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METHOD OF GENERATION OF ELECTRICAL ENERGY FROM THE ROTARY MOVEMENT OF AXLES OF VEHICLES

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(57) Claim

1. A method of generating electrical energy from the rotary movement of an axle of a vehicle, including:

providing a generator arrangement in association with the axle for producing an output voltage;

determining the rate of rotation of the axle directly from a voltage curve obtained from the output voltage produced by the generator arrangement, the rate of rotation being determined from at least one of the possible pulse parameters of both upper and lower half-waves of the voltage curve; and

obtaining a magnetic saturation at low axle revolutions and which is maintained substantially constant up until maximum revolutions of the axle so that the output voltage is substantially constant.

5. An axle-driven generator arrangement which generates electrical energy according to the method of claim 1, including:

a rotor coupled to the axle of the vehicle, said rotor having permanent magnets distributed around its circumference;

a stator provided with induction coils, separated from the rotor by an air gap;

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an electronic control for producing an output voltage; and

wherein the stator is mounted co-axially around the outer periphery of the rotor and wherein a magnetic conductor component of the stator, with regard to its effective pole surface, in its axial extent, is smaller than the axial extent of a pole surface of the rotor, in such a way that the pole overlapping ratio between the rotor and the stator in every operating situation is greater than 1.0, and wherein radially orientated permanent magnets are disposed within the conductor component of the rotor with regard to its pole axis.

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ORIGINAL

COMPLETE SPECIFICATION

STANDARD PATENT

Invention Title:

METHOD OF GENERATION OF ELECTRICAL ENERGY FROM THE
ROTARY MOVEMENT OF AXLES OF VEHICLES.

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



The present invention relates to a method for generation of electrical energy from the rotary movement of axles of vehicles, especially vehicles limited to running on rails, by means of a generator arrangement in which, along with the generation of electrical energy, the rate of rotation of the axle involved is also determined, as well as an axle-driven generator arrangement, in particular for implementation of the method in accordance with Claim 1, in accordance with the preamble to Claim 5. Furthermore, the present invention is concerned with the utilisation of the axle-driven generator arrangement which is driven by the method in accordance with Claim 1.

10 An alternating-voltage generator for installation in an axle-bearing cover of a railway carriage is known from the German Specification DE-PS 25 51 009. It is known from this that, within the alternating-voltage generator, it is possible to build-in a digital rotation-angle detector, by means of which it is possible to determine the rate of rotation of the axle of the railway vehicle which is connected to the rotor of the generator. The disadvantage here is that a supplementary rotation-angle detector is required to determine the rate of rotation of the axle. This increases not only the cost of construction during the fabrication of such a generator, but also the cost of maintenance of this supplementary equipment. The rotor of this known type of alternating-voltage generator is rigidly attached to the axle of the vehicle and is provided with permanent magnets, the emergence of the field lines of which occurs in the axial direction towards the stator. Thus, the stator is disposed axially in relation to the rotor, with the appropriate arrangement of induction coils and ferrite cores. Stator and rotor, which are disposed co-axially, are separated from each other by a defined air gap. This leads to the result that the electrical energy produced in every operating situation is dependent upon the dimensions of the air gap between rotor and stator and therewith upon the axial position of the axle of the vehicle. Because of the fact that, when in operation, by way of example during

rapid travel around curves, there is offsetting of the axles, the alterations of the air gap occasioned by this inescapably exert a deleterious influence on the continuity and constancy of the energy generation. That such an axial offsetting is quite unavoidable, arises from the fact that the rotor must be coupled to the axle and correspondingly must rotate with it, and the stator must be firmly held in a fixed position, which, by way of example, is achieved by rigid connection to the axle-bearing support. The disadvantageous effect of axial displacement of the axles in the case of the known generator, arise from the fact that displacements even in the millimetre range cause a decided alteration of the air gap and, therewith, of the amount of electrical energy produced. The resultant voltage fluctuations of the electrical energy produced are a disadvantage in the utilisation of electrical energy in sensitive measuring- and control-systems within the railway vehicle, since a very reliable constant-voltage electrical energy source must be available for their safe operation. Between the energy source or "producer" and the "consumer", an accumulator is generally provided to act as a "buffer", but even here it is a disadvantage for there to be continual fluctuations of the electrical voltage. For the case where there is breakdown or a defect in the accumulator during travelling operation in which the energy supply to important elements must be guaranteed for technical safety reasons, a source of electrical energy with large fluctuations of voltage is a great, even dangerous, disadvantage. Because differing voltage values may even arise as the result of variations in the travelling speed, and the voltage must none the less be kept constant by means of electronics, the compensation of such an additional voltage fluctuation as described in the foregoing would necessitate supplementary expenditure on electronic equipment.

The arrangement, as disclosed in the afore-named state of the art, involving a separate digital rotation-angle detector within the generator, uncouples the functions of energy generation and rotation rate determination and makes the

system more susceptible to disruption.

Starting out from this state of the art, the invention has assumed the task of providing a method for operation of an axle-driven generator arrangement and of the axle

- 5 generation arrangement itself, as well as a utilisation synchronised with it, which allows for dispensing with a separate rotation-angle detector and guarantees a safe and reliable supply of energy having the highest attainable constant voltage under all operating conditions.

- 10 The invention provides a method of generating electrical energy from the rotary movement of an axle of a vehicle, including:

providing a generator arrangement in association with the axle for producing an output voltage;

- 15 determining the rate of rotation of the axle directly from a voltage curve obtained from the output voltage produced by the generator arrangement, the rate of rotation being determined from at least one of the possible pulse parameters of both upper and lower half-waves of the
20 voltage curve; and

obtaining a magnetic saturation at low axle revolutions and which is maintained substantially constant up until maximum revolutions of the axle so that the output voltage is substantially constant.

- 25 The invention also provides a system for generating electrical energy from the rotary movement of an axle of a vehicle, including:

a generator for mounting on the axle of the vehicle for producing an output voltage; and

- 30 a controller for determining the rate of rotation of the axle directly from a voltage curve obtained from the output voltage produced by the generator, the rate of rotation being determined from at least one of the possible



pulse parameters of both upper and lower half-waves of the voltage curve and for producing a magnetic saturation at low axle revolutions and which is maintained substantially constant up until maximum revolutions of the axle so that
5 the output voltage is substantially constant.

With regard to the axle-driven generator arrangement for vehicles, especially vehicles limited to running on rails, having a rotor coupled to the axle of the vehicle, said rotor having permanent magnets distributed around its
10 circumference, and a stator provided with induction coils, as well as electronics for evaluation of the generator function, in particular for carrying out the method in accordance with Claim 1, the task is accomplished in accordance with the present invention by having the stator
15 mounted co-axially around the outer periphery of the rotor and by having the magnetic conductor component of the stator packet, with regard to its effective pole surface, in its axial extent, smaller than the axial extent of the pole surface of the rotor packet, in such a way that the
20 pole overlapping ratio between rotor packet and stator packet in every operating situation is greater than 1.0, and that radially orientated permanent magnets are disposed within the conductor component of the rotor packet with



regard to its pole axis.

Additional advantageous implementations with regard to the axle-driven generator arrangement are dealt with in the subordinate Claims.

5 With regard to the utilisation of the axle-driven generator arrangement operated in accordance with the method, it is proposed, in accordance with the present invention, to incorporate it into a protective non-skid system for vehicles, especially vehicles limited to running on rails, in which the energy supply to each of the protective non-skid systems, from each vehicle to the next coupled vehicle, especially of a railway train, is electrically entirely self-sufficient and the
10 rotation rate information which is determined in each case is used for feeding in as the input parameter to the control circuit of the protective non-skid system. In additional utilisations, it is proposed in accordance with the present invention, that the method and the axle-driven generator arrangement should be incorporated into a drive slip regulator for vehicles, especially vehicles limited to
15 running on rails, in which the rotation rate information which is determined in each case is used for feeding in as the input parameter to the control circuit of the drive slip regulator.

With regard to the method there is the advantage that, because of the direct determination of the rate of rotation from the pulse parameter of every induction
20 voltage gradient, it is possible to dispense with the use of a separate rate of rotation detector. This simplifies the method to such an extent that it additionally results in greater operational safety. The pulse-width determination of the induction voltage gradient proposed in a further development of the invention is actually advantageous for utilisation, not only for the rate of
25 rotation determination, but also for function control of the generator and its windings. In an advantageous manner, it is possible to determine the speed of

the vehicle simultaneously in a very simple fashion from the measured pulse-widths. The determination of the speed is certainly already known from the cited state of the art, but it is effected there by means of a separate rate of rotation detector, which may be dispensed with in the present invention. A
5 further possibility arises in this proposed method in accordance with the present invention because of the fact that it is also possible to determine the speed of the vehicle from the pulse-height and also the rate of rotation from the induced voltage gradient.

10 With regard to the axle-driven generator arrangement, a whole series of advantages may be derived from the proposed features in accordance with the present invention.

The axle-driven generator, in its constructive configuration adapted to the method, possesses the advantage that, because of the given pole overlapping ratio, greater continuity and constancy of the generated voltage is guaranteed.
15 This pole overlapping is here designed in such a way that the axial extent of the rotor packet overlaps the axial extent of the stator packet. The arrangement of the stator packet relative to the rotor packet is additionally selected in such a manner that, for every practically-possible axle displacement, the stator packet is completely overlapped by the rotor packet. The fact that, in addition, the stator
20 in the operating condition is arranged concentrically around the rotor, has the effect, in conjunction with the pole overlapping as described, that the induction in the air gap which is established between rotor and stator remains independent of axial displacements. An axial displacement of axle of the vehicle and of the rotor attached to it, in contrast to the initially discussed state of the
25 art, thus does not result in an alteration of the air gap and, in an advantageous manner, it completely eliminates any voltage fluctuations which might be occasioned by axial displacements. The arrangement of a shrink ring made from

a non-magnetic but electrically conducting material has the advantage that this acts as a reluctance damping cage. This signifies that, even with displacement of the axle in the radial direction there is certainly a sectional alteration of the air gap but, none the less, there is no resultant voltage fluctuation because the damping cage compensates for this in an electrical manner. The shrink ring which acts as a non-magnetic reluctance damping cage has the additional mechanical function which ensures that the permanent magnets are protected against being thrown out by centrifugal action during the rotation of the rotor. The shrink ring also has an extremely important electrical function, namely compensation for voltage fluctuations and harmonic oscillations and voltage peaks in the case of possible electrical load changes of the generator. The term "load change" is meant to imply that, by way of example, the abrupt switching on of a consumer to the electrical generator output would produce an induction peak which, however, is compensated for by the shrink ring. This compensation is effected because a current is produced in the shrink ring by an alteration of the magnetic flux in the air gap and this produces an opposing field, and the outcome is that, even with an electrical load change, the air gap induction is kept constant. Voltage peaks and the like are thus avoided, which is especially important for protection of the electronics for evaluation of the rate of rotation. The dimensions of the magnetic circuit, and thus the geometry of the stator in relation to the stator with regard to the poles and the intended pole-overlapping ratio are here adapted advantageously in such a manner that the generator, even at very low rates of rotation, in respect of its generator output current, experiences a saturation which, even with a very rapid increase in the rate of rotation, will almost certainly remain constant. This is very simply achieved by selecting the dimensions, such that the magnetic saturation of the entire magnetic circuit is attained at a very early stage, that is to say, even with low rates of rotation. By means of this earliest-possible saturation, a deliberate reduction of the degree of effectiveness of the generator is envisaged. This

ensures, in a very simple advantageous manner, the possibility of connecting evaluation electronics to the output of the generator, for determination of the rate of rotation, because the output is very stable. Because of the highest possible constancy of the generator output current achieved in this way, the generator is extremely resistant to short circuits and guarantees that the electronics required for determination of the rate of rotation may be connected in an extremely operationally safe manner. Because of this fuse protection it is therewith possible to guarantee the determination of the rate of rotation directly from the induction voltage gradient without endangering the evaluation electronics used for this purpose.

The configuration of the axle-driven generator as a three- phase generator, in combination with the inventive method, has the advantage that every winding provides an induction voltage gradient for itself and thus, on the basis of the spatial distribution of the windings or of the induction coils, a high local resolution of the rate of rotation determined from the pulse-width is possible.

With regard to the utilisation of the axle-driven generator arrangement using the method in accordance with Claim 1, where not only the operational procedure but also the constructional features of the axle-driven generator can supply a reliable, operationally safe and continuously constant output voltage, a whole series of advantages are derived from the sensitive elements which determine the operational safety of the vehicle. The utilisation of the method and of the axle-driven generator arrangement operated by it in a protective non-skid system in vehicles, especially vehicles limited to running on rails, in which the energy supply to each of the protective non-skid systems from each vehicle to the next coupled vehicle, especially of a railway train, is electrically entirely self-sufficient, guarantees a high degree of safety, in an advantageous manner. This is very desirable, especially for high-speed trains. With is inventive utilisation, the

advantages derived from the method are especially in evidence because the particular rate of rotation which is determined each time is fed in as the input parameter to the control circuit of the protective non-skid system. The advantage of the method for complete realisation of the energy supply and determination of the rate of rotation within the generator itself and thus, purely apart from the determination of the rate of rotation, to be able autonomously to carry out the functional control of the generator itself, leads to the attainment, especially in a protective non-skid system, of an extremely high degree of safety of the entire operation of the railway train. This advantage of the simultaneous assured energy production and of the rate of rotation determined directly from the induction voltage gradient is also able to be exploited, with the guarantee of a high degree of operational safety, in a drive slip regulator for vehicles, especially vehicles limited to running on rails. Accompanying this, there is also the advantage that in the method, in accordance with the present invention, the proposed rate of rotation determination with the utilisation of the axle-driven generator arranged in accordance with the present invention, a high local resolution of the rotational position of the axle of the vehicle is evident. This rate of rotation determination, with a high local and rapid resolution of the rate of rotation, makes the drive slip regulating system correspondingly sensitive. This sensitivity provides the basis for the extremely advantageous ability to combine the method, the axle-driven generator arrangement and its utilisation. In this way, the possibility is provided of being able to satisfy the very high demands on safety in high-speed trains with the use of technically simple and extremely reliable measures.

25 This utilisation is especially advantageous for high-speed freight trucks because these are subject to the same safety requirements as passenger trains. That is to say, that braking to a stop from high speeds has to be guaranteed to take place within a distance of 1000 metres. The self-sufficient energy supply to every

single truck, and therewith the possibility of direct localised actuation of the braking system, guarantees that the braking signal emitted by the prime-mover traction vehicle, independent of the length of the train, simultaneously initiates the braking process without delay from one truck or carriage to the next. Any
5 delay, for example due to sluggishness in the flow of pressure medium from one carriage to the next, is thereby circumvented. For regulation of the braking pressure and optimisation of the braking distance, a protective non-skid system (ABS) is incorporated, which, independent of the coefficient of adhesion between wheel and rail, the optimal brake pressure is determined and
10 transmitted to the pressure medium and to the brake triggered in this way.

The essential thing here is that the utilisation of the method in accordance with the present invention and the axle-driven generator which operates on its principles uses the determined frequency of the generated voltage as the input parameter for the protective non-skid system (ABS). This makes superfluous the
15 monitoring of the rate of rotation of the axles, because the rate of rotation is determined here, by way of example, from the measured pulse-width of the generated voltage. In the further utilisation of the method and of the axle-driven generator for regulation of drive slip (ASR), by way of example for traction engines, it has likewise been shown to be advantageous that the rate of rotation
20 of the particular axle involved may be determined in the inventive manner already described. In the arrangement of such a system on a traction engine, it would even be possible to dispense with the utilisation of a tacho-generator, because the determination of the speed may be derived from the measured pulse parameters.

The invention is illustrated in the drawings and will now be described in greater detail.

Fig. 1 is a block diagram showing the method of functioning of the generator and the evaluation of the rate of rotation,

Fig. 2 is a block diagram of the evaluation of the induced voltage gradient for the rate of rotation,

Fig. 3 is a section through the axle-driven generator,

Fig. 4 depicts the parallel connection of a plurality of axle-driven generators operating under load.

From Fig. 1, the method of functioning in the utilisation of the method proposed in accordance with the present invention and of the proposed axle-driven generator 10 may be gleaned. The voltage generated by the generator 10 is supplied to an electronics unit which, according to the method, determines the corresponding parameters and, in addition, provides a constant controlled output voltage, as well as providing a digital pulse-width signal at an additional separate output. The pulse-width signal produced, by way of example, as a square wave signal is conveyed to an electronics unit 20 for determination of the speed of the particular axle involved, which provides the determined speed at the output.

This determined or calculated speed, on the one hand, is conveyed as the actual value to a speed-comparator 24 which, in its turn, interrogates the corresponding nominal value at the second input. That is to say, it is determined whether or not the peripheral speed of the wheel is in agreement with the actual speed of the vehicle. In other words, it is determined whether the wheel is rotating with adherent friction without any difference between the

speeds, or whether it is rotating with slippage friction with corresponding difference between the speeds. The difference between the speeds if any exists is conveyed to a logic unit 25, which triggers the measures required for initiation of the braking and therewith the control of the valves 26, 27 which actuate the

5 braking process. Parallel to this, the acceleration is calculated by electronically implemented mathematical derivation from the actual speed and supplied in parallel to two comparators 22, 23 which decide whether it is a matter of a positive or a negative acceleration, by which it is intended to state whether it is a matter of acceleration or of braking. Depending upon whether deceleration or

10 acceleration is occurring, the corresponding output is supplied to the logic unit 25 in which a decision is made about the braking effect to be achieved and is conveyed from the output to an amplifier for production of the signals required by the electrically triggered valves 26, 27. In summary, this signifies that, in parallel from a consideration of the speed and consideration of the acceleration,

15 not only the protective non-skid system anti-blocking system (ABS), but also the drive slip regulation (ASR), may be evaluated. It could also be conceived, only from consideration of the acceleration relationships, to supply not only ABS but also ASR, but none the less the consideration of speed is interesting for ASR when the "spinning" of the driving wheels occurs at a higher rate of rotation.

20 Under such operating conditions, a reference speed is established within the traction vehicle, in an imaginary manner or by way of an additional axle, so that an evaluation of the speed difference is more advantageous.

In the utilisation of a drive slip regulation system, the individual elements cooperate in a similar fashion. Likewise, first-of-all, the pulse-width of the

25 generated voltage proportional to the rate of rotation is measured and from this the speed is determined. Following this, there is calculation of the delay or the acceleration of the driven wheel sets and there is a comparison made between the speed differences of the various wheel sets. By way of the evaluation of the

speed differences of various wheel sets on one carriage, it is actually possible to detect vibration of the wheel sets, which, by way of example, may arise from asymmetric driving forces and thus from torsion. Furthermore, there arises the possibility, in an advantageous manner, of exerting an influence on the rate of rotation of the engine, by way of which such vibrations of the wheel sets may be compensated for.

The logic unit 25 is provided with two outputs, each of which by way of an amplifier, on the one hand, effects the bleeding of air from the valve 26 triggering the brake, and by way of the second path which effects the supply to the valve 27 which blocks the working pressure. This brings about the result, in appropriately coordinated sequence, that, by way of example, during a braking event, the brake is subjected to the action of pressure medium because of the opening of the working pressure valve 27 and is actuated thereby, and that during short-term release, by way of example during the triggering of the ABS, the brake must be released, because bleeding takes place through the pressure-medium line controlled by the valve 26 and the working pressure valve 27 must be closed.

The determination of the pulse parameter from the induced voltage gradient of the induction coils of the axle-driven generator is represented in Fig. 2. The direct three-phase output of the stator, before this is conveyed to a rectifier, is tapped off in parallel and is transmitted to an arrangement of optical couplers 31, 31' . . . The output phases are designated as U, V and W, where the optical couplers are arranged in such a way that between each pair of phases two optical couplers 31, 31' are respectively arranged, so that one of them picks up the upper half-wave and the other one picks up the lower half-wave. In this manner, with this three-phase arrangement, there is obtained a total of six corresponding time-interval offset pulse-width signals. These are conveyed, in

each case by way of an RC-member 32, . . . to a Schmitt-trigger 33 . . . , each of which on the output side drives a monostable multivibrator 34 . . . Each of the pulse-width signals are ultimately collected together in a logic unit, coordinated and evaluated time-wise. The utilisation of optical couplers brings about not only

5 a galvanic separation of the output phases UVW and the electronics for determination of the rate of rotation, but also pulse-width signals are essentially formed from the induction voltage gradient. The arrangement of the RC-members, of the Schmitt triggers and lastly of the multivibrators results in interference signals being kept away from the evaluation logic 35 for the rate of

10 rotation. The currently involved monostable multivibrator 34 is occupied in each case with a time constant of 0.5 mm/sec, which signifies that interference signals with a time constant of less than 0.5 mm/sec are not accepted as pulse-width signals but, as interference signals, have no influence on the determination of the rate of rotation. This time constant of 0.5 mm/sec may be altered at every

15 start, so that, in each case, this selected time constant is actually smaller than the time constant of the detected pulse-width signal. Because every pulse, by means of its time-offset sequence to the next pulse, locally resolves the information of the ultimate rotor-stator position, this provides a sensitive local resolution of the rate of rotation. In other words, this states that, after one-sixth of a revolution of

20 the wheel, it is possible to evaluate the rate of rotation; it is thus not necessary to wait for a complete revolution of the wheel to be able to evaluate the rate of rotation and the speed of travel. This provides support, especially in the utilisation in an ABS or an ASR. In parallel with this, there is also depicted in Fig. 2 the continued parallel supply of the three phase alternating voltage to a

25 rectifier B6. A parallel run controller is disposed at the output, which, in its turn, maintains the relevant electrical output of the generator constant for the energy supply. From here, the connections to the individual consumers are made and, parallel to them, to the accumulator 40.

Fig. 3 is a section through the proposed axle-driven generator in accordance with the present invention. The rotor 13 is directly connected to the axle 11 of the vehicle by means of a flange 12. The stator 14 is disposed in such a manner, within the axle cover 18, which also serves as the housing for the generator, that during the assembly, after the rotor 13 has been affixed to the axle 11, the stator can effectively be pushed onto the rotor, so that an air gap remains between them. The housing-like cover 18 of the axle-driven generator 10 then encloses the entire arrangement. The housing itself may, by way of example, be attached to the support housing 11' of the axle bearing. The air gap between rotor 13 and stator 14 is thus orientated radially between rotor and stator, contrary to the state of the art described initially, in which the air gap is orientated in the axial direction.

The axial extent of the poles or pole surfaces 13' of the rotor 13 is greater here than the axial extent of the pole surface 14' of the stator packet 14. In other words, the pole overlapping ratio between rotor and stator is greater than 1.0. Herewith it is to be recognised that, even with axial displacement of the rotor 13, the pole surface 14' of the stator 14 will always still be overlapped by the pole surface 13' of the rotor 13. In this case, the dimensions of the stator 14 are definitive for the effect of early attainment of magnetic saturation. The dimensions of the stator packet are here dependent upon the desired magnetic saturation and may be calculated with the use of the conventional formal relationships. The pole surface 13' of the rotor 13 is therefore over-dimensioned, so that the effect of the axial displacement referred to previously remains without influence on the air gap induction. The calculation of the magnetic saturation of the stator packet 14 is then to be selected in such a manner that, at the desired speed, saturation of the flux is already achieved. The stator packet 14 and the rotor packet 13 are laminated, that is to say, they are comprised of packets of sheet metal for reduction of eddy current losses. The induction coils

15 of the stator 14 are to be arranged in the appropriate manner as depicted. The permanent magnets 16 of the rotor 13 are, with regard to their pole axes, radially magnetised, that is to say, the field lines are directed radially outwards. The permanent magnets 16 are mutually arranged so that, from one magnet to the next, the magnetic polarities emerging at the circumference are reversed in each case.

Within the generator housing 18, that is to say, inside the cover, the rectifier 19 for rectification of the alternating voltage is integrally arranged, so that the entire electrical output of the generator 10 is completely arranged on the generator itself. The output of the generator 10 is then, by way of example, connected directly to a charging controller 41 for feeding the accumulator 40 and for supplying the device for determination of the rate of rotation.

The flange 12, attached to the rotor 13 in this axle-driven generator for affixing to the axle 11, is configured in such a way that it reaches the internal surface of the wall of the generator cover 18. The stationary fixed-position generator cover 18 has a rounded internal configuration. The flange 12 is provided with a labyrinthine seal 12' on the external periphery to make contact with the cover wall. This labyrinthine seal 12' is provided with a toothed peripheral surface as depicted in Fig. 3. This labyrinthine seal 12' may be connected integrally to the flange 12, and thus is moulded onto it in some parallel groves machined around the periphery of the flange.

However, it is also possible to provide the flange 12 with a separate labyrinthine seal which prevents the ingress of bearing grease into the space around the generator and thus seals it off hermetically.

Fig. 4 depicts a multiple arrangement of generators which are connected in parallel. The capability to connect them in parallel is made possible, especially because of the proposed configuration of the axle-driven generator in accordance with the present invention, in which an extremely constant controlled output of the current is made available in the manner described previously. Because the voltage is also kept constant to the greatest possible extent, the proposed axle-driven generator in accordance with the present invention is particularly suitable for connection in parallel. The outputs connected in parallel which are grouped together are conveyed in common to a temperature actuated charging controller which monitors and regulates the charging of the accumulator in an appropriate manner. The temperature monitoring is effected here by means of a temperature-dependent resistance which is mechanically connected to the accumulator in a heat-conducting manner.

The proposed method in accordance with the present invention, as well as the axle-driven generator and its utilisation represent an optimal solution of the problem because of their features which are optimally attuned to each other. It is possible to dispense with a separate rate of rotation detector, which simplifies the system and, because of the configuration of axle-driven generator, electrical energy is available in such a way that an ABS- and/or ASR-system can be advantageously utilised in an extremely operationally safe manner. The feature of the method for determination of the rate of rotation directly from evaluation of the pulse-width, in conjunction with the spatial arrangement of the coils as well as the six-pulse evaluation of the induction voltage gradient, makes possible a high localised resolution and therewith an extremely sensitive determination of the rate of rotation, which are "vitally essential" for ABS and ASR.

In the method in accordance with the present invention, the proposed evaluation of the pulse parameter for determination of the rate of rotation, and

the consideration of the pulse-width as the pulse parameter proposed in the example of embodiment is advantageous here for the reasons already discussed along with their technical explanation. However, it is also possible to determine the rate of rotation by using other pulse parameters, by way of example from the pulse-height, the distance between pulses, the pulse shape and so forth. Because a generator, depending upon the type of winding of the induction coils of the stator along with, for example, a sinusoidal induction voltage, can also provide rectangular- or triangular-shaped voltage gradients, under certain circumstances the consideration of the pulse-height or the distance between pulses, as compared with the evaluation of the pulse-width, may be more advantageous. The method thus increases the possibility of additional applications. Furthermore, because of the nice clean attuning of method, axle-driven generator and its utilisation, its application to other types of vehicles, for example heavy-duty trucks with a number of towed trailers, is a sensible development.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of generating electrical energy from the rotary movement of an axle of a vehicle, including:
providing a generator arrangement in association
5 with the axle for producing an output voltage;
determining the rate of rotation of the axle directly from a voltage curve obtained from the output voltage produced by the generator arrangement, the rate of rotation being determined from at least one of the possible
10 pulse parameters of both upper and lower half-waves of the voltage curve; and
obtaining a magnetic saturation at low axle revolutions and which is maintained substantially constant up until maximum revolutions of the axle so that the output
15 voltage is substantially constant.
2. The method according to claim 1, wherein a three-phase alternating voltage is induced, and from an induction voltage gradient of each phase the pulse-widths are evaluated for determination of the rate of rotation.
- 20 3. The method according to claim 1 or 2, wherein control of the generator function is effected by way of the determination of the rate of rotation.
4. The method according to claim 2, wherein the speed of the vehicle is determined from measured pulse-
25 widths of the induced voltage gradient.
5. An axle-driven generator arrangement which generates electrical energy according to the method of claim 1, including:
a rotor coupled to the axle of the vehicle, said
30 rotor having permanent magnets distributed around its circumference;
a stator provided with induction coils, separated from the rotor by an air gap;



an electronic control for producing an output voltage; and

wherein the stator is mounted co-axially around the outer periphery of the rotor and wherein a magnetic
5 conductor component of the stator, with regard to its effective pole surface, in its axial extent, is smaller than the axial extent of a pole surface of the rotor, in such a way that the pole overlapping ratio between the rotor and the stator in every operating situation is
10 greater than 1.0, and wherein radially orientated permanent magnets are disposed within the conductor component of the rotor with regard to its pole axis.

6. The axle-driven generator according to claim 5,
15 wherein the rotor is directly connected to the axle of the vehicle by means of a flange.

7. The axle-driven generator according to claim 5 or 6, wherein the permanent magnets of the rotor are held by a shrink ring made from a non-magnetic material which serves at the same time as a reluctance ring.

20 8. The axle-driven generator according to any one of claims 5 to 7, wherein the stator is mounted in a fixed position within an axle cover and wherein the axle cover mechanically independent of the rotor is affixed to a support housing for the axle bearing of the vehicle.

25 9. The axle-driven generator according to claim 8, wherein, within the axle cover of the generator, an electrical rectifier unit, of the electronic control, is integrally arranged.

30 10. The axle-driven generator according to any one of claims 5 to 9, wherein, the electronic control includes optical couplers for electrically coupling



phases of the output voltage and for digitalisation of pulse-width signal.

11. The axle-driven generator according to claim 10, wherein, between each pair of phases, two optical couplers
5 are respectively arranged in such a way, so that the first optic coupler picks up the upper half-wave and the other optical coupler picks up the lower half-wave of the generated alternating voltage.

12. The axle-driven generator according to claim 8,
10 wherein the axle cover of the generator extends partly over the axle bearing support housing and wherein a rotor flange is provided with a labyrinthine seal on its periphery to make contact with the wall of the axle cover.

13. A system for generating electrical energy from
15 the rotary movement of an axle of a vehicle, including:

a generator for mounting on the axle of the vehicle for producing an output voltage; and

a controller for determining the rate of rotation of the axle directly from a voltage curve obtained from the
20 output voltage produced by the generator, the rate of rotation being determined from at least one of the possible pulse parameters of both upper and lower half-waves of the voltage curve and for producing a magnetic saturation at
25 low axle revolutions and which is maintained substantially constant up until maximum revolutions of the axle so that the output voltage is substantially constant.

Dated this 14th day of February 1995

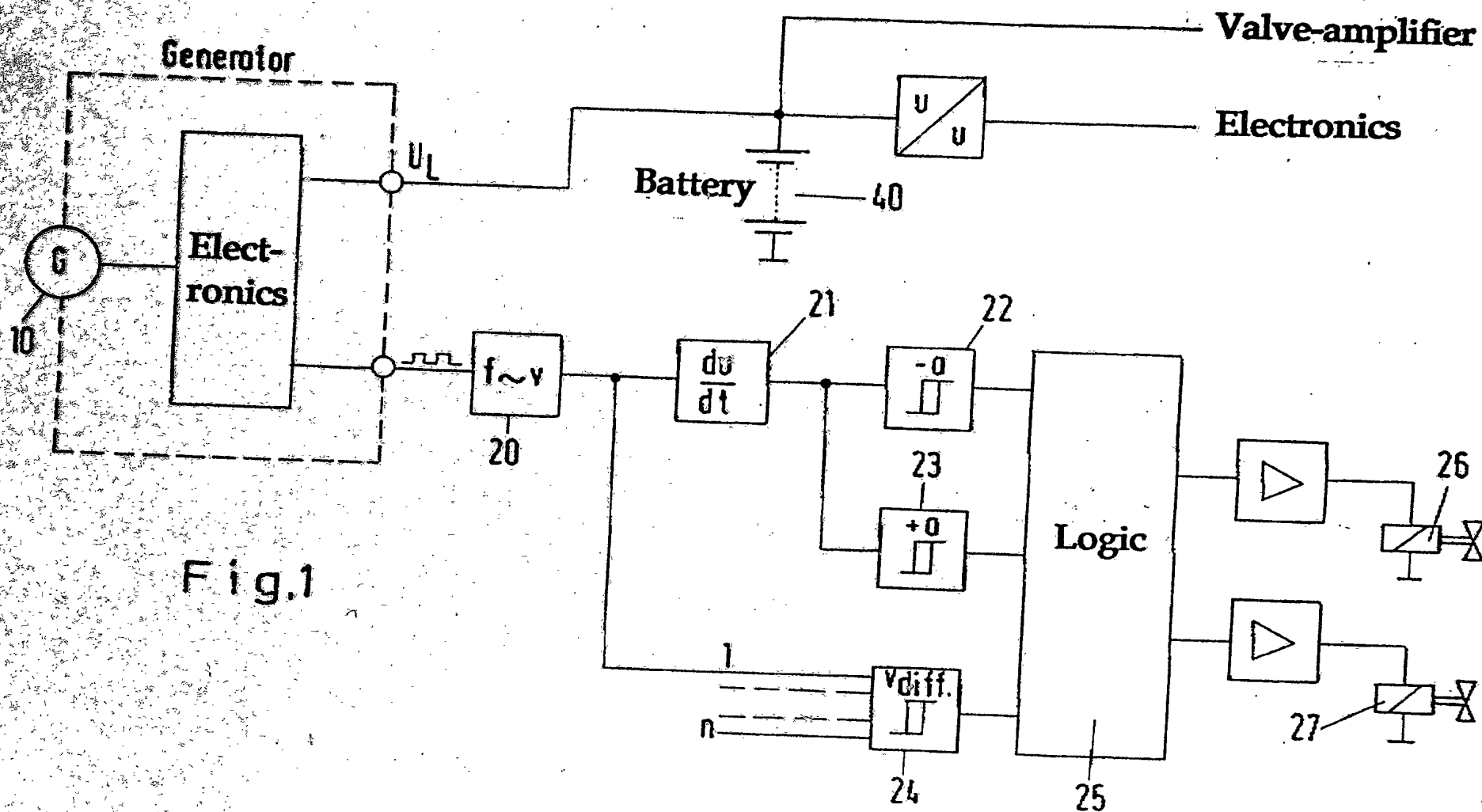
MANNESMANN AKTIENGESELLSCHAFT and
STUTZEL GMBH & CO. KG GMUNDER MOTOREN-WERKE
30 By Their Patent Attorneys:

GRIFFITH HACK & CO.
Fellows Institute of Patent Attorneys of Australia.



ABSTRACT

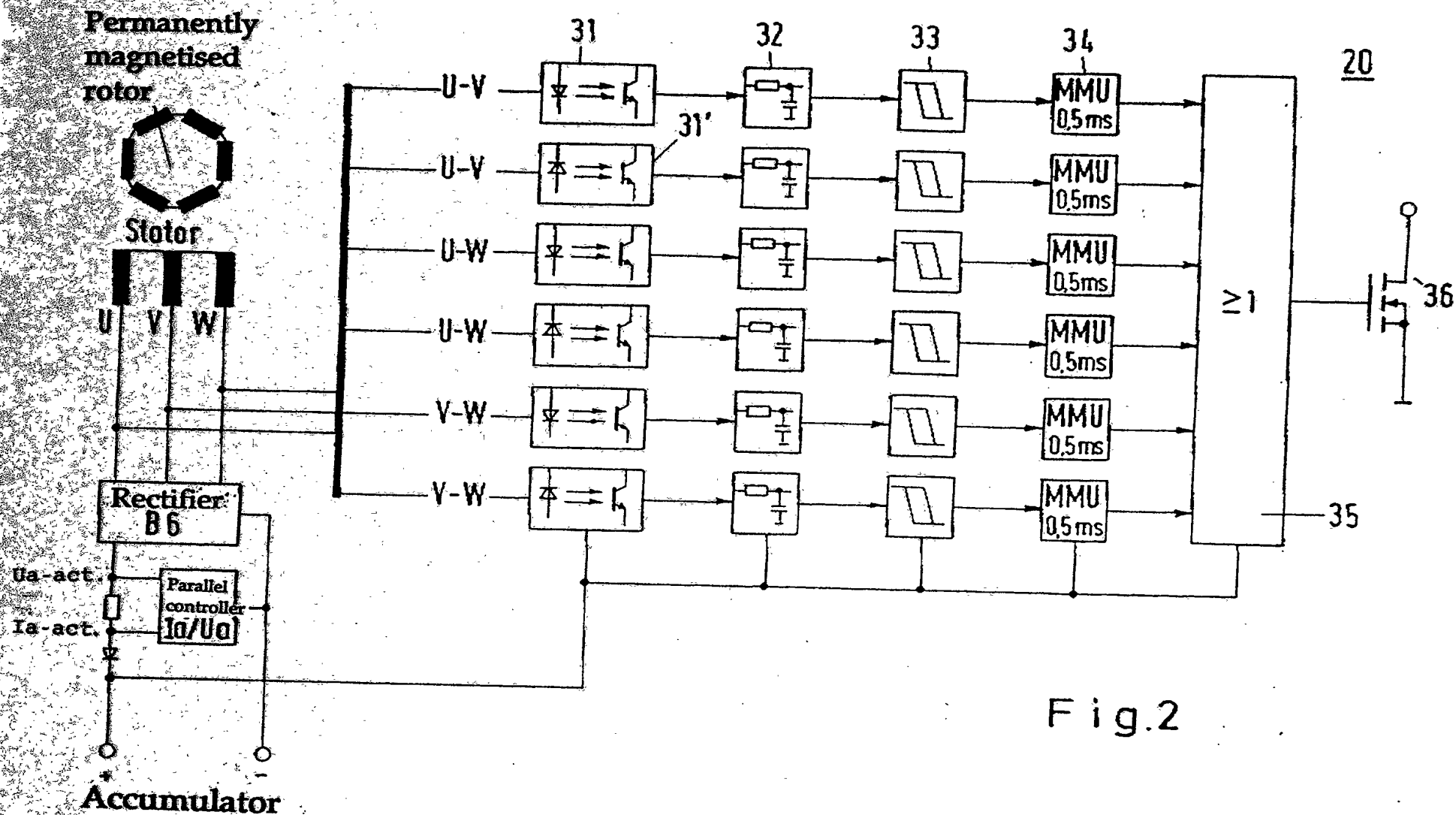
The present invention relates to a method for generation of electrical energy from the rotary movement of axles of vehicles, especially vehicles limited to running on rails, by means of a generator arrangement in which, along with the generation of electrical energy, the rate of rotation of the axle involved is also determined, wherein not only the electrical energy generation but also the determination of the rate of rotation is effected exclusively by way of the generator function, where the pulse parameters of every induced potential gradient are evaluated for determination of the rate of rotation. It also relates to an axle-driven generator arrangement, in particular for vehicles limited to running on rails, having a rotor coupled to the axle of the vehicle, said rotor having permanent magnets distributed around its circumference, and a stator provided with induction coils, separated from the rotor by an air gap, as well as electronics for evaluation of the generator function, in particular for carrying out the method in accordance with Claim 1, wherein, in the assembled state, the stator is mounted co-axially around the outer periphery of the rotor and wherein the magnetic conductor component of the stator packet, with regard to its effective pole surface, in its axial extent, is smaller than the axial extent of the pole surface of the rotor packet, in such a way that the pole overlapping ratio between rotor packet and stator packet in every operating situation is greater than 1.0, and wherein radially orientated permanent magnets are disposed within the conductor component of the rotor packet with regard to its pole axis.



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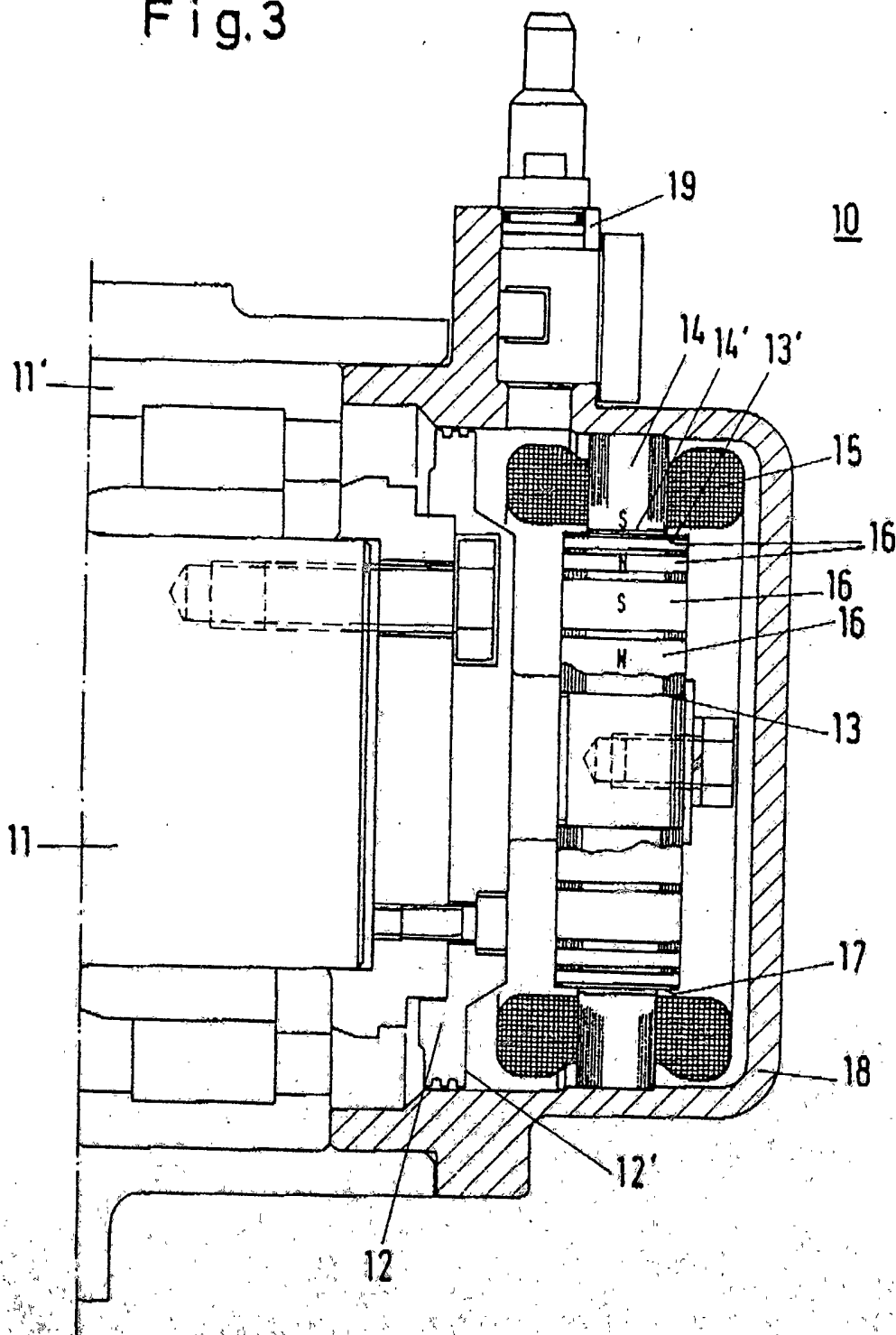
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Fig.3



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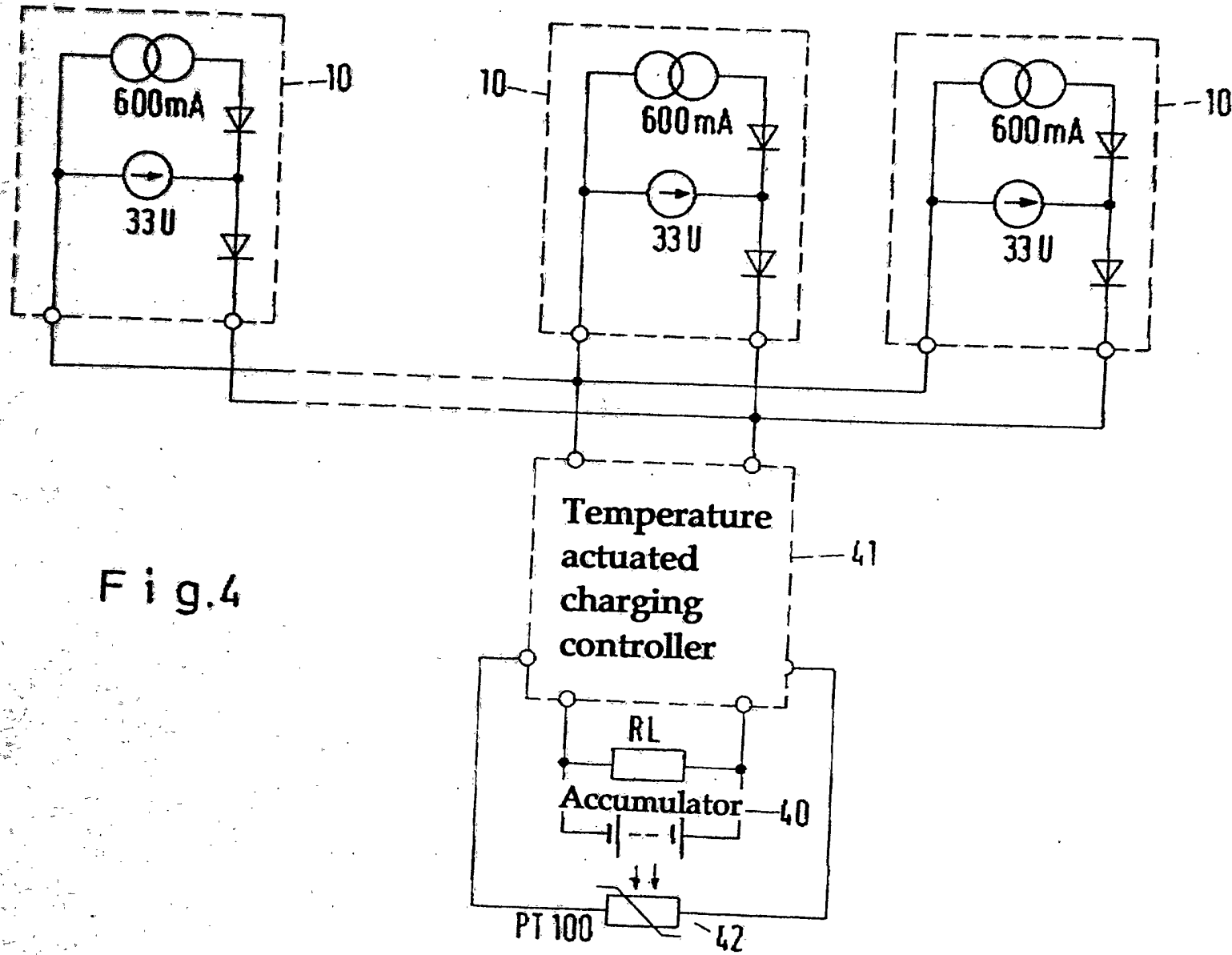


Fig.4