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FORM 1

SPRUSON & FERGUSON

COMMONWEALTH OF AUSTRALIA
PATENTS ACT 1952
APPLICATION FOR A STANDARD PATENT

Kabelmetal Electro GmbH, of Kabelkamp 20, D-3000 Hannover 1, FEDERAL REPUBLIC OF GERMANY, hereby apply for the grant of a standard patent for an invention entitled:

Switching Arrangement for Controlling the Welding Current in Dependence on the Welding Speed

which is described in the accompanying complete specification.

Details of basic application(s):-

<u>Basic Applic. No:</u>	<u>Country:</u>	<u>Application Date:</u>
P 40 11 647.6	DE	11 April 1990
P 40 14 275.2	DE	4 May 1990

The address for service is:-

Spruson & Ferguson
Patent Attorneys
Level 33 St Martins Tower
31 Market Street
Sydney New South Wales Australia

DATED this TENTH day of APRIL 1991

Kabelmetal Electro GmbH

REPRINT OF RECEIPT

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10/04/91

Registered Patent Attorney

TO: THE COMMISSIONER OF PATENTS
OUR REF: 154070
S&F CODE: 56401

5845/7

DECLARATION IN SUPPORT OF A CONVENTION APPLICATION FOR A PATENT

AUSTRALIA CONVENTION STANDARD & PCTTY PATENT DECLARATION SFP4

In support of the Convention Application made for a patent for an invention entitled:

Title of Invention

Switching arrangement for controlling the welding current in dependence on the welding speed

Full name(s) and address(es) of Declarant(s)

We Eberhard Mende and Reimer Köster of Im Hespe 42, 3008 Garbsen 4, and Pelikanweg 11, 3008 Garbsen 9, both in Federal Republic of Germany respectively do solemnly and sincerely declare as follows:-

Full name(s) of Applicant(s)

1. I am/We are the applicant(s) for the patent (or, in the case of an application by a body corporate)

1. I am/We are authorised by

Kabelmetal Electro GmbH

the applicant(s) for the patent to make this declaration on its/their behalf.

2. The basic application(s) as defined by Section 141 of the Act was/were made

Basic Country(ies)

in Federal Republic of Germany

Priority Date(s)

on April 11, 1990 and May 5, 1990

Basic Applicant(s)

both by Kabelmetal Electro GmbH

Full name(s) and address(es) of inventor(s)

3. I am/We are the actual inventor(s) of the invention referred to in the basic application(s)

(or where a person other than the inventor is the applicant)

3. Rainer BRUENN and Wolfram KLEBL

of Schmiedelweg 10, 3031 Essel and Sieversdamm 2 b, 3004 Isernhagen 2, both in the Federal Republic of Germany respectively (respectively)

is/are the actual inventor(s) of the invention and the facts upon which the applicant(s) is/are entitled to make the application are as follows:

Set out how Applicant(s) derive title from actual inventor(s) e.g. The Applicant(s) is/are the assignee(s) of the invention from the inventor(s)

The said applicant is the assignee of the actual inventors.

4. The basic application(s) referred to in paragraph 2 of this Declaration was/were the first application(s) made in a Convention country in respect of the invention (s) the subject of the application.

Declared at Hanover this 18th day of January 1991

Eberhard Mende

Reimer Köster

To: The Commissioner of Patents

Signature of Declarant(s)



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(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 643984

(54) Title
SWITCHING ARRANGEMENT FOR CONTROLLING THE WELDING CURRENT IN DEPENDENCE ON
THE WELDING SPEED

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(71) Applicant(s)
KABELMETAL ELECTRO GMBH

(72) Inventor(s)
WOLFRAM KLEBL; RAIMER BRUENN

(74) Attorney or Agent
SPRUSON & FERGUSON , GPO Box 3898, SYDNEY NSW 2001

(56) Prior Art Documents
US 3619554
US 3286074
US 3261960

(57) Claim

1. A method for regulating the welding current or the welding power in dependence upon the weld-advance rate in welding apparatus for the continuous longitudinal-seam welding of metal strips combined to form a tube, characterized in that a rate-dependent voltage amplitude is added to an adjustable fixed-voltage amplitude.

3. Circuitry for carrying out the method for dc arc welding apparatus according to Claim 1, wherein the welding electrodes are energized from a voltage source via a transformer, a regulating element adjusting the welding current, and rectifier elements and the regulating element is influenced by a weld-advance rate-dependent tacho generator connected to a regulator, characterized in that the tacho generator and a fixed-voltage source are separately connected with their outputs to the inputs of a summing amplifier the output of which acts upon the regulator, with an output of this regulator connected with ~~the~~^a dc converter.

5. Circuitry for carrying out the method according to Claim 1 for a laser welding apparatus, characterized in that the output power of the welding laser is adjustable through a regulator to the input of which there is connected a series circuit composed of a weld-advance rate-dependent tacho generator and an adjustable fixed-voltage source.

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FORM 10

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PATENTS ACT 1952

COMPLETE SPECIFICATION

(ORIGINAL)

FOR OFFICE USE:

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Complete Specification Lodged:
Accepted:
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Related Art:

Name and Address
of Applicant:

Kabelmetal Electro GmbH
Kabelkamp 20
D-3000 Hannover 1
FEDERAL REPUBLIC OF GERMANY

Address for Service: Spruson & Ferguson, Patent Attorneys
Level 33 St Martins Tower, 31 Market Street
Sydney, New South Wales, 2000, Australia

Complete Specification for the invention entitled:

Switching Arrangement for Controlling the Welding Current
in Dependence on the Welding Speed

The following statement is a full description of this invention, including the
best method of performing it known to me/us

Abstract

In order to regulate the welding current or the welding power in dependence upon the weld-advance rate in welding apparatus for the continuous longitudinal-seam welding of metal bands combined to form a tube, a rate-dependent voltage amplitude is added to an adjustable fixed-voltage amplitude.

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TECHNICAL FIELD

The present invention relates to a method and to circuitry for regulating the welding current or the welding power in dependence upon the weld-advance rate in welding apparatus for the continuous longitudinal-seam welding of metal strips combined to form a tube.

BACKGROUND OF THE INVENTION

There is known circuitry (German Application 19 00 856 Laid Open for Public Inspection) wherein the electrodes of welding apparatus are influenced from a voltage source via a transformer, a regulating element adjusting the welding current, and a rate-dependent tacho-generator. There are provided means for regulating the amplitude of the welding current in dependence upon the supply voltage, the electrode spacing, as well as in dependence upon the supply voltage, the electrode spacing, as well as in dependence upon temperature fluctuations. In such a control circuit for dc welding, the instantaneous amplitude of the welding current is continuously measured and the regulating element is influenced by means of an error variable feedforward even in the case of minimal fluctuations so that the welding current amplitude corresponds to the instantaneous requirements. The regulation can be effected within a short time so that fluctuations of the supply voltage, of the electrode spacing or also temperature fluctuations do not manifest themselves in regard to the welding current but that the welding current amplitude is always given the value required for complete welding of the welding seam.

However, difficulties are encountered when increased production rates are required and different metals or strip thicknesses are employed. High production rates enhance the disturbing influence of the ripple of the welding current so that it is no longer possible to ensure that proper welding seams can be produced with known control means.

In order to remedy this, one could incorporate filter elements in the control circuit but, owing to the time constants of the control circuit, there exist limitations to the enlargement of such filters. Also the replacement of known regulating elements by, say, transistors, does not always render the desired effect or requires additional expenses, e.g., for dissipating excess energy via appropriate cooling agents, such as water or air.

SUMMARY OF THE INVENTION

Therefore, the problem underlying the invention is to obtain a welding current regulation or a regulation of the welding power, when a laser welding apparatus is involved, in dependence upon the production rate, which guarantees problem-free welding of any metals and metal strips of different strip thicknesses with an optimal waveform of the welding current.

According to the invention, this problem is solved by adding a rate-dependent voltage amplitude to an adjustable fixed-voltage amplitude. The adjustment of this fixed-voltage amplitude, e.g., in dependence upon the strip thickness selected, results in a zero-point shift on the current-rate diagram, whereas the addition of the rate-dependent voltage amplitude leads to the welding current characteristic or welding load characteristic beginning at the respective zero point. This measure facilitates the selection of any current value and power value in dependence upon the welding rate, an adaptation to any welding conditions is possible.

In order to practice the invention in the case of a dc arc-welding apparatus, there proved to be useful a circuit arrangement in which the welding electrodes are energized from a voltage source via a transformer, a regulating element adjusting the welding current, and rectifier elements, and the regulating element is influenced by a rate-dependent tacho generator connected to a regulator. It is essential that, in expanding the invention, an adjustable fixed-voltage source is connected in series with the tacho generator. The tacho generator provides the rate-dependent voltage of, say, 0-20 v, whereas the adjustable fixed-voltage source, e.g., any step switch, provides a basic voltage amplitude of 0-10 v.

The voltage amplitudes, which were added in a corresponding circuit, are applied to the input of a welding current regulator, whereas the instantaneous welding current amplitude is inputted from the current transformer to the other input. A comparison of the nominal value with the instantaneous value in the welding-current regulator results in the required welding current at the output.

In practising the invention, it is an other advantageous possibility to energize the welding electrodes from a voltage source via a transformer, a regulating element adjusting the welding current, and rectifier elements, with the regulating element being influenced by a welding-rate dependent tacho generator which is connected with a regulator. There, in practising the invention, the tacho generator and a fixed-voltage source are with their separate outputs connected to the inputs of a summing amplifier the output of which influences an input of the welding-current regulator, whereas an other input of this regulator is connected with the dc converter. In this arrangement, a direct mutual interaction in the summation of the two voltage amplitudes is ruled out, and clear electrical conditions have been created. As indicated above, the output voltage of the summing amplifier is also in this case applied to the input of a welding current regulator, whereas the other input of this regulator is supplied with the instantaneous welding current amplitude from the current converter.

A further improvement of the welding current regulation is ensured by providing a voltage divider between the output of the tacho generator and the input of the summing amplifier. The slope of the welding current characteristic can be adjusted with its aid.

When in place of the dc arc welding apparatus mentioned above, laser welding apparatus, e.g., in the form of a CO₂ laser, is employed, the summed voltage amplitudes are fed into a corresponding regulator of the laser or the output of the summing amplifier is allowed to influence the input of the laser regulator.

The problem of the invention, namely to ensure optimal conditions for welding metal strips combined to form tubes by reducing the ripple of the welding current, in further development of the inventive concept leads to the measure of the regulating element being a thyristor rectifier arrangement controlled by a subsequent transistor unit controlled by the regulator in a welding-current regulating system in which the welding electrodes are energized from a voltage source via a transformer, a regulating element adjusting the welding current, and rectifier elements and the regulating element is influenced by a welding-rate dependent

tacho generator. Such a configuration results in a reduction of the power dissipated in the transistors so that an occasionally rather expensive cooling of these switching elements becomes redundant. At the same time, in applications of the invention one makes use of the advantage of short regulating times resulting from the use of transistors. The thyristor rectifier arrangement is controlled so that the voltage drop at the transistors and the resulting power dissipation are minimized.

In practising the invention, it proved to be expedient to provide an additional regulating amplifier in the feedback circuit from the transistor unit to the thyristor rectifier arrangement. In this way, problem-free control of the thyristor rectifiers is possible, and this holds also in the case of high production rates.

In order to ensure optimum conditions for the welding of metal strips combined to form a tube by reducing the ripple of the welding current, in developing the inventive concept further one can employ higher-pulsed rectifier arrangements as the regulating element; e.g., one can resort to a twelve-pulse rectifier unit.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The invention will be explained in detail with reference to the embodiments shown in Figures 1 to 5.

As can be inferred from Figure 1, denoted by 1 is a supply voltage source which may be, for example, the 50 Hz ac power net. A transformer 2, the secondary winding of which is connected with thyristor 3, is connected to the voltage source 1. Between the electrodes 4, denoted by (+) and (-), of the welding apparatus (not shown) and thyristor 3 there is connected a dc converter 5 at the secondary terminals of which a voltage corresponding to the instantaneous amplitude of the welding current can be picked up. Regulator 6 is energized via a power supply not shown.

It is a well-known fact that the thyristor rectifier arrangement 3 becomes non-conductive at any zero crossing of the voltage and need be re-ignited thereafter. This ignition is effected by regulator 6 which sets the time of ignition of thyristor 3 sooner or later in dependence upon

the circumstances so that, accordingly, more or less current reaches the welding electrodes 4. Thyristor unit 3 is not directly controlled by regulator 6 but, as indicated, by transistor unit 7 which follows the thyristor rectifier arrangement 3 but has a feedback 8 to the same, with the aid of which thyristor arrangement 3 is controlled via a servo amplifier so that the voltage drop at transistors 7 and, hence, their power dissipation can be minimized. By using transistor unit 7, the regulation is improved further, and a substantial reduction of the ripple of the welding current is achieved even at high uncoiling rates. A further improvement can be obtained by placing a filter 10 between the thyristor rectifier arrangement 3 and the following transistor unit 7.

As expounded above, occasionally it may be advantageous for the invention to apply to regulator 6 a voltage which is composed of an adjustable fixed-voltage amplitude and a rate-dependent voltage amplitude. In order to accomplish this, there is provided a summing circuit consisting of the tacho generator 11 and a voltage source 13 which is adjustable via resistor 12. The voltage amplitude obtained from the circuit components 11 and 13 is applied to regulator 6 which is connected to the dc converter 5 and receives from it the instantaneous dc amplitude which is then compared with the voltage amplitude supplied by the tacho generator 11 and the adjustable voltage source 13 and used for regulation.

Figure 2 shows an arrangement at variance with the embodiment shown in Figure 1, wherein the, say, six-pulse thyristor rectifier arrangement 3 is replaced by a twelve-pulse arrangement 14. Accordingly, the transformer 16 which is energized by the supply voltage source 15 is provided with a second secondary coil. All the other circuit components of the circuitry according to the invention correspond to those used in Figure 1 for practising the invention.

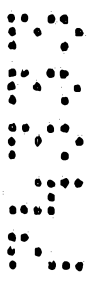
As can be inferred from Figure 3, the supply voltage source is denoted by 21, which source may be, for example, the 50 Hz ac power net. A transformer 22, the secondary coil of which is connected with thyristor 23, is connected to voltage source 21. Between the electrodes 24 (denoted by (+) and (-)) of the welding apparatus and the thyristor 23

there is connected a dc converter 25 from the secondary side of which a voltage corresponding to the instantaneous amplitude of the welding current can be obtained. The regulator 26 is energized from the power supply 27. As indicated above, the thyristor 23 becomes non-conductive at each zero crossing of the voltage and thereafter has to be re-ignited. This ignition is effected by regulator 26 which sets the time of ignition of the thyristor sooner or later in dependence upon the circumstances so that, accordingly, more or less current reaches the welding electrodes 24.

It is essential for the invention that to the regulator 26, which can be replaced by the input of a laser, there is applied a voltage which results from an adjustable fixed-voltage amplitude and a rate-dependent voltage amplitude. In order to achieve this, there is provided a summing circuit consisting of the tacho generator 28 and the adjustable voltage source 29. The voltage amplitude determined by 28 and 29 is applied to the regulator 26 which is connected with the dc converter 25 and receives from it the instantaneous welding current amplitude which is then compared with the voltage amplitude supplied by the tacho generator 28 and the adjustable voltage source 29 and used for regulation. The dc converter 25 can be formed by a shunt with a following isolating amplifier.

At variance therewith, in Figure 4 there has been adopted an arrangement in which, for the purpose of summing the two voltage amplitudes, there is used a summing amplifier 30 of conventional design. The output of the summing amplifier is connected with the input of the regulator 26 or with the input of, for example, an adjustable high-frequency generator controlling the output power of a welding laser, whereas the other input is connected with the current converter 25. The fixed-voltage amplitude required for the summation is fed from the adjustable voltage source 31 to the one input of the summing amplifier 30, with the adjustment of the respective voltage amplitude effected through the voltage divider 32. The rate-dependent value is provided by the tacho generator 33, with the slope of the rate-dependent characteristic adjustable by means of step switch 34.

Figure 5 shows in a diagram the functioning of the circuits described in Figures 3 and 4. The welding current, expressed in A, is plotted as a function of the weld-advance rate expressed in m/min. The permanently adjustable voltage amplitude, which is applied to the summing amplifier 30, results in a certain base current; as can be inferred from the figure, any change of this voltage amplitude causes a parallel translation of the zero point toward the current axis or a corresponding parallel translation of the family of curves C. Furthermore, it is essential for the invention that the slope of the family of curves C can be changed by the step switch 34 which precedes the tachogenerator 33, so that, according to the requirements, one can work with smaller or larger welding current amplitudes per unit time in dependence upon the weld-advance rate. Particularly Figure 4 shows the advantages of the invention, which apply in equal fashion to dc arc welding apparatus and laser welding apparatus and result from the fact that the voltage amplitudes supplied by the tachogenerator 33 and the fixed-voltage source 33 to the summing amplifier do not influence each other and that a common zero point exists.



The claims defining the invention are as follows:

1. A method for regulating the welding current or the welding power in dependence upon the weld-advance rate in welding apparatus for the continuous longitudinal-seam welding of metal strips combined to form a tube, characterized in that a rate-dependent voltage amplitude is added to an adjustable fixed-voltage amplitude.

2. Circuitry for practising the method for dc arc welding apparatus according to Claim 1, wherein the welding electrodes are energized from a voltage source via a transformer, a regulating element adjusting the welding current, and rectifier elements and the regulating element is influenced by a weld-advance rate-dependent tacho generator connected to a regulator, characterized in that an adjustable fixed-voltage source is connected in series with the tacho generator.

3. Circuitry for carrying out the method for dc arc welding apparatus according to Claim 1, wherein the welding electrodes are energized from a voltage source via a transformer, a regulating element adjusting the welding current, and rectifier elements and the regulating element is influenced by a weld-advance rate-dependent tacho generator connected to a regulator, characterized in that the tacho generator and a fixed-voltage source are separately connected with their outputs to the inputs of a summing amplifier the output of which acts upon the regulator, with an output of this regulator connected with ^athe dc converter.

4. The circuitry according to Claim 3, characterized in that a voltage divider is inserted between the output of the tacho generator and the input of the summing amplifier.

5. Circuitry for carrying out the method according to Claim 1 for a laser welding apparatus, characterized in that the output power of the welding laser is adjustable through a regulator to the input of which there is connected a series circuit composed of a weld-advance rate-dependent tacho generator and an adjustable fixed-voltage source.

6. Circuitry for carrying out the method according to Claim 1 for a laser welding apparatus, characterized in that the output power of the welding laser is adjustable through a regulator to the input of which



there is connected the output of a summing amplifier the inputs of which are separately connected with the outputs of a weld-advance rate-dependent tacho generator and a fixed-voltage source.

7. The circuitry according to claim 6, characterized in that a voltage divider is inserted between the output of the tacho generator and the input of the summing amplifier.

8. Circuitry for carrying out the method for dc arc welding apparatus according to claim 1, wherein the welding electrodes are energized from a voltage source via a transformer, a regulating element adjusting the welding current, and rectifier elements and the regulating element is influenced by a weld-advance rate-dependent tacho generator connected to a regulator, characterized in that the regulating element is a thyristor rectifier arrangement which is controlled by a following transistor unit controlled by the regulator.

9. The circuitry according to claim 8, characterized in that a summing amplifier is provided in a feedback circuit from the transistor unit to the thyristor rectifier arrangement.

10. The circuitry according to claim 8 or 9, characterized in that a twelve-pulse rectifier arrangement is used as the regulating element.

11. The circuitry according to claim 8 or 9, characterized in that a filter is inserted between the thyristor rectifier arrangement and the following transistor unit.

12. A method for regulating the welding current of the welding power in dependence upon the weld-advance rate in welding apparatus for the continuous longitudinal-seam welding of metal strips combined to form a tube, said method being substantially as described with reference to Fig. 1 or Fig. 2 or Figs. 3 or 4 and Fig. 5 of the accompanying drawings.

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13. Circuitry for carrying out the method for dc arc welding according to claim 1 or claim 12, said circuitry being substantially as described with reference to Fig. 1 or Fig. 2 or Figs. 3 or 4 and Fig. 5 of the accompanying drawings.

DATED this SEVENTEENTH day of NOVEMBER 1992
Kabelmetal Electro GmbH

Patent Attorneys for the Applicant
SPRUSON & FERGUSON

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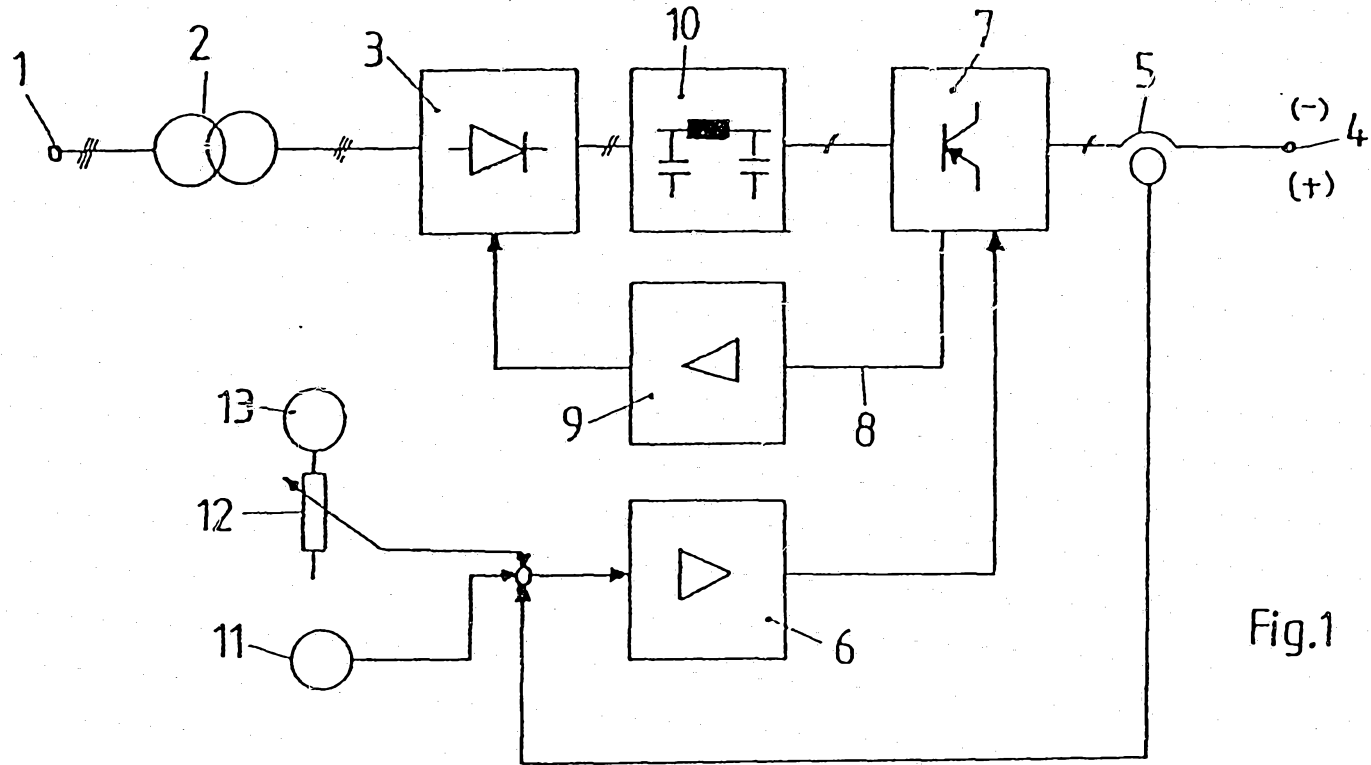


Fig.1

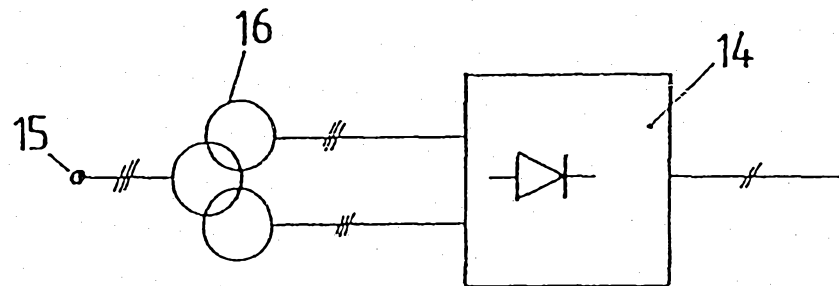
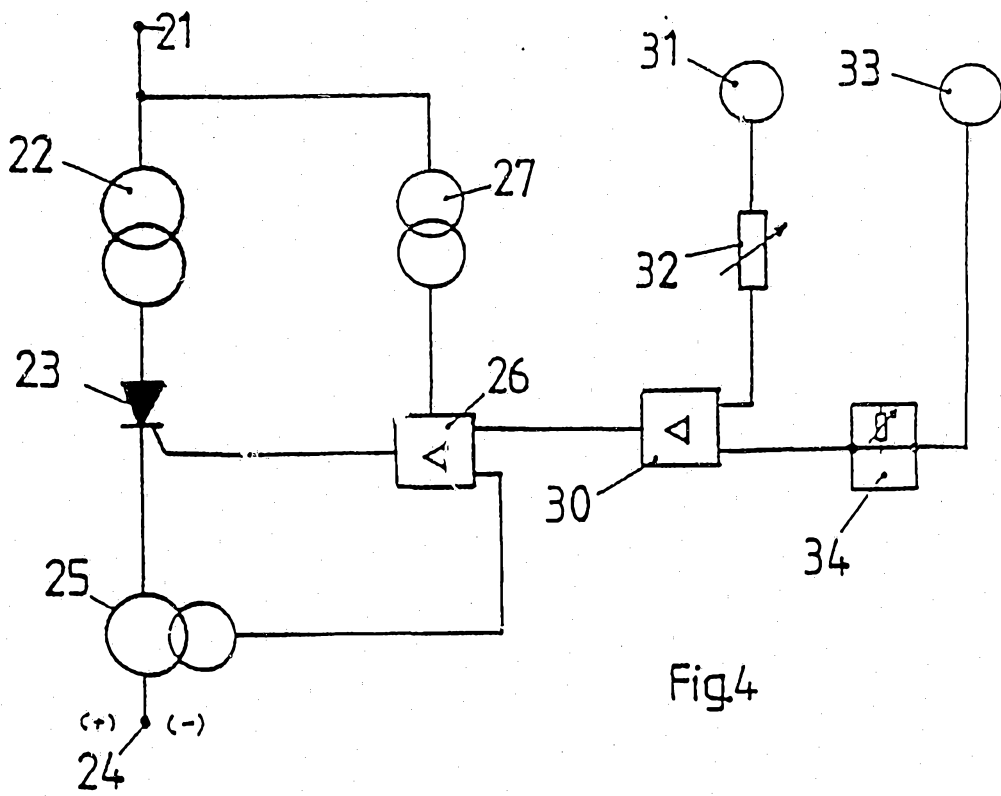
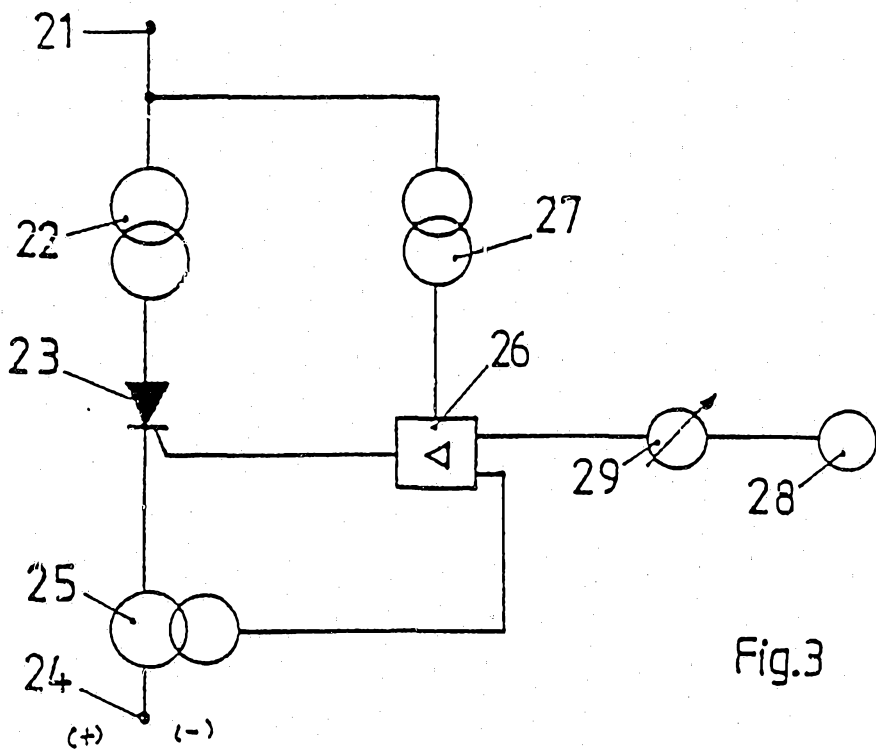


Fig.2

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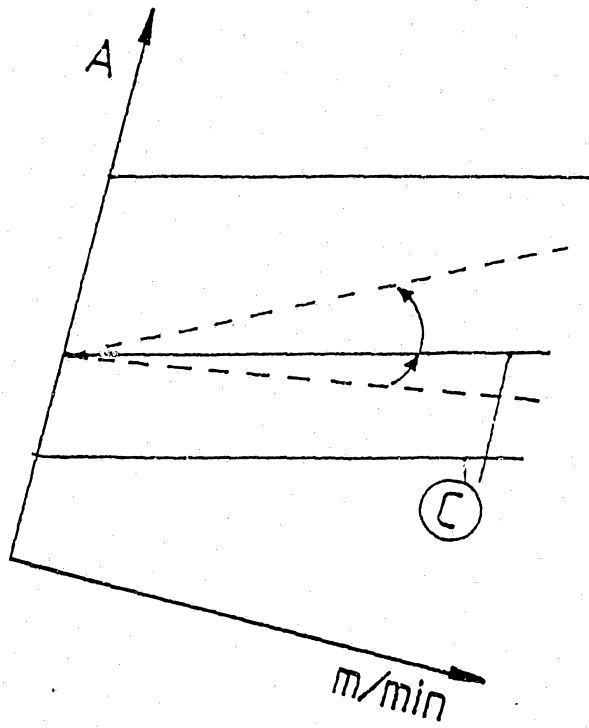


Fig.5