AU9343230

(12) PATENT ABRIDGMENT (11) Document No. AU-B-43230/93
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 677007

(54) Title
PROCESS FOR DRIVING ELECTRIC, CURRENT-CONTROLLED ACTUATORS

International Patent Classification(s)
(51)[5] **G05B 019/40**

(21) Application No. : **43230/93** (22) Application Date : **04.06.93**

(87) PCT Publication Number : **WO93/25946**

(30) Priority Data

(31) Number	(32) Date	(33) Country
4218782	**06.06.92**	**DE GERMANY**

(43) Publication Date : **04.01.94**

(44) Publication Date of Accepted Application : **10.04.97**

(71) Applicant(s)
ZF FRIEDRICHSHAFEN AG

(72) Inventor(s)
HANS-JURGEN EGE; GUNTHER HORSAK; PETER WIGGERMANN

(74) Attorney or Agent
LORD & COMPANY , 4 Douro Place, WEST PERTH WA 6005

(56) Prior Art Documents
DE 3931962
EP 294918

(57) Claim

1. Process for operating electric, current-controlled actuators (5), utilising a microprocessor (1) with a storage facility, which stores process related data, maps and sequential programs, with inputs (2,3), to which input signals are applied, which are processed into current set point values for output to a set of actuators (5) by the microprocessor (1) according to a logical process using the process related data, maps and sequential programs, characterised by the fact that the current of the individual actuators (5) is measured and that the current signal is applied to the inputs (3) of the microprocessor (1), that when an input signal is not changing, during which time no input signals are present at the inputs (2) of the microprocessor (1) that are intended to cause a position adjustment of the actuators (5), the microprocessor (1), based on a standardised modulation program, issues set point values for the individual actuators (5) that are lower than the response threshold of the process, that the microprocessor (1), using the electrical current changes which result from the modulation and which allow the output

.../2

signal to be modified with respect to the presence of interference signals, determines a compensation value and stores the compensation value temporarily, and that the compensation value stored last is used to determine a manipulated variable, as soon as an operating signal is present at an input (2).

OPI DATE 04/01/94 APPLN. ID 43230/93
AOJP DATE 24/03/94 PCT NUMBER PCT/EP93/01421

AU9343230

(51) Internationale Patentklassifikation 5 :
G05B 19/40

A1

(11) Internationale Veröffentlichungsnummer: WO 93/25946

(43) Internationales Veröffentlichungsdatum: 23. Dezember 1993 (23.12.93)

(21) Internationales Aktenzeichen: PCT/EP93/01421

(22) Internationales Anmeldedatum: 4. Juni 1993 (04.06.93)

(30) Prioritätsdaten:
P 42 18 782.6 6. Juni 1992 (06.06.92) DE

(71) Anmelder *(für alle Bestimmungsstaaten ausser US)*: ZF FRIEDRICHSHAFEN AG [DE/DE]; Löwentaler Straße 100, Postfach 25 20, D-7990 Friedrichshafen 1 (DE).

(72) Erfinder; und
(75) Erfinder/Anmelder *(nur für US)* : EGE, Hans-Jürgen [DE/DE]; Weidenstraße 4, D-7980 Ravensburg (DE). HORSAK, Günther [DE/DE]; Pfannenstiel 4, D-7990 Friedrichshafen (DE). WIGGERMANN, Peter [DE/DE]; Dorfstraße 12, D-7994 Langenargen (DE).

(74) Gemeinsamer Vertreter: ZF FRIEDRICHSHAFEN AG; Postfach 25 20, Löwentaler Straße 100, D-7990 Friedrichshafen 1 (DE).

(81) Bestimmungsstaaten: AU, JP, KR, US, europäisches Patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Veröffentlicht
Mit internationalem Recherchenbericht.

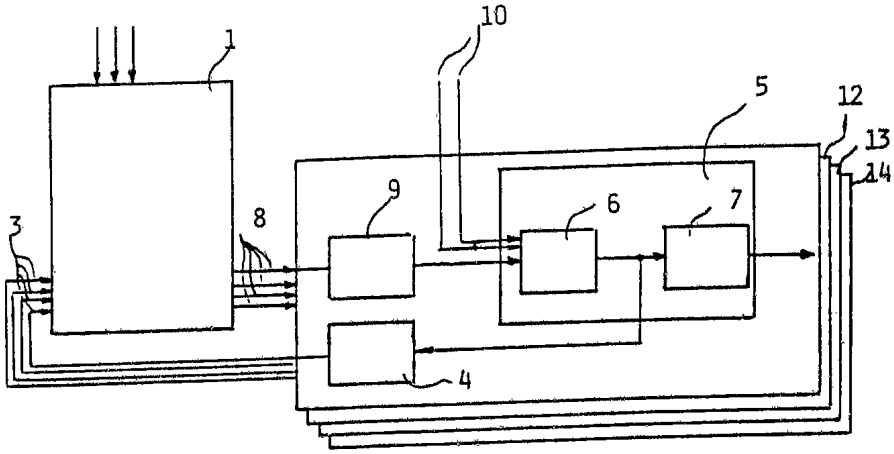
677007

(54) Title: PROCESS FOR DRIVING ELECTRIC, CURRENT-CONTROLLED ACTUATORS

(54) Bezeichnung: VERFAHREN ZUM ANSTEUERN VON ELEKTRISCHEN, STROMGESTEUERTEN STELLGLIEDERN

(57) Abstract

A process has an open-loop which detects the total current intensity of actuators and supplies it to a microprocessor (1). In a modulation mode, the microprocessor successively generates at its output modulated set value signals for each actuator. The set value signals lie below the response level of the process. The microprocessor then determines compensating values from the total current signal with which the set values of the actuators are corrected. The (regulating) speed of a control is thus combined with the accuracy of a regulation, and the hardware expenditure (costs) is minimized thanks to the total current detection instead of individual current detection.



(57) Zusammenfassung

Das Verfahren beinhaltet einen offenen Regelkreis, bei dem die Summenstromstärke von Stellgliedern erfaßt und einem Mikroprozessor (1) zugeführt wird. Dieser erzeugt in einem Modulationsmodus an seinen Ausgängen nacheinander für jedes Stellglied modulierte Sollwertsignale für die Stellglieder, wobei die Sollwertsignale unterhalb der Ansprechschwelle des Prozesses liegen. Aus dem Summenstrom-Signal ermittelt nun der Mikroprozessor Kompensationswerte, mit den die Sollwerte der Stellglieder korrigiert werden. Die (Stell-)Geschwindigkeit einer Steuerung wird mit der Genauigkeit einer Regelung kombiniert. Durch Summenstrom- statt Einzelstrom-Erfassung wird der Hardware-Aufwand (Kosten) minimiert.

Process for operating electric, current-controlled actuators

The invention describes a process for operating electric, current-controlled actuators in accordance with the main claim. An increasing number of electric, current-controlled actuators, such as proportional control valves, whose current is controlled as a function of process-related parameters in open or closed control loops, are used in vehicle engineering. Control loops of this kind are commonly known, for example from VDI-Nachrichten *[Verein Deutscher Ingenieure* (Association of German Engineers) - *News]* No. 38, 8 September 1981, page 16; or VDI-Berichte (VDI-Reports) No. 418, 1981, page 186; or Automotive Engineering, 1984, page 79.

In closed-loop control systems, a microprocessor is used to process those parameters that are intended to cause a movement of the actuators; the set point value for the current is determined from those parameters and is provided as an output which is then compared with the actual current value of the actuator. The manipulated variable is increased or decreased in accordance with the difference between the set point and the actual value. In order to determine the current value on each actuator, a current measurement facility for each actuator is required. Furthermore, a relatively powerful microprocessor is necessary to process the data. The time constant of such closed-loop control systems depends mainly on the power of the microprocessor used.

AUSTRALIAN PATENT OFFICE

Control systems in which the actual current value is not measured and compared with the set point operate faster. However, those types of control systems are usually not accurate enough, since they do not give sufficient consideration to the interference signals that influence the process-related parameters and actuators. Known solutions measure the most important interference signals separately and compensate for their influence by means of suitable programs. This becomes very expensive, however, if a large number of interference signals and actuators need to be covered. An additional factor is that not all interference signals can be measured directly.

It is the task of the invention to create a process for operating electric, current-controlled actuators that provides fast and accurate control of the actuators.

In accordance with the present invention there is provided a process for operating electric, current-controlled actuators, utilising a microprocessor with a storage facility, which stores process related data, maps and sequential programs, with inputs, to which input signals are applied, which are processed into current set point values for output to a set of actuators by the microprocessor according to a logical process using the process related data, maps and sequential programs, characterised by the fact that the current of the individual actuators is measured and that the current signal is applied to the inputs of the microprocessor, that when an input signal is not changing, during which time no input signals are present at the inputs of the microprocessor that are intended to cause a position adjustment of the actuators, the microprocessor, based on a standardised modulation program, issues set point values for the individual actuators that are lower than the response threshold of the process, that the microprocessor, using the electrical current changes which result from the modulation and which allow the output signal to be modified with respect to the presence of interference signals, determines a compensation value and stores the compensation value temporarily, and that the compensation value stored last is used to determine a manipulated variable, as soon as an operating signal is present at an input.

The invented process is an open-loop control process, in which the current set points of the individual actuators are determined and output in the commonly used way in dependence of the process-related parameters by means of a microprocessor. The interference signals, however, are not measured individually but only in their combined effect on the current to the actuators. For this purpose, the intermediate time periods, during which no operating signals from parameters are applied at the microprocessor inputs, is used to activate a program for determining the correction variables (modulation program) which produces output signals for each individual actuator (modulation) in sequence, at a level that lies below the response threshold of the process. The actuator current is measured simultaneously, and compensation values are determined from the current signals and stored temporarily. As soon as process-relevant operating signals are present at the microprocessor input, they are processed together with the compensation values stored last to produce and output the set point values for the individual actuators.

The expenditure for such a process is particularly small if, according to one embodiment of the invention, a single current-measuring facility is used to measure the total current of a number of, or of all, actuators, and if the microprocessor, in its modulation mode, produces the modulation outputs consecutively for the individual actuators. Since at the same time during the modulation program only the set point for one actuator is modulated and the set point values for the remaining actuators remain constant, conclusions can be drawn from the total current signal at different times as to the influence of the interference signals on the individual actuators.

The invention is explained by means of the diagram. Shown are in:

Fig. 1 an embodiment using a number of current-measuring facilities;

Fig. 2 an embodiment using a single current-measuring facility to determine the total current value.

AUSTRALIAN PATENT

A microprocessor, designated with 1, comprises memory for process-related data, characteristics families and sequencing programs as well as inputs for 2 process-related parameters, which are intended to cause a position adjustment of the actuators. In the following description, the signals are called operating signals. In addition, inputs 3 are provided for current signals that are produced by current-measuring facilities 4. They measure the current value of electric, current-controlled actuators, in this particular case electromagnetic proportional control valves 5, which have an electrical part 6 and a magnetic-hydraulic part 7.

In dependence of the operating signals, the microprocessor 1 determines the current set point values of the electrical parts 6 of the proportional valves 5 by using the stored data and programs. During this process, the set points are corrected by compensation values, which the microprocessor 1 has determined and placed in short-term memory. The set point signals are present at the outputs 8 of the microprocessor 1 and cause, via a power output stage 9, a corresponding current in the electric parts 6 of the proportional control valves 5.

Of several actuators and proportional control valves 5, only one each is depicted; others (in the example three) are suggested by the layered diagrammatic circuits 12 to 14.

Interference signals 10, for example, the supply voltage, temperature, etc., affect the control process. The interference signals 10 influence the current value in the electrical part 6 of the proportional control valves 5. In order to determine the value of this influence and to process it into compensation values, a modulation program is activated during those times, in which no operating signals are present at the inputs 2, thus causing at the outputs 8 the issuing of modulated set point signals for the individual proportional control valves 5, at a signal level below the response threshold of the process. The current signals determined from those set point values can be used to deduct the overall influence of the interference signals and to determine a corresponding compensation value. If operating signals are present at the inputs 2, the modulation process is terminated and the compensation values stored last are used to form the new set point values.

The embodiment according to Fig. 2 is differentiated from the embodiment shown in Fig. 1 only in that it provides, instead of one current-measuring facility 4 for each proportional control valve 5, a single current-measuring facility 11 which measures the total current of all (in the example four) proportional control valves 5 and supplies it to the microprocessor 1. In modulation mode, this processor modulates the set point values separately and consecutively for each proportional control valve and thus determines from the total current the compensation values for the individual proportional control valves 5.

AUSTRALIAN PATENT

Legend

1	Microprocessor
2	Input
3	Input
4	Current-measuring facility
5	Proportional control valve
6	Electrical part
7	Magnetic-hydraulic part
8	Output
9	Power output stage
10	Interference signals
11	Current-measuring facility
12	Diagrammatic circuit
13	Diagrammatic circuit
14	Diagrammatic circuit

AUSTRALIAN PATENT OFFICE

The claims defining the invention are as follows:

1. Process for operating electric, current-controlled actuators (5), utilising a microprocessor (1) with a storage facility, which stores process related data, maps and sequential programs, with inputs (2,3), to which input signals are applied, which are processed into current set point values for output to a set of actuators (5) by the microprocessor (1) according to a logical process using the process related data, maps and sequential programs, characterised by the fact that the current of the individual actuators (5) is measured and that the current signal is applied to the inputs (3) of the microprocessor (1), that when an input signal is not changing, during which time no input signals are present at the inputs (2) of the microprocessor (1) that are intended to cause a position adjustment of the actuators (5), the microprocessor (1), based on a standardised modulation program, issues set point values for the individual actuators (5) that are lower than the response threshold of the process, that the microprocessor (1), using the electrical current changes which result from the modulation and which allow the output signal to be modified with respect to the presence of interference signals, determines a compensation value and stores the compensation value temporarily, and that the compensation value stored last is used to determine a manipulated variable, as soon as an operating signal is present at an input (2).

2. Process according to claim 1, characterised by the fact that the total current of several or of all actuators (5) is measured by a single current-measuring facility (11) and that the microprocessor (1) determines in its modulation mode the compensation values consecutively for the individual actuators (5); the manipulated variables for the individual actuators being corrected individually with the corresponding compensation values.

3. Process for operating electric, current controlled actuators substantially as hereinbefore described with reference to figure 1 and figure 2 of the accompanying drawings.

DATED THIS 5TH DAY OF FEBRUARY 1997

ZF FRIEDRICHSHAFEN AG
By their Patent Attorneys
LORD & COMPANY
PERTH, WESTERN AUSTRALIA

Summary

Process for operating electric, current-controlled actuators

The process comprises an open-loop control circuit in which the total current of the actuators is determined and made available as an input to a microprocessor. In modulation mode, this processor produces at its outputs modulated set point signals for each actuator in sequence, whereby the set point signal levels are below the response threshold of the process. From the total current signal, the microprocessor determines compensation values with which the set point values of the actuators are corrected.

The (regulating) speed of an (open-loop) control system is thus combined with the accuracy of a [closed-loop] control system.

The hardware expenditure (cost) is minimised as a result of measuring the total current instead of measuring each individual current.

43230/43

FIG. 1

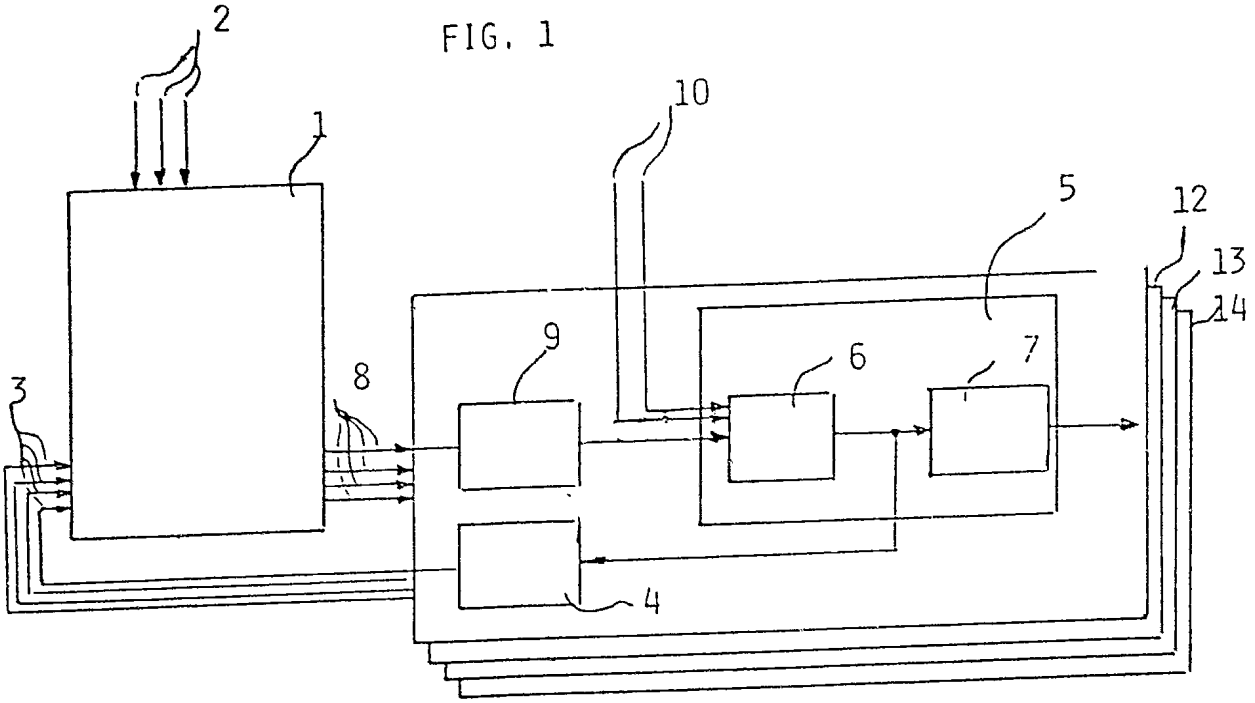
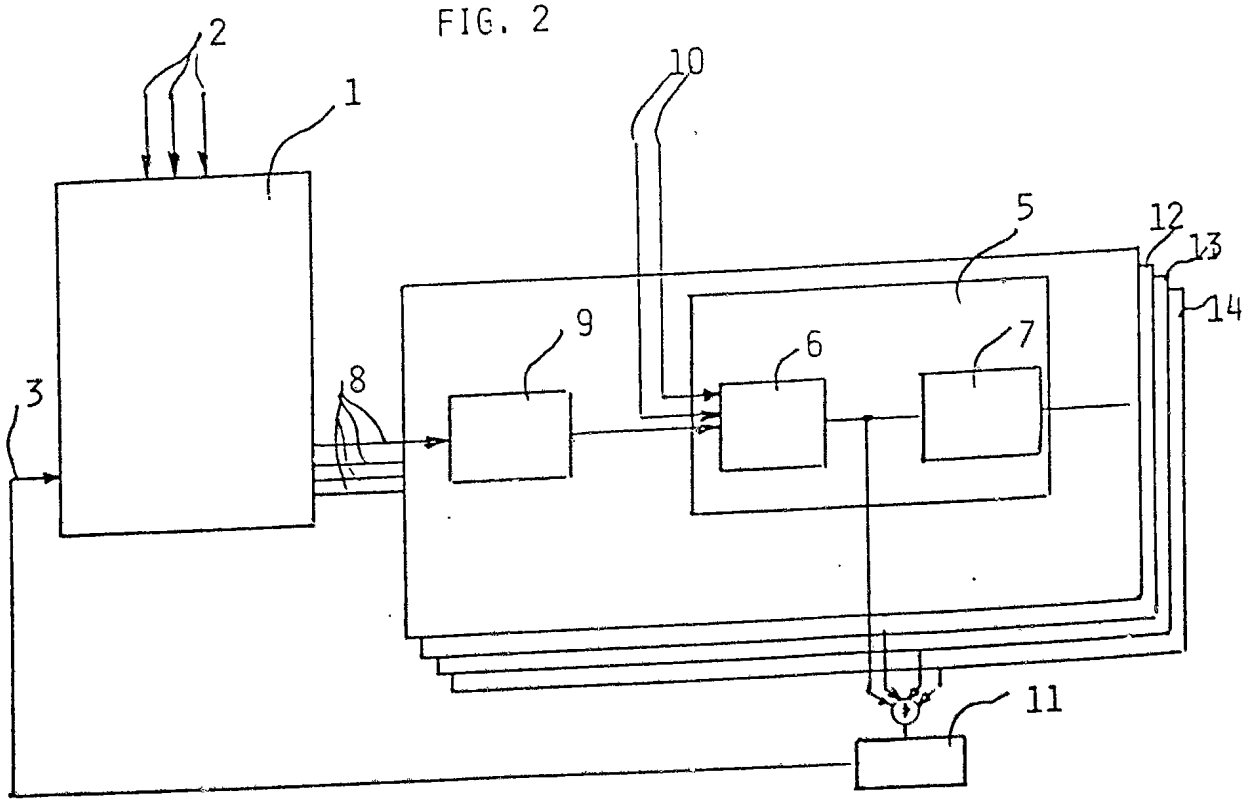


FIG. 2



ZF 6539

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP 93/01421

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl.5 G05B19/40

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)

Int.Cl.5 G05B; G05D

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 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, A, 3 931 962 (MANNESMANN REXROTH) 4 April 1991 see column 4, line 36-column 5, line 68 ---	1
A	EP, A, 0 294 918 (THE BABCOCK AND WILCOX COMPANY) 14 December 1988 see page 3, line 19-line 52 ---	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" 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

"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
16 September 1993 (16.09.93)	30 September 1993 (30.09.93)
Name and mailing address of the ISA/ EUROPEAN PATENT OFFICE **Facsimile No.**	**Authorized officer** **Telephone No**

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

EP 9301421
SA 74963

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 16/09/93

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A-3931962	04-04-91	JP-A- 3149602	26-06-91
		US-A- 5179330	12-01-93
EP-A-0294918	14-12-88	AU-B- 593722	15-02-90
		AU-A- 1284588	15-12-88
		JP-A- 63317812	26-12-88

INTERNATIONALER RECHERCHENBERICHT

PCT/EP 93/01421

Internationales Aktenzeichen

I. KLASSIFIKATION DES ANMELDUNGSGEGENSTANDS (bei mehreren Klassifikationssymbolen sind alle anzugeben)[6]

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

Int.Kl. 5 G05B19/40

II. RECHERCHIERTE SACHGEBIETE

Recherchierter Mindestprüfstoff [7]

Klassifikationssytem	Klassifikationssymbole
Int.Kl. 5	G05B ; G05D

Recherchierte nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Sachgebiete fallen [8]

III. EINSCHLAGIGE VEROFFENTLICHUNGEN [9]

Art.°	Kennzeichnung der Veröffentlichung [11], soweit erforderlich unter Angabe der maßgeblichen Teile [12]	Betr. Anspruch Nr.[13]
A	DE,A,3 931 962 (MANNESMANN REXROTH) 4. April 1991 siehe Spalte 4, Zeile 36 - Spalte 5, Zeile 68 ---	1
A	EP,A,0 294 918 (THE BABCOCK AND WILCOX COMPANY) 14. Dezember 1988 siehe Seite 3, Zeile 19 - Zeile 52 -----	1

° Besondere Kategorien von angegebenen Veröffentlichungen [10] :

"A" Veröffentlichung, die den allgemeinen Stand der Technik definiert, aber nicht als besonders bedeutsam anzusehen ist

"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)

"O" Veröffentlichung, die sich auf eine mündliche Offenbarung, eine Benutzung, eine Ausstellung oder andere Maßnahmen bezieht

"P" Veröffentlichung, die vor dem internationalen Anmeldedatum, aber nach dem beanspruchten Prioritätsdatum veröffentlicht worden ist

"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

"X" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als neu oder auf erfinderischer Tätigkeit beruhend betrachtet werden

"Y" Veröffentlichung von besonderer Bedeutung; die beanspruchte Erfindung kann nicht als auf erfinderischer Tätigkeit beruhend betrachtet werden, wenn die Veröffentlichung mit einer oder mehreren anderen Veröffentlichungen dieser Kategorie in Verbindung gebracht wird und diese Verbindung für einen Fachmann naheliegend ist

"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

IV. BESCHEINIGUNG

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
16.SEPTEMBER 1993	30.09.93
Internationale Recherchenbehörde	**Unterschrift des bevollmächtigten Bediensteten**
EUROPAISCHES PATENTAMT	KELPERIS K.

ANHANG ZUM INTERNATIONALEN RECHERCHENBERICHT ÜBER DIE INTERNATIONALE PATENTANMELDUNG NR.

EP 9301421
SA 74963

In diesem Anhang sind die Mitglieder der Patentfamilien der im obengenannten internationalen Recherchenbericht angeführten Patentdokumente angegeben.
Die Angaben über die Familienmitglieder entsprechen dem Stand der Datei des Europäischen Patentamts am 16/09/93
Diese Angaben dienen nur zur Unterrichtung und erfolgen ohne Gewähr.

Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie		Datum der Veröffentlichung
DE-A-3931962	04-04-91	JP-A-	3149602	26-06-91
		US-A-	5179330	12-01-93
EP-A-0294918	14-12-88	AU-B-	593722	15-02-90
		AU-A-	1284588	15-12-88
		JP-A-	63317812	26-12-88

EPO FORM P0473