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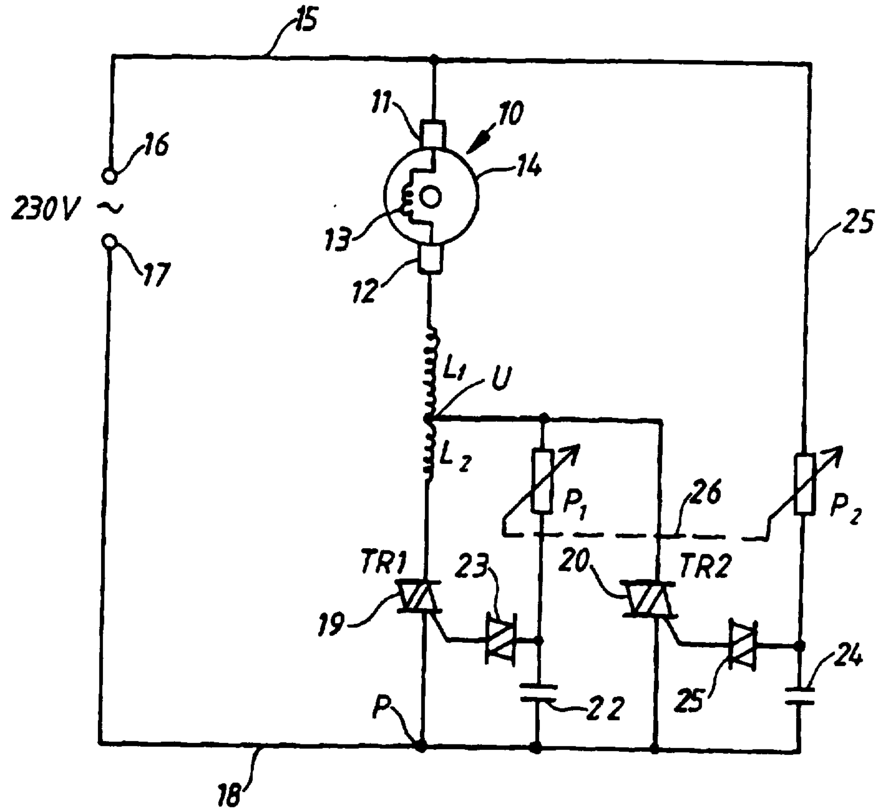
(54) Title: A DEVICE FOR CONTROL OF THE SPEED OF A SERIES MOTOR

(57) Abstract

In a device for control of the speed of a series motor (10) powered from an AC source (16, 17), the free end of the rotor winding (13) is connected to one terminal (16) of the power source and the free end of the stator winding (L1, L2) is connected to the other terminal (17) of the power source via a first two-way silicon controlled rectifier (19), and the stator winding (L1, L2) being further provided with a tap (U) connected to the other terminal (17) of the power source via a second two-way silicon controlled rectifier (20). Means (P1, 22, 23; P2, 24, 25) are provided to generate and supply first trigger pulses to the first controlled rectifier (19) and second trigger pulses to the second controlled rectifier (20), the trigger pulse generating means (P1, 22, 23; P2, 24, 25) being adapted to supply the second trigger pulses only when the first controlled rectifier (19) is fully conducting.



A device for control of the speed of a series motor

The present invention refers to a device for control of the speed of a series motor powered from an AC power source, the free end of the rotor winding being connected to one terminal of the power source and the free end of the stator winding being connected to the other terminal of the power source via a first two-way silicon controlled rectifier, and the stator winding being provided with a tap connected to the other terminal of the power source via a second two-way silicon controlled rectifier. Such device is defined in the preamble of the appending claim 1.

A device of the kind indicated is described in DE-A-3200753. In this device a control circuit is provided for the purpose of generating trigger pulses applied to the control electrodes of the respective one of the two-way silicon controlled rectifiers. By the tap provided in the stator winding the full stator winding can be used when operating the motor in a lower speed range whereas a reduced winding with a corresponding lower magnetization of the stator can be utilized for operating the motor in a higher speed range.

The described device has proved useful in avoiding problems of increased degree of harmonics in the current taken from an AC mains network when driving a series motor of the kind referred to above in a power range exceeding about 1000 watts.

The use of phase control of silicon controlled rectifiers of the type thyristor or triac may give cause to transients which in turn generate sinusoidal harmnonics. If a motor of the kind referred to is operated in a power range exceeding about 1000 watts the degree of harmonics will be unallowably high causing interference acting upon other appliances connected to the network. One way of attacking the problem is the use of filters comprising inductive or capacitive means or the use of a PWM regulator. A common feature of these solutions is that in connection with motors in vacuum cleaners, for example, with a maximum power of about 1.500 watts high costs will be involved which of course increase the overall cost of the product in an undesirable way.

The object of the invention is to provide a control device for a series motor of the kind referred to above which permits a power loading up to about 1.500 watts without any increase of the degree of harmonics in the current drawn above predetermined acceptable values. The object is achieved by a control device incorporating the features of claim 1.

the invention will now be described more in detail in connection with two embodiments with reference to the enclosed drawings, in which:

Fig. 1 shows a circuit diagram of a control device according to the invention in a first embodiment;

fig. 2 shows a circuit diagram of a control device according to the invention in a second embodiment, and

Fig. 3 is a diagram showing waveforms of the motor current and of the tap voltage, respectively, in the device according to Fig. 1. Three partial diagrams a, b and c are shown.

In Fig. 1 a series motor 10 is shown which in the usual way is provided with brushes 11, 12 and a rotor winding, schematically designated by 13, the ends of which being connectible to the respective brush 11, 12 via a commutator 14. Via a conductor 15, the brush 11 is connected to one terminal 16 of an AC source providing, for example, an AC voltage of 230 volts and the frequency 50 Hz. The opposite terminal of the AC source is designated by 17 and is connected to a common junction P in the circuit via a conductor 18.

The brush 12 in the motor is connected to one end of the stator winding formed by coils L1 and L2 between which a tap U is provided. The free end of the coil L2 is connected to the junction P via a first two-way silicon controlled rectifier 19, such as a triac. The tap U is connected to the junction P via a second silicon controlled rectifier 20 of the type triac. Without any change in function the motor can be provided with a split stator winding in which one half of the winding, corresponding to the winding L1, L2, is provided between the brush 11 and the conductor 15. This winding half has no tap.

A first trigger circuit for the triac 19 comprises a potentiometer P1 connected to the junction P via a capacitor 22. The junction between the potentiometer P1 and the capacitor

22 is connected to the control electrode of the triac 19 via a trigger component 23 of the type DIAC.

A second trigger ciruit for the triac 20 is formed by a potentiometer P2 connected to the junction P via a capacitor 24. The opposite end of the potentiometer P2 is connected to the terminal 16 of the AC source via a conductor 25 and the conductor 15. The junction between the potentiometer P2 and the capacitor 24 is connected to the the control electrode of the triac 20 via a trigger component 25 of the type DIAC. The two potentiometers P1 and P2 are mechanically interconnected for reasons to appear in the following. The interconnection has been indicated by a dashed line 26.

The function of the device according to Fig. 1 will now be described with reference also to the diagram of Fig. 3. In a lower power range,for example up to about 1000 watts, the triac 19 is used for controlling the speed of the motor 10 to a desired level. Due to the phase control used, up to that power level the corresponding current draw will not cause harmonics of a rate exceeding acceptable values.

The triac 19 with associated trigger circuit, comprising the potentiometer P1, the capacitor 22 and the DIAC 23, functions in the conventional way and, as appears from Fig. 3a, the trigger circuit emits a trigger signal at the desired time t1, determined by the setting of the potentiometer 19, and the triac 19 starts to conduct. Then, the triac continues to conduct for the rest of the half period. During a following negative half period the course is similar.

When the motor is to be driven in a higher speed range corresponding to power levels up to maximum power the phenomenon is used according to which a lower magnetization in the motor makes it possible for the motor to operate at higher speed. The driving of the motor is then controlled by the triac 20 via the tap U and coil L2 is disconnected. The prerequisite for this to happen without problems is that before the triac 20 can start conducting triac 19 is fully conducting, i.e. has been conducting from the beginning of the half period. To that end the potentiometers can be ganged, i.e. they can be arranged on the same shaft and in such a way that before P2 is allowed to leave its zero position, or position with the maximum resistance, potentiometer P1 has taken a position of minimum resistance. This state is shown in Fig. 3b which illustrates how triac 19 conducts right from the beginning of the half period to the point t2 where P2 is operated so that trigger pulses are emitted to the triac 20 causing the latter to conduct. As is apparent, the current increases in a step from a value I1 to a higher value I2 and then follows a higher curve I´up to the end of the half period. In Fig. 3c the tap voltage U is shown which is also the voltage across the conducting triac 19. The voltage goes negative at the time t2 when triac 20 starts conducting thereby turning off triac 19. This is important for the desired function to be obtained. If triac 19 should continue conducting heat problems may occur in coil L1.

Fig. 2 illustrates an alternative embodiment of the invention in which the simple trigger circuits of Fig. 1 have been replaced by an integrated electronic control circuit 27 of a common type. As in Fig. 1 the motor is controlled by triacs 19, 20 and same reference numerals as in Fig. 1 have been used to designate identical parts. The control circuit has an output TR1 connected to the control electrode of the triac 19 via a conductor 28. Moreover, the control circuit has an output TR2 connected to the control electrode of the triac 20 via a conductor 29. An input IN of the control circuit 27 has a voltage or current applied which can be varied by means of a potentiometer P3 for the purpose of setting the desired speed within the full speed range of the motor. The potentiometer P3 can be replaced by another setting means, such as a pressure sensitive device (vacuum box) for automatic setting and control of the desired speed. Alternatively, the setting means can apply at the input IN a digital signal containing information on the desired speed. A terminal A on the control circuit 27 is connected to the junction P.

The function of the embodiment according to the invention shown in Fig. 2 is similar to that of the embodiment of Fig. 1. However, same conditions apply as before in that triac 19 has to be fully conducting before triac 20 can start conducting. This condition can be put in the control circuit 27 so that, for example, trigger pulses are emitted on the output TR2 only if the setting means (P3) has been set for a speed higher than that for which the trigger pulses on the first output (TR1) causes the first two-way silicon controlled rectifier (19) to be fully conducting. The control circuit can be a microcomputer and the control parameters can be programmed in a known way.

C l a i m s

1. A device for control of the speed of a series motor (10) powered from an AC source (16,17), the free end of the rotor winding (13) being connected to one terminal (16) of the power source and the free end of the stator winding (L1,L2) being connected to the other terminal (17) of the power source via a first two-way silicon controlled rectifier (19), and the stator winding (L1,L2) being further provided with a tap (U) connected to the other terminal (17) of the power source via a second two-way silicon controlled rectifier (20), **characterized** in that means (P1,22,23;P2,24,25) are provided to generate and supply first trigger pulses to the first controlled rectifier (19) and second trigger pulses to the second controlled rectifier (20), the trigger pulse generating means (P1,22,23;P2,24,25) being adapted to supply the second trigger pulses only when the first controlled rectifier (19) is fully conducting.

2. A device according to claim 1, **characterized** in that the trigger pulse generating means (P1,22,23;P2,24,25) comprise a first trigger circuit with a first potentiometer (P1) for the first silicon controlled rectifier (19) and a second trigger circuit with a second potentiometer (P2) for the second silicon controlled rectifier (20), the first potentiometer (P1) being supplied with an AC voltage from the tap (U) of the stator winding (L1,L2) while the second potentiometer (P2) is supplied from the first terminal (16) of the AC source, the two potentiometers (P1,P2) being mechanically interconnected (20) or otherwise mutually controlled so that a change in resistance of the second potentiometer (P2) towards values causing an increase of the speed of the motor takes effect only when the first potentiometer (P1) is in a position in which the first silicon controlled rectifier (19) is fully conducting.

3. A device according to claim 2, **characterized** in that the first and second trigger circuits each consists of a series circuit comprising the respective potentiometer (P1;P2) and a capacitor (22;24) the opposite end of the latter being connected to the second terminal (17) of the AC source, the junction between the potentiometer (P1;P2) and the capacitor (22;24)

being connected to the control electrode of the respective silicon controlled rectifier (19;20) via a DIAC (23;25).

4. A device according to claim 1, **characterized** in that the trigger pulse generating means comprise an integrated control circuit (27) including a setting member (P3) for setting of the motor speed over the full speed range by supplying to an input (IN) of a suitable voltage, current, digital signal or the like, said control circuit having a first output terminal (TR1) adapted to emit trigger pulses to the first two-way silicon controlled rectifier (19) and a second output (TR2) adapted to emit trigger pulses to the second two-way silicon controlled rectifier (20), trigger pulses being emitted on the second output (TR2) only when the setting member (P3) have been set for providing trigger pulses on the first output (TR1) causing the first two-way silicon controlled rectifier (19) to fully conduct.

5. A device according to claim 4, **characterized** in that the setting member (P3) is a potentiometer adapted to apply to the input (IN) of the control circuit (27) a current or voltage corresponding to the desired speed.

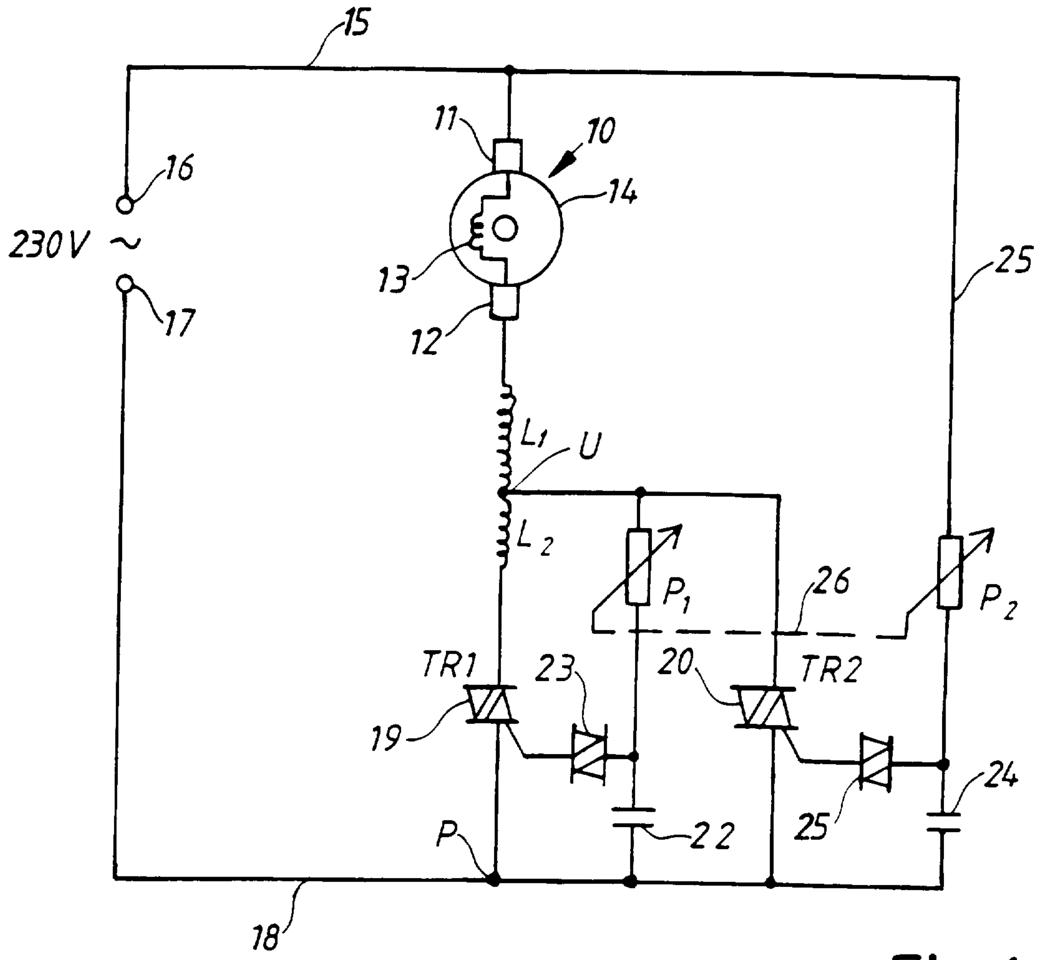

15
16
230V ~
17
11
10
14
13
12
25
L1
U
L2
P1
26
P2
TR1
23
20
TR2
19
24
P
22
25
18

Fig.1

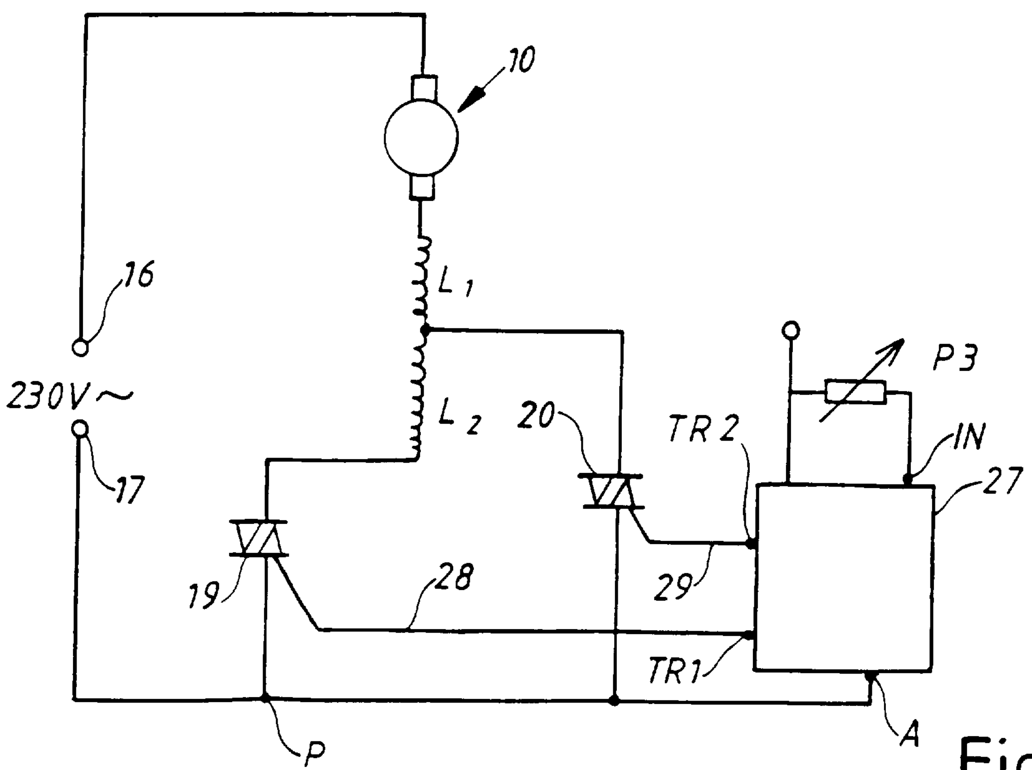

10
16
L1
230V~
17
L2
20
P3
TR 2
IN
27
19
28
29
TR1
P
A

Fig. 2

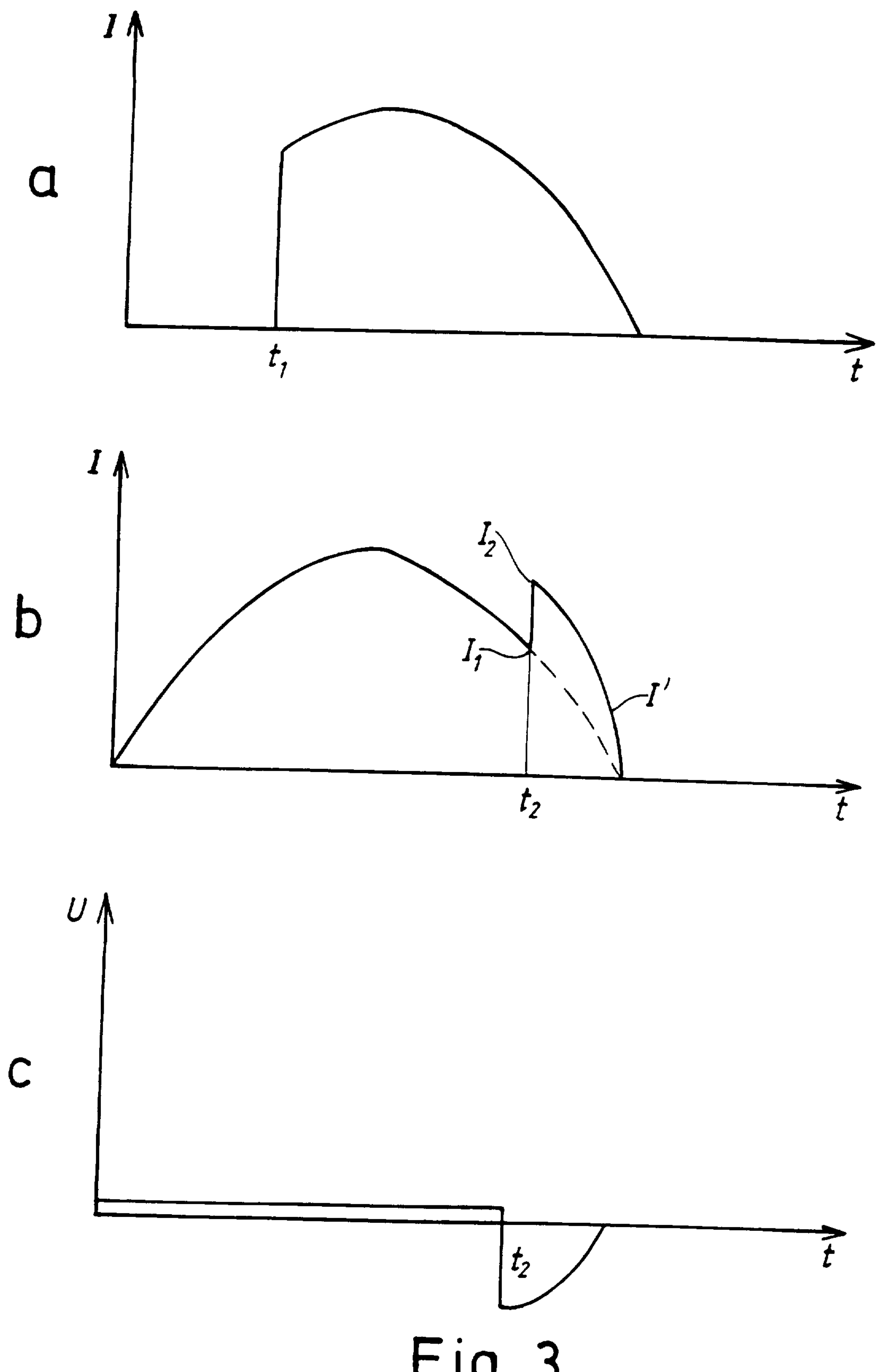


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 96/00055

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H02P 7/638
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)

IPC6: H02P

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

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, 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	DE 3200753 C2 (AKO-WERKE GMBH), 21 July 1983 (21.07.83), column 1, line 64 - column 2, line 46 --	1
A	DE 3728609 A1 (LICENTIA PATENT-VERWALTUNGS-GMBH), 9 March 1989 (09.03.89), column 3, line 6 - line 54 --	1
A	GB 2270428 A (TAI-HER YANG), 9 March 1994 (09.03.94), page 3, line 26 - page 4, line 30 --	1
A	DE 2365898 A1 (SIEMENS AG), 16 December 1976 (16.12.76), page 2, line 16 - line 35 -- --------	1

☐ Further documents are listed in the continuation of Box C. ☒ See patent family 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" erlier document but published on or after the international filing date
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"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
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"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

Date of the actual completion of the international search	Date of mailing of the international search report
23 April 1996	30 -04- 1996
Name and mailing address of the ISA Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Peter Jacobsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

01/04/96

International application No.
PCT/SE 96/00055

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
DE-C2-	3200753	21/07/83	NONE		
DE-A1-	3728609	09/03/89	FR-A,B-	2620877	24/03/89
GB-A-	2270428	09/03/94	NONE		
DE-A1-	2365898	16/12/76	DE-A-	2358803	05/06/75