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NOTICE OF ENTITLEMENT

We, **PHYSIOMED-MEDIZINTECHNIK GmbH** of Bayreuther Strasse 14, D-91220 Schnaittach, Germany state the following in connection with Australian Application No. 29239/95:

1. We are the nominated person.

2. The nominated person is the assignee of the actual inventor.

3. The nominated person is the applicant of the basic application listed in the declaration under Article 8 of the PCT.

4. The basic application is the application first made in a Convention country in respect of the invention.

Dated: 25 November 1996

By **PHILLIPS ORMONDE & FITZPATRICK**
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To: The Commissioner of Patents

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FLUORESCENT TUBE CONTROL

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(57) Claim

1. Method of controlling fluorescent lamps of a lighting system operated by an a.c. power supply, wherein each lamp includes a series circuit having an impedance for current limitation, a fluorescent tube with preheatable electrodes and a control element with an electronic power switch including an arithmetic and logic unit for heating and igniting pulse production with isolation of the discharge section, wherein the control element additionally has a signal processor provided with a digital input unit, a non-volatile memory, a random access memory, a clock generation means and digital output unit, and a phase detector and power supply unit, wherein control signals for the power switch for modes of operation, starting and/or dimming and/or extinction and/or feedback are produced by means of a control program stored in the non-volatile memory and from phase information of the phase detector, and wherein the control element is arranged in the heating circuit of the fluorescent tube.

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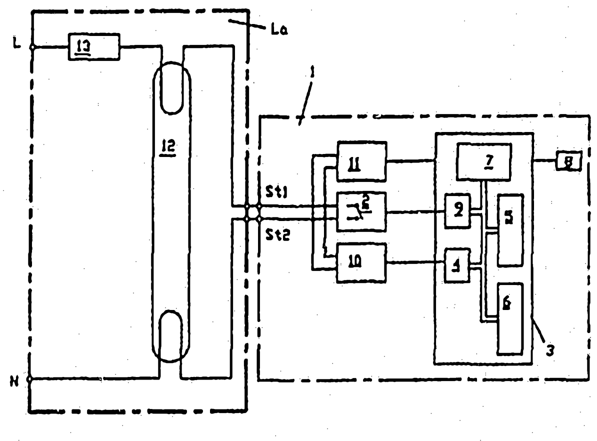
(54) Title: FLUORESCENT TUBE CONTROL

(54) Bezeichnung: STEUERUNG FÜR LEUCHTSTOFFLAMPEN

(57) Abstract

A process is disclosed for independently controlling one or several fluorescent tubes of a lighting installation connected to an AC network. The process ensures the following main functions: fast switching-on, intensity control (dimming), switching-off and storage of a state of operation to be re-established when the installation is once again switched on. The invention is characterised in that it allows already existing conventional lighting installations to be retrofitted without additional installation costs. All that is required is to exchange the conventional starter by the disclosed control circuit, and to exchange the conventional light switch by the disclosed signal generator. For that purpose, a controller (1) is connected instead of the known starter to the heating circuit of a lamp (La) that consists of a fluorescent tube (12) connected in series to a ballast (13). The controller (1) consists of at least the following components: power switch (2), phase detector (10), current supply (11), signal processor (3), clock generator (8) and a control software stored in the non-volatile memory (5) that among others generates signals for controlling the power switch (2) from information supplied by the phase detector (10).



TRANSLATION

Controller for fluorescent lamps

The invention relates to a method for the independent control of individual or a group of fluorescent lamps of a lighting system operated by the a.c. supply system with the main functions of rapid start, brightness control (dimming), extinction and storage of an operating state for switching on the system after it has been switched off. A feature of the invention resides in the possibility of converting existing conventional lighting systems without additional installation costs merely by exchanging the respective conventional starter for a control circuit according to the invention and by exchanging the conventional light switch for transducers according to the invention. Further features of the invention are the monitoring of the operability of the individual lamps, the disconnection of individual lamps in the case of defects, and a mode of operation which extends the service life of the individual tubes.

The main advantages of a lighting system with fluorescent lamps in comparison to incandescent lamps reside in the higher light yield and the longer service life of the tubes and therefore in a considerable saving in costs for energy and maintenance. A further advantage of fluorescent tubes over incandescent bulbs resides in the very low inertia of the discharge and in the possibility for free selection of the light colour in wide limits owing to the use of suitable luminous substances so they can be used for lighting systems with rapidly changing light and colour effects, as required, for example, in advertising or for signalling purposes.

However, these advantages can only be used unsatisfactorily in lamp circuits which are conventional nowadays and are formed essentially by an impedance connected in series with the tube and limiting the lamp current and by a conventional commercial starter arranged in the heating circuit, usually a bimetallic glow starter. This is due to the fact that conventional commercial starters do not perform the lamp start with the optimum preheating time and igniting voltage which are significant for the service life of the tubes and depend not only on the tube type but also on environmental parameters such as temperature and atmospheric humidity. The associated high so-called erosion on switching on which reduces the service life restricts the operation of lighting systems with fluorescent lamps, which are more economical than incandescent lamps, to applications where no change in the lighting output is required for a prolonged period. The use of electronic preswitching devices is also unsuccessful in most cases owing to its considerably higher costs and the additional installation cost for each lamp, even though they could represent a good solution to the above-mentioned restrictions owing to their different action principle.

Many attempts have been made on the one hand to optimise the lamp start in the sense of extending the service life of the tubes and on the other hand to expand the sphere of use of fluorescent lamps to applications in which timing of the light output which is flexible within wide limits is demanded of a group of lamps or individual lamps of a lighting system, without the production costs substantially exceeding those of conventional systems.

A circuit arrangement for the ignition and brightness control of fluorescent lamps is known from DE 33 27 189. An electronic switch in the heating circuit of a fluorescent tube connected in series with an inductor is controlled from an adjustable phase shifter such that heating current initially flows through the heating electrodes of the tube during each half wave of the a.c. supply voltage and an inductive voltage pulse corresponding to the preceding heating current leads to ignition and illumination for the remainder of the half wave after opening of the switch.

A drawback of the known arrangement is the dependency of the igniting pulse energy on the heating current flowing at the moment of disconnection. It is not therefore possible to adjust the value of the igniting pulse and the duration of heating independently of one another such that an igniting pulse strength necessary for any desired operating state is produced.

As shown in practice, excessively strong and excessively weak igniting pulses have a number of serious drawbacks which are listed briefly hereinafter.

Excessively strong igniting pulses lead to increased erosion of the sensitive emission layer due to field emission even when the lamp electrodes are adequately heated. In addition, they increase the electromagnetic noise level, leading to increased expenditure on suppressing agents. Furthermore, they lead to undesirable noise evolution and increased electrical losses in the conventional ballast inductors not designed for pulsed operation and these not only reduce efficiency but can also lead to overheating of the lamps. The voltage-sensitive semiconductor components also have to be protected from excessively high voltage peaks which in turn leads to an increase in the losses and additional heating of the circuit.

On the other hand, an excessively low igniting voltage leads to unstable operation of the dimmed tube and to quenching of the discharge.

A controller which also provides an electronic switch in the heating circuit of a fluorescent tube for limiting the lighting phase and the preheating of the electrodes is known from DE 27 02 490. It is proposed therein that a central control device be arranged in a conventional commercial flush-type box and the control circuit for each tube be arranged in a respective housing similar to the dimming starters.

A drawback of this known arrangement resides in the considerable installation costs for a lighting system in which the lamps are to be controlled independently of one another as each lamp has to be connected to its own control line with the control device in addition to the power supply line. Therefore, simple modification of conventional lighting systems is not possible, in particular, with the known arrangement.

According to the present invention there is provided a method of controlling fluorescent lamps of a lighting system operated by an a.c. power supply, wherein each lamp includes a series circuit having an impedance for current limitation, a fluorescent tube with preheatable electrodes and a control element with an electronic power switch including an arithmetic and logic unit for heating and igniting pulse production with isolation of the discharge section, wherein the control element additionally has a signal processor provided with a digital input unit, a non-volatile memory, a random access memory, a clock generation means and digital output unit, and a phase detector and power supply unit, wherein control signals for the power switch for modes of operation, starting and/or dimming and/or extinction and/or feedback are produced by means of a control program stored in the non-volatile memory and from phase information of the phase detector, and wherein the control element is arranged in the heating circuit of the fluorescent tube.

A number of advantageous effects emerge:

A multiprocessor arrangement with decentralised parallel processing may be formed by the use of a respective signal processor with its own control program for each tube, synchronisation taking place via the mains frequency common to all lamps. The brightness values for each half wave of the a.c. supply voltage can therefore be varied individually in each tube so very complex, rapidly changing light patterns and, if differently coloured tubes are used, also coloured patterns can also be achieved, as demanded, for example, in advertising.

A further advantageous effect of the invention allows the entire control circuit to be incorporated into a conventional starter housing so a lighting system according to the invention does not necessitate additional installation costs in comparison with a conventional system. Furthermore, an existing system can also be converted by exchanging the conventional starters for the control means according to the invention. This can also be carried out only for parts of the system or only for individual lamps, and the non-converted lamps can still be operated in the conventional manner.

The method according to the invention also still allows all the following advantageous modes of operation: the tubes ~~are~~ may be rapidly started without flickering due to increased heating current and can all be ignited at the same moment, also allowing the rapid start in duplex circuits. The unnecessary attempts at starting or cold starts which otherwise restrict the service life of the tubes are therefore avoided in all tubes.

In all modes of operation, each tube ~~is~~ may be operated automatically with the igniting voltage most desirable for each type of tube, on the one hand preventing increased electrode wear due to excessively high igniting voltage and on the other hand preventing unstable discharge due to excessively low igniting voltage. An advantage of the method according to the invention is that the power category as well as tube type can be detected automatically and the same control element can therefore be used for all tubes.

Defective tubes ~~are~~ may be recognised and disconnected at the start, avoiding not only continuous undesirable flickering but also the risk of overheating and unnecessary power consumption.

To save power, tubes can be disconnected completely even when the operating voltage is applied, so no heating current flows, in contrast to dim operation.

A further advantage of the method according to the invention resides in the possibility of being able to influence the sequence of the control program by equipping the control element with sensors in order thus to adapt the mode of operation to environmental influences or to signal specific environmental conditions.

A further advantage is the feature of being able to influence the control programs in the control elements by remote control, a particularly advantageous feature of the method according to the invention, which proposes information transmission via the supply system, residing in the fact that no additional hardware components ~~are~~ may be required for receiving this information but merely an additional subroutine in the control software.

Embodiments of the invention are illustrated in the drawings and will be described in detail hereinafter.

Figure 1 is a block circuit diagram of a lamp with control element.

Figure 2 is a block circuit diagram of a control element for additional functions.

Figures 3, 4 each show a flow chart for igniting pulse generation.

Figure 5 is a flow chart for the limitation of lighting time.

Preferred embodiments of the present invention will now be described with reference to the accompanying drawings wherein:-

Figure 1 is a block circuit diagram of a lamp with control element.

Figure 2 is a block circuit diagram of a control element for additional functions.

Figures 3, 4 each show a flow chart for igniting pulse generation.

Figure 5 is a flow chart for the limitation of lighting time.

Figure 6 is a flow chart for determining the type of ballast.

Figure 7 is a flow chart for determining the power category of the ballast device.

Figure 8 is a flow chart for determining the type of tube.

Figure 9 is a flow chart for rapid starting.

Figure 10 is a flow chart for rapid starting with capacitive ballast device.

Figure 11 is a flow chart for brightness control.

Figure 12 is a flow chart for extinction of the discharge.

Figure 13 is a flow chart for evaluating the control signals contained in the phase signal.

Figure 14 is a flow chart for evaluating the phase difference from figure 13.

Figure 15 is a circuit diagram of an embodiment of a control element with a conventional commercial microprocessor as signal processor.

Figure 16 is a circuit diagram of a control element with additional functions.

Figure 17 is a circuit diagram of the switching over of the reference voltage of the analogue digital converter.

Figure 18 shows the trend of the tube voltage with adequate igniting pulse strength.

Figure 19 shows the trend of tube voltage with excessively low igniting pulse strength and incipient instability.

Figure 20 shows the trend of the tube voltage in the region of the transition of the igniting pulse to arc voltage with various igniting pulse strengths.

Figure 21 is a block circuit diagram of a transducer which can be looped into the supply line.

Figure 22 is a circuit diagram of an embodiment of a simple transducer.

Figure 23 is a flow chart for the transmission of a byte of information.

As shown in figure 1, the lamp La consists of the conventional series circuit of ballast impedance 13 for power limitation and fluorescent tube 12 with preheatable electrodes. The ballast impedance 13 can be an inductor coil or also a series circuit of inductor coil and capacitor, of the type used in the so-called duo circuit for reactive-current compensation. The lamp La is connected in parallel to the other lamps of a lighting system to the a.c. power supply via the terminals N and L. A capacitor, not shown, for reactive current compensation can also be connected in parallel with these terminals.

St1 and St2 designate the two terminals of the conventional starter socket connected parallel to the discharge section of the tube. The conventional glow starter is replaced in the controller according to the invention by the control element 1 preferably having a mechanical construction similar to glow starters. This allows conventional commercial fluorescent lamps to be used without additional modifications for the construction of a lighting system which is to be controlled by a method according to the invention in that a control element 1 according to the invention is merely inserted into the starter socket. Furthermore, it is also simple to convert an existing lighting system to a control method according to the invention by exchanging the glow starters for control elements according to the invention.

In its basic design, the control element 1 consists of an electrically controllable power switch 2 which is connected in parallel with the connections St1 and St2 and through which the heating current limited by the ballast impedance 13 flows in its switched on state and which bridges the discharge section between the tube electrodes in a low-resistance manner so the tube voltage is reduced to values far below the operating voltage. The functions of extinction of an existing gas discharge and heating of the lamp electrodes are achieved by switching on the power switch.

The heating current is interrupted and the low-resistance bridging of the discharge section is eliminated by switching off the power switch 2, so on the one hand the energy stored in the inductor coil and dependent on the instantaneous value of the heating current is liberated as a voltage pulse to the tube electrodes and on the other hand a gas discharge current limited by the inductor coil can flow via the lamp electrodes. The functions of igniting pulse generation and isolation of the discharge section are therefore fulfilled by switching off the power switch 2.

The phase detector 10 which can convert the voltage at St1 and St2 into an in-phase rectangular signal with an amplitude suitable for further processing is a further component of the control element 1. The edges of this rectangular voltage therefore signal the passages through zero of the residual voltage applied to the power switch and therefore of the heating current when the power switch 2 is closed. When the power switch is opened and the discharge ignited, the edges correspond to the passages through zero of the lamp current and, when the discharge is not ignited, to the passages through zero of the a.c. supply voltage applied to the lamp.

The signal processor 3 is a further component of the control element 1. It can be a conventional commercial simple microprocessor or also an integrated circuit specific to the customer, at least the functional blocks of arithmetic and logic unit (ALU) 7, non-volatile memory 5, random access memory (RAM) 6, digital input unit 4 and digital output unit 9 being connected via a bus structure in a known arrangement. The non-volatile memory 5 serves for the permanent storage of the control programs and operating parameters and can consist of mask-programmed memory (ROM), of one-time programmable memory (one time PROM) or of a memory which is extinguishable by UV light or electricity (EPROM, EEPROM) or of a combination of these types of memory. The unit 8 is used to produce the system clock for the signal processor 3.

The power supply unit 11 is a further component of the control element 1. It provides a stabilised operating voltage for the signal processor 3 and can be very simple in design if the signal processor is produced by current-saving technology such as C-MOS technology. Furthermore, a RESET is triggered after a predetermined delay time when the operating voltage is applied in the signal processor 1. This procedure is called "power on reset" and corresponds to the status of microprocessor technology.

Figure 2 shows the construction of a control element 1 for additional functions, individual or all additional components being provided according to the requirement of the control programs used.

In addition to the components of the control element according to figure 1, an adaptation unit 14 is provided which converts the voltage applied to the connections St1 and St2 such that it can be supplied to an analogue digital converter 16 additionally provided in the signal processor. This allows the control program to monitor the value and timing of the igniting pulse and of the arc voltage at the tube 12 and, when the discharge is extinguished, also of the a.c. supply voltage.

The adaptation unit 15 which converts the current strength flowing through the power switch such that it can be supplied to the analogue digital converter 16 additionally provided in the signal processor forms an additional component. This allows the control program to monitor the value and timing of the heating current through the electrodes of the tube 12.

The adaptation unit 18 forms an additional component. Its object is to convert a signal from a sensor unit 17 connected to it such that it can be supplied to the analogue digital converter 16 and/or the digital input unit 4. This allows the control program to monitor the signals of the sensor unit 17. Examples of the sensor unit 17 include temperature sensor, light sensor, radiation sensor, sound sensor, movement sensor, gas sensor, and known receiver circuits of the type used for the remote control of devices.

Figure 15 shows an example of a simple embodiment of a control element for the method according to the invention using a conventional commercial microprocessor Ic1. The diodes D1 to D4 together with the MOS-FET transistor T1 form the a.c. power switch. A Zener diode D7 at the gate of the transistor T1 prevents the gate voltage from rising to unallowably high values. The capacitor C1 which is charged to a high voltage in the blocking state of T1 via the diode D5 and the resistor R2 is provided to cover the gate voltage requirement of T1, which most conventional commercial high voltage MOS-FET transistors require for complete and rapid forced tripping. T1 is in the blocking state when the transistor T2 connected to its gate receives basic current from the Ic1 via R6, thus becomes conductive and therefore draws the gate to approximately zero potential. If the basic current from the Ic1 is switched off, T2 passes into the blocking state so charge from the capacitor C1 flows via the resistor R2 to the gate and therefore switches T1 into the conductive state. The resistor R5 has very high resistance and prevents the switching through of T1 at the moment of application of the operating voltage, while Ic1 is not yet operating properly. The transistor T3 with the resistors R1 and R7 forms the phase detector for the a.c. voltage applied to St1 and St2. If St2 is positive relative to St1, a basic current can flow in T3 via R1 so its collector voltage and therefore the voltage at the digital input of Ic1 assumes LO level. With reversed polarity, no basic current can flow, T3 blocks and the digital input is drawn to HI level by the resistor R7 connected to the positive supply voltage of Ic1. The capacitor C2 connected to the supply voltage connection of Ic1 is used in a known manner to suppress disturbing pulses from the voltage supply unit. The voltage supply unit is very simple in construction owing to the low power consumption of the module Ic1 designed according to C-MOS technology. The capacitor C5 is charged via the diode D6 and the resistor R4 during the blocking phase of T1, its voltage being limited by the Zener diode D8 to the operating voltage permitted for Ic1. Providing that T1 is conducting, D6 prevents the capacitor discharge from flowing from C5. C3 and C5 together with the resonator Q in a known arrangement serve to produce the clock for Ic1.

Figure 16 shows an example of an embodiment of a control element for the method according to the invention with additional functions. The resistor R8 located in the main current circuit of the power switch T1 forms a simple adaptation circuit in order to convert the instantaneous value of the current strength flowing through the power switch T1 into a voltage which can be processed by an analogue digital converter integrated in the processor Ic1. Together with the signal of the phase detector as a sign, the trend of the heating current through the electrodes of the fluorescent tube can therefore be detected. To allow the same control element to be used for lamps of different power, R8 is calculated such that the peak current flowing with maximum lamp power leads to a measurement voltage which does not exceed the analogue input voltage range of the processor Ic1. Therefore, the current strength trend is detected with lower resolution for smaller lamp powers, but this is sufficient for the functions of the control program associated with current strength measurement. With higher requirements for the resolution of the measured current strength, it is possible to make the reference voltage determining the input voltage range of the analogue digital converter switchable, switching being effected by a software-controlled voltage divider as shown by way of example in figure 17. Together with the resistors R12 to R14 which can be switched on by the open drain transistors integrated in the processor Ic1, resistor R11 forms a switchable voltage divider which is supplied by the reference voltage source Vref and of which the pick-off is connected to the reference voltage input Vrefin.

In figure 16, the resistors R9 and R10 represent an example of a simple adaptation circuit for converting the instantaneous value of the voltage applied to the drain connection of the transistor T1 into a voltage which can be processed by an analogue digital converter integrated in the processor Ic1. Together with the signal of the phase detector as a sign, the voltage trend at the electrodes of the fluorescent tubes can be detected.

In figure 16, the optocoupler Oc1 together with the resistor R15 forms a simple example of the connection of a sensor and the adaptation of its output signal to the processor Ic1. In the illustrated example, the sensor can be used for detecting the environmental brightness, the lamp brightness or also for the transmission of information. Other types of sensor can be used accordingly for detecting other values for processing by the control software.

The discrete components used in the circuit examples according to figures 15 to 17 can be largely integrated in the semiconductor chip of the signal processor if an integrated circuit specific to the customer is used instead of the conventional commercial microprocessor, so the number of components can be considerably reduced. This allows simple, inexpensive construction of the control element according to the invention. The use of an integrated circuit specific to the customer is also particularly advantageous and economical with respect to the expected high number of items. It can be assumed that the production costs for a control element according to the invention will not be significantly higher than those of conventional starters, particularly when applying fully automatic SMD assembly methods.

The control software deposited in the non-volatile memory of the signal processor is responsible for functioning of the control element, the subroutines responsible for carrying out the various basic functions of the control element being called up in an appropriate sequence from a main program depending on the intended mode of operation of the lighting system. Examples of functions which can be called up from the main program are shown in the flow charts in figures 3 to 14.

Figure 3 shows an example of a subroutine for producing an igniting pulse of a variable predetermined set strength Wz. This utilises the fact that the energy W stored in the inductor coil with inductance L depends on the current strength i according to W = 1/2*i*i*L flowing at the moment of disconnection and this energy minus the losses converted into heat is liberated as strength of the igniting pulse when the power switch is switched off. The disconnecting current strength can therefore be determined for each lamp power by a table deposited in the ROM of the signal processor in order to generate an igniting pulse of a predetermined set strength Wz.

Figure 4 shows a further example of a subroutine for producing an igniting pulse of a variable predetermined set strength Wz. This utilises the fact that the current strength flowing in the inductor coil at the moment of disconnection depends on the moment t which expired after the passage of the current through zero. i=isp*sin(2*pi*f*t) applies to sinusoidal inductor current with the peak value isp and frequency f. The current flow time Tz during which the power switch must be switched on after the passage of the current through zero in order to produce an igniting pulse of a predetermined set strength Wz by its disconnection can therefore be determined for each lamp output by a table deposited in the ROM.

Figure 5 shows an example of a subroutine for reducing the brightness of the tubes by limiting the lighting time T1. This utilises the fact that the arc voltage is fallen below considerably and the discharge therefore quenched by switching on the power switch owing to the discharge section which now bridges with low resistance. The fact that heating current continues flowing through the tube electrodes so reignition takes place in the next half period when the electrodes are adequately heated is beneficial to the service life of the tube.

Figure 6 shows an example of a subroutine for determining the type of ballast device used in a lamp. This allows the same control element 1 to be used similarly for lamps of a lighting system equipped with various types of ballast device. This is particularly important with the lighting systems designed in a duo circuit and very widespread nowadays, in which a capacitor is connected in series with the conventional ballast inductor in every second tube for reactive-current compensation.

Owing to this series capacitor, the control program for some functions such as the rapid heating of the tube electrodes demands changed subroutines. As it cannot generally be detected with lamps in duo circuit without disassembly which starter socket is connected to which type of ballast device, it would barely be possible, in particular for people not specially trained, to convert and maintain such a system perfectly without automatic recognition and adaptation to the type of ballast device.

The subroutine utilises the fact that, with a tube operated on an inductive ballast device, the phase of the heating current lags considerably relative to the phase of the a.c. operating voltage but leads considerably in a capacitive ballast device with series capacitor. If the ballast device consists of a non-reactive ballast resistor, there is no phase shift between heating current and a.c. operating voltage.

A condition for determining the phase position of the a.c. operating voltage is that no current flows through the ballast device, and this is only possible with extinguished discharge. It is therefore advantageous that the subroutine is called up before ignition of the tube after application of the operating voltage. However, it is also possible to call up a subroutine to extinguish the tube according to figure 12. It is possible to determine by voltage measurement whether the tube is extinguished.

The period duration T of the a.c. operating voltage is accordingly determined by timing successive phase reversal of the phase detector signal. The power switch is accordingly switched on at moment t1 at the beginning of a new period and the time t2-t1 to moment t2 of the beginning of the following period is measured. The phase shift P=T-(t2-t1) is calculated and compared with a threshold value Pmin. The type of ballast device determined from che size and sign of this phase shift is stored for automatic adaptation.

Figure 7 shows an example of a subroutine for determining the power category V1 of the ballast device. The possibility of automatically adjusting the optimum operating parameters for tubes of different power is therefore created. This utilises the fact that the peak value of the heating current imax depends on the nominal power of the ballast device characteristically for a given operating voltage. Therefore, the peak value imax of the heating current allocated to each nominal power value can be stored in a table deposited in the non-volatile memory of the signal processor.

When the power switch is switched on, the current strength peak imax of the heating current is initially determined during a period of the a.c. supply voltage and the value of the power category V1 corresponding to this current value imax then inferred from the table and stored for automatic adaptation.

Figure 8 shows an example of a subroutine for determining the type of fluorescent tube used. This allows the same control element 1 to be used similarly for all lamps of a lighting system even if they are equipped with tubes of a different type. There are still many lighting systems in operation which are equipped with the formerly used tubes in addition to the energy-saving tubes with a reduced diameter conventional nowadays. Owing to the considerably higher igniting voltage requirement of the energy-saving tubes, the control program demands correspondingly adapted subroutines for careful tube operation for some functions such as dimming. Without automatic recognition and adaptation to the type of tube, it would be difficult for people not specially trained to exchange spent tubes for tubes of a different type and could easily lead to disturbances in operation as the corresponding control element 1 would also have to be exchanged in each case.

The subroutine utilises the fact that instability occurs in the discharge if the igniting pulse strength is inadequate and makes itself noticeable in that the tube voltage drops to the arc voltage with a delay after the igniting pulse has died down, as shown in figure 19, whereas the arc voltage is adjusted immediately after the igniting pulse has died down if the igniting pulse strength is adequate, as shown in figure 18. For a rigidly predetermined test lighting time tm, the igniting pulse strength Wz during which the tube voltage trend according to figure 18 changes into that according to figure

19 is a measure of the igniting voltage requirement of the tube type used. The associated tube type Rt can be determined via a table deposited in the memory, in which the power category V1 of the ballast device can also be allowed for, and can be stored for automatic adaptation. For this purpose, the tube is operated with the constant test lighting time tm. Starting from a maximum value, which reliably leads to a voltage trend according to figure 18, the igniting pulse strength Wz is reduced stepwise until the voltage trend according to figure 19 characteristic of the incipient instability of the discharge is adjusted. To determine the voltage trend and the change thereof, some voltage values Ui are measured at fixed moments in each case during the isolation time tm and are compared with the corresponding values measured prior to the last igniting pulse reduction until a clear increase in the majority of voltage values is adjusted.

Figure 9 shows an example of a subroutine for the rapid start of fluorescent tubes. The type of ballast device used is initially interrogated and, in the case of a capacitive ballast device, is branched into a subroutine according to figure 10. If a further interrogation reveals no inductive ballast device, the rapid start is interrupted. The fact that the current increases vigorously through the ballast inductor and therefore through the tube heater when the tube heater is permeated by a pulsating direct current is utilised for the rapid start with an inductive ballast device. For this purpose, the power switch is switched on in each case at the beginning of an a.c. period so heating current flows. After the change of period, that is at the beginning of the half period with opposed polarity, a vigorous igniting pulse is produced after expiry of a short preheating time to avoid cold starts. The discharge section is isolated for the remainder of this half period so it can be checked by voltage measurement whether the tube has ignited, that is whether the tube voltage has dropped to the arc voltage. If so, a corresponding flag is placed to signal the successful start of the tube to the interrogating program, and the subroutine is left. Otherwise, the procedure is repeated until a maximum heating time which is harmless to the tube electrodes has elapsed and the subroutine is left. An error flag signals the failed attempt to start to the interrogating program, whereupon a new attempt is made to start or the tube can also be blocked for further starts.

Figure 10 shows an example of a subroutine for the rapid start of fluorescent tubes which are operated by a capacitive ballast device. This utilises the fact that the current flow through the ballast inductor and therefore through the tube electrodes increases vigorously when the current flow starts with a delay in each half period as the reduced current flow time corresponds to an increase in frequency in the direction of the resonance frequency of the series circuit consisting of ballast inductor and capacitor. For this purpose, the power switch is switched off at the beginning of each half period, this switching off taking place with the production of a vigorous igniting pulse after a short preheating time to avoid cold starts. If the following voltage measurement produces a value higher than the arc voltage of the tube, the beginning of the current flow can be delayed by delayed switching on of the power switch such that the increased heating current is adjusted. The process is repeated in each half wave until a reduction of the tube voltage to the arc voltage indicates ignition of the tube or a maximum heating time which is harmless for tube heating is reached, the placing of corresponding flags signalling to the calling up program whether the tube has been successfully started. In the case of a false start, the calling up program can attempt to start again or can also block the tube for further starts.

Figure 11 shows an example of a subroutine for the brightness control of a fluorescent tube for a half period in each case. The production of an igniting pulse in the strength optimum for any brightness adjustment is an important feature, the igniting pulse strengths advantageous for the type of tube used being taken from a table deposited in the memory for rough adjustment and the fact being used for fine adjustment that the voltage trend at the transition of the igniting pulse to the arc voltage has a characteristic trend according to figure 20, curve a, with optimum igniting pulse strength but takes place according to curves b or c if the strength is too high or too low. Fine adaptation can be carried out particularly simply in that the voltage values required for at least one predetermined moment t are taken from a table deposited in the memory for the tube type used and the igniting pulse strength is controlled such that these voltage values are adjusted.

In the example of brightness control according to figure 11, it is therefore initially checked whether the brightness adjustment and therefore the lighting time t1 has changed relative to the value t1alt of the preceding half period. If so, the value of the igniting pulse strength Wz suitable for the new lighting time t1 is determined from a table for the type of tube used, optionally while incorporating additional data such as type of ballast device, power of ballast device or also ambient temperature. After the change of period, an igniting pulse of strength Wz is produced and the tube voltage measured at least at a fixed moment t and compared with the set voltage value Uset stored in a further table for the type of tube used. Wz is now increased or reduced depending on whether the tube voltage is too high or too low, and the new value is stored. It is therefore available for the next half period as an optimised value for the igniting pulse strength and is utilised if the brightness adjustment is not changed. The lighting time is now limited to t1 and the subroutine left.

Figure 12 shows a subroutine for extinguishing the discharge of a fluorescent tube in a lamp connected to the complete operating voltage. This utilises the fact that a fluorescent tube which is operated with minimum brightness adjustment quenches without increased igniting voltage. The tube is initially adjusted to minimum brightness, i.e. the lighting time adjusted to the lowest value tmin. The igniting pulse strength is now adjusted to its lowest value so the discharge quenches. The tube heater can also be disconnected if minimum igniting pulse strength is maintained.

The functions described hitherto are examples of basic functions of which a control program can be composed by the method according to the invention. It is possible to control even very complex procedures with high timing dynamics for a fluorescent tube as the emission of light can be varied for every half period of the a.c. operating voltage.

If control elements with a control program produced individually for each tube are now allocated to each tube of a lighting system and if the control programs take place synchronously with one another in the individual control elements, a multiprocessor controller with parallel processing is created with which even very complex and highly dynamic light and colour structures can be controlled for the entire system. For synchronisation, the a.c. operating voltage serves as a clock signal to which all lamps are connected in parallel. The program start is synchronised via the power on reset logic provided in every signal processor.

Other embodiments of the method are proposed, depending on the concrete application and object of a lighting system controlled according to the invention, to allow intervention in the sequence of programs in the individual control elements during operation. This is to be illustrated by a few examples.

With light sensors for detecting the environmental brightness, it is possible, for example, to produce lighting systems which adapt themselves automatically to the changing daylight without a central control device being necessary. Control which is more complex and which can allow, for example, for the time of day, season, day of the week, etc. is possible in addition to mere brightness control. Such requirements are imposed, for example, on lighting systems for illuminating streets, public buildings, tunnel entrances, workplaces, etc. However, a light sensor of this type can also be used to detect the brightness of the light emitted by the fluorescent tube, for example in order to regulate constant light emission independent of the age of the tube or contamination.

All types of proximity and movement sensors represent a further example of the use of sensors to influence the control program. Lighting systems can therefore easily be produced in which, for example, the presence or the movement of people or also vehicles acts on the sequence of the individual control programs. This is adopted in control systems, for example, for underground garages, underground railways or in advertising.

A further example of the use of sensors includes those suitable for tracing dangerous situations such as gas, smoke or even radiation sensors. A lighting system can therefore be embodied which uses light signals to provide an automatic warning about regions in which there is a corresponding dangerous situation of the type occurring, for example, in mining, tunnels, etc.

In addition to intervention via sensors into the programs in the control elements, the remote control of the program sequence in the individual control elements is proposed in a further embodiment of the method according to the invention. The control information is transmitted by a transducer to a signal receiver in the control element, and wireless methods of transmission such as ultrasound, light or high-frequency electromagnetic waves can also be used as well as those using a special signalling line for transmission. The transmission of signals via the supply line to which all lamps are connected is a further method of transmission.

An important criterion in the choice of the method of transmission used is the fact that a large number of control elements generally have to be equipped with a signal receiver in a lighting system according to the invention whereas the number of transducers used is small. To minimise the production costs of the control elements, it is therefore desirable to be able to design the signal receiver particularly simply. The transducers have to meet the requirement of being easily exchangeable for conventional light switches to allow easy conversion of an existing conventional lighting system to the control method according to the invention, and this represents one of the objects of the invention. This entails a method of transmission which must allow the transducer to be merely looped into one of the supply lines as the second pole of the supply voltage is not generally guided to the light switches. This is allowed for in an advantageous embodiment of the method according to the invention in which signal transmission via the supply system is adopted and in which no additional hardware components but merely an additional subroutine is required for receiving the signals in the individual control elements.

With the method of transmission used, the half periods of the a.c. supply voltage are influenced so as to produce an evaluatable displacement of the passages through zero of the voltages at the respective terminals St1 and St2 of the control elements 1 in the individual lamps of the lighting system. The resultant displacement of the edges of the phase detector signal is evaluated by a program loop running in the background of the control program of which figure 13 shows a simple example.

The respective duration Tn or Tp of the prevailing half period is determined and added to the value Tp or Tn of the preceding half period of opposing polarity. With the prevailing period duration T thus obtained and the period duration Talt similarly determined in the preceding half period, the phase shift Dif is obtained by subtraction. If the absolute value of the phase shift Dif exceeds a predetermined threshold value Difmin, the information contained in the phase shift is evaluated in a further program segment, of which figure 14 shows a simple example.

The logic level of the receiving Bit_i is initially determined by means of the sign of the phase shift. Decoding is then carried out in a known manner with error checking and error correction and, if there are no non-correctable errors, the receiving Bit_i is added to the receiving byte Bit_0,...,Bit_imax and the bit counter i incremented. This procedure is continued until the bit counter i indicates that all bits of the receiving byte have been transmitted without error, whereupon the bit counter i is reset for receiving a new byte. If an uncorrectable error is detected, the reception of the prevailing byte is interrupted by resetting the bit counter i.

Figure 21 is a block circuit diagram of an example of a transducer 27 which can be looped into an A.c. supply line of a lighting system via the terminals S1 and S2 instead of a light switch. The fact is utilised that the energy of this half period converted in each ballast device is increased or reduced during a half period or part of a half period by a series connection of a voltage source 19 with identical or opposed polarity to the instantaneous polarity of the a.c. supply voltage, and this leads to a corresponding increase or reduction in the current flow time and therefore to a corresponding shift in the passage through zero by the current. The power switch 20 is a component of the transducer according to figure 21. In its first switch state it bridges the terminals S1 and S2 with low resistance and in its second switch state it connects them to the voltage source 19 which can essentially consist of a memory element such as a capacitor, a coil or an accumulator or of a semiconductor element such as a diode with voltage-dependent breakdown behaviour. The phase detector 22 which transforms the voltage at S1 and S2 into an in-phase rectangular signal with an amplitude suitable for further processing is a further component of the transducer 27. The signal processor 23 is a further component of the transducer 27. It can be a conventional commercial simple microprocessor or also a simple integrated circuit specific to the customer, the arrangement of the functional blocks corresponding to that of the signal processor 3 in the control element 1. The unit 25 is used to produce the system clock for the signal processor 23 and the unit 21 for the power supply. The unit 24 is a further component. It represents a keypad for operation of the transducer and can additionally also contain a display panel for feedback. An additional interface connection 26 can additionally be provided in a known manner.

Figure 22 shows an example of a simple embodiment of a transducer for the method according to the invention using a conventional commercial microprocessor Ic2. The voltage at S1 and S2 which is connected in series with the operating voltage Ub can be switched over between the low passage voltage of the diodes D9 and D12 or D10 and D11 and the breakdown voltage of the power Zener diode D13 by the MOS-FET power transistor T4. When the power switch T4 is switched on, roughly the a.c. operating voltage Ub is therefore applied to the lamps La but when the power switch is switched off, roughly the operating voltage reduced by the breakdown voltage of D13. Unnecessary losses and associated heating are avoided by closing a mechanical switch Sch in the operating pauses of the transducer.

The transistor T5 forms with the resistors R16 and R18 the phase detector for the a.c. voltage applied to S1 and S2. If S2 is positive relative to S1, a basic current can flow via R16 into T5 so its collector voltage and therefore the voltage at the digital input of Ic2 assumes LO level. With opposing polarity, no basic current can flow, T5 blocks and the digital input is drawn to HI level by the resistor R18 connected to the positive supply voltage of Ic2. Owing to the low current consumption of the module Ic2 of CMOS design, the voltage supply is very simple in construction. The capacitor C9 is loaded via the diode D14 and the resistor R17 during the blocking phase of T4, its voltage being limited to the operating voltage permitted for Ic2 by the Zener diode D15. While T4 conducts, D14 prevents the capacitor charge from flowing from C9. C7 and C8 together with the resonator Q1 serve for clock generation for Ic2 in a known manner.

The control software deposited in the non-volatile memory 5 of the signal processor 23 is responsible for operation of the transducer 27. In addition to the known routines not described in detail here for communication with the user via a keypad 24 and/or via the optionally provided interface connection 26, it consists of a routine according to figure 23 for the transmission of a data byte Bit0,...,Bitimax. For the transmission of information, one of the two voltages U0 or U1 is added to the a.c. operating voltage or subtracted from it for the duration tp according to its sign after each phase reversal after a delay time tv. This procedure is designated by "produce U0-pulse" or "produce U1-pulse" in the flow chart in figure 23.

Experiments have shown that with a lighting system with lamps in a duo circuit, for example, a value of 0 to 1 ms is suitable for tv and, for example, a value of 1 ms to 3 ms for tp in order to obtain a sufficiently strong receiving signal in each case despite the different phase shift of the inductive ballast device relative to the capacitive ballast device. A value of 12 V has been used in a circuit according to figure 22 for D13, which denotes a reduction in the A.c. operating voltage by about 1.5 V when the power switch for U0 is switched on and a reduction of about 13.5 V when the power switch for U1 is switched off.

Figure 23 shows a simple example of the transmission of a transmission byte Bit0,...Bit_i_max which is first initiated with the production of a U1-pulse for the two half periods of a period. The individual Bit_i are then transmitted in that a

U0-pulse is produced in each case for each LO bit for the two half periods of a period and a U1-pulse in each case for the two half periods of the next period. A HI bit is accordingly transmitted by two U1-pulses followed by two U0-pulses. In addition to that used in the example, many other known methods of coding can be employed.

To avoid transmission errors due to disturbances which are transmitted onto the supply system of the lighting system from outside, it is also possible, in addition to the use of special filter circuits, to evaluate the signal of the phase detector in the transducer itself using a software routine according to figure 13 and figure 14 and to emit additional information for error correction in a known manner if an error occurs.

Furthermore, information from other transducers which are used in the same lighting system can also be received and evaluated via the phase detector in the transducer. It is similarly possible to receive and evaluate signals produced by a control element 1. In the same manner as with the transducer, a change in the energy converted in a ballast device during a half period leads to a phase shift which can be measured by the phase detector 22 of the transducer 27 and can be evaluated in the signal processor 23. This change in the converted energy is brought about by changing the lighting time for a half wave. This allows, for example, the operability of a lamp to be monitored in that the control element 1 in this lamp is caused by a control command of the transducer 27 to make a specific switching sequence which characteristically acts on the output signal of the phase detector in the control element and can therefore be evaluated.

If appropriate transmission protocols are employed, a data flow in any direction is possible with a lighting system according to the invention, and each transducer and each control element can be caused to respond via an individual address. In addition to the control and monitoring functions, data transmission also serves permanently to store operating parameters in the non-volatile memory of the signal processor and, if an electrically extinguishable non-volatile memory is provided for this purpose, also to change them. This allows a lighting system according to the invention to be adapted to frequently changing requirements and allows the new adjusted .lues to be stored permanently so they are immediately available each time the system is switched on again.

The use of electrically extinguishable non-volatile memories also allows the control programs in the individual control elements to be reprogrammed by each transducer. This allows new control programs for new light and colour patterns to be transmitted at any time into the individual control elements of a lighting system, as is advantageous, for example, for advertising or signalling. The respective programs for the individual control elements 1 can advantageously be developed on an external computer, for example a PC with corresponding development software. The regenerated data are then transmitted by the PC via the optional interface 26 to the transducer 27 and conveyed from it to the individual control elements 1 and stored there in a non-volatile manner. To minimise the amount of individual control program data and therefore the transmission time to the individual control elements and the memory space requirement, a macro language which is optimised for this task and of which the elements essentially correspond to the basic functions such as starting, brightness adjustment, extinction, etc. is advantageously used.

It is also proposed that, for the transmission of larger quantities of data in a shorter time, a programming device be connected instead of the a.c. operating volt.ge, the programming device utilising a frequency which is substantially higher than the mains frequency and simultaneously producing the phase modulation required for data transmission. It also receives the data via an interface from the external computer used for program development. By frequency measurement at the start of the control program in each control element 1, it is possible to switch over automatically on recognition of the high frequency into a particular programming state which prevents a start of the lamp and thus allows rapid programming with larger quantities of data. If the normal a.c. operating voltage is then applied again, the system starts again with normal operation.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. Method of controlling fluorescent lamps of a lighting system operated by an a.c. power supply, wherein each lamp includes a series circuit having an impedance for current limitation, a fluorescent tube with preheatable electrodes and a control element with an electronic power switch including an arithmetic and logic unit for heating and igniting pulse production with isolation of the discharge section, wherein the control element additionally has a signal processor provided with a digital input unit, a non-volatile memory, a random access memory, a clock generation means and digital output unit, and a phase detector and power supply unit, wherein control signals for the power switch for modes of operation, starting and/or dimming and/or extinction and/or feedback are produced by means of a control program stored in the non-volatile memory and from phase information of the phase detector, and wherein the control element is arranged in the heating circuit of the fluorescent tube.

2. Method according to claim 1, characterised in that the control element additionally has an adaptation element for the voltage applied to the connections of the control element and in that the signal processor has an additional analogue input and an analogue digital converter by means of which the adapted voltage value can be made available to the control program.

3. Method according to claim 1 or 2, characterised in that the control element additionally has an adaptation element for the current strength flowing through the connections of the control element and the signal processor an additional analogue input and an analogue digital converter by means of which the adapted current strength value can be made available to the control program.

4. Method according to any one of claims 1 to 3, characterised in that the control element additionally has sensors for detecting environmental parameters such as the ambient temperature and/or the atmospheric humidity and/or the brightness or colour of the environmental light and/or of pollutants and/or the presence or movement of a body with the respective corresponding adaptation circuit, and the signal processor has corresponding analogue inputs and associated analogue digital converters or digital inputs by means of which the value of the respective environmental parameter can be made available to the control program.

5. Method according to any one of claims 1 to 4, characterised in that the control program has a subroutine for producing an igniting pulse of variable strength, wherein the strength of the igniting pulse can be adjusted by switching off the power switch at a variable moment after the passage of the current through zero or with a variable amount of the measured heating current.

6. Method according to any one of claims 1 to 5, characterised in that the control program has a subroutine for limiting the lighting time by limiting the isolation time of the discharge section after opening of the power switch by closing the power switch and associated switching on of the tube heating.

7. Method according to any one of claims 1 to 6, characterised in that the control program has a subroutine for determining the type of ballast device used, the signal of the phase detector corresponding to the phase of the applied a.c. voltage being compared, when the ballast device is unloaded, i.e. when the discharge is not ignited and the power switch is open, to the signal of the phase detector corresponding to the phase of the current when the power switch is closed, a lead of the current phase indicating a series circuit comprising compensation capacitor and inductance whereas a lag of the current phase indicates an inductive ballast device, and no significant phase shift denoting a ballast resistor.

8. Method according to any one of claims 1 to 7, characterised in that the control program has a subroutine for determining the power category of the ballast device used, the power category being determined by computer or by comparison with a table stored in the ROM from the peak value of the flowing heating current when the power switch is closed.

9. Method according to any one of claims 1 to 8, characterised in that the control program has a subroutine for determining the type of tube used by detecting the igniting voltage requirement, the value of the igniting voltage for each period being reduced stepwise when the tube is warm from operation and the lighting time reduced, until the evaluation of the voltage trend during the lighting phase shows the increase in voltage characteristic of incipient instability in the discharge or the quenching thereof, or the igniting voltage has reached its lowest value, and the subroutine determines the type of tube by comparing this value, optionally also allowing for the stored value for the power, to a table deposited in the ROM.

10. Method according to any one of claims 1 to 9, characterised in that the control program has a subroutine for the rapid preheating and starting of a tube operated by an inductive ballast device, the power switch being closed in each case during every second half period, i.e. every even-numbered half period, so an increased pulsating direct current flows through the ballast inductor and the tube heater and after a brief heating period of, for example, 0.1 s to 0.5 s during each following half period, a high igniting pulse is produced and this procedure is interrupted if the tube voltage has dropped to the arc voltage in the half period without heating current or the procedure is interrupted after a further time interval of, for example, 0.5 s.

11. Method according to any one of claims 1 to 9, characterised in that the control program has a subroutine for the rapid preheating and starting of a tube operated on a ballast device consisting of a series circuit comprising compensation capacitor and inductance, the power switch being switched on with a delay in each half period so that the increase in frequency corresponding to the reduced current flow time in the direction of series resonance frequency leads to an increase in the heating current and, after a short heating time of, for example, 0.1 s - 0.5 s a high igniting pulse is additionally produced in each half period until the tube arcs or the procedure is interrupted after a further time interval of, for example, 0.5 s.

12. Method according to any one of claims 1 to 11, characterised in that the control program has a subroutine for adjusting the brightness of the tube, an igniting pulse being triggered in each case after the passage of the current through zero signalled by the phase detector and the subsequent lighting time being limited to a predeterminable value, wherein igniting pulses of various values of which the values are taken from a table deposited in the ROM are produced for various lighting times.

13. Method according to claim 12, characterised in that various tables are stored in the ROM for various types of tube and/or various types of ballast device and/or various ballast device powers and/or various values of the ambient temperature, and in that the subroutine selects the table corresponding to the lamp configuration used and this choice can additionally be determined by the value of a sensor measuring the ambient temperature.

14. Method according to claim 12 or 13, characterised in that the tables contain additional data for voltage values to which the tube voltage drops after predetermined short time intervals if the value of the igniting voltage is sufficiently high and in that the subroutine reduces the igniting pulse strength stepwise providing these values are not exceeded and increases the igniting pulse strength if these values are exceeded.

15. Method according to any one of claims 1 to 14, characterised in that the control program has a subroutine for tube types with an increased igniting voltage requirement for extinguishing the discharge, the lighting time being adjusted to a minimum value in a first stage, the igniting pulse strength being adjusted to a minimum value in a second stage so the discharge quenches and the heating being switched off in the third stage with minimum igniting pulse strength.

16. Method according to any one of claims 1 to 15, characterised in that for controlling a lighting system for generating light and/or colour patterns, varying in time, the respective part of the entire control program responsible for controlling each individual tube is stored in the program memory of the control element responsible for the respective tube, the signal, derived from the mains frequency, of the respective phase detector serving as a common clock for synchronising the partial programs in each control element and the program sequence being started in each signal processor after a delay time equal for all of them after the operating voltage has been switched on.

17. Method according to any one of claims 1 to 16, characterised in that the sequence of the control program in the individual control elements is influenced by evaluating the signals of sensors connected to them, so the mode of operation of the lamp can be controlled, for example by environmental brightness, temperature, movement, or also by pollutants.

18. Method according to any one of claims 1 to 17, characterised in that the sequence of the control program in the individual control elements can be influenced by signal transmission from one or more transducers to these control elements, the transducers activating, by emitting an address, the control element or the group of control elements allocated to this address for receiving and evaluating the subsequently transmitted command.

19. Method according to claim 18, characterised in that signal transmission takes place in a wireless manner, for example by ultrasound, by light or by high-frequency electromagnetic waves, the control element additionally having a corresponding signal receiver and the signal processor additionally having a digital input for the received signal.

20. Method according to claim 18, characterised in that signal transmission is wire-bound via a common signal line, the control element having an additional connection for the signal line and an adaptation circuit, and the signal processor having an additional digital input for the signals from the adaptation circuit.

21. Method according to claim 18, characterised in that signal transmission takes place via the power supply line to which the lamps are connected, one or more transducers connected to the line modulating a signal with a frequency which is selected sufficiently high for the signal still to be transmitted with adequate strength via the winding capacity of the ballast inductor to the connections of the control element and the control element additionally having a resonance circuit adapted to the signal frequency with an adaptation circuit and the signal processor having an additional digital input for the signals from the adaptation circuit.

22. Method according to claim 18, characterised in that signal transmission takes place via the power supply line to which the lamps are connected, at least one transducer connected to the line for transmitting a unit of information changing the voltage trend of at least one half period of the a.c. supply voltage such that this change leads to a corresponding displacement of the edges of the signal of the phase detector in the control element and in that the control program in the control element has a subroutine for evaluating the information contained in the signal of the phase detector.

23. Method according to claim 22, characterised in that at least one transducer is looped instead of the conventional light switch into a supply line of the lighting system or part thereof which then changes the voltage trend of at least one half period of the a.c. supply voltage for transmitting an information unit in that, via its terminals, a power switch connects in series a power source identically or opposingly directed to the instantaneous polarity for parts of the half period or the entire half period, a signal processor supplied by the voltage supply unit generating the control signals for the power switch from the signal of the phase detector which signals the beginning and the polarity of a half period and the data of a keypad and/or of an optional interface connection by means of a control program.

24. Method according to claim 22 or 23, characterised in that the control program in the signal processor of the transducer has a routine for evaluating the information contained in the signal of the phase detector.

25. Method according to claim 24, characterised in that transmission errors are detected by comparing the information transmitted from a transducer to the supply line with the received information and are corrected by emitting additional information.

26. Method according to claim 22, characterised in that the control element acts as a transducer and, for transmitting an information unit via the supply line,

changes the lighting time for one or more half periods, which also leads to a correspondingly evaluatable displacement of the signal edges of the phase detector signals.

27. Method according to any one of claims 1 to 26, characterised in that at least a portion of the non-volatile memory in the signal processors consists of an electrically erasable programmable memory for picking up and changing operating parameters and control programs to allow adaptation of a lighting system to changing requirements without having to exchange the control elements.

28. Method according to claim 27, characterised in that, for changing the parameters and/or the programs, data transmission is carried out via the supply line with a programming voltage source having a substantially higher frequency and in that, on detecting this high frequency, the control elements automatically branch into a programming routine in which no lamp start occurs.

29. Method of controlling fluorescent lamps of a lighting system operated by an a.c. power supply substantially as herein described with reference to the accompanying drawings.

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Abstract

Controller for fluorescent lamps

The invention relates to a method for the independent control of individual or a group of fluorescent lamps of a lighting system operated by the a.c. supply system with the main functions of rapid start, brightness control (dimming), extinction and storage of an operating state for switching on the system after it has been switched off. A feature of the invention resides in the possibility of converting existing conventional lighting systems without additional installation costs merely by exchanging the respective conventional starter for a control circuit according to the invention and by exchanging the conventional light switch for transducers according to the invention. To achieve this, a control element (1) instead of the known starter is connected into the heating circuit for a lamp La formed from a series circuit of a fluorescent tube (12) with a ballast device (13). The control element (1) consists at least of the components of power switch (2), phase detector (10), power supply (11), signal processor (3), clock generation means (8) and control software deposited in the non-volatile memory (5) and generating the control signals of the power switch (2) among other things from the information of the phase detector (10).

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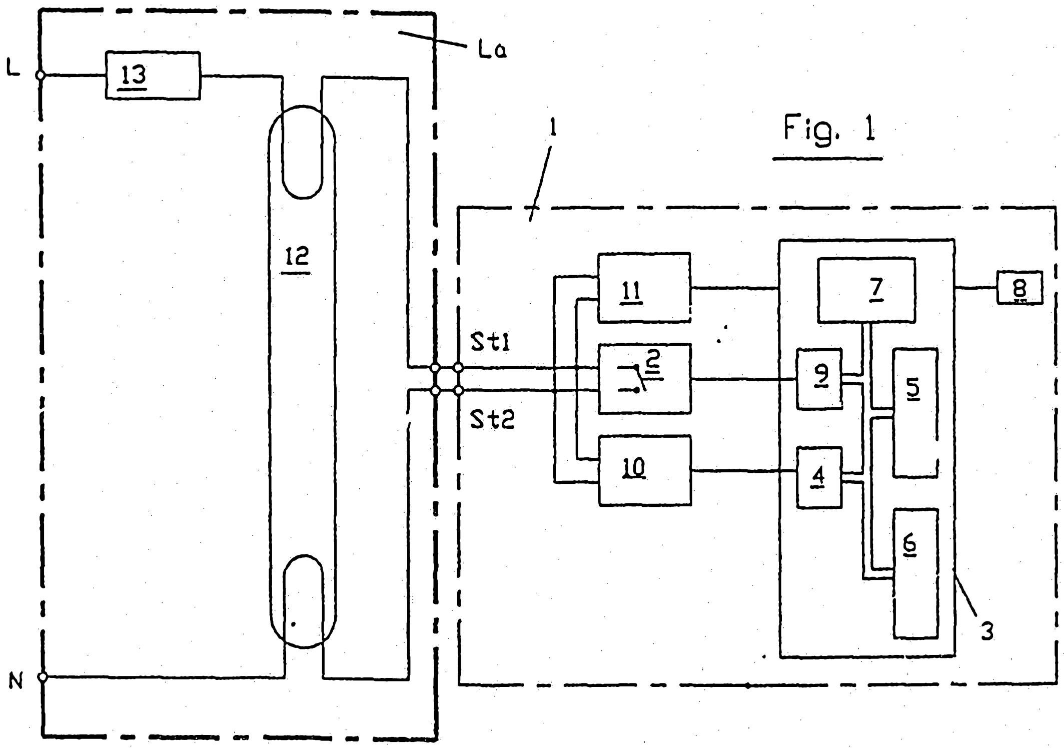


Fig. 1

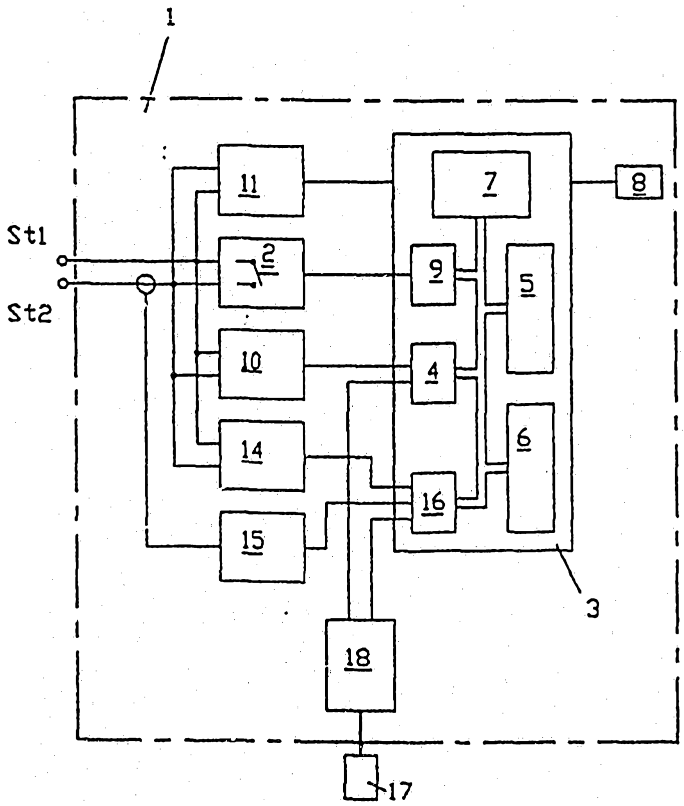


Fig. 2

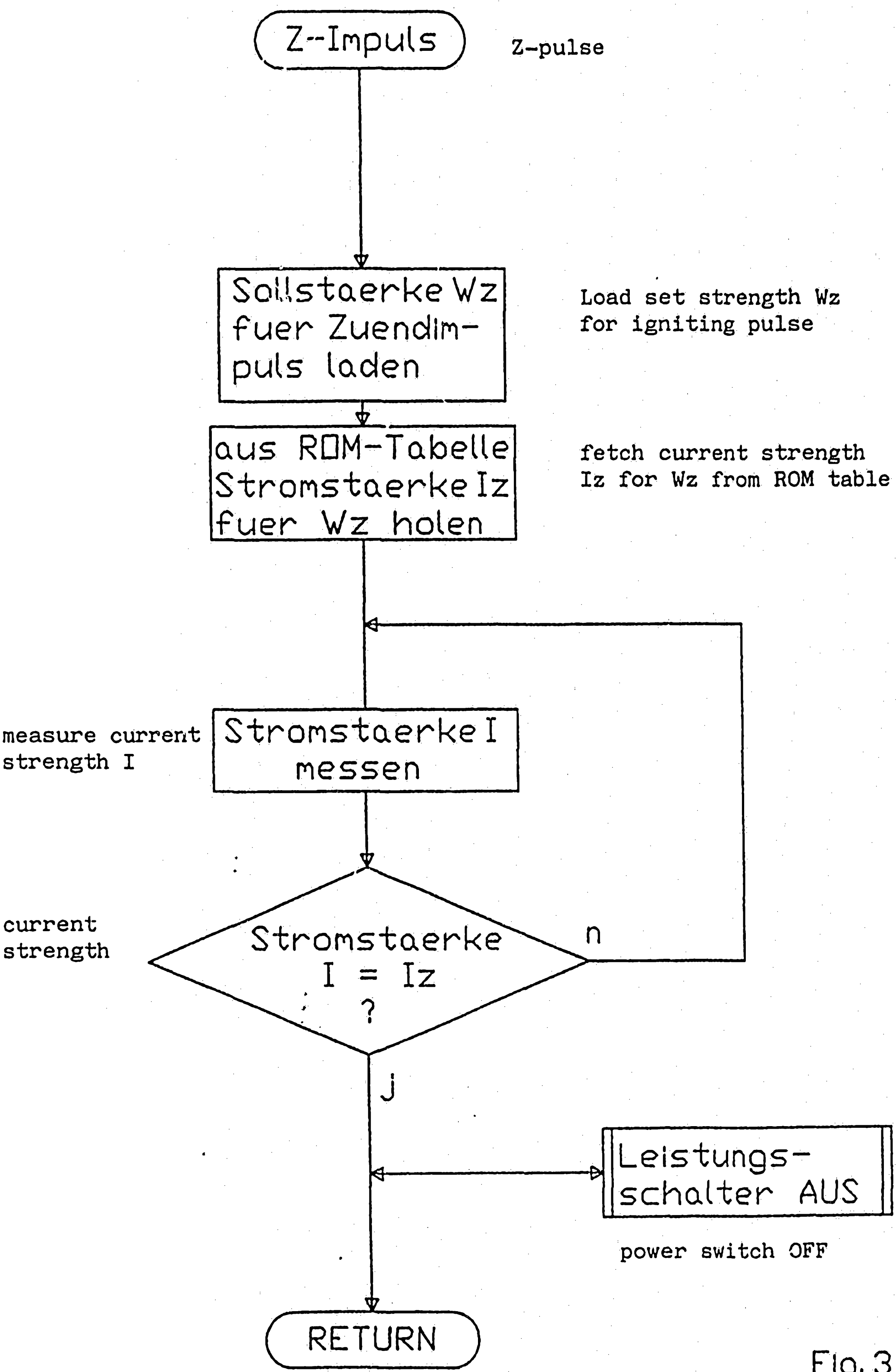

Z--Impuls
Z-pulse
Sollstaerke Wz fuer Zuendimpuls laden
Load set strength Wz for igniting pulse
aus ROM-Tabelle Stromstaerke Iz fuer Wz holen
fetch current strength Iz for Wz from ROM table
Stromstaerke I messen
measure current strength I
Stromstaerke I = Iz ?
current strength
n
j
Leistungs-schalter AUS
power switch OFF
RETURN

Fig. 3

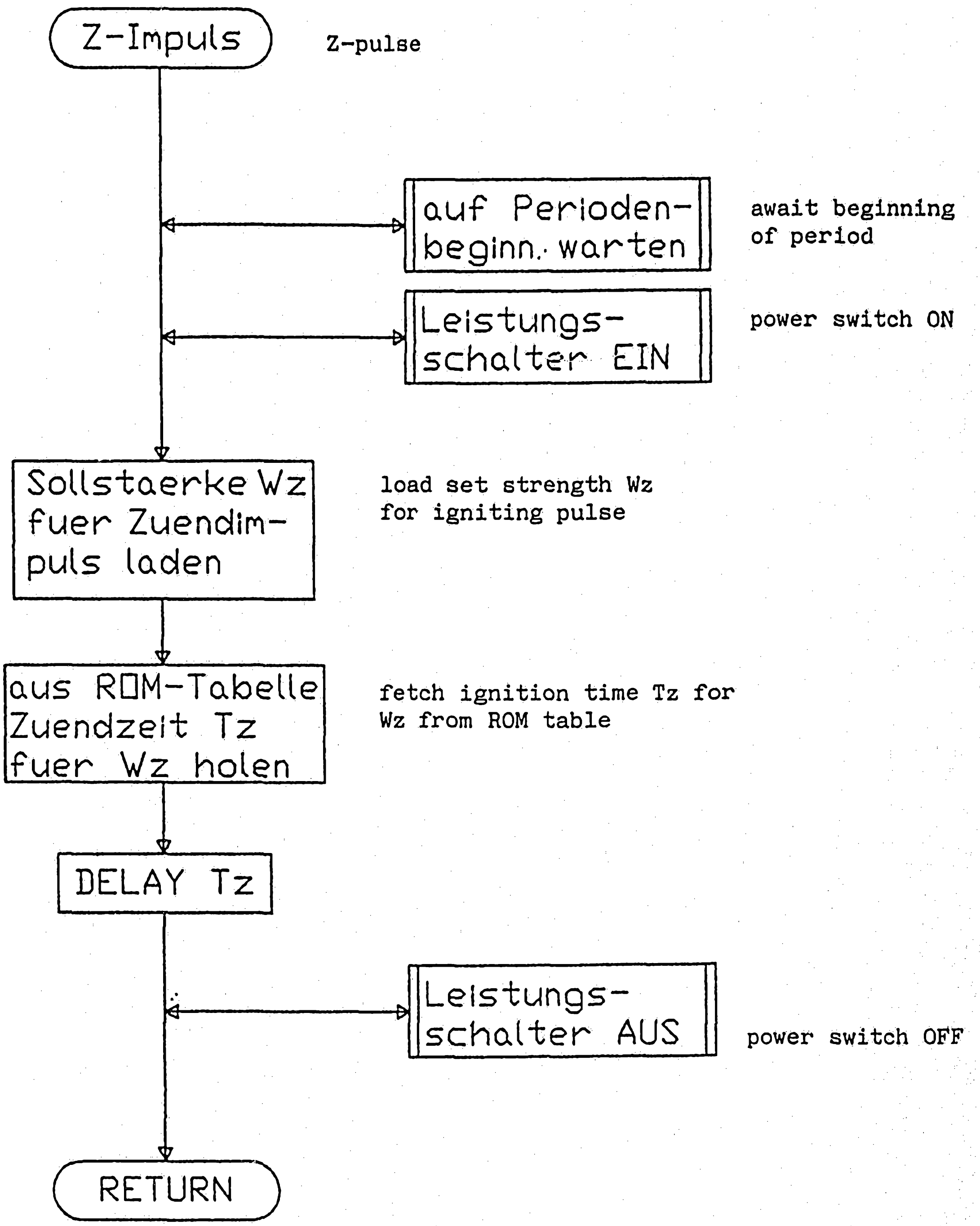

Z-Impuls
Z-pulse
auf Perioden-beginn. warten
await beginning of period
Leistungs-schalter EIN
power switch ON
Sollstaerke Wz fuer Zuendim-puls laden
load set strength Wz for igniting pulse
aus ROM-Tabelle Zuendzeit Tz fuer Wz holen
fetch ignition time Tz for Wz from ROM table
DELAY Tz
Leistungs-schalter AUS
power switch OFF
RETURN

Fig. 4

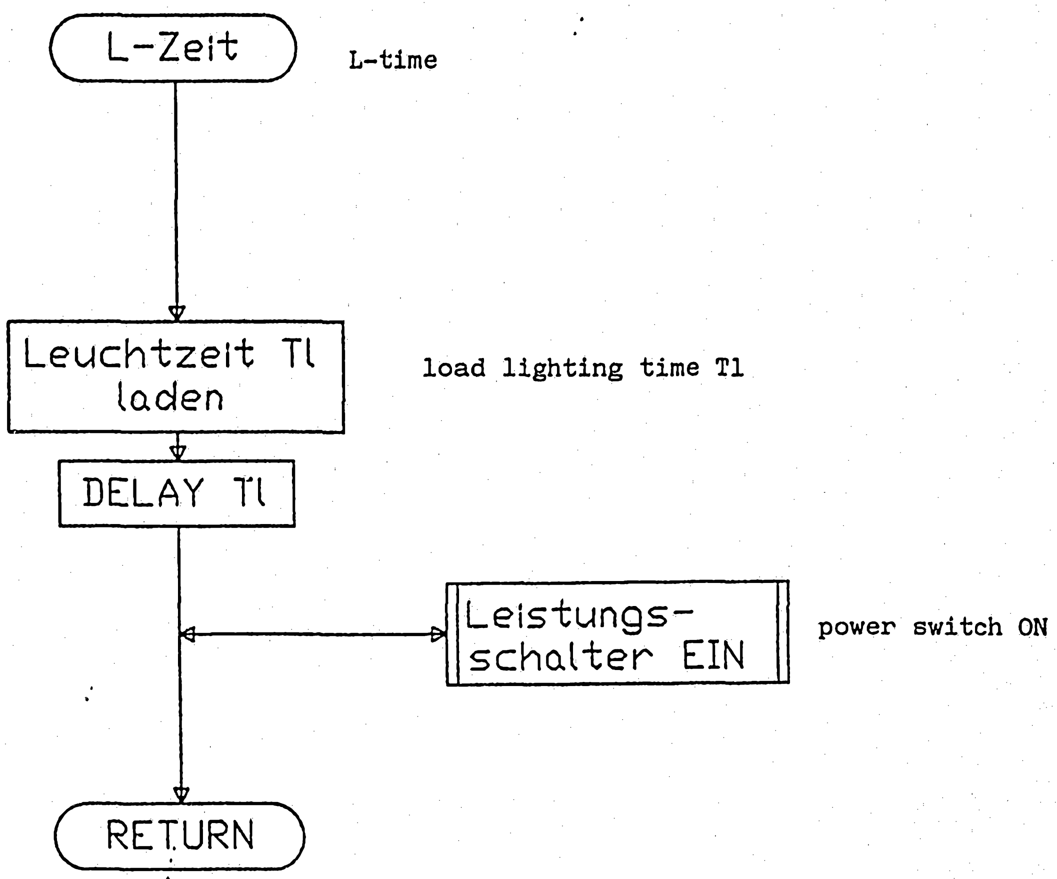

L-Zeit
L-time
Leuchtzeit Tl laden
load lighting time Tl
DELAY Tl
Leistungs-schalter EIN
power switch ON
RETURN

Fig. 5

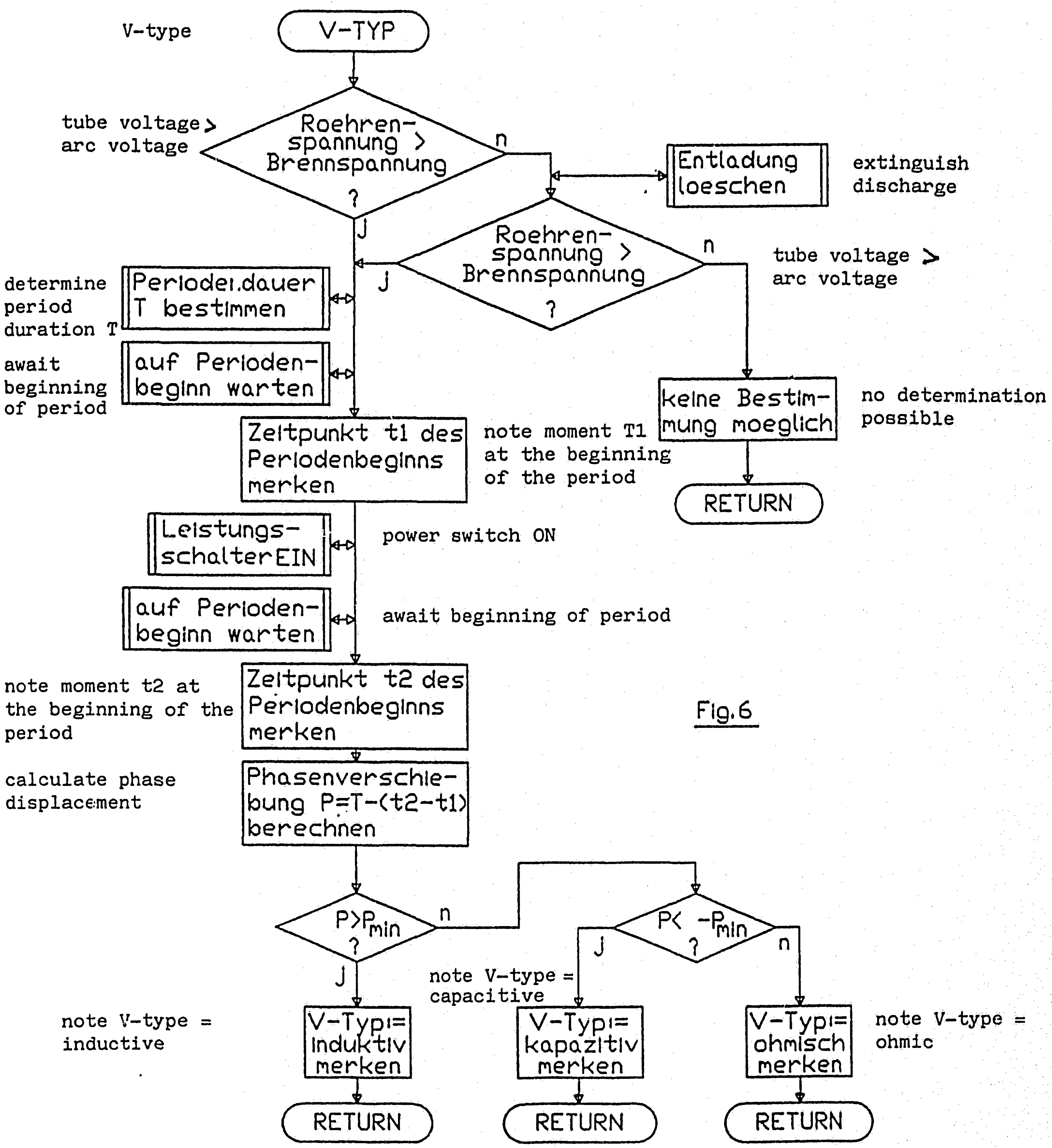

V-type
V-TYP
tube voltage > arc voltage
Roehren-spannung > Brennspannung ?
n
J
Entladung loeschen
extinguish discharge
Roehren-spannung > Brennspannung ?
n
J
tube voltage > arc voltage
determine period duration T
Periodei.dauer T bestimmen
await beginning of period
auf Perioden-beginn warten
keine Bestim-mung moeglich
no determination possible
Zeitpunkt t1 des Periodenbeginns merken
note moment T1 at the beginning of the period
RETURN
Leistungs-schalter EIN
power switch ON
auf Perioden-beginn warten
await beginning of period
note moment t2 at the beginning of the period
Zeitpunkt t2 des Periodenbeginns merken
calculate phase displacement
Phasenverschie-bung P=T-(t2-t1) berechnen
P>Pmin ?
n
J
P< -Pmin ?
J
n
note V-type = capacitive
note V-type = inductive
V-Typ= induktiv merken
V-Typ= kapazitiv merken
V-Typ= ohmisch merken
note V-type = ohmic
RETURN
RETURN
RETURN

Fig.6

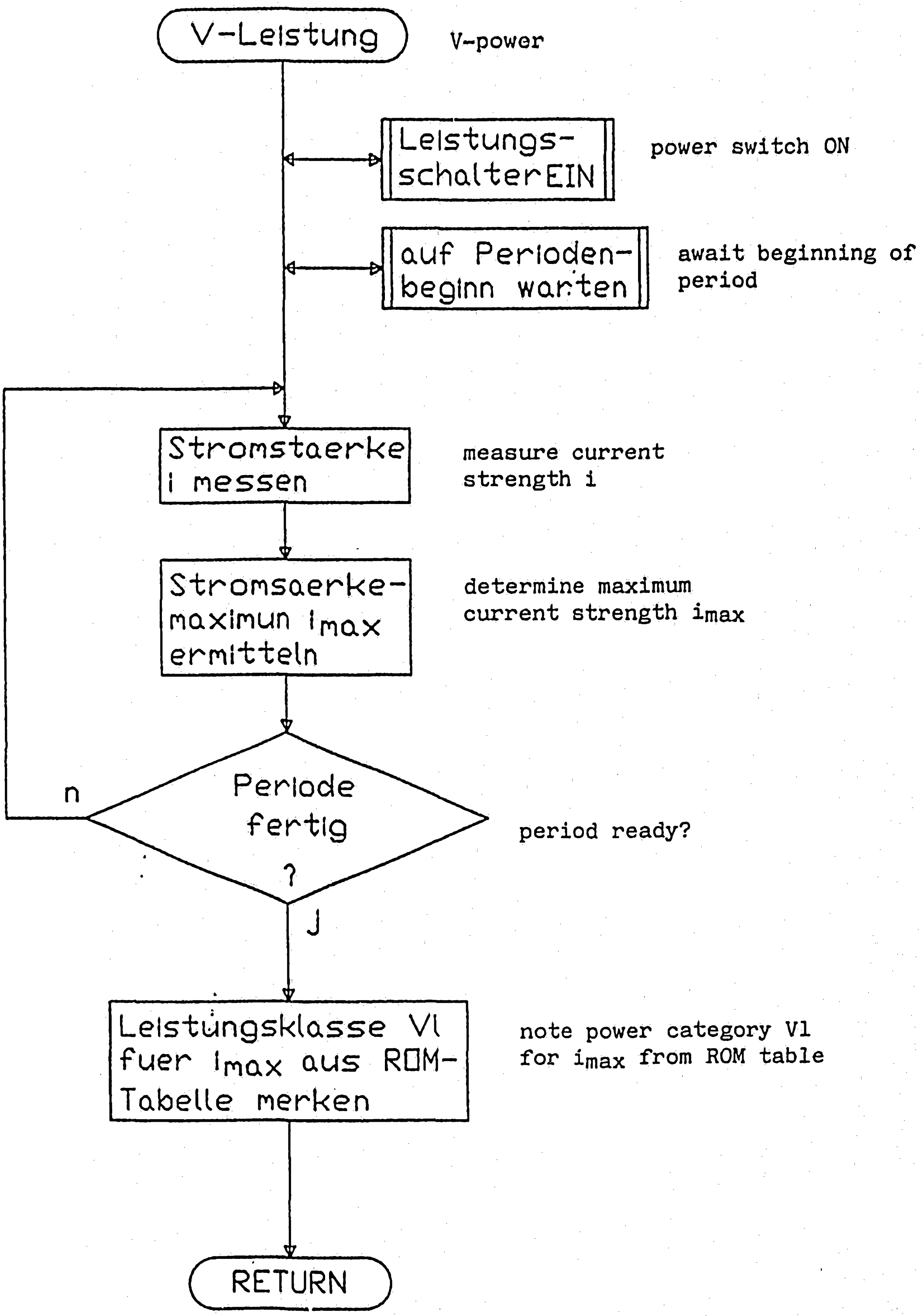

V-Leistung
V-power
Leistungs-schalterEIN
power switch ON
auf Perioden-beginn warten
await beginning of period
Stromstaerke i messen
measure current strength i
Stromsaerke-maximun imax ermitteln
determine maximum current strength imax
Periode fertig ?
period ready?
n
J
Leistungsklasse Vl fuer imax aus ROM-Tabelle merken
note power category Vl for imax from ROM table
RETURN

Fig.7

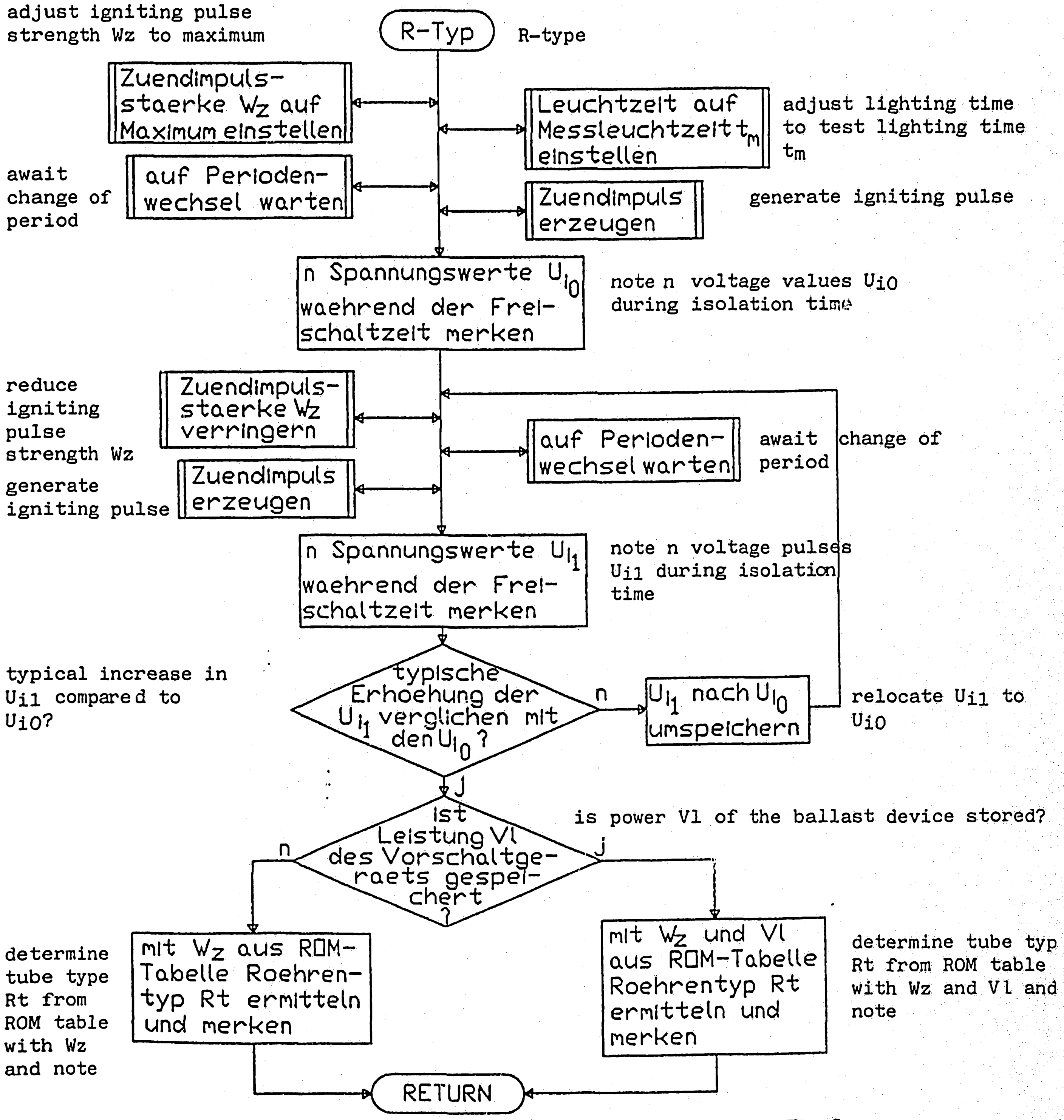

R-Typ
R-type
Zuendimpulsstaerke Wz auf Maximum einstellen
adjust igniting pulse strength Wz to maximum
Leuchtzeit auf Messleuchtzeit tm einstellen
adjust lighting time to test lighting time tm
auf Perioden-wechsel warten
await change of period
Zuendimpuls erzeugen
generate igniting pulse
n Spannungswerte Ui0 waehrend der Freischaltzeit merken
note n voltage values Ui0 during isolation time
Zuendimpulsstaerke Wz verringern
reduce igniting pulse strength Wz
auf Periodenwechsel warten
await change of period
Zuendimpuls erzeugen
generate igniting pulse
n Spannungswerte Ui1 waehrend der Freischaltzeit merken
note n voltage pulses Ui1 during isolation time
typische Erhoehung der Ui1 verglichen mit den Ui0 ?
typical increase in Ui1 compared to Ui0?
n
Ui1 nach Ui0 umspeichern
relocate Ui1 to Ui0
J
ist Leistung Vl des Vorschaltgeraets gespeichert ?
is power Vl of the ballast device stored?
n
j
mit Wz aus ROM-Tabelle Roehrentyp Rt ermitteln und merken
determine tube type Rt from ROM table with Wz and note
mit Wz und Vl aus ROM-Tabelle Roehrentyp Rt ermitteln und merken
determine tube typ Rt from ROM table with Wz and Vl and note
RETURN

Fig. 8

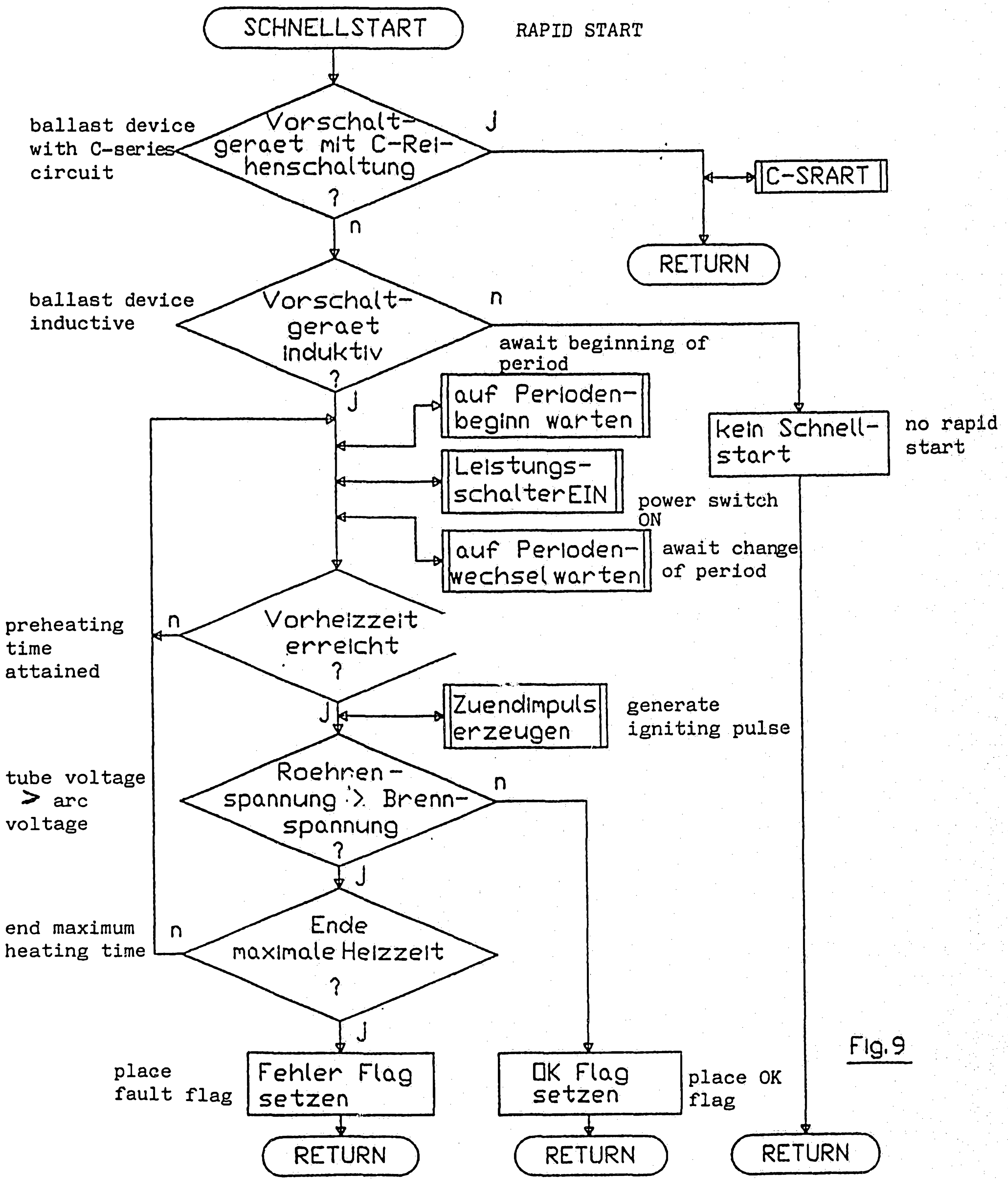

SCHNELLSTART
RAPID START
Vorschalt-geraet mit C-Rei-henschaltung ?
ballast device with C-series circuit
J
C-SRART
RETURN
n
Vorschalt-geraet induktiv ?
ballast device inductive
n
await beginning of period
J
auf Perioden-beginn warten
kein Schnell-start
no rapid start
Leistungs-schalterEIN
power switch ON
auf Perioden-wechsel warten
await change of period
Vorheizzeit erreicht ?
preheating time attained
n
J
Zuendimpuls erzeugen
generate igniting pulse
Roehren-spannung > Brenn-spannung ?
tube voltage > arc voltage
n
J
Ende maximale Heizzeit ?
end maximum heating time
n
J
Fehler Flag setzen
place fault flag
OK Flag setzen
place OK flag
RETURN
RETURN
RETURN

Fig. 9

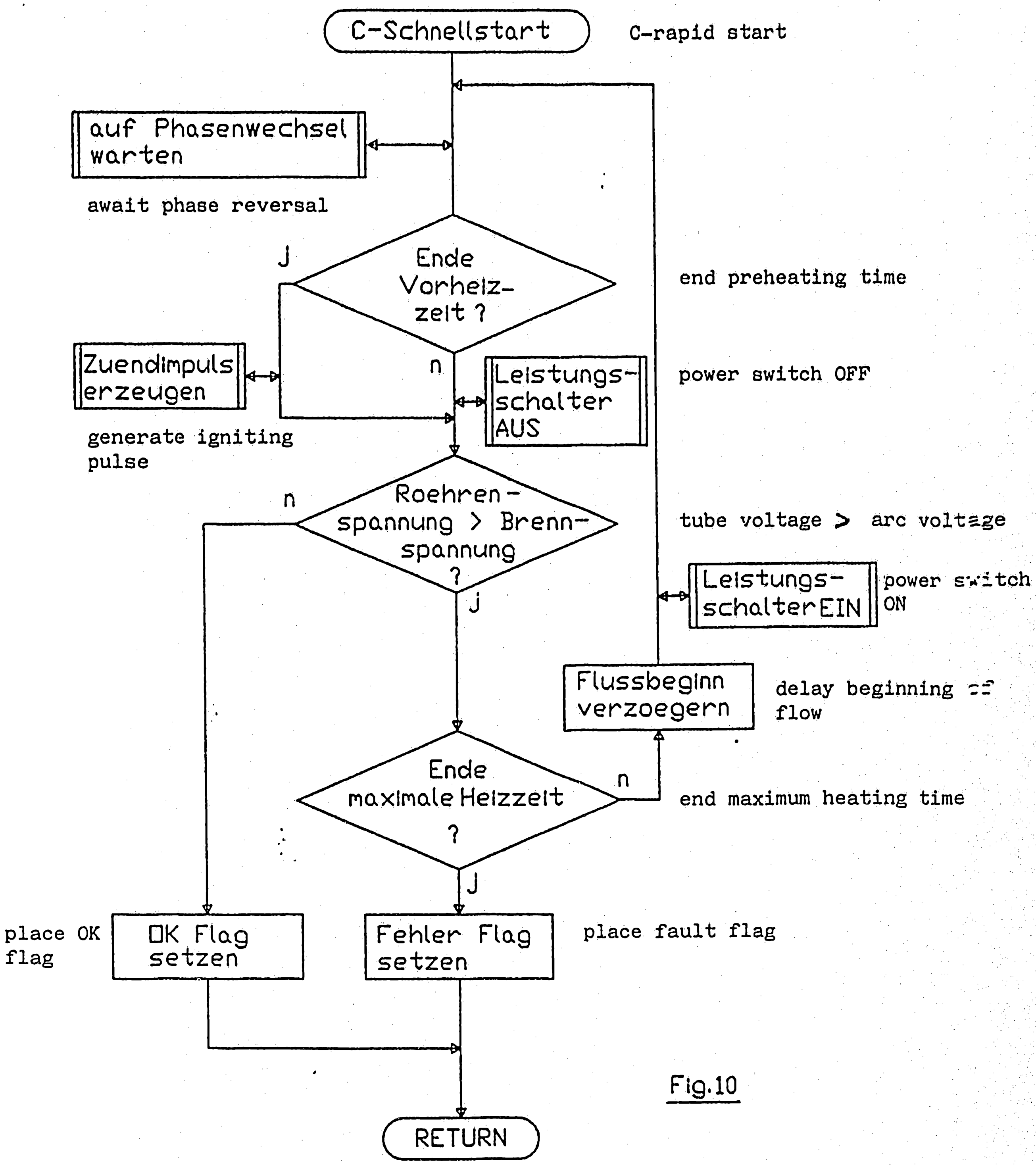
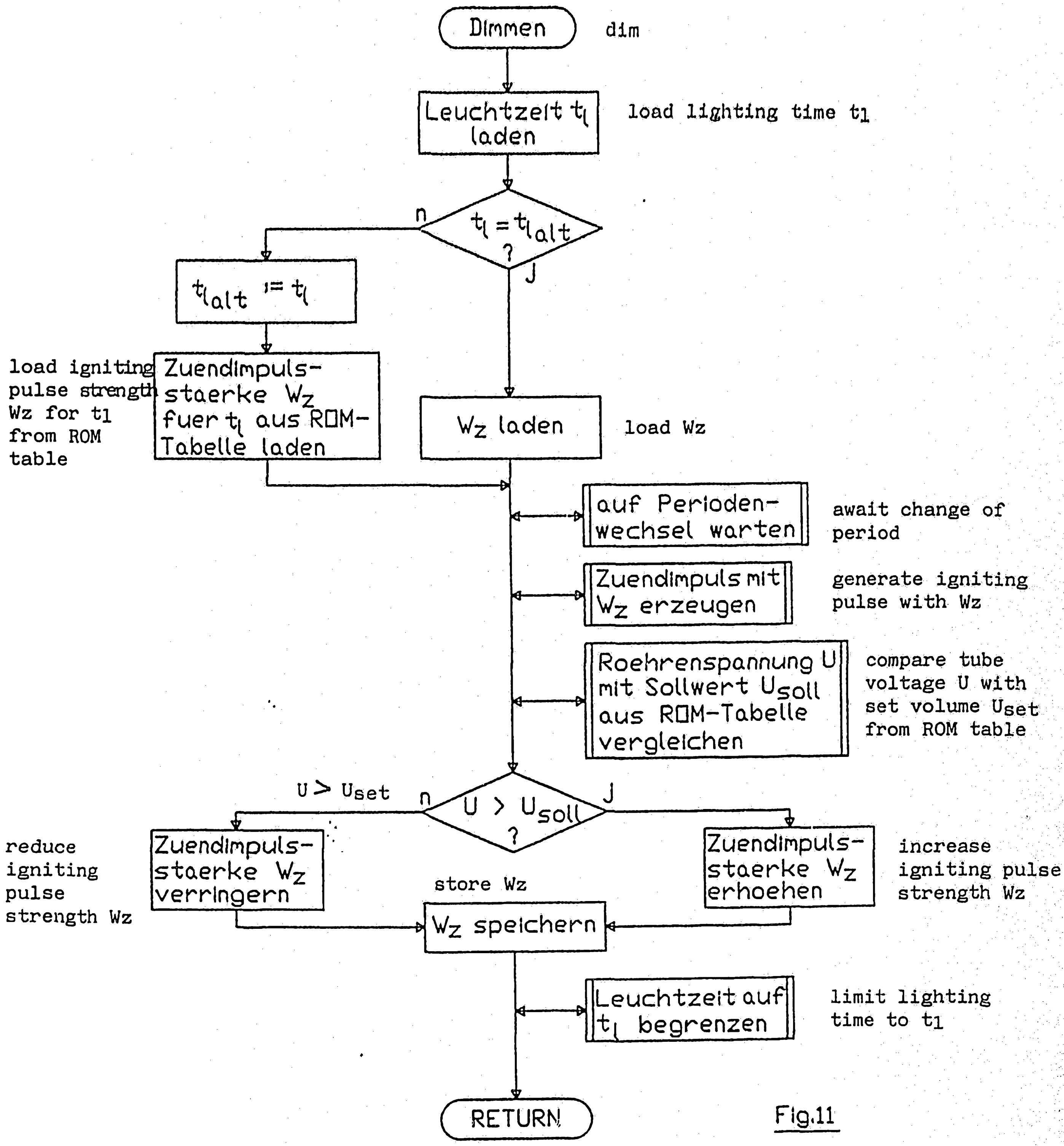

C-Schnellstart
C-rapid start
auf Phasenwechsel warten
await phase reversal
J
Ende Vorheiz-zeit ?
end preheating time
n
Zuendimpuls erzeugen
generate igniting pulse
Leistungs-schalter AUS
power switch OFF
n
Roehren-spannung > Brenn-spannung ?
tube voltage > arc voltage
J
Leistungs-schalter EIN
power switch ON
Flussbeginn verzoegern
delay beginning of flow
n
Ende maximale Heizzeit ?
end maximum heating time
J
place OK flag
OK Flag setzen
Fehler Flag setzen
place fault flag
RETURN

Fig.10



Dimmen
dim
Leuchtzeit t_l laden
load lighting time t_l
$t_l = t_{l alt}$?
n
J
$t_{l alt} := t_l$
load igniting pulse strength Wz for t_l from ROM table
Zuendimpuls-staerke W_Z fuer t_l aus ROM-Tabelle laden
W_Z laden
load Wz
auf Perioden-wechsel warten
await change of period
Zuendimpuls mit W_Z erzeugen
generate igniting pulse with Wz
Roehrenspannung U mit Sollwert U_{soll} aus ROM-Tabelle vergleichen
compare tube voltage U with set volume U_{set} from ROM table
U > U_{set}
U > U_{soll} ?
n
J
reduce igniting pulse strength Wz
Zuendimpuls-staerke W_Z verringern
Zuendimpuls-staerke W_Z erhoehen
increase igniting pulse strength Wz
store Wz
W_Z speichern
Leuchtzeit auf t_l begrenzen
limit lighting time to t_l
RETURN

Fig.11

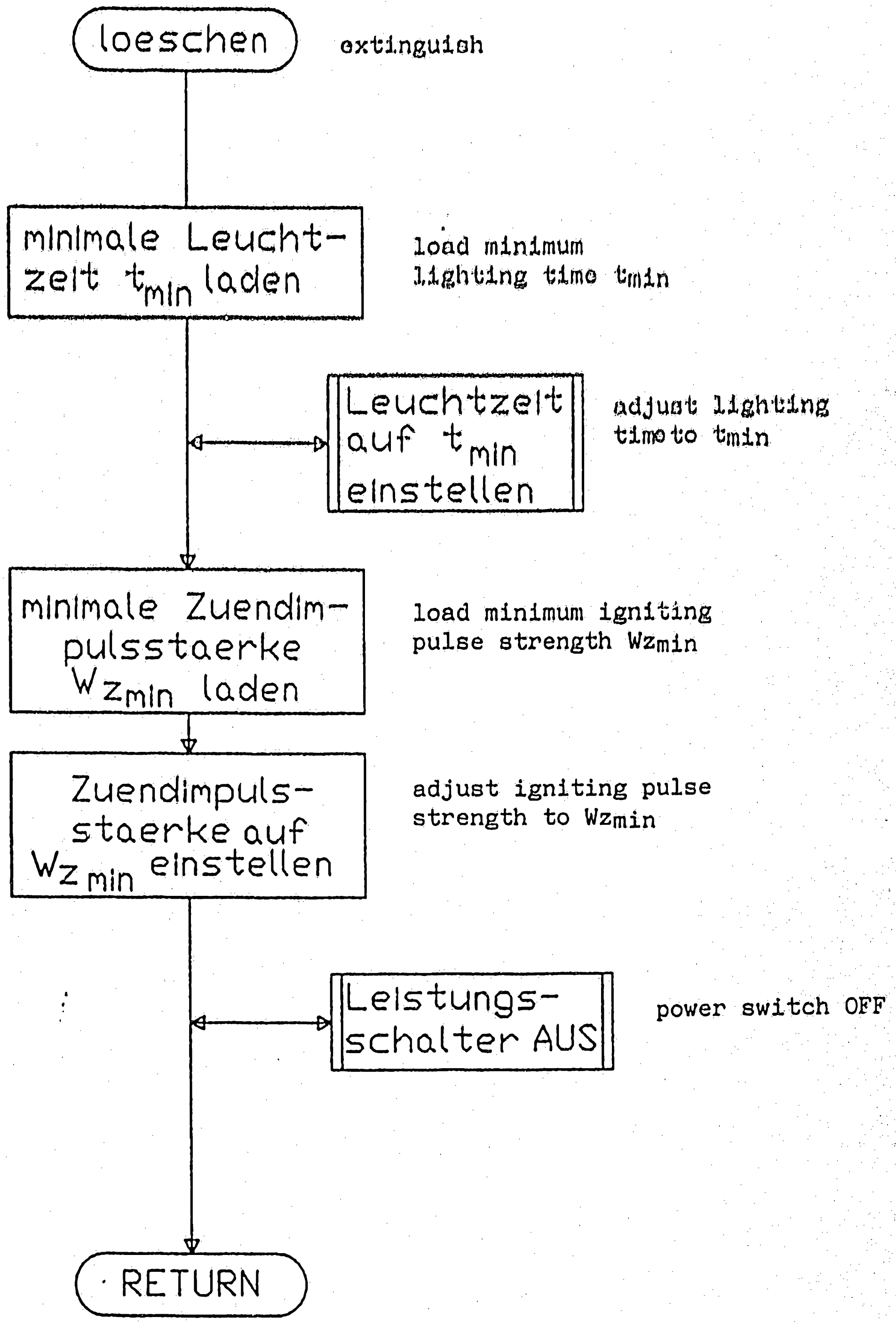

loeschen
extinguish
minimale Leuchtzeit t_{min} laden
load minimum lighting time t_{min}
Leuchtzeit auf t_{min} einstellen
adjust lighting time to t_{min}
minimale Zuendimpulsstaerke $W_{z_{min}}$ laden
load minimum igniting pulse strength W_{zmin}
Zuendimpulsstaerke auf $W_{z_{min}}$ einstellen
adjust igniting pulse strength to W_{zmin}
Leistungsschalter AUS
power switch OFF
RETURN

Fig. 12

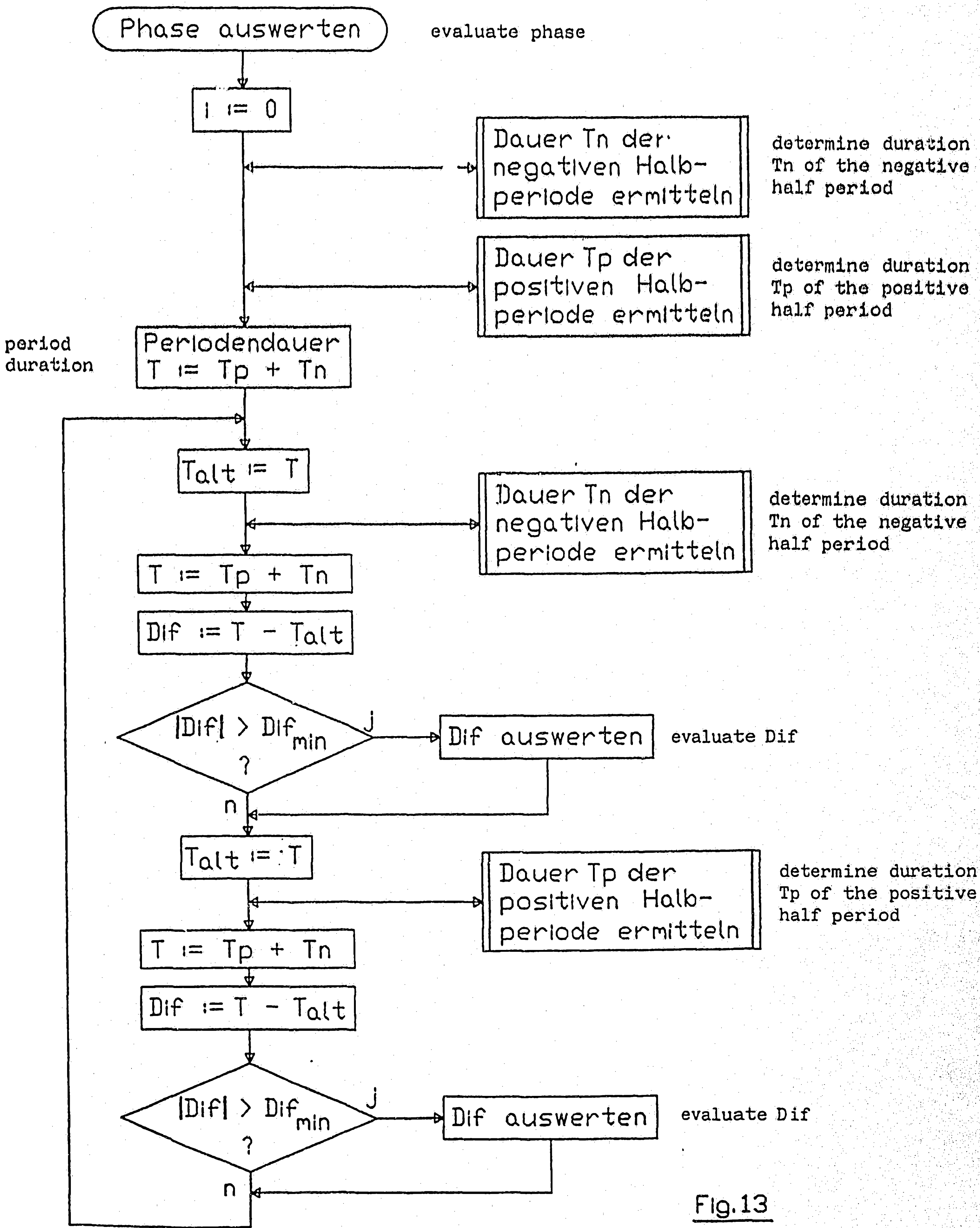

Phase auswerten
evaluate phase
i := 0
Dauer Tn der negativen Halbperiode ermitteln
determine duration Tn of the negative half period
Dauer Tp der positiven Halbperiode ermitteln
determine duration Tp of the positive half period
period duration
Periodendauer T := Tp + Tn
Talt := T
Dauer Tn der negativen Halbperiode ermitteln
determine duration Tn of the negative half period
T := Tp + Tn
Dif := T - Talt
|Dif| > Difmin ?
j
n
Dif auswerten
evaluate Dif
Talt := T
Dauer Tp der positiven Halbperiode ermitteln
determine duration Tp of the positive half period
T := Tp + Tn
Dif := T - Talt
|Dif| > Difmin ?
j
n
Dif auswerten
evaluate Dif

Fig.13

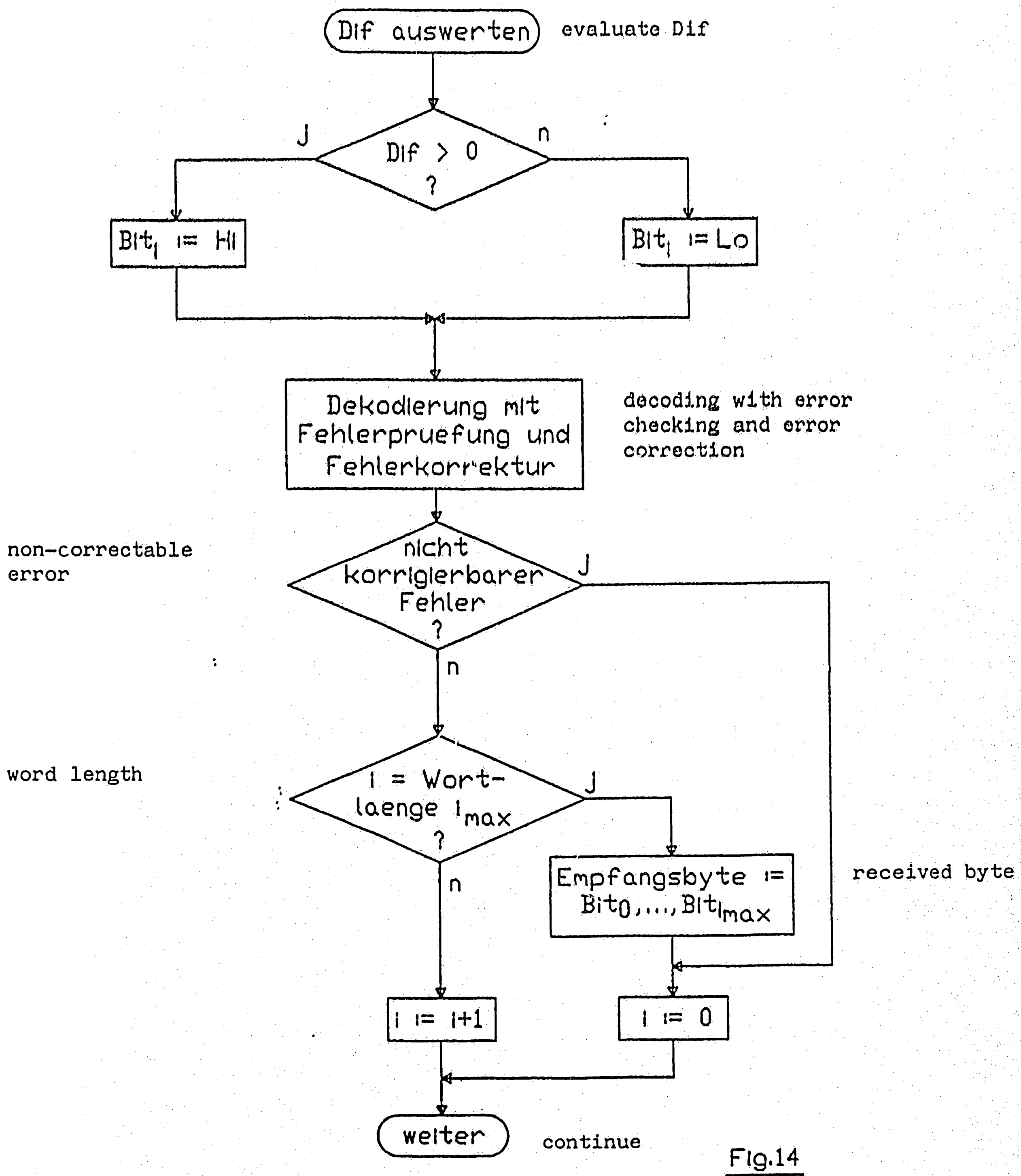

Dif auswerten
evaluate Dif
J
n
Dif > 0 ?
Bit_i := Hi
Bit_i := Lo
Dekodierung mit Fehlerpruefung und Fehlerkorrektur
decoding with error checking and error correction
non-correctable error
nicht korrigierbarer Fehler ?
J
n
word length
i = Wortlaenge i_{max} ?
J
n
Empfangsbyte := $Bit_0, \ldots, Bit_{imax}$
received byte
i := i+1
i := 0
weiter
continue

Fig.14

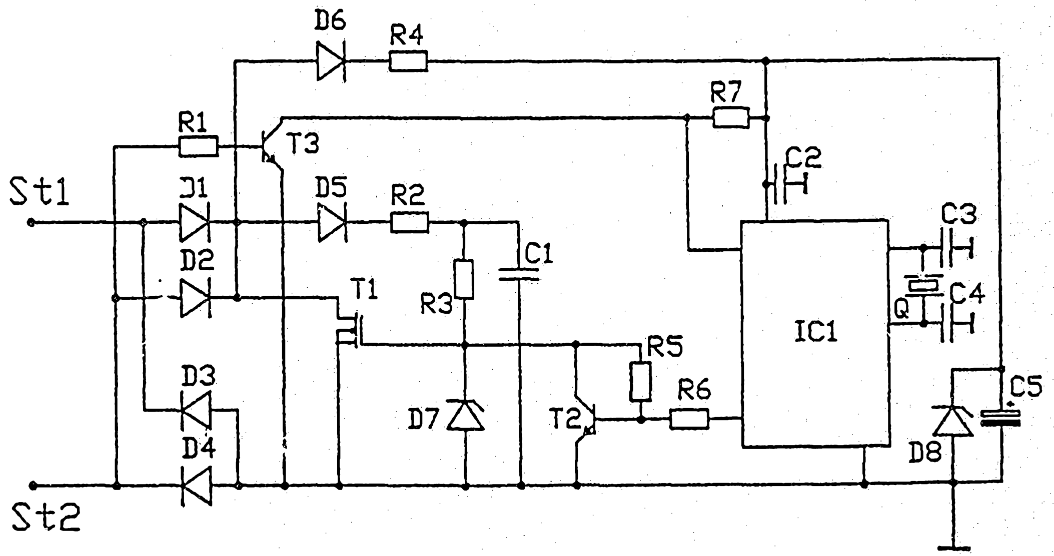

D6
R4
R7
R1
T3
C2
St1
D1
D5
R2
C3
C1
D2
T1
Q
C4
R3
IC1
R5
D3
C5
R6
D7
T2
D4
D8
St2

Fig. 15

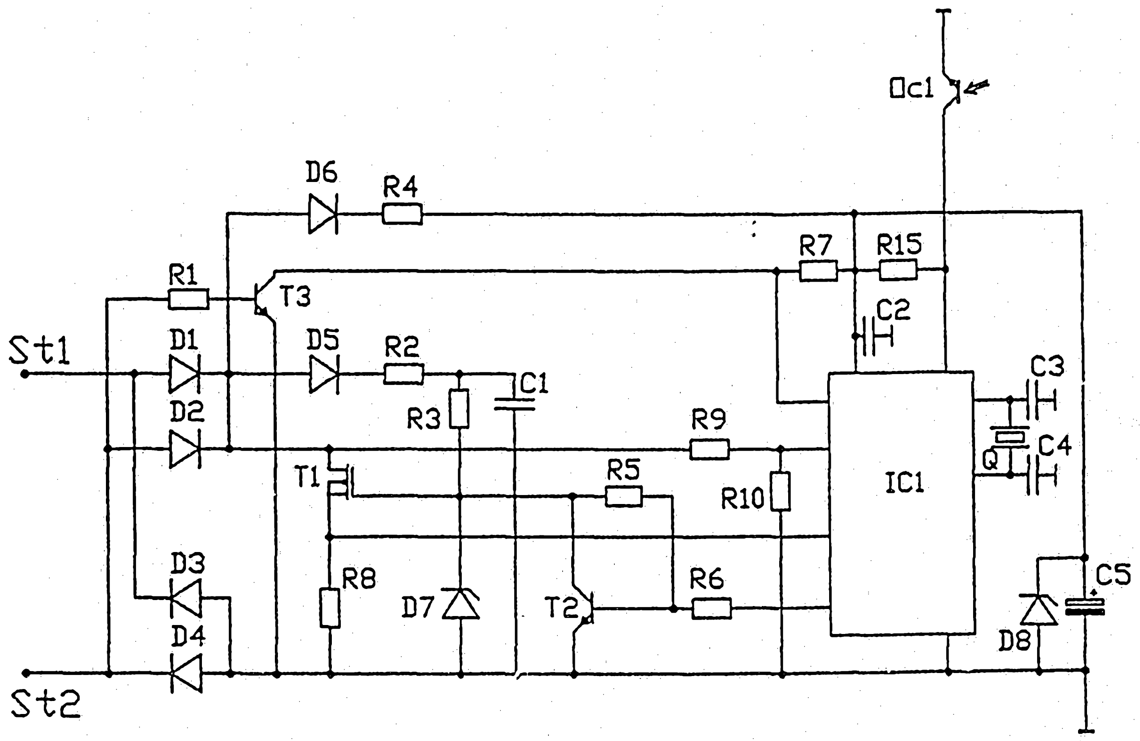

Oc1
D6
R4
R7
R15
R1
T3
C2
St1
D1
D5
R2
C1
C3
D2
R3
R9
Q
C4
T1
R5
R10
IC1
D3
R8
R6
C5
D7
T2
D8
D4
St2

Fig.16

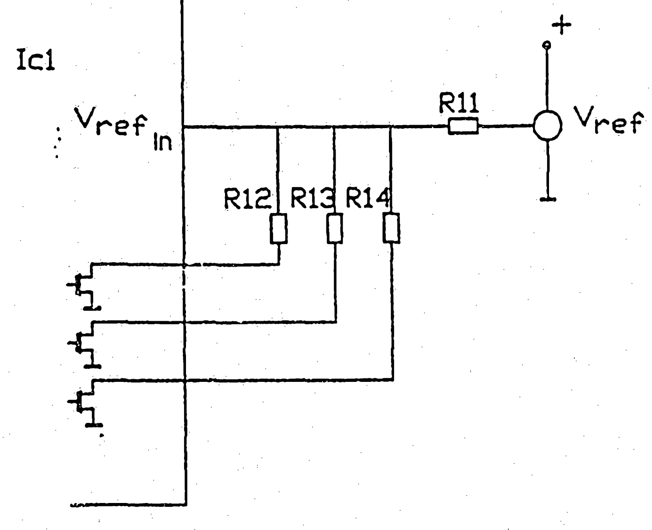

+
Ic1
Vref In
R11
Vref
R12
R13
R14

Fig.17

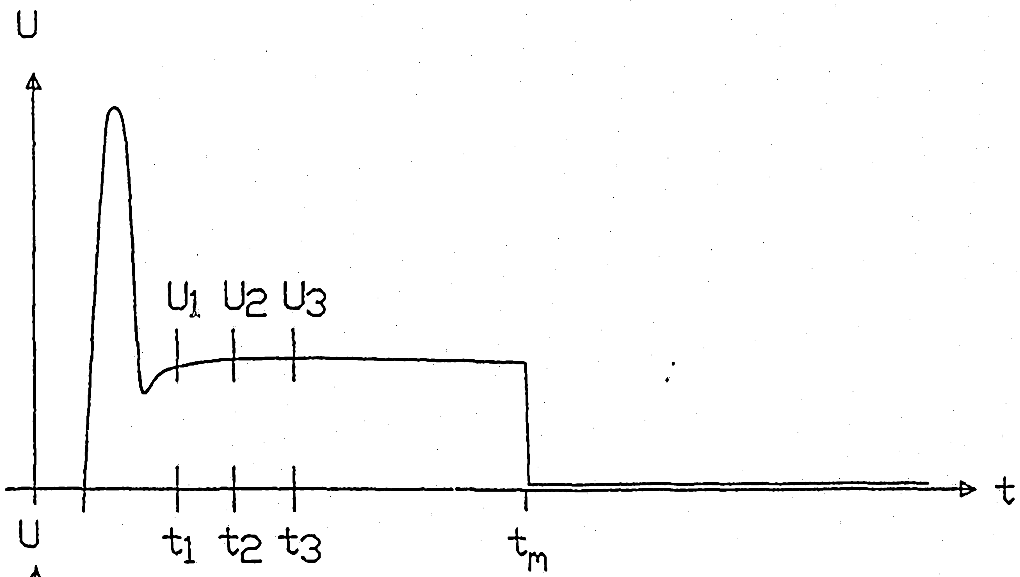


Fig.18

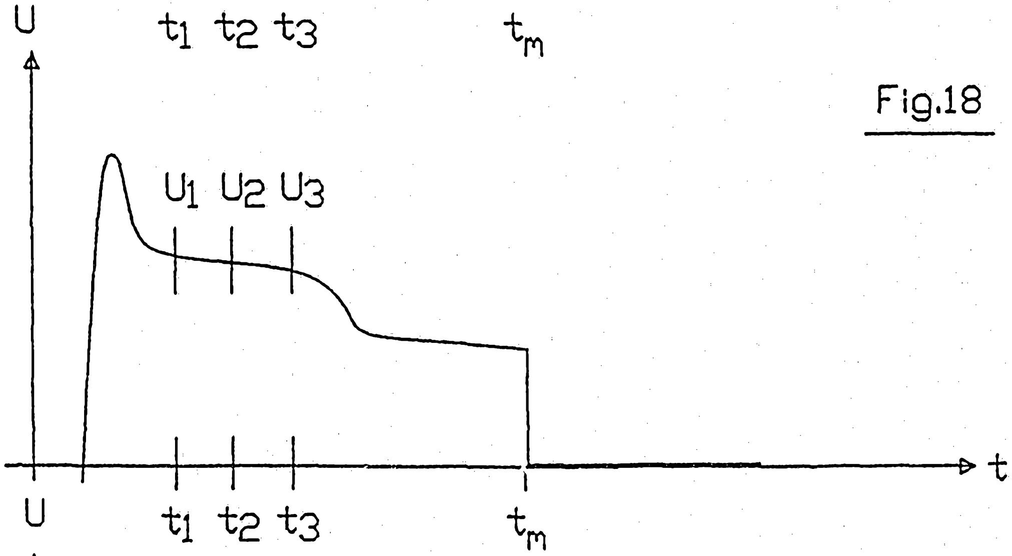


Fig.19

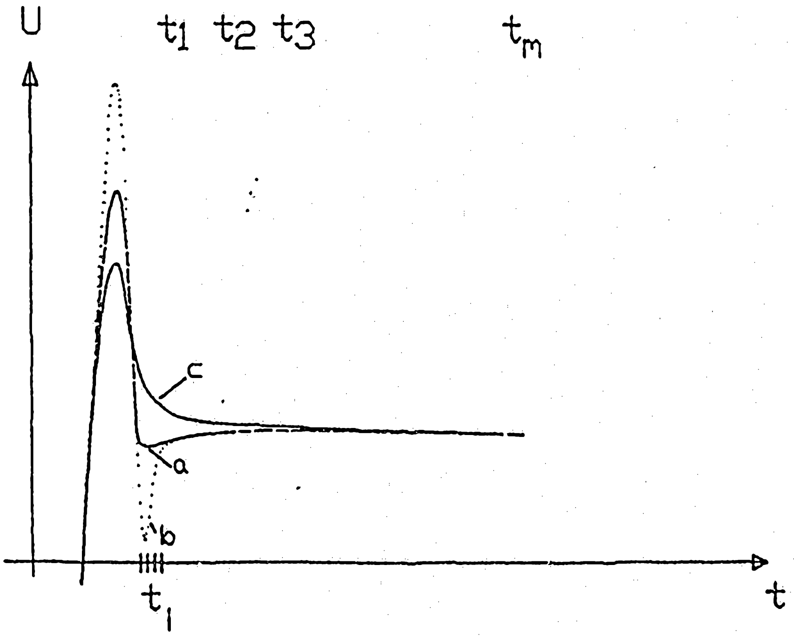


Fig.20

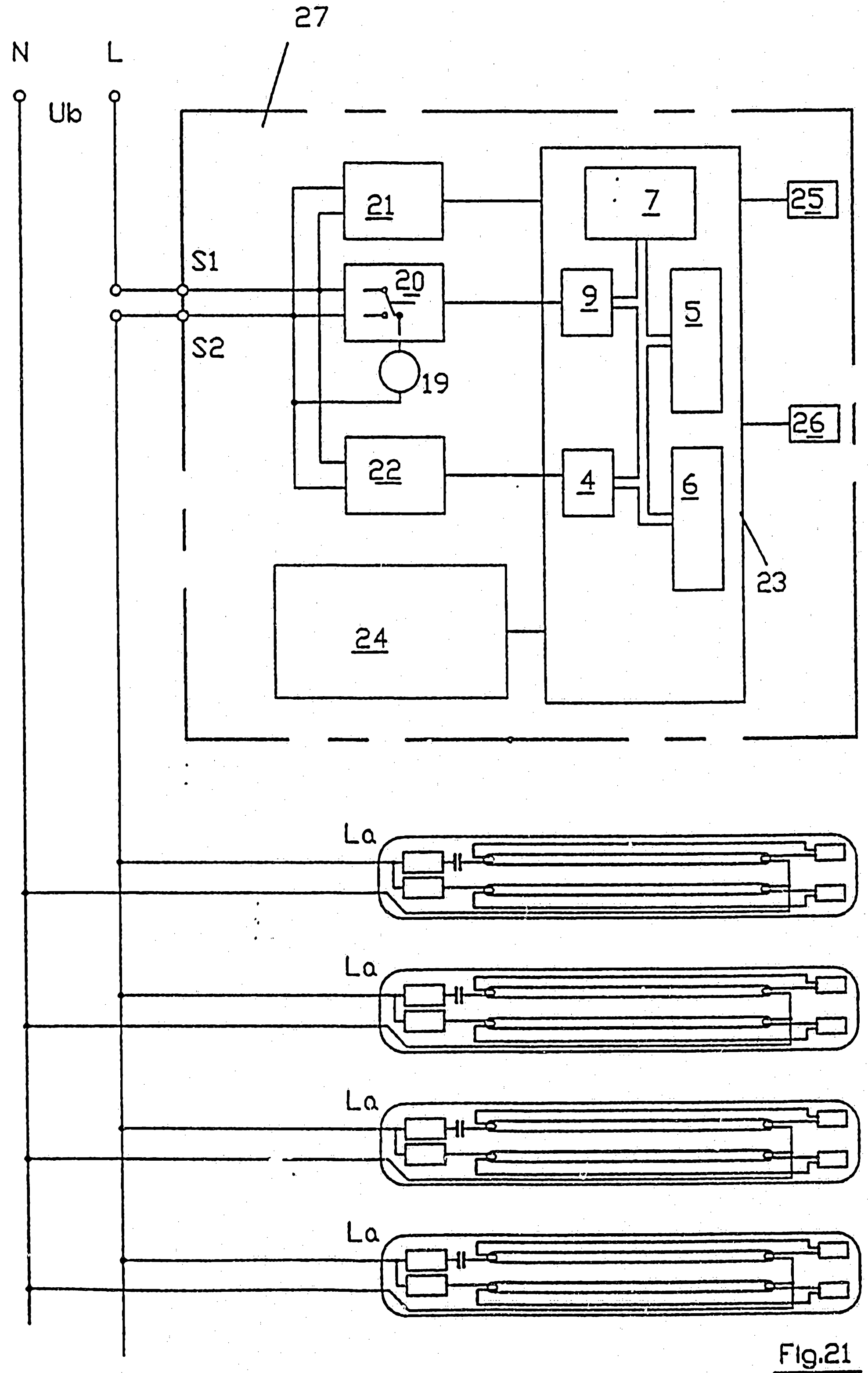


Fig.21

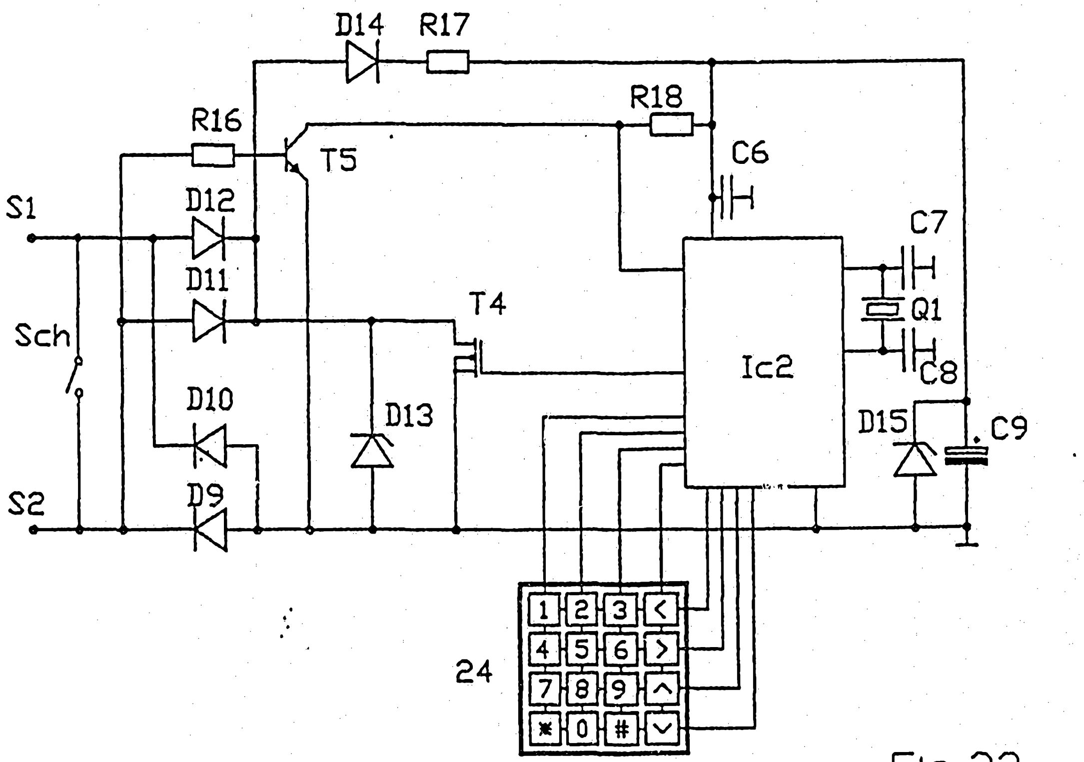

D14
R17
R18
R16
T5
C6
S1
D12
C7
D11
T4
Q1
Sch
Ic2
C8
D10
D15
D13
C9
S2
D9
1
2
3
4
5
6
7
8
9
0
#
24

Fig. 22

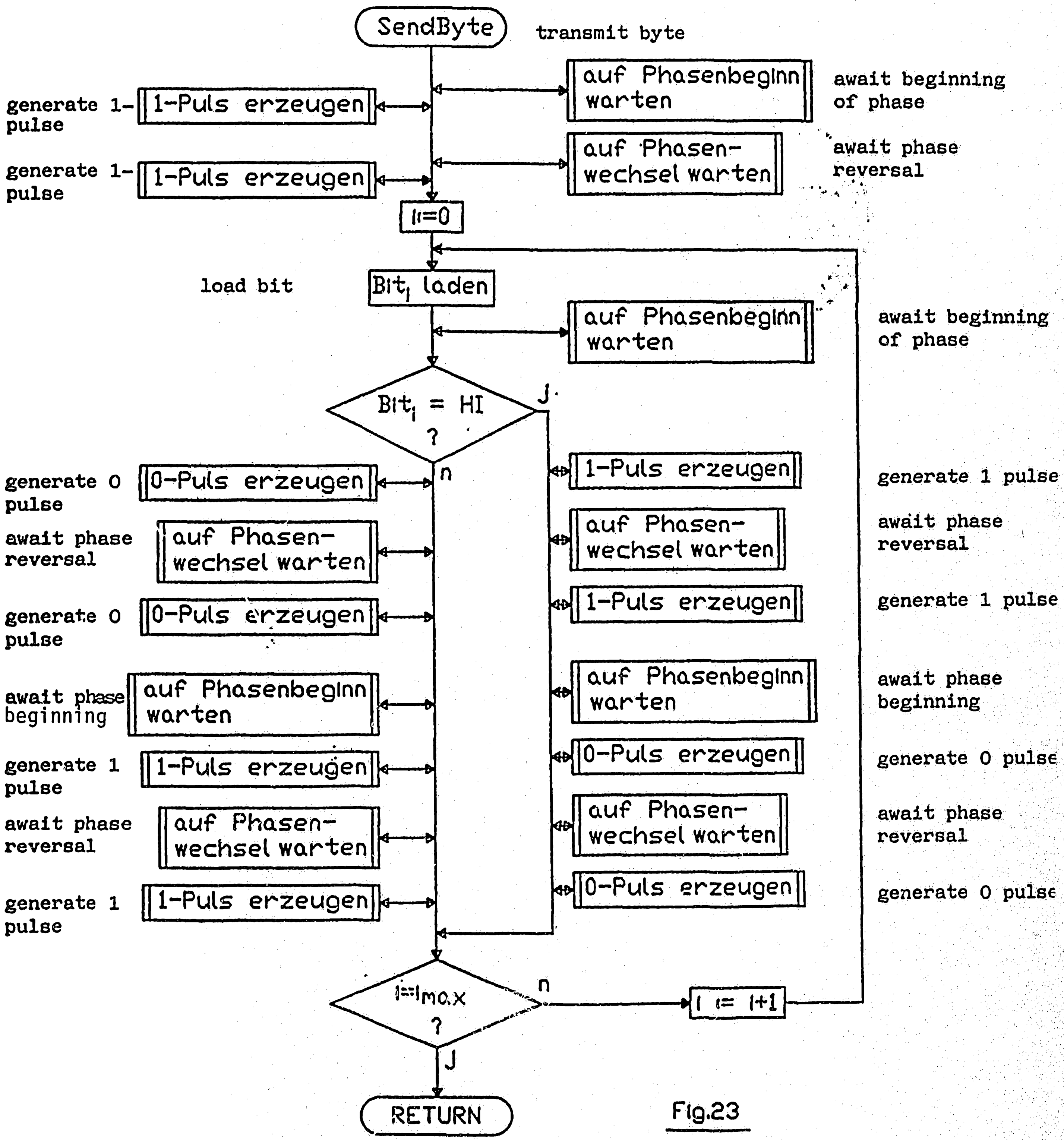


Fig.23

- End of Translation -

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 95/02439

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05B41/392 H05B41/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 046 395 (THE GENERAL ELECTRIC CO.) 24 February 1982 see page 4, line 7 - page 8, line 21; figures 1-3	1,2,6, 16,17, 21-24
A	EP,A,0 078 790 (F. WITTMANN) 11 May 1983 see page 3, line 17 - page 7, line 17; figures 1,2	1,2,10
A	EP,A,0 471 332 (DIEHL GMBH & CO) 19 February 1992 see column 4, line 33 - column 7, line 58; figures 1-6	1-3,5,6
A	EP,A,0 413 991 (TOSHIBA LIGHTING & TECHNOLOGY) 27 February 1991	

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
9 October 1995	20.10.95

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Albertsson, E

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE,A,30 09 725 (VOSSLOH-WERKE GMBH) 17 September 1981 -----	

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 95/02439

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-46395	24-02-82	GB-A,B	2082359	03-03-82
EP-A-78790	11-05-83	NONE		
EP-A-471332	19-02-92	DE-A-	4025938	20-02-92
		US-A-	5175471	29-12-92
EP-A-413991	27-02-91	JP-A-	3059995	14-03-91
		JP-B-	7066864	19-07-95
		KR-B-	9311849	21-12-93
		US-A-	5039921	13-08-91
DE-A-3009725	17-09-81	NONE		

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP 95/02439

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
IPK 6 H05B41/392 H05B41/04

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
IPK 6 H05B

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	EP,A,0 046 395 (THE GENERAL ELECTRIC CO.) 24.Februar 1982 siehe Seite 4, Zeile 7 - Seite 8, Zeile 21; Abbildungen 1-3 ---	1,2,6, 16,17, 21-24
A	EP,A,0 078 790 (F. WITTMANN) 11.Mai 1983 siehe Seite 3, Zeile 17 - Seite 7, Zeile 17; Abbildungen 1,2 ---	1,2,10
A	EP,A,0 471 332 (DIEHL GMBH & CO) 19.Februar 1992 siehe Spalte 4, Zeile 33 - Spalte 7, Zeile 58; Abbildungen 1-6 ---	1-3,5,6
A	EP,A,0 413 991 (TOSHIBA LIGHTING & TECHNOLOGY) 27.Februar 1991 --- -/--	

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

[X] Siehe Anhang Patentfamilie

* Besondere Kategorien von angegebenen Veröffentlichungen :

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"E" älteres Dokument, das jedoch erst am oder nach dem internationalen Anmeldedatum veröffentlicht worden ist

"L" Veröffentlichung, die geeignet ist, einen Prioritätsanspruch zweifelhaft erscheinen zu lassen, oder durch die das Veröffentlichungsdatum einer anderen im Recherchenbericht genannten Veröffentlichung belegt werden soll oder die aus einem anderen besonderen Grund angegeben ist (wie ausgeführt)

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"T" Spätere Veröffentlichung, die nach dem internationalen Anmeldedatum oder dem Prioritätsdatum veröffentlicht worden ist und mit der Anmeldung nicht kollidiert, sondern nur zum Verständnis des der Erfindung zugrundeliegenden Prinzips oder der ihr zugrundeliegenden Theorie angegeben ist

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"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
9.Oktober 1995	20. 10. 95

Name und Postanschrift der Internationale Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Albertsson, E

Formblatt PCT/ISA/210 (Blatt 2) (Juli 1992)

C.(Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	DE,A,30 09 725 (VOSSLOH-WERKE GMBH) 17.September 1981	

INTERNATIONALER RECHERCHENBERICHT

Angaben zu Veröffentlichungen, die zur selben Patentfamilie gehören

In. .ionales Aktenzeichen
PCT/EP 95/02439

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie		Datum der Veröffentlichung
EP-A-46395	24-02-82	GB-A,B	2082359	03-03-82
EP-A-78790	11-05-83	KEINE		
EP-A-471332	19-02-92	DE-A-	4025938	20-02-92
		US-A-	5175471	29-12-92
EP-A-413991	27-02-91	JP-A-	3059995	14-03-91
		JP-B-	7066864	19-07-95
		KR-B-	9311849	21-12-93
		US-A-	5039921	13-08-91
DE-A-3009725	17-09-81	KEINE		