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DESCRIPTION

TECHNICAL FIELD

[0001] The present invention relates to an electrostatic precipitator unit with at least two individual power supplies for pulsed operation of electrostatic precipitators, wherein the power supplies are powered by a common feeding. The invention furthermore relates to methods of operation of such an electrostatic precipitator unit.

PRIOR ART

[0002] With the increasing concern for environmental pollution, the reduction of particle emissions by using Electrostatic Precipitators (ESPs) is a highly important issue for coal fired power plants. ESPs are highly suitable dust collectors. Their design is robust, and they are very reliable. Moreover, they are most efficient. Degrees of separation above 99.9% are not unusual. Since, when compared with fabric filters, their operating costs are low and the risk of damage and stoppage owing to functional disorders is considerably smaller, they are a natural choice in many cases. In an ESP, the polluted gas is conducted between electrodes connected to an ESP power supply. Usually, this is a high-voltage transformer with thyristor control on the primary side and a rectifier bridge on the secondary side. This arrangement is connected to the ordinary AC mains and thus is supplied at a frequency, which is 50 or 60 Hz. The power control is effected by varying the firing delays of the thyristors. The smaller the firing angle, i.e. the longer the conducting period, the more current supplied to the ESP and the higher the voltage between the electrodes of the ESP.

[0003] Modern ESPs are divided into several bus sections for increasing the collection efficiency. Each of these bus sections has its own power supply (PS), which is controlled individually and has a typical output power range of 10-200kW and an output voltage range of 30-150kVDC.

[0004] Modern ESP's power supplies are often based on resonant converters in order to utilize the transformer's nonidealities and to have soft switching for a wide operation range. One exemplary power supply for ESP's is known from US 2009/0129124.

[0005] US 4 613 346 A relates to a method of controlling an electrostatic precipitator which has one or more precipitator sections, the or at least one section being charged from an independent power supply for supplying a pulse superimposed DC-voltage, and more particularly to a method of controlling the entire electrostatic precipitator towards minimum energy consumption at a certain efficiency. To control an electrostatic precipitator towards minimum energy consumption at a given efficiency the dust content in the exit air of the precipitator is measured and the efficiency of the precipitator regulated upwardly or

downwardly accordingly. Regulation is carried out in accordance with a selected one of a plurality of predefined stored strategies by a central unit which controls the parameters of the independent power supplies to the precipitator sections.

SUMMARY OF THE INVENTION

[0006] Modern ESP's are often operated in pulsed mode. Pulsed operation of an electrostatic precipitator considerably influences the mains power quality, since it can result in high line current distortion (total harmonic distortion) and unbalanced mains phase loading. Thus, interruption and malfunction of equipment fed by a common feeding, audible noise, heating in transformers, generators and power lines, electric resonance in the mains, mechanical oscillations in generators, engines, etc. can be caused. These problems can become worse if, for example, a group of power supplies with pulsed operation are fed by a common feeding, since the pulses in different supplies can occur at the same instant. On the other hand, if the pulses in each power supply are scheduled in an optimal way it should be possible to reduce the undesirable effects in this type of operation, so that the power consumption becomes more continuous in time. At the moment, the power supply systems for ESP application do not use any strategy for pulse scheduling and not even allow to do so; therefore, arbitrary current waveform at the input occurs.

[0007] This is where the present invention has its origin, proposing a new and improved electrostatic precipitator setup for the operation of at least two power supplies connected to a common feeding, said power supplies destined to provide pulsed power output for the pulsed operation of one or several ESPs operated with said power supplies.

[0008] So, this invention deals with mains' energy quality optimization for a group of power supplies feeding an Electrostatic Precipitator (ESP) with pulsed operation.

[0009] The modified electrostatic precipitator device and the corresponding optimization strategy that will be presented here can be applied to any group of power supplies operating in pulsed mode. Thereby, a considerable improvement of the line current by just controlling the starting time of the different pulses can be achieved without any additional means.

[0010] The "best case" for an ESP system occurs when all supplies at full load operate feeding the ESP with continuous power, where the mains' phase currents are balanced and the relation between the average value of the power consumption and the harmonic components are at the lowest. Considering this, the main idea of this optimization is to allow to arrange the pulses in an optimal sequence, so that the group of pulsed power supplies has similar line behaviour to that which an equivalent single power supply, which operates in continuous mode, would have.

[0011] So, one of the cores of the invention can be summarized as follows:

The proposed modified electrostatic precipitator unit allows to arrange the pulses of the

individual power supplies in an optimal sequence by shifting the initial pulses of each power supply by a delay time with respect to one reference. The aim is essentially to provide a structure which enables to fill the gaps between the reference pulses by the pulses of the other power supplies.

[0012] Best behavior is observed when the pulses are essentially uniformly distributed within the reference pulse period and by shifting all pulses of one field by the same delay with respect to the other fields.

[0013] More specifically, the present invention relates to an electrostatic precipitator unit with at least two individual power supplies for pulsed operation of electrostatic precipitators, wherein the power supplies are powered by a common feeding (mains).

[0014] In accordance with the present invention which is defined by claim 1, each individual power supply comprises a control unit, and these individual control units are at least indirectly connected among each other by communication lines allowing for a controlled relative scheduling of the pulsed operation of the individual power supplies.

[0015] The power supplies of the unit which are powered by a common feeding can be powering at least two individual electrostatic precipitators, e.g. each being part of a different exhaust duct. In each of these ducts there may again be several bus sections powered by individual independent power supplies also powered by a common feeding.

[0016] According to another embodiment the power supplies are part of one electrostatic precipitator, typically powering different bus sections thereof or powering different modules within one bus section.

[0017] The control may be realized in the unit either in a manner such that there are communication lines between the individual control units and one control unit takes the lead and controls the relative scheduling or this control is shared between the control units forming part of individual power supplies. On the other hand, it is also possible and in accordance with another preferred embodiment of the present invention, that the unit further comprises a control computer (which can be dedicated computer, or which can be a computer also dealing with other tasks in the precipitator or in the power plant) connected to the communication lines and controlling the scheduling of the power supplies.

[0018] The relative scheduling of the pulsed operation of the individual power supplies can be effected in that one power supply is defined to be the reference power supply, and the initial pulses of each further power supply are shifted by controlled delays with respect to the pulses of the reference power supply so as to fill the gaps between the reference pulses by the pulses of the further power supplies. In this case the controlled delays can be determined so as to essentially uniformly distribute the pulses of the further power supplies in the pulse period of the reference power supply, wherein preferably, if the accumulated pulse width of all power supplies is smaller than the largest pulse period, the controlled delays are determined such

that the gaps between all pulses are essentially identical, if the accumulated pulse width of all power supplies is equal to the largest pulse period the controlled delays are determined such that there are no gaps between all pulses, and if the accumulated pulse width of all power supplies is larger than the largest pulse period, the overlap length of all pulses is equal.

[0019] Typically, the power supplies used in this context are high voltage transformer based, preferably IGBT (integrated gate bipolar transistor) based converters, preferably series loaded resonant converters allowing to have high power and high voltage, preferably said high power being in a range of 10-200 kW and/or said high voltage being in a range of 50-150 kV DC.

[0020] According to yet another preferred embodiment, the system is adapted to operate with DC pulses provided to the electrostatic precipitators having pulse widths in the range of 0.1-20 ms, and/or having pulse periods in the range of 0.5ms - 2s, wherein preferably the pulse ratio defined as the pulse width divided by the pulse period in the range of 1-1/2000.

[0021] The electrostatic precipitator may comprise at least one bus section for pulsed operation and at least one further bus section for continuous operation.

[0022] Furthermore, the unit may, in accordance with another preferred embodiment, comprise at least three power supplies, preferably at least four power supplies, most preferably at least six power supplies, preferably all of them connected and powered by a common feeding and at least indirectly connected by communication lines. In case of large precipitator units there may be up to 24 or even 36 power supplies or more which are individually controlled and scheduled with all powered by a common feeding.

[0023] Furthermore, the present invention relates to an industrial application comprising an electrostatic precipitator unit as described above, e.g. a power plant, preferably a fossil fuel operated power plant, most preferably a coal operated power plant the exhaust gases of which are cleaned by the electrostatic precipitator unit. The electrostatic precipitator unit can also be used for another dust producing process such as a sinter band sieving system, a cement manufacturing process, or the like.

[0024] In addition to the above the present invention relates to a method as defined in claim 11 for the operation of a unit as outlined above, wherein preferably one power supply is defined to be the reference power supply, and wherein the initial pulses of each further power supply are shifted by controlled delays with respect to the pulses of the reference power supply so as to fill the gaps between the pulses of the reference power supply by the pulses of the further power supplies, and wherein preferentially the reference power supply is the power supply of the system which has the largest pulse period.

[0025] According to a preferred embodiment of this method, the controlled delays are determined so as to essentially uniformly distribute the pulses of the further power supplies in the pulse period of the reference power supply, wherein preferably, if the accumulated pulse width of all power supplies is smaller than the largest pulse period, the controlled delays are

determined such that the gaps between all pulses are essentially identical, if the accumulated pulse width of all power supplies is equal to the largest pulse period the controlled delays are determined such that there are no gaps between all pulses, and if the accumulated pulse width of all power supplies is larger than the largest pulse period, the overlap length of all pulses is equal.

[0026] Further embodiments of the invention are laid down in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Preferred embodiments of the invention are described in the following with reference to the drawings, which are for the purpose of illustrating the present preferred embodiments of the invention and not for the purpose of limiting the same. In the drawings,

Fig. 1

shows a typical ESP installation scheme, specifically a system with several sequential bus sections driven by 24 power supplies;

Fig. 2

a) shows a schematic of a single high frequency ESP power supply, b) a schematic of a typical single-phase mains frequency ESP power supply, c) a schematic of a high frequency power processing ESP power supply;

Fig. 3

schematically shows the pulsed and continuous charging method;

Fig. 4

shows a group of 3 ESP power supplies;

Fig. 5

shows the pulse train in power supply 1 (a), power supply 2 (b) and power supply 3 (c) as well as the total power drained from the power grid (d);

Fig. 6

shows for a second example in (a) an ESP power supply 1 with a pulse ratio 1/3, in (b) an ESP power supply 2 with a pulse ratio 1/5, in (c) an ESP power supply 3 with a pulse ratio 1/7 and in (d) the total power drained from the power grid;

Fig. 7

shows a setup with direct communication between individual ESP's powered by a common feeding;

Fig. 8

shows a setup with communication via a host computer between individual ESP's powered by a common feeding; and

Fig. 9

shows an optimized example 3 and the corresponding pulse train in power supply 1 (a), power supply 2 (b) and power supply 3 (c) as well as the total power drained from the power grid (d).

DESCRIPTION OF PREFERRED EMBODIMENTS

[0028] Usually an ESP system is divided into several bus sections to improve the particulate collection efficiency. In small systems, only 2 or 3 bus sections are connected in series and in large ones, several bus sections are connected in parallel and in series. Different power supplies with different power ratings often energize the bus sections in order to optimize the collection efficiency of the single bus section.

[0029] Figure 1 shows a typical ESP installation with several sequential bus sections driven by 24 power supplies. The electrostatic precipitator 5 comprises an inlet side trough which a gas flow 4 loaded with particles, e.g. coal dust, enters the ESP. The ESP has an inlet field 6, followed by middle fields 7 and is terminating by an outlet field 8, the outlet of which is connected to a stack 9 through which the cleaned exhaust gas 10 exits to the environment.

[0030] So, the ESP is mechanically sectionalized in series connected fields and parallel connected cells to utilize the collection efficiency. Each field/cell position is called a bus section. One ESP power supply is feeding a single bus section with high voltage.

[0031] Each of the fields 6 - 8 has two rows of individually powered precipitator systems (four cells and six fields), leading to 24 bus sections, and to this end 24 power supplies (PS) are provided for the energization of the precipitators. The general topology of such a power supply will be discussed further below. The power supplies are energized via the common feeding 1, which via a low or medium voltage line 2 and distribution transformers 3 connects to the individual power supplies. In other words, the totality of the power supplies is connected to a common feeding system 1 and if these power supplies or at least a fraction thereof are operated in pulsed mode the load on the main can be heavily unbalanced.

[0032] A high frequency three phase mains power supply 11 for powering one of the individual precipitators in a setup according to figure 1 is illustrated in figure 2 a. On the input side the power supply 11 is connected to the mains 1 and first comprises an input rectifier 12. At the output side of the input rectifier 12 a direct current (DC) is provided and between the levels there is located a DC link capacitor 18. This direct current is then fed through a full bridge inverter 13 with a number of correspondingly fired transistors. The operation of the full bridge inverter 13 is controlled by drivers 22 in turn controlled by a control unit 23. The alternating current on the output side of the full bridge inverter 13 enters a resonant tank and transformer unit 14, the resonant circuit given by a series arrangement of a capacitor 19 and an inductor 20 followed by a transformer 21. On the output side the unit 14 is coupled to an output rectifier 15 the output side of which is then coupled to the electrodes of the electrostatic precipitators 5.

[0033] For pulsed operation of such a power supply the full bridge inverter is operated in pulsed mode via the control unit 23 and the drivers 22. In order to control the whole system,

there is provided a current and voltage sensor 16 the output of which is used for controlling the unit 23.

[0034] The present invention is not limited to high frequency three-phase power supplies as illustrated in figure 2a and also further schematically in figure 2c, which typically operate at a frequency in the resonant tank in the 20 - 200 kHz range. Also possible are mains frequency power processing units as illustrated in figure 2b, where a single-phase mains 1 is switched in unit 17, transformed by a transformer 21 and rectified for the final use at the ESP after the output rectifier 15.

[0035] The charging method for each ESP power supply 11 can be either continuous mode 25 or pulsed mode 26 of current 27, see figure 3. The continuous charging method can be used in most processes where low resistivity dust is collected. The pulsed charging method is used when the dust has a medium or high resistivity or in order to save power consumption for same dust collection efficiency. Each ESP power supply is individually optimized during pulsed mode operation.

[0036] The problems occur when a group of ESP power supplies 11 are operating in pulsed charging mode and is fed by the same mains 1, as illustrated in figure 4. Here three individual power supplies #1, #2 and #3 are powered by the distribution line 2 by a common feeding. Each power supply drives an individual bus section 29, 30, 31, respectively, of the electrostatic precipitator 5. Generally speaking the bus sections can either be part of one single electrostatic precipitator, they may however also be parts of different electrostatic precipitators. Each of the power supplies 11 comprises an individual control unit 23 responsible for the control of the pulses via the above-mentioned full bridge inverter 13. The individual control unit 23 are interconnected via communication lines/control lines 32. In accordance with the invention these lines 32 are used to provide for a control scheduling of the pulse trains of the individual power supplies in order to minimize distortions and in order to optimize the load on the mains.

[0037] The current pulse from each ESP power supply has variable pulse width PW and variable pulse period time T_P as defined in figure 3. These parameters are optimized based on either manual or automatic tuning principles within each power supply individually. Due to that each ESP power supply controller unit 23 is individually optimizing the current pulse parameters, pulses from different ESP power supplies are however according to the state-of-the-art not coordinated and may occur at the same instant, which is illustrated in figure 5. The pulse period in figure 5 is chosen to 9 ms for all three ESP power supplies #1-#3 for simplicity, but still it is a realistic example. The pulse width is 2 ms for power supply #1, 3 ms for power supply #2 and 4 ms for power supply #3 in this first example.

[0038] The example in figure 5 is showing the instantaneous moment when all ESP power supplies are pulsing simultaneously, i.e. starting at the same moment in time. This leads to the repetitive pattern of the instant power drained (IPDM) from the mains as illustrated in figure 5 d. Normally there is a continuous drift between the ESP power supplies pulsing giving rise to a discontinuous current drained from the power grid.

[0039] The second example illustrated in figure 6 is showing three ESP power supplies that are pulsing with different pulse ratios. The pulse ratio is defined as the relationship between the pulse width and the pulse period. The resulting problem with pulsed mode operation of the ESP is that the line currents will show a high Total Harmonic Distortion (THD), sub - harmonics, unbalanced phase load and even a DC component in the line current. In this case, interruption and malfunction of equipment connected to the same energy system; audible noise, heating in transformers, generators and power lines; electric resonance in the mains; mechanical oscillations in generators, engines, etc. can be generated.

[0040] The proposed solution is that the different ESP power supplies or groups of ESP power supplies communicate as illustrated in figure 4 via lines 32 or as illustrated for a situation where three individual precipitators are controlled in figure 7. In such a way the occasions for the pulses are adjusted (scheduling) so that the power flow is as even as possible.

[0041] A different approach for the communication interface can be to use a dedicated host computer, managing the time slots for the controller unit in each local ESP power supply.

[0042] Figure 8 shows a setup where there is provided such a dedicated control computer 33 controlling the scheduling in the individual precipitators 5.

[0043] The variation in the power flow can be minimized by using a line distortion optimization algorithm in each local controller. The purpose is to limit the number of pulses from different ESP power supplies that occurs at the same instant, see figure 9. The pulse period in figure 9 is chosen to be 9 ms for all ESP power supplies for simplicity, and the pulse widths in figures 9a), b), and c) are the same as described in relation with figure 5a), b), and c) respectively, but still it is a realistic example. One can see that the instant power drained from the mains becomes essentially completely homogeneous over time for this particular situation where the sum of the pulse widths of the individual power supplies is equal to the pulse period.

[0044] To summarise what distinguishes the invention from existing technologies is that

- there are controllers in the ESP power supplies;
- there is provided means for communication between the local controllers; the controller units are exchanging information on timing for pulsing and delay in order to avoid / minimize simultaneous pulsing in different bus sections.
- there is adjustment of the pulse occasions so that the line distortion is minimized.

(Line distortion optimizing algorithm).

[0045] This allows to solve at least the following problems:

- Possibility to meet the line distortion standards in pulsed mode operation.
- Reduction of excessive losses in the grid, power cables and feeding transformers.
- Reduced risk for malfunction of other equipment due to line distortion.

LIST OF REFERENCE SIGNS

[0046]

1	mains, common feeding	23	control unit
2	low or medium voltage level line	25	current for continuous operation
3	distribution transformer	26	current for pulsed operation
4	gas flow loaded with particles, e.g. coal dust	27	secondary current
		28	current limit
5	electrostatic precipitator	29	bus section 1
6	inlet field	30	bus section 2
7	middle fields	31	bus section 3
8	outlet field	32	communication line
9	stack	33	control computer
10	cleaned exhaust gas		
11	power supply	t	time
12	input rectifier	T_P	pulse period, intra-pulse delay
13	full bridge inverter		
14	resonant tank and transformer	PW	pulse width
15	output rectifier	IPDM	instant power drained from the mains
16	current and/or voltage sensor		
17	thyristor blocks	V	voltage
18	DC link capacitor	#1	ESP power supply number 1
19	capacitor in series	#2	ESP power supply number 2
20	inductor in series	#3	ESP power supply number 3
21	transformer		
22	drivers		

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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PATENTKRAV

1. Elektrostatisk udskillerenhed, der omfatter
mindst to elektrostatiske udskillere (5),
5 mindst to individuelle strømforsyninger (11) til pulsdrift af de
elektrostatiske udskillere (5),
 hvor hver af strømforsyningerne (11) føder én af de elektrostatiske
udskillere (5);
 en fælles føddning (1), som effektforsyner strømforsyningerne (11); og
10 en styreenhed (23) til hver af strømforsyningerne (11),
 hvor strømforsyningernes (11) styreenheder (23) er mindst indirekte
forbundet ved hjælp af kommunikationsledninger (32), **kendetegnet ved, at**
styreenhederne (23) er anbragt med henblik på at tilvejebringe en styret relativ
tidsplanlægning af pulsdriften af de individuelle strømforsyninger (11) via
15 kommunikationsledninger (32), således at effektstrømmen er så jævn som
muligt med henblik på at minimere forvrængninger og med henblik på at optimere
belastningen på strømforsyningsnettet.
2. Elektrostatisk udskillerenhed ifølge krav 1, hvor strømforsyningerne (11)
20 effektforsyner mindst to individuelle elektrostatiske udskillere (5), hvor fortrinsvis
hver af de individuelle elektrostatiske udskillere (5) omfatter mere end én
individuel uafhængig strømforsyning (11).
3. Elektrostatisk udskillerenhed ifølge et hvilket som helst af de foregående
25 krav, hvor den elektrostatiske udskillerenhed endvidere omfatter en styrecomputer
(33), der er forbundet med strømforsyningernes (11) kommunikationsledninger
(32), med henblik på at styre tidsplanlægningen.
4. Elektrostatisk udskillerenhed ifølge et hvilket som helst af de foregående
30 krav, hvor den relative tidsplanlægning af pulsdriften af de individuelle
strømforsyninger (11) foretages ved hjælp af én strømforsyning (11), der defineres
som en referencestrømforsyning, og hvor initialimpulser fra hver yderligere
strømforsyning (11) forskydes ved hjælp af styrede forsinkelser for impulserne fra
referencestrømforsyningen med henblik på at udfylde mellemrum mellem

impulserne fra referencestrømforsyningen med impulser fra de yderligere strømforsyninger (11).

5. Elektrostatisk udskillerenhed ifølge krav 4, hvor de styrede forsinkelser
5 bestemmes med henblik på i det væsentlige ensartet at fordele impulserne fra de
yderligere strømforsyninger (11) i mellemrummet mellem impulser for en
impulsperiode for referencestrømforsyningen, og hvis alle strømforsyningers
akkumulerede impulsbredde er mindre end den største impulsperiode, fastsættes
der styrede forsinkelser, således at mellemrum mellem alle impulser er ens, hvis
10 alle strømforsyningers akkumulerede impulsbredde er lig med den største
impulsperiode, fastsættes der ikke styrede forsinkelser for nogen mellemrum
mellem impulser, og hvis alle strømforsyningers akkumulerede impulsbredde er
større end den største impulsperiode, fastsættes der styrede forsinkelser, således
at overlapslængden for hver impuls er ens.

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6. Elektrostatisk udskillerenhed ifølge et hvilket som helst af de foregående
krav, hvor strømforsyningerne (11) er enkelt- eller trefasede eller 50 Hz- eller
60 Hz-baserede strømforsyninger eller højspændingstransformatorbaserede eller
bipolære transistorbaserede omformere med integreret gate eller seriebelastede
20 resonansomformere til høj effekt og høj spænding, hvilken høje effekt er i et
område fra 10 til 200 kW, eller hvilken høje spænding er i et område fra 50 til
150 kV jævnstrøm.

7. Elektrostatisk udskillerenhed ifølge et hvilket som helst af de foregående
25 krav, hvor den elektrostatiske udskillerenhed er tilpasset til at fungere med
jævnstrømsimpulser, der leveres til de elektrostatiske udskillere (5) med
impulsbredder i området 0,1-20 ms eller med impulsperioder i området 0,5 ms-2 s,
hvor impulsforholdet for impulsbredde divideret med impulsperioden er 1 til
1/2000.

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8. Elektrostatisk udskillerenhed ifølge et hvilket som helst af de foregående
krav, hvor hver af de elektrostatiske udskillere (5) omfatter mindst ét busafsnit til
pulsdrift og mindst ét yderligere busafsnit til kontinuerlig drift.

9. Elektrostatisk udskillerenhed ifølge et hvilket som helst af de foregående krav, hvor den elektrostatiske udskillerenhed omfatter mindst tre til seks strømforsyninger (11), der hver især er forbundet og strømforsynes ved hjælp af en fælles fødnings (1) og mindst indirekte forbundet ved hjælp af
- 5 kommunikationsledninger (32).
10. Industriel applikation, kraftværk, kraftværk drevet med fossilt brændsel eller kuldrevet kraftværk, der omfatter: en elektrostatisk udskillerenhed ifølge et hvilket som helst af de foregående krav til rensning af udstødningsgasser fra
- 10 applikationen eller anlægget.
11. Fremgangsmåde til drift af en elektrostatisk udskillerenhed ifølge et af kravene 1 til 9, hvilken fremgangsmåde omfatter: definition af én strømforsyning (11) som en referencestrømforsyning og forskydning af initialimpulser fra hver
- 15 yderligere strømforsyning (11) ved hjælp af styrede forsinkelser fra impulser fra referencestrømforsyningen med henblik på at udfylde mellemrum mellem impulserne fra referencestrømforsyningen med impulser fra de yderligere strømforsyninger (11), hvor referencestrømforsyningen er strømforsyningen til den elektrostatiske udskillerenhed med de største mellemrum mellem impulser for en
- 20 impulsperiode.
12. Fremgangsmåde ifølge krav 11, hvor de styrede forsinkelser fastsættes med henblik på i det væsentlige ensartet at fordele impulserne fra de yderligere strømforsyninger (11) i impulsperioden for referencestrømforsyningen, og hvis alle
- 25 strømforsyningers akkumulerede impulsbredde er mindre end den største impulsperiode, fastsættes der styrede forsinkelser, således at mellemrum mellem impulser er ens, hvis alle strømforsyningers akkumulerede impulsbredde er lig med den største impulsperiode, fastsættes de styrede forsinkelser ikke for nogen mellemrum mellem impulser, og hvis alle strømforsyningers akkumulerede
- 30 impulsbredde er større end den største impulsperiode, fastsættes de styrede forsinkelser, således at overlapslængden for hver impuls er ens.
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DRAWINGS

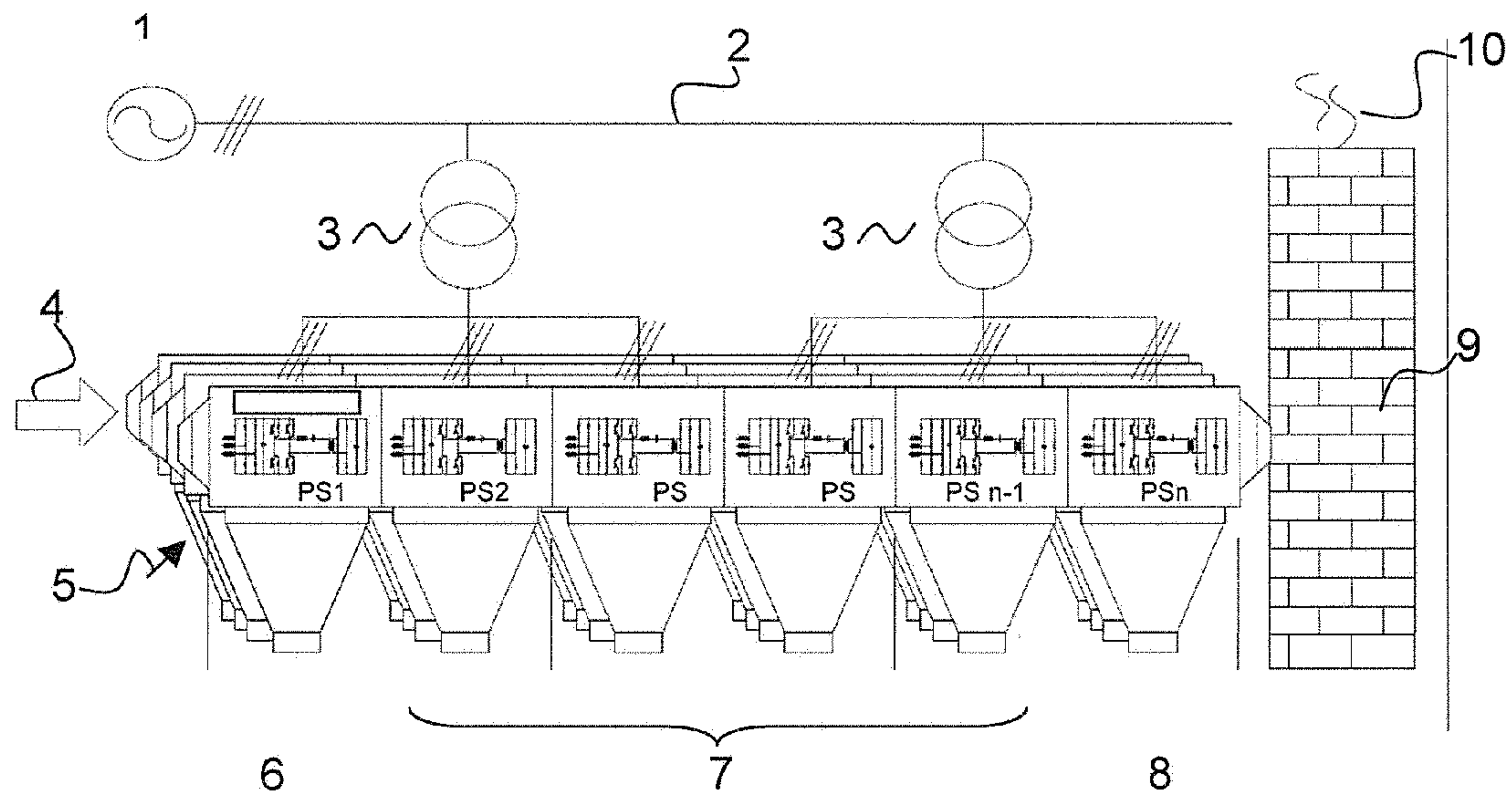


FIG. 1

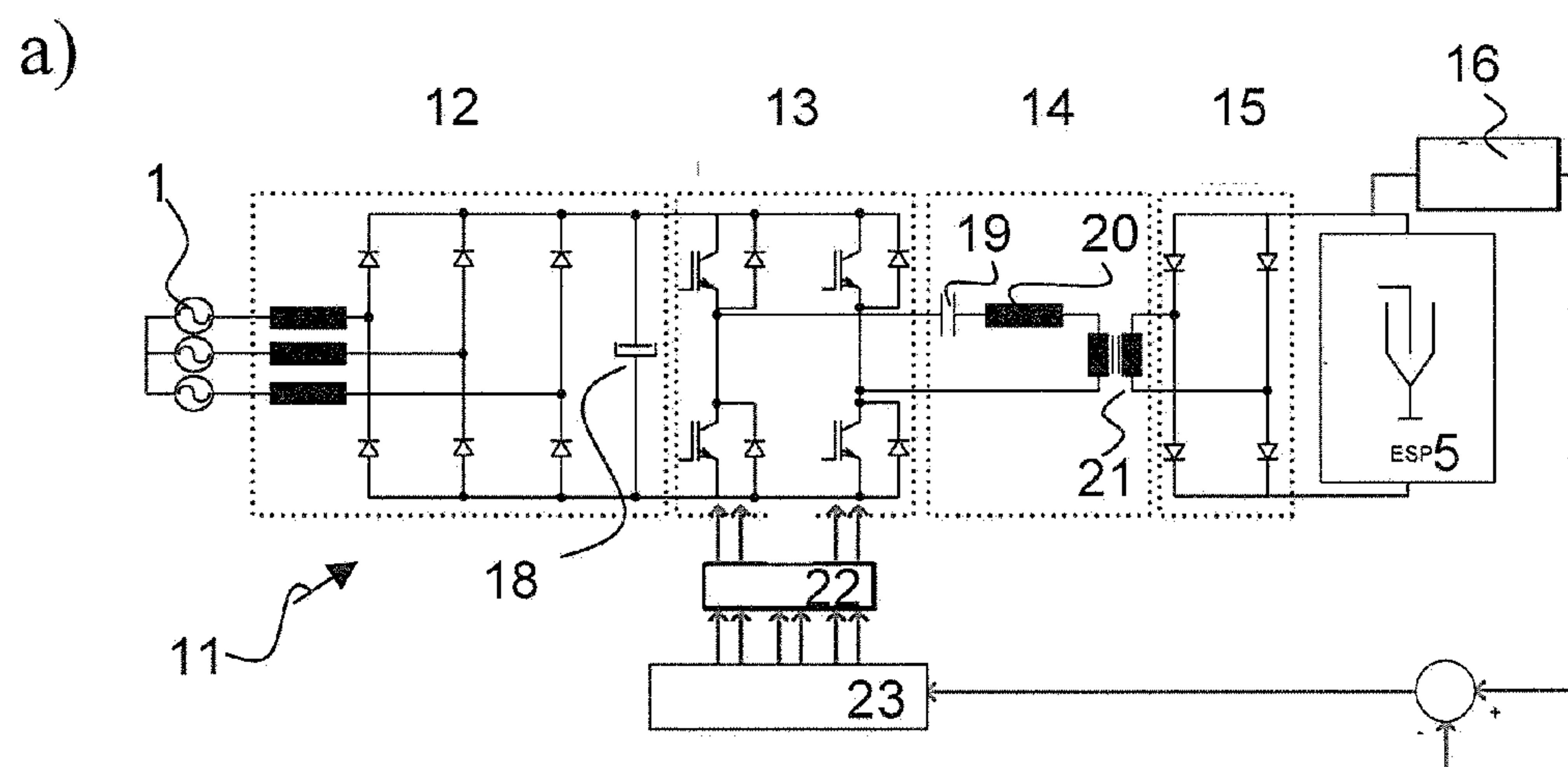


FIG. 2

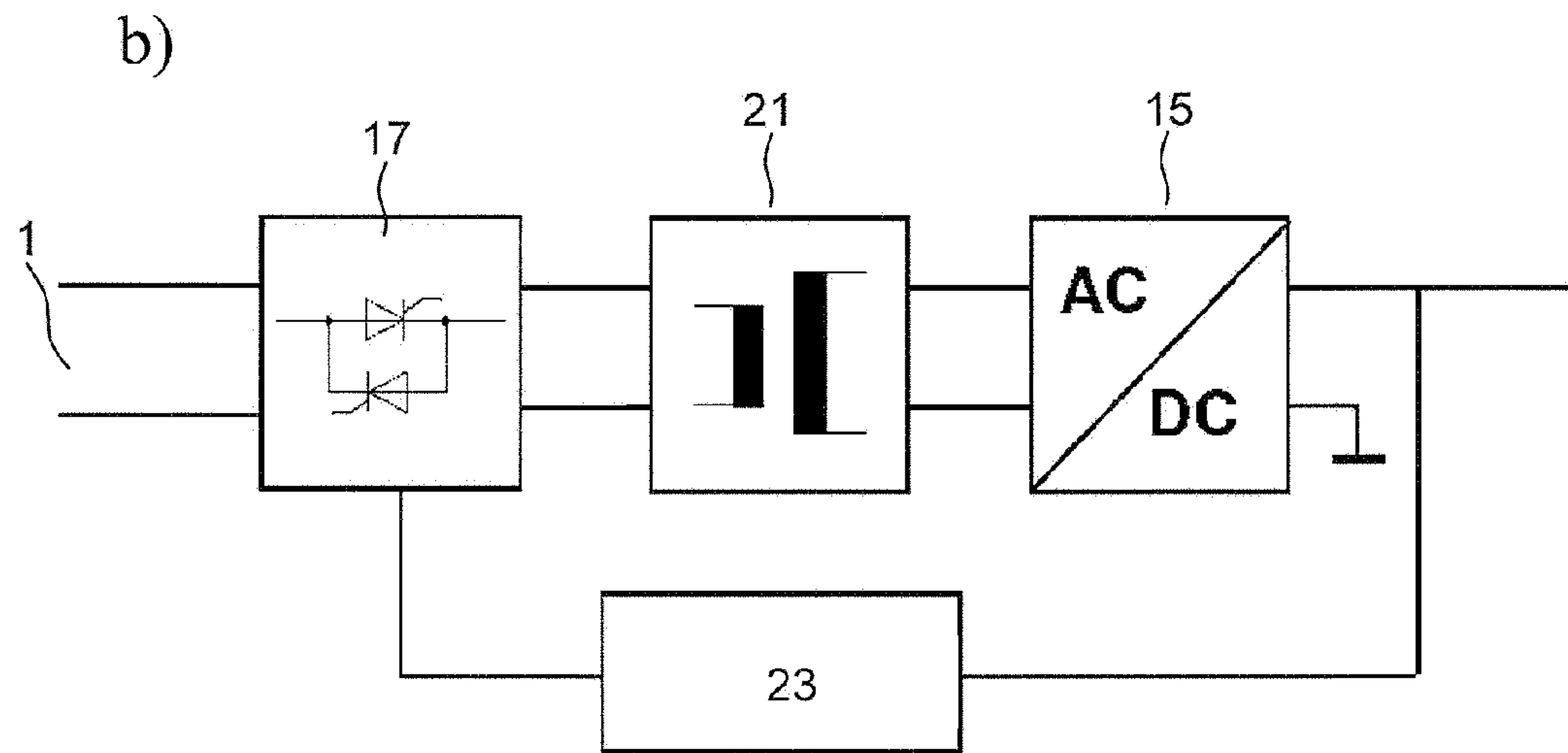


FIG. 2

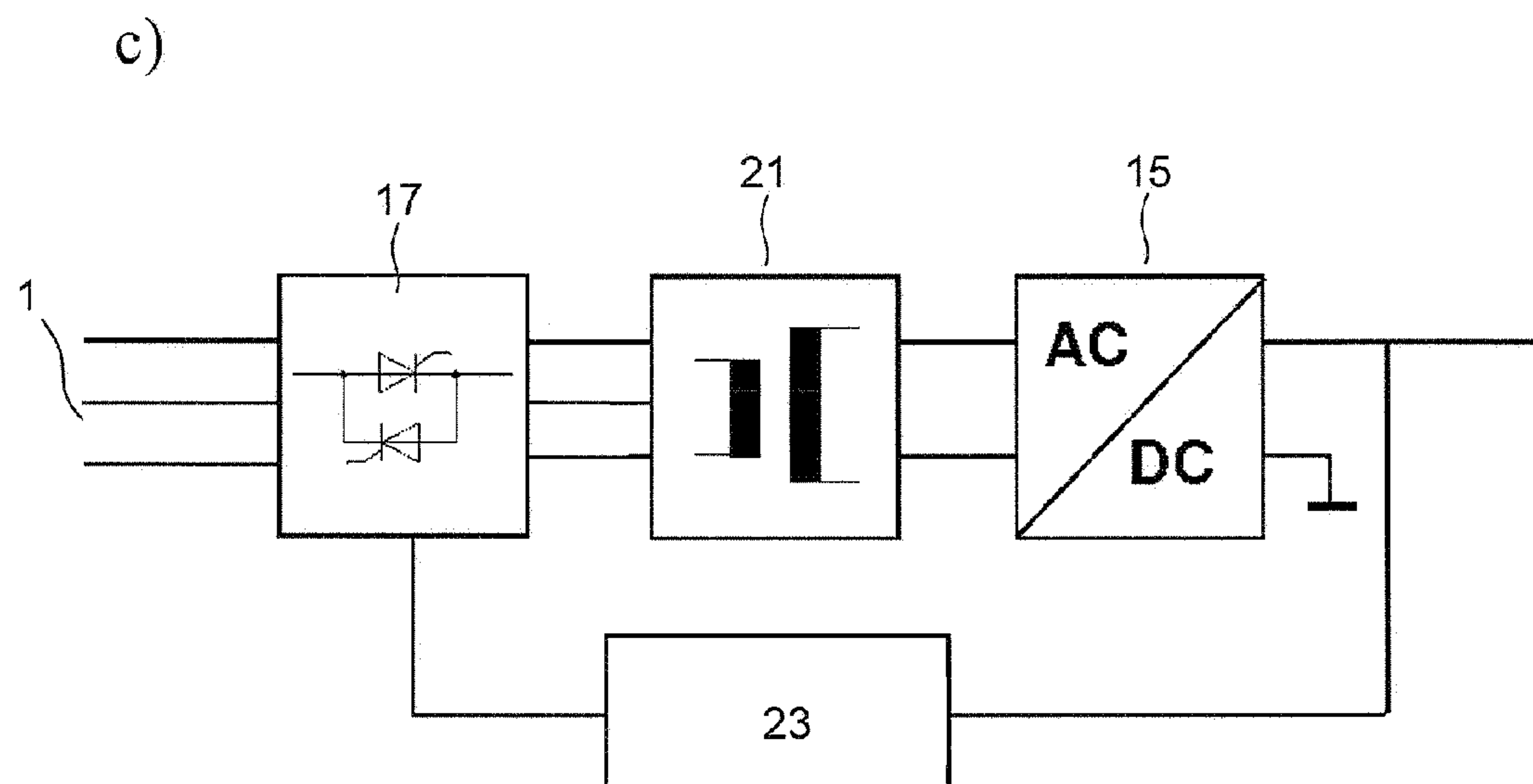


FIG. 2

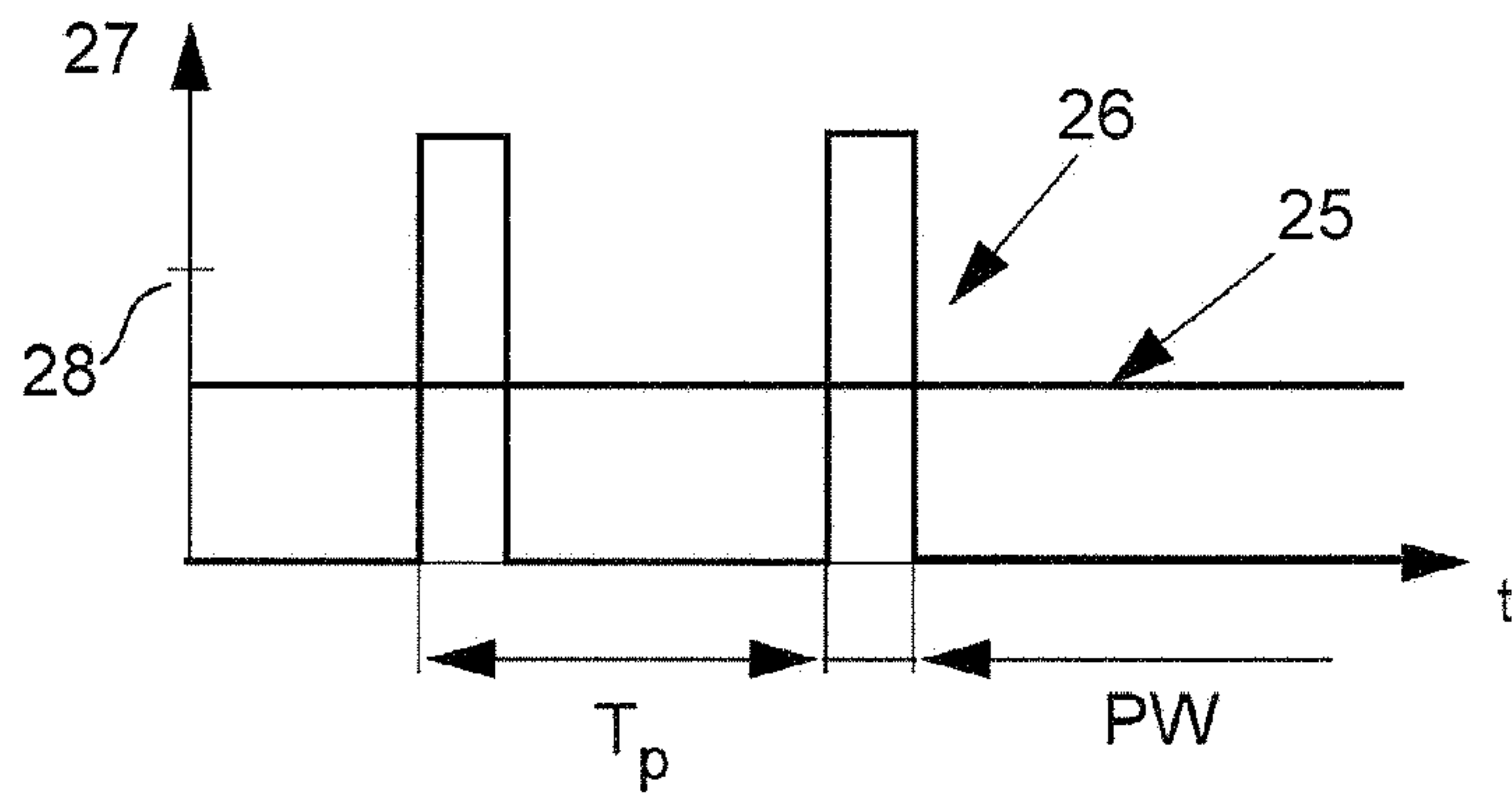


FIG. 3

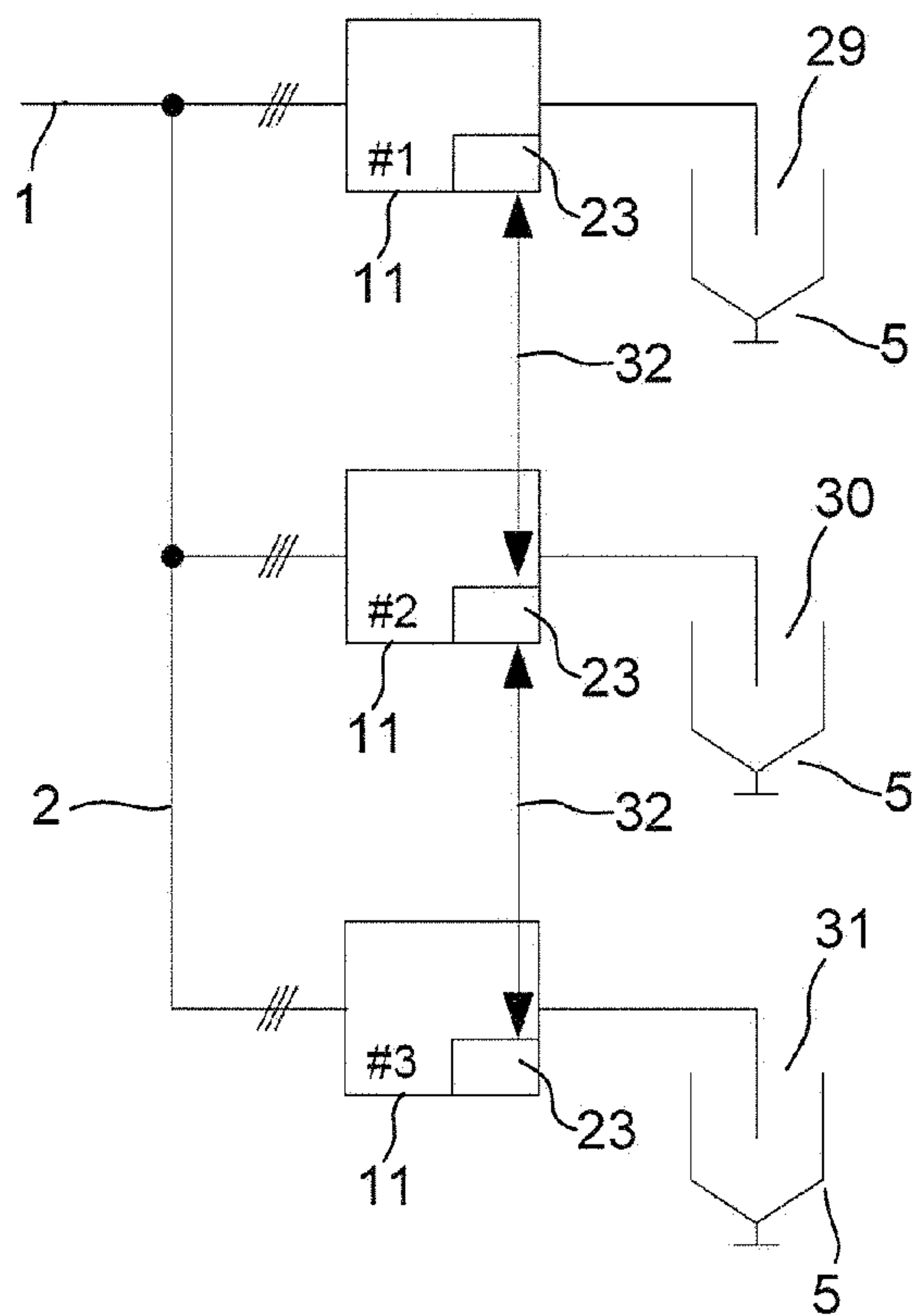


FIG. 4

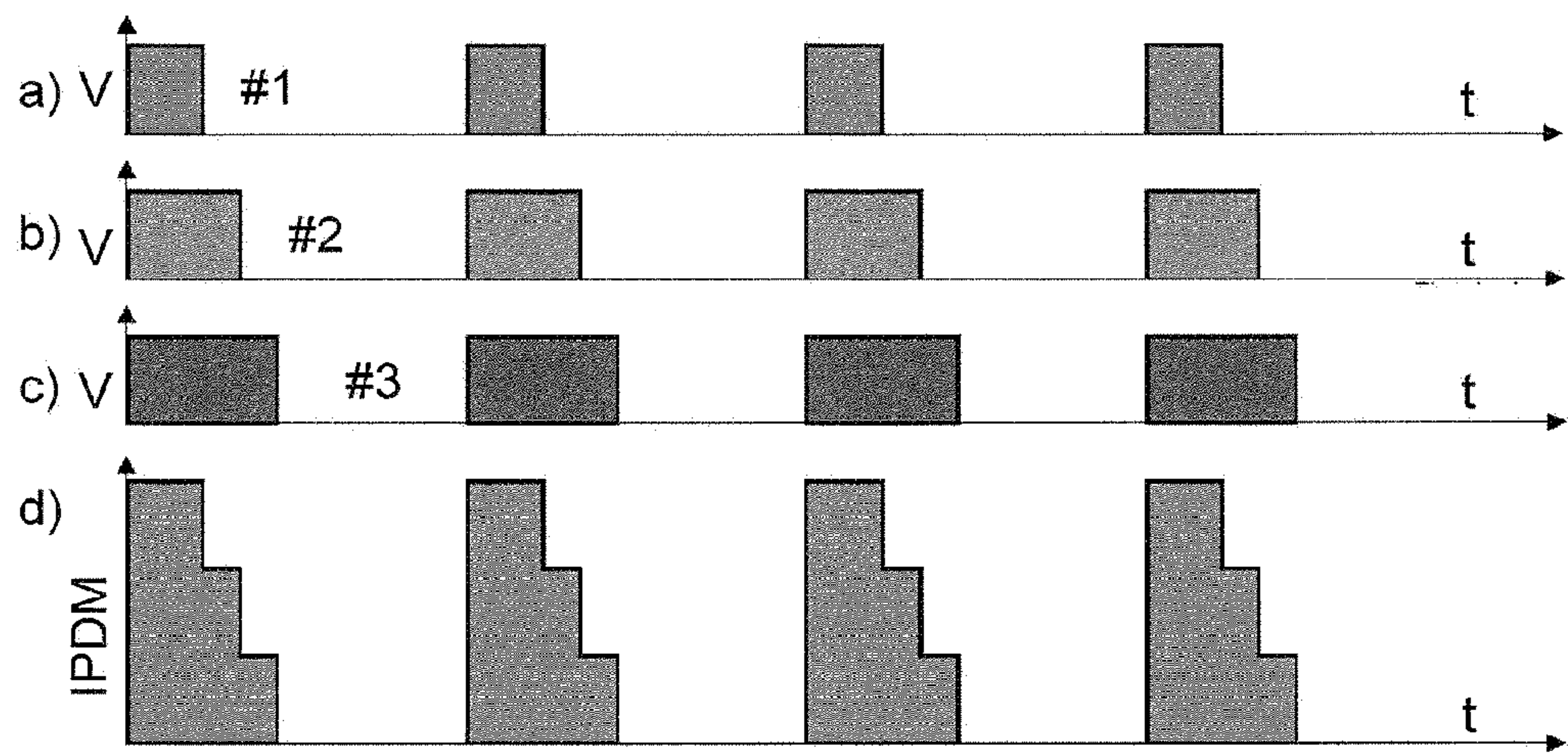


FIG. 5

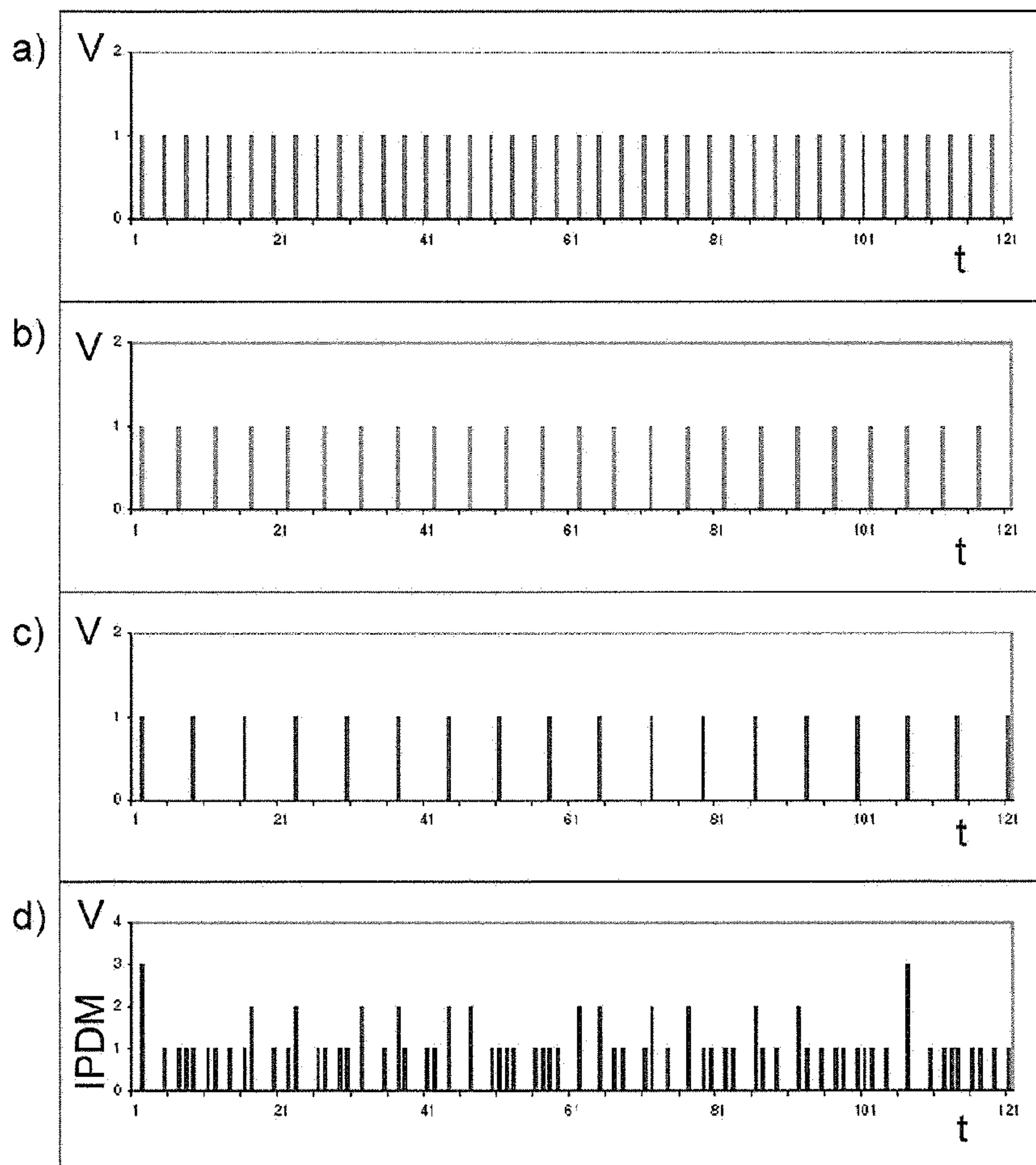


FIG. 6

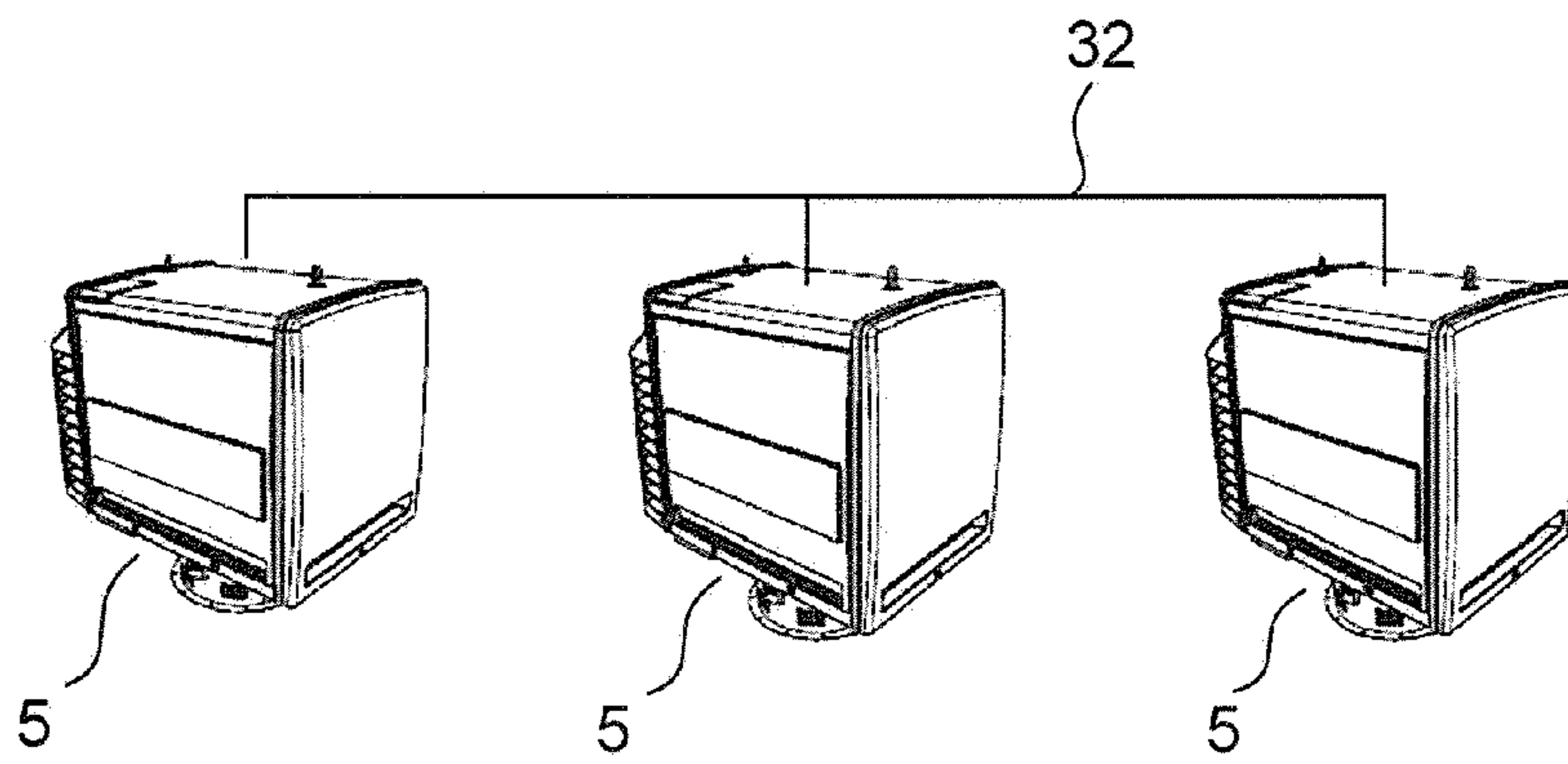


FIG. 7

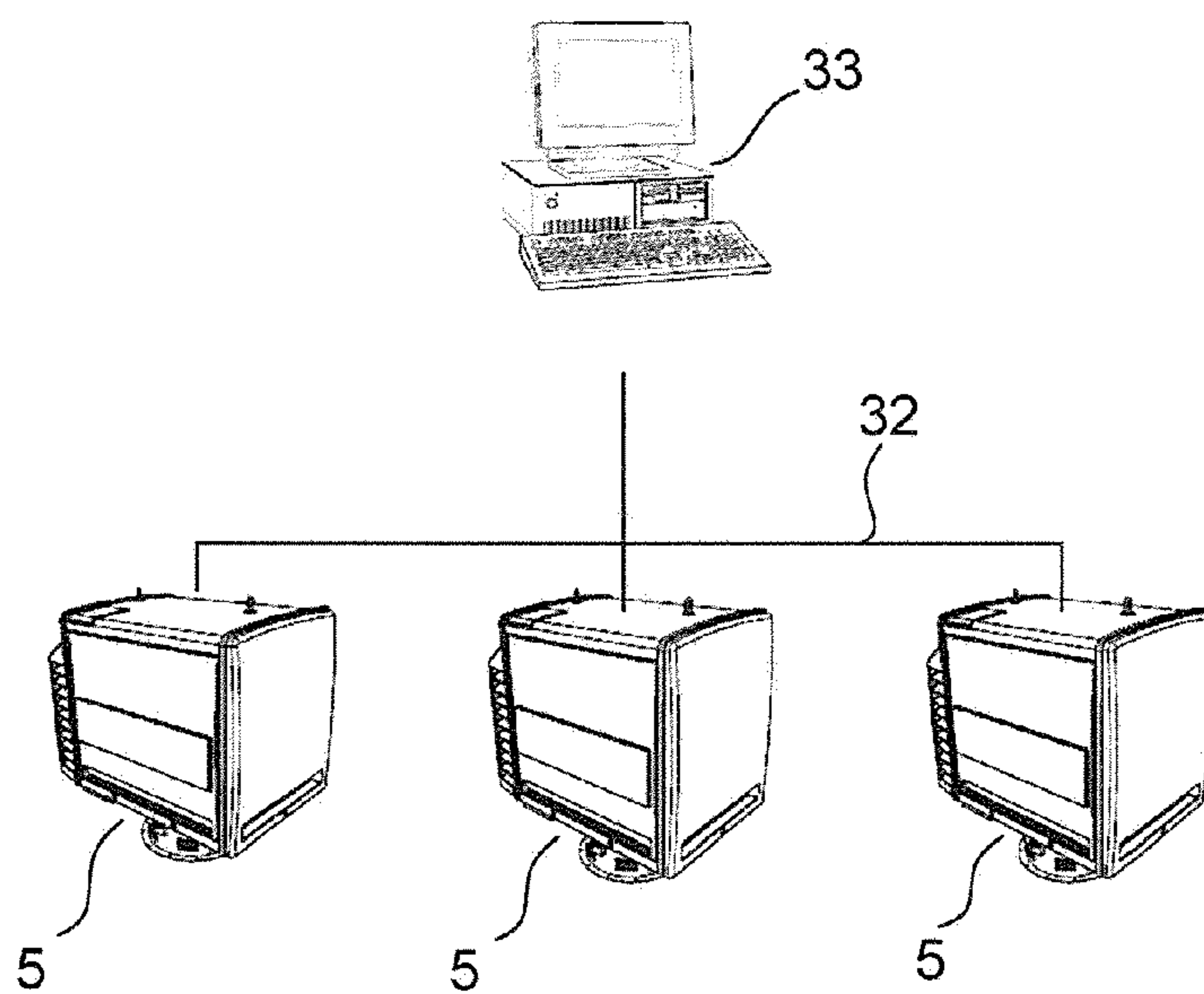


FIG. 8

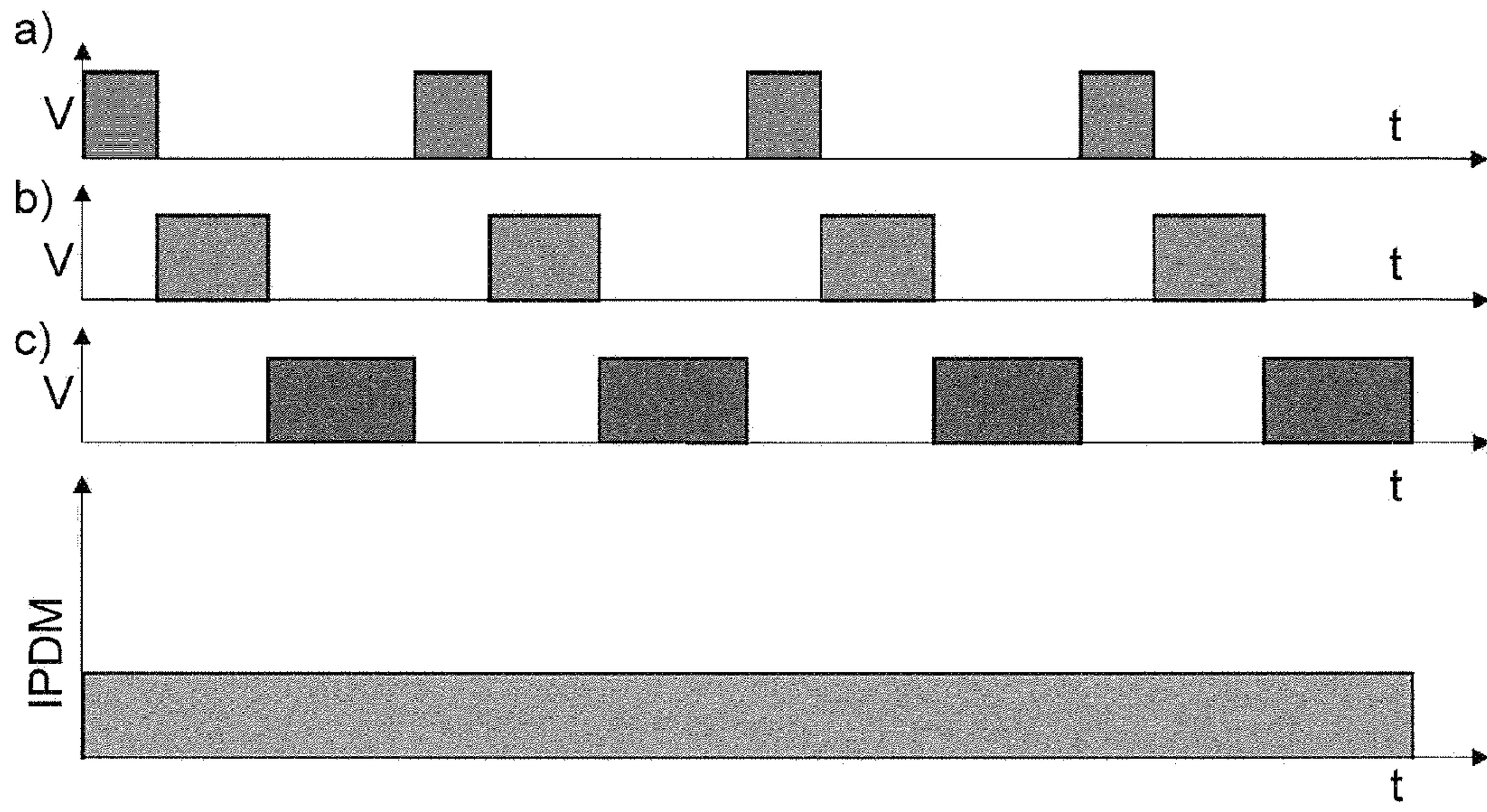


FIG. 9