 – Functional diagram of normalizer together with reference level shifting block;

Fig.3 – Normalizer input armature coil voltage diagram;

The AC converter-fed motor 1 is provided with a permanent magnet rotor 2 functioning as an inductor and a rotor 3 made of soft magnetic material with an exciting coil 4. Armature “star” coils 5, 6, 7 are connected to the outputs of a half-wave frequency converter 8 constructed as a three-phase reverse diode bridge and to the inputs 12, 13 and 14 of a normalizer 9. The inputs 11 and 15 of the normalizer 9 are connected to the voltage sources. The signals coming from the outputs 16, 17, 18, 19, 20 and 21 of the normalizer 9 are transmitted to a microcontroller 10 that generates the rates of control combinations specified for the frequency converter 8. The normalizer 9 consists of a divider 22 and a comparator block 23 provided with two reference level inputs 24 and 25. A reference level shifting block 26 used for estimation of comparator operation thresholds is provided between the divider 22 and the comparator block 23.

The reference level shifting block 26 consists of a current sensor 27, a voltage sensor 28, two adders 29 and 30 and an inverter 31. The inputs of the adder 29 are connected to the current sensor 27 and the voltage sensor 28, and the inputs of the adder 30 are connected to the output of the adder 29 and the midpoint of the divider 22. The output of the adder 30 is connected to the reference level input 24 directly and the reference level input 25 by way of the inverter 31.

The following parameters are specified in the input voltage diagram of the normalizer 9:

- t – time of section cutoff from "+" of power source;
- T – time interval within which current is transmitted under the influence of the self-induction EMF over the frequency converter reverse diode 8 in the same direction;
- Sections ab and cd – intervals within which the rate of voltage specified at the input of the normalizer 9 matches the counter-EMF of the

section;

- $U_{см}$ - rate of reference level shifting voltage formed by means of the reference level shifting block depending on voltage $U_{пит}$ and load current;

- t1 – time of counter-EMF crossing the section of reference voltage level corresponding to angle α_0-n^0;

- t2 – time of counter-EMF crossing section 6 of zero level corresponding to angle α_0;

- t3 – time of section 6 being connected to " – " of power source;

- T1 – time ratio to be specified by microcontroller when calculating the rates of switching time and normalizer filter delays;

- t4 – switching time with the armature response shift unavailable corresponding to angle α_0+30^0;

- t5 – time of the section being shut off from " – " of the power source;

- t6 – time of the section being connected to "+" of the power source

- T2 – the maximum allowable rate of switching time shift to be estimated with respect to the time period within which the counter-EMF passes over the zero level section.

- T3 – the maximum allowable rate of switching time shift to be estimated with respect to the time period, within which the counter-EMF passes over the reference level section U_{CM}.

Embodiment of Claimed Invention

The claimed method of AC converter-fed motor control may be implemented as follows. On starting up the motor by means of EMF signals actuated from the armature coil current-free sections, microcontroller 10 produces the rates of cyclic control combination and transmits them to the full-wave frequency converter 8 for 120° key switching. The rotor 2 or 3 starts turning. If, with the first control combination transmitted, frequency converter 8 shuts off, for example, section 6 from "+" of the power source at time t (Fig. 3), the normalizer 9 consisting of the reference level shifting block converts the rate of voltage specified at section 6 of input 13 in the logical level discrete signals delivered to outputs 18 and 19. The signals transmitted to the inputs of the microcontroller 10 contain the following information:

- Time data - T (Fig.3) - time interval within which current is transmitted under the influence of the self-induction EMF over the frequency converter reverse diode 8 in the same direction;

- Time data - t1 (Fig.3) – time specified for EMF passing over the section disconnected fr om the voltage source conforming to angle α_0-n^0 depending on level U_{CM}.

The microcontroller 10 calculates the time specified for connection of the section 6 to " – " of the power source (time of I + 1st combination) using the time parameters between t1 and the section passed by EMF and disconnected from the voltage corresponding to angle α_0-n^0. The parameter T is used for the estimation of the armature response and the determination of the switching time. For this purpose, the time parameter estimated is shifted by a value proportional to the parameter T. As may be seen in Fig. 3, with the switching time estimated with respect to the EMF passing over zero free phase – the parameter t2 (angle α_0) – the time interval T2 is considered as the range of accessible switching. In fact, the period of normalizer filter delay is rated in 10 – 15 electric degrees (time T1) and the rate of switching time is evaluated by the processor only after t2.

In the claimed method, the interval T3 is specified as an accessible switch zone, because the rate of filter delay and calculation time is measured from parameter t1 (angle α_0–n). As a matter of fact, the large switching time shift angles are accessible and make it possible to operate the AC converter-fed motors within electric fields of large distortion coefficients.

The method of AC converter-fed motor control may be efficiently applied in conditions where cables of excessively long length are required, for example with an oil extracting submersible pump driven by an AC converter-fed motor controlled from a surface-based station.

Formula of Invention

1. Method of the AC converter-fed motor control using “star” armature coils connected to full-wave frequency converter outputs constructed as a three-phase reverse diode bridge including such functions as start-up and rotary rotation actuated by EMF signals transmitted over a current-free armature coil, conditioning of EMF signals by means of a normalizer and their transformation to logical level discrete signals, delivery of discrete signals to microcontroller inputs, determination by means of a microcontroller of a certain type of electrical motor mathematical model consisting of the armature coil switching time with respect to the parameters with EMF zero passing over the current-free coil and shift of switching time with respect to the parameters with EMF zero value passing over the current-free coil depending on the rates of current load, rotor speed and armature coil inductance, where timing of current coming over the three-phase bridge reverse diode is used for the integral estimation of the load current, rotor speed and armature coil inductance existing values. The switching time parameters are subject to estimation and shifting with respect to the parameters with the EMF passing over the voltage level free coil sections different from zero and compliant to the rotor angle specified for this kind of motor.

2. The device used for the purpose of claim 1 consists of a full-wave

frequency converter constructed as a three-phase reverse diode bridge, a microcontroller and a normalizer comprising two reference inputs, and is characterized by a reference level shift block provided between the divider and comparator block and comprising a current sensor, a voltage sensor, two adders and an inverter, in which the first adder inputs are connected to the current and voltage sensors, the second adder inputs are connected to the first adder output and to the divider midpoint, and the second adder output is connected to first reference level input directly and to the second reference level input by way of the inverter.

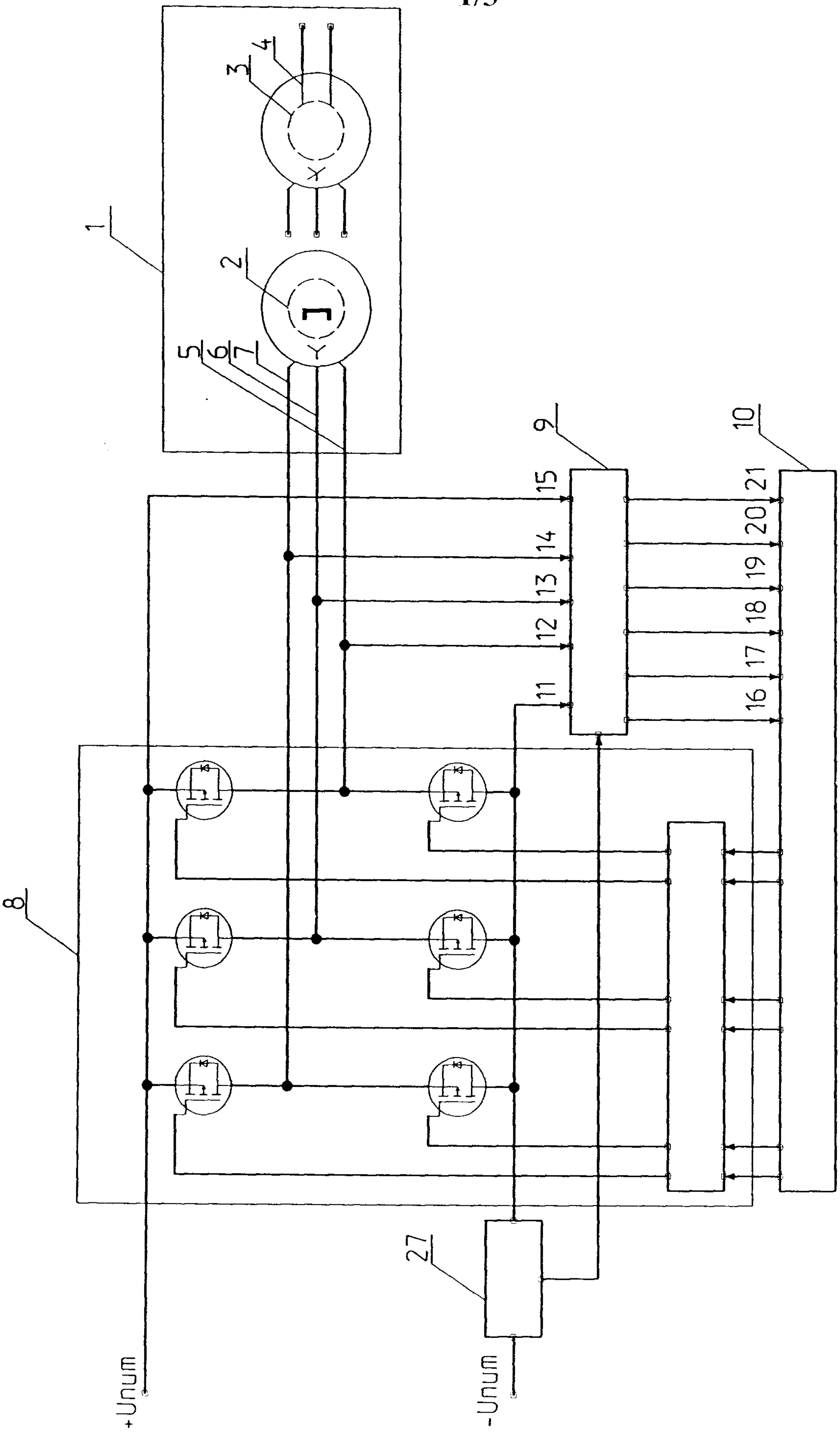


Figure 1

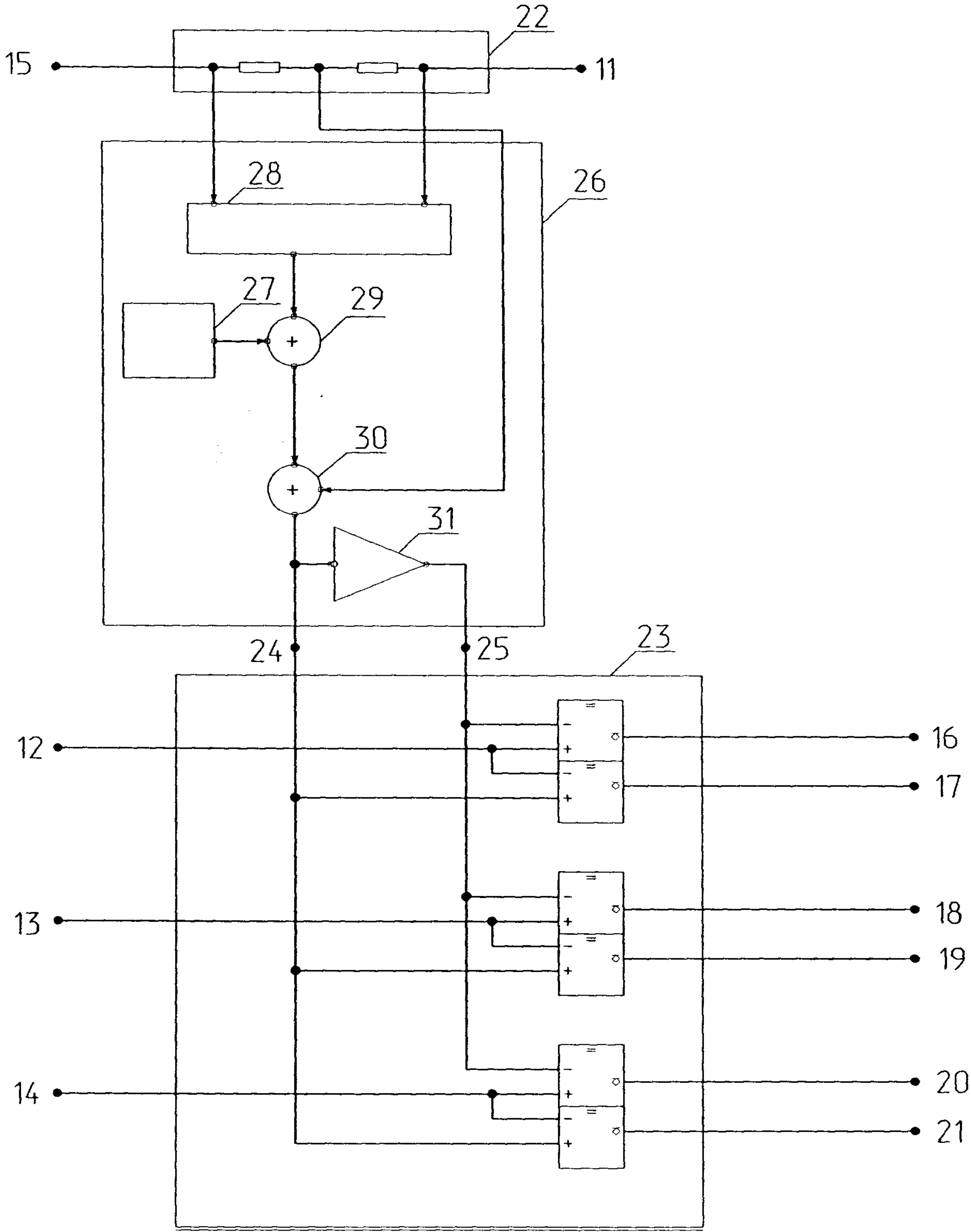


Figure 2

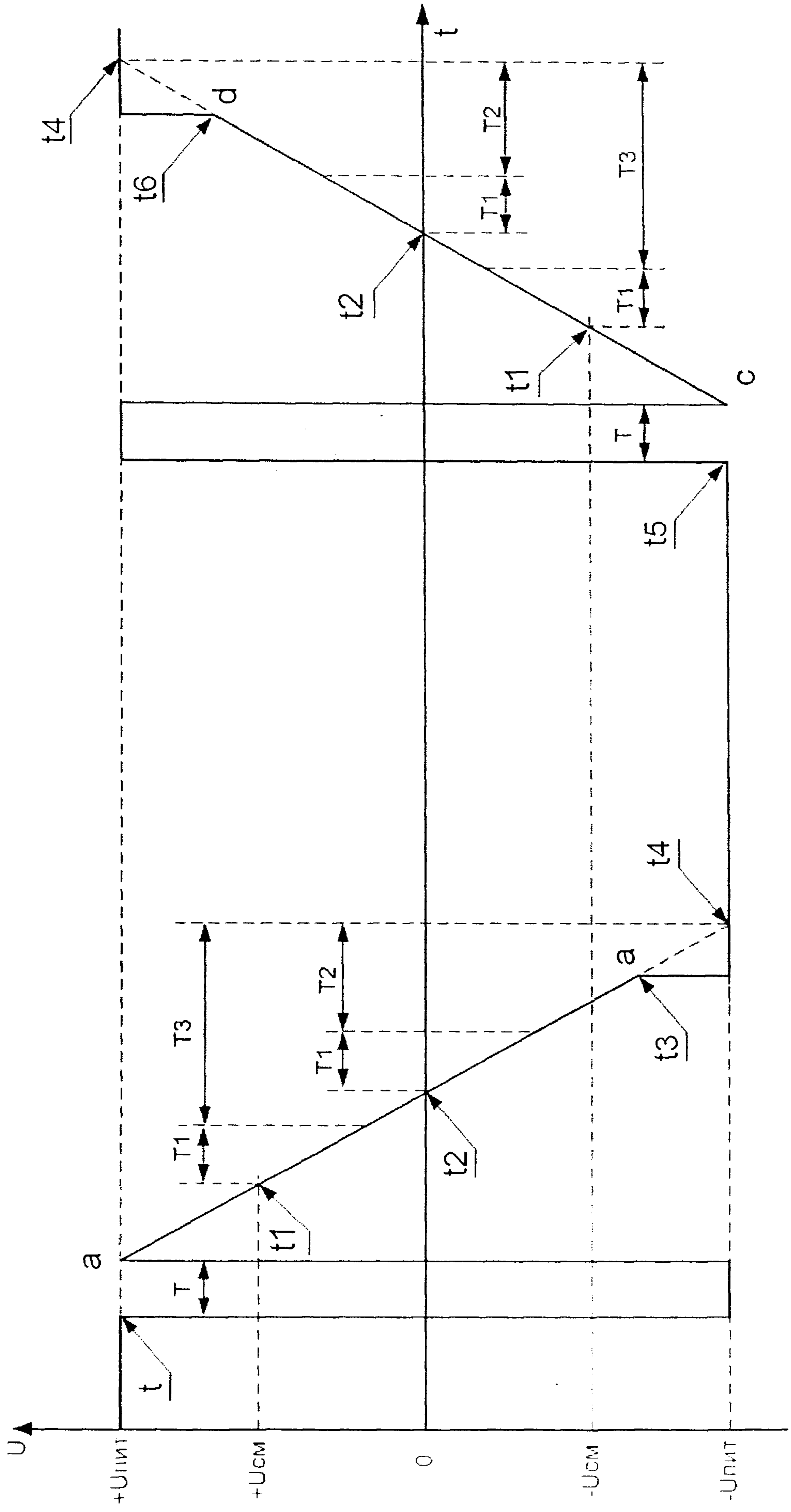
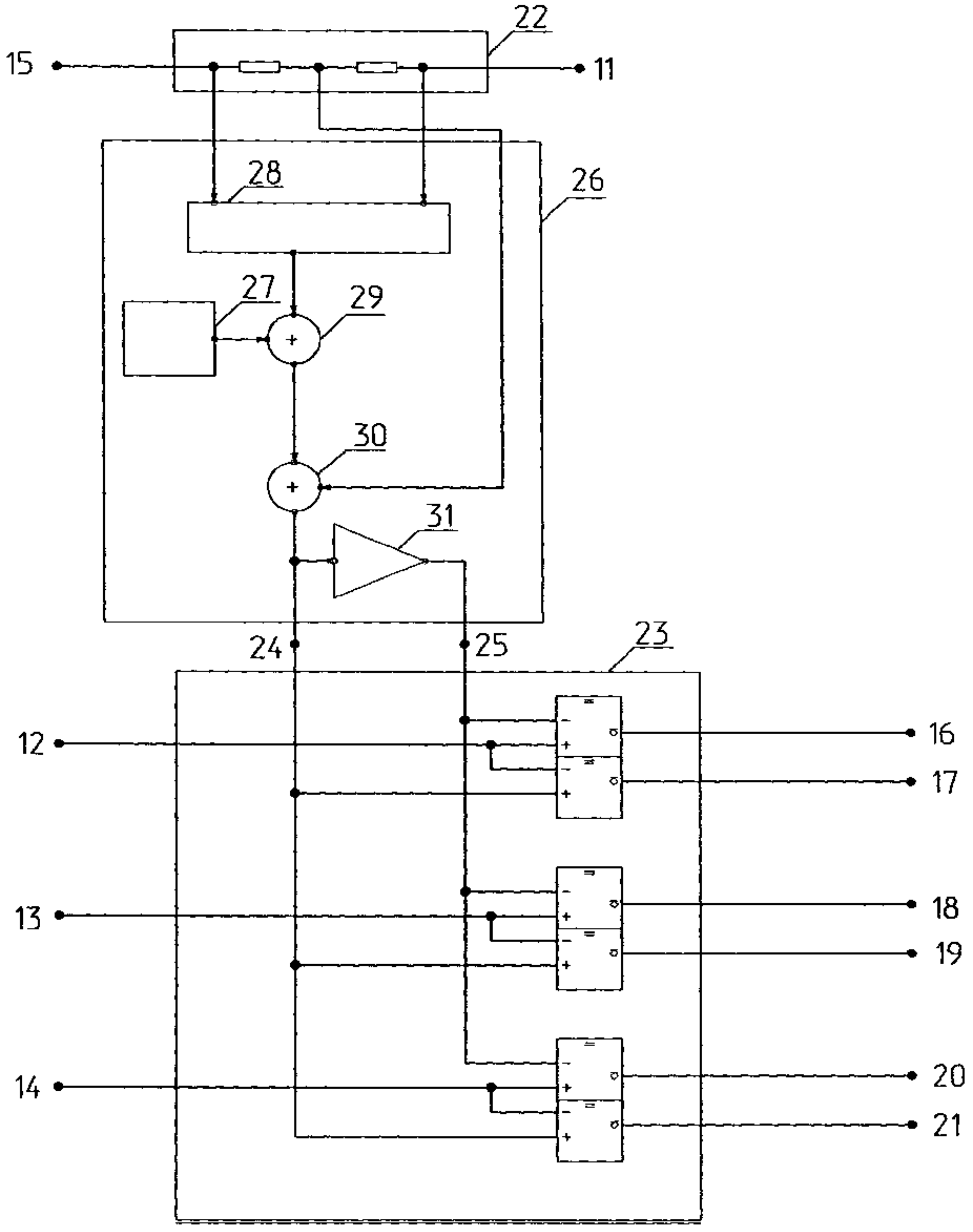


Figure 3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