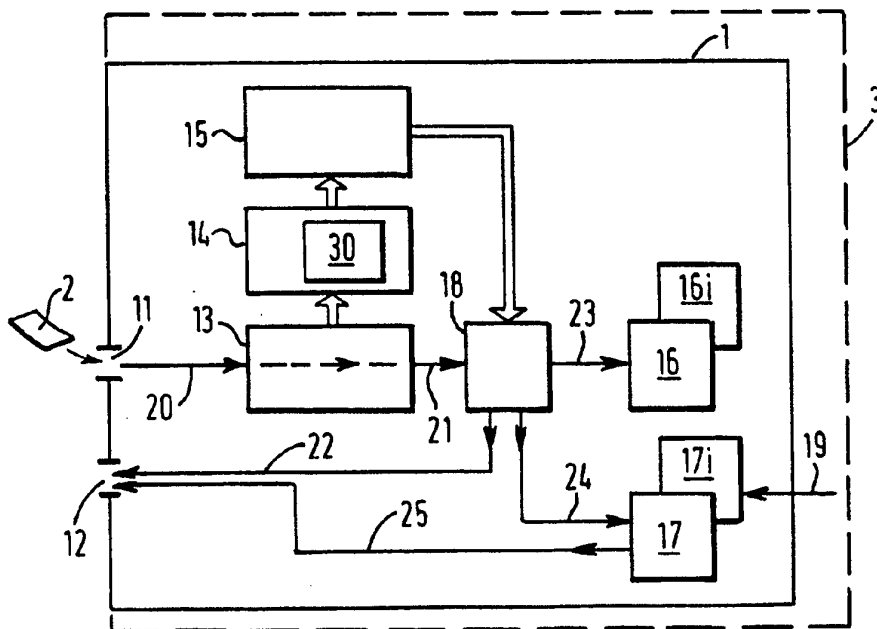




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<p>(21) International Application Number: PCT/IB94/00184 (22) International Filing Date: 28 June 1994 (28.06.94) (30) Priority Data: 9313317.1 28 June 1993 (28.06.93) GB (71) Applicant (for all designated States except US): MARS, INCORPORATED [US/US]; 6885 Elm Street, McLean, VA 22101-3883 (US). (72) Inventor; and (75) Inventor/Applicant (for US only): WACHTER, Arnold, Walter [CH/CH]; Avenue Ste-Cécile, 11, CH-1217 Meyrin (CH). (74) Agent: BURKE, Steven, D.; R.G.C. Jenkins & Co., 26 Caxton Street, London SW1H 0RJ (GB).</p>		<p>(81) Designated States: JP, KR, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>

(54) Title: VALIDATING VALUE CARRIERS



(57) Abstract

The method of checking the acceptability of value carriers (2) in automatic machines (3) that both accept and return such value carriers consists of carrying out the check according to two acceptance criteria. The first defines the conditions for the acceptance of a value carrier; the second, more rigorous, criterion defines the conditions for the re-use of a value carrier. The device (1) for carrying out the method includes a measuring unit (13), a decision unit (14) and a control unit (15). The value carriers that are not to be re-used are conveyed by transport means (21, 23) to one-way stores (16); those that are available to be re-used are conveyed by transport means (21, 24) to two-way stores (17). The value carriers that are not accepted are transported directly back to the dispensing opening (12).

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VALIDATING VALUE CARRIERS

The invention relates to a method and apparatus for validating value carriers, such as banknotes, coins or tokens.

5 The method of the present invention can be applied where value carriers are to be accepted from one person by an automatic machine, such as an automatic teller machine or a vending machine, and passed on to another person. In the following, the
10 description is restricted to use with banknotes, that is to say, where automatic machines accept banknotes in payment and dispense accepted banknotes as money returned, for example, either as change in vending machines or payphones or as banknotes of lower
15 denomination or of a different currency in banknote-changing machines. Thus "dispensing" as used in this specification is intended to be construed accordingly, as opposed to the return of a value carrier which is deemed by a machine not to be valid. Furthermore, the
20 term "valid" could, for example, imply that a credit value is established or incremented in respect of the value carrier presented.

Automatic machines that allow banknotes that have been paid in to be re-used, that is to say put into
25 circulation again as dispensed money, are already

known, for example, from U.S. Patent 5,076,441. In such automatic machines, the "acceptability", that is, for example, the authenticity, and frequently, in addition, the general condition of the banknotes offered to the automatic machine are also checked. This is done by comparing one or more measurements that can be made of the banknote with corresponding given reference values or tolerance ranges which are normally stored in the automatic machine. The choice of parameters which are measured depends primarily upon the recognition characteristics existing on the banknote. A pre-requisite for this, of course, is that "acceptable" and non-"acceptable" notes can be statistically differentiated by measuring techniques, that is to say that at least the expected values of the measured parameters are different.

If the measurement or measurements of a banknote do not fall within the given tolerance ranges, it is concluded that the banknote is not acceptable, that is to say either is not genuine or is not in a good condition. It is therefore rejected by the automatic machine. Conversely, if the measurement or measurements lie within the tolerance ranges, it is concluded that the banknote is acceptable, that is to say is genuine and in a good condition. It is therefore accepted by the automatic machine in payment

for a return service, is stored and is available for re-use, if required, in the form of dispensed money. Such a checking method is subject to two opposing requirements: on the one hand, when checking whether
5 the banknote offered for payment is acceptable, the risk of a "good" banknote being rejected is to be restricted to a minimum. This is achieved, in an automatic machine that is in itself adjusted correctly, fundamentally by making the acceptance
10 criterion broader. On the other hand, the accepted banknote which is available to the automatic machine as money for change purposes is, with the greatest possible reliability, to be actually "acceptable", that is to say genuine and in a good condition.
15 Although the percentage of "bad" banknotes accepted with a given acceptance criterion naturally depends upon how the "bad" banknotes differ from the "good", it is nevertheless clear that making the acceptance criterion broader basically increases the probability
20 of a "bad" banknote being accepted by the automatic machine. The second requirement, therefore, corresponds to the opposite requirement that the acceptance criterion be made narrower.

In practice, therefore, a compromise is made in
25 which the tolerance value or values are chosen such that both the probability of an acceptable banknote

being rejected and the probability of a non-acceptable banknote being re-used are kept within limits. In known automatic machines, an acceptance rate of, for example, 95-99 % is chosen, that is to say 95-99 % of all "good" banknotes checked by the automatic machine are accepted. Thus, the probability of a "bad" banknote being accepted and subsequently re-used can normally be kept sufficiently small, such as below 1%.

In accordance with the present invention there is provided a method of, and apparatus for, accepting, validating and dispensing value carriers, wherein one or more parameters of a value carrier presented by a user are measured and the value carrier is accepted as valid if each parameter falls within a corresponding first acceptance range, wherein the value carrier is subsequently dispensed only if each parameter falls within a corresponding second acceptance range narrower than the first.

In the preferred embodiments, validation is carried out against the first acceptance range in such a manner that as few genuine banknotes as possible are rejected and, against the second acceptance range, in such a manner that, of the banknotes accepted and stored according to the first acceptance range, as far as possible all banknotes that may not be genuine are retained in the automatic machine.

Preferred embodiments of the invention are described below with reference to the drawings, in which:

Figure 1 shows a probability distribution of a measuring parameter for "good" banknotes with two acceptance criteria and a probability distribution for "bad" banknotes; and

5 Figure 2 is a diagrammatic view of the device for validating banknotes.

Figure 1 shows, by way of example, the probability distribution $W(x)$ for a measuring parameter x with a mean value m . The measurement in
10 question is one with which non-acceptable banknotes have parameter values y that have a probability distribution $W(y)$ that is changed by comparison with x .

The given tolerance values A and B define the two
15 acceptance ranges T_A and T_B : if, for the measured parameter value x , the absolute value of $(x-m)$ is less than A , the banknote is regarded as acceptable. The probability of a genuine note being rejected is given by the area $F1+F2$. The probability of a non-
20 acceptable banknote being accepted is given by the area $F3+F4$. Of the notes accepted there are then selected for re-use, in a second decision, only those banknotes in which the absolute value of $(x-m)$ does not exceed the value B . This measure further
25 increases the probability that only genuine banknotes will be re-used: the area $F3$ corresponds to the

probability of a counterfeit note being regarded as genuine and re-used. The area F4 corresponds to those banknotes which, although accepted by the automatic machine, are no longer assigned for re-use.

5 In the normal case, several measuring parameters x_1, x_2, \dots, x_n are measured and compared with acceptance ranges $T_{A1}, T_{A2}, \dots, T_{An}$ and $T_{B1}, T_{B2}, \dots, T_{Bn}$ ($B_i < A_i$), the acceptance range T_{A_i} having a mean value m_i and a maximum deviation of $A_i > 0$, i.e.

$$10 \quad T_{A_i} = [m_i - A_i, m_i + A_i]$$

and the acceptance range T_{B_i} has the same mean value m_i and a maximum deviation of $B_i > 0$ (where $A_i > B_i$), i.e.

$$T_{B_i} = [m_i - B_i, m_i + B_i],$$

the first acceptance criterion consisting in that, for

$$15 \quad x_i \text{ in } T_{A_i} \text{ for all } i, i=1, \dots, n,$$

the banknote is accepted, and the second acceptance criterion consisting in that, for

$$x_i \text{ in } T_{B_i} \text{ for all } i, i=1, \dots, n,$$

the banknote is assigned for re-use.

20 The characteristic values $\{m_i\}$, $\{A_i\}$ and $\{B_i\}$ are stored in a data store 30 of the decision unit 14.

One possible measuring parameter x_i is the dimension, that is to say the length, width or thickness of the banknote. Another advantageous
 25 measuring parameter x_i is the spectrum of the light reflected or transmitted by the banknote, as described

in DE-A-2 924 605. One or more predetermined parts of the banknote may be measured. A further measuring parameter x_i that can be used is the change produced in a magnetic field by a banknote provided with magnetic printing ink, as described in US-A-4 864 238.

The measurements $\{x_i\}$ are compared with acceptance ranges $\{T_{Ai}\}$ and $\{T_{Bi}\}$ stored in the decision unit 14. Preferably, the initial acceptance ranges $\{T_{Ai}\}$ are determined offline with the aid of a representative amount of acceptable banknotes, are stored in the data store 30 of the decision unit 14 and are adapted in the course of time to the changes in the measuring apparatus and to the characteristics of the banknotes in circulation (see, for example, GB-A-2 059 129).

The method can also be applied to automatic machines that accept different types of banknote w_1, w_2, \dots, w_n and dispense them again. The method is in that case preceded by a first step in which first the type of banknote w_i is determined. In most countries, this can be done on the basis of identifying the dimensions of the notes; it may, however, be the case that this test is not sufficiently reliable or even possible, such as, for example, in the case of U.S. notes which all have the same dimensions.

Figure 2 shows the diagrammatic arrangement of a

device 1 according to the invention. It has at least one acceptance opening 11 and at least one dispensing opening 12 for accepting and returning value carriers, and further consists of a measuring unit 13, a
5 decision unit 14 with data store 30, a control unit 15, at least one one-way store 16, 16i and at least one two-way store 17, 17i. These units are connected by transport means 20, 21, 22, 23, 24, 25 and a common routing element 18.

10 After a value carrier 2 has been inserted into the acceptance opening 11 it is taken by a first transport means 20 to the measuring unit 13 which contains the measuring apparatus required for checking acceptability. The parameter measurements determined
15 there are passed to the decision unit 14 which compares them with the tolerance ranges stored in the data store 30 and decides whether the value carrier is acceptable and, if so, whether it can be assigned for re-use. The control unit 15 is instructed to control
20 the common routing element 18 of the transport system accordingly: upon leaving the measuring unit 13
- a non-acceptable value carrier is transported directly back to the dispensing opening 12,
- an acceptable value carrier that is not to be re-
25 used is directed by the routing element 18 onto transport means 23 and is transported to one of

several one-way stores 16, 16i,
- an acceptable value carrier that is to be available
for re-use is directed by the routing element 18 onto
transport means 24 and is taken to one of several two-
5 way stores 17, 17i and stored.

The two-way stores 17, 17i can be controlled by
the automatic machine 3 via control means 19 to supply
the desired type and number of value carriers 2 to the
dispensing opening 12 via transport means 25.

10 The acceptability test is carried out in detail
as follows: after the banknote 2 has been inserted
into the measuring unit 13 the n scheduled
measurements x_1, x_2, \dots, x_n are determined and passed
on to the decision unit 14 where it is established
15 whether the measurement x_i falls within the range T_{Ai}
for all i . If that is not the case, the banknote is
returned to the user by the automatic machine at the
dispensing opening 12. If x_i is within T_{Ai} and also
within T_{Bi} , for all $i, i=1, \dots, n$, the banknote is
20 conveyed to one of the two-way stores 17, 17i from
whence it is available for re-use as money returned.
If that is not the case, that is, while x_i is within
 T_{Ai} it is not within T_{Bi} for all $i, i=1, \dots, n$, the
banknote is deposited in one of the one-way stores 16,
25 16i where it remains until the automatic machine 3 is
emptied.

Although, in the preferred embodiments, two separate storage devices are provided for each type of value carrier, it would be possible to provide a single storage device wherein the position of the value carrier within that storage device is known. In this case, the value carriers would be dispensed selectively so that only those which meet both acceptance criteria are dispensed, while retaining those value carriers which meet only one of the acceptance criteria.

Alternatively, all value carriers accepted by the machine according to the first criterion K1 could be stored in a single storage device and a subsequent validation performed according to the second criterion K2 on value carriers leaving the storage device. Such value carriers would either be returned to the user or retained within the automatic machine in dependence on whether or not the second criterion K2 is met.

Furthermore, although separate acceptance and dispensing openings have been described, it is possible to provide a single opening for performing both functions.

CLAIMS:

1. A method of accepting, validating and dispensing value carriers, wherein one or more parameters of a value carrier presented by a user are measured and the value carrier is accepted as valid if each parameter falls within a corresponding first acceptance range, wherein the value carrier is subsequently dispensed only if each parameter falls within a corresponding second acceptance range narrower than the first.

2. A method as claimed in claim 1, wherein all accepted value carriers are stored in a single storage means, the position within said storage means being known and used selectively to dispense said value carriers.

3. A method as claimed in claim 1, wherein all accepted value carriers are stored in a single storage means, and wherein each parameter is compared with the corresponding second acceptance range for value carriers leaving the storage means.

4. A method of checking value carriers in automatic machines which accept value carriers in

payment comprising storing them in at least first and second storage means, and, when instructed by a control unit, returning them to a user of the automatic machine, wherein, before acceptance and storage, one or more parameters of each value carrier are each compared with a corresponding first acceptance range wherein the method further comprises comparing each parameter of each value carrier with a corresponding second acceptance range which is narrower than the first, storing the value carriers for which the or each parameter satisfies only the corresponding first acceptance range in said first storage means and storing the value carriers for which the or each parameter satisfies the corresponding second acceptance range in said second storage means, the value carriers stored in said second storage means being available to be re-dispensed to a user.

5. A method according to claim 4, wherein the first acceptance range is determined on the basis of measurements of said corresponding parameter performed on a representative number of acceptable value carriers and is stored in the automatic machine before being put into service.

6. A method according to claim 5, wherein the

stored first acceptance range is adapted during service to compensate for changes in the measuring apparatus and changes in the characteristics of the value carriers in circulation.

- 5 7. A method according to any one of claims 4 to 6, wherein each first acceptance range T_{Ai} has a mean value m_i and a maximum deviation of $A_i > 0$, i.e.

$$T_{Ai} = [m_i - A_i, m_i + A_i],$$

- 10 and each second acceptance range T_{Bi} has the same mean value m_i and a maximum deviation of $B_i > 0$, where $A_i > B_i$, i.e.

$$T_{Bi} = [m_i - B_i, m_i + B_i],$$

and the characteristic values $\{m_i\}$, $\{A_i\}$ and $\{B_i\}$ are stored in a data store of a decision unit.

- 15 8. A method according to claim 7, wherein a change in the measuring apparatus is detected by periodically measuring a fixed reference value and is corrected by adapting the mean values $\{m_i\}$ stored in the data store.

- 20 9. A method according to claim 7 or claim 8, wherein a change in the characteristics of the value carriers in circulation is compensated for by adapting the mean values $\{m_i\}$ stored in the data store

according to the parameter values measured in the accepted value carriers.

10. A method according to any one of claims 1 to 9, wherein the value carriers belong to various types
5 w1, w2, ..., wn the method further comprising identifying the type of value carrier wi, the type-specific characteristic values of the first and second acceptance ranges being stored, and the accepted value carriers being stored in separate, type-specific first
10 and second storage means.

11. A method as claimed in any preceding claim, wherein if each said parameter does not fall within said corresponding first acceptance range, the value carrier is returned directly to a dispensing opening.

15 12. A method as claimed in any preceding claim, in which the one or more parameters are indicative of the authenticity of the value carrier.

20 13. Apparatus for accepting, validating and dispensing value carriers, the apparatus comprising means for validating a value carrier presented by a user by measuring one or more parameters of the value carrier and accepting said value carrier as valid if

each parameter falls within a corresponding first acceptance range but subsequently dispensing the value carrier if each parameter falls within a second acceptance range narrower than the first.

5 14. Apparatus for accepting and returning value carriers comprising means defining at least one opening for accepting and/or dispensing a value carrier, a measuring unit for measuring one or more parameters of a value carrier presented by a user, a
10 decision unit for deciding whether each parameter falls within a corresponding first acceptance range and a corresponding second acceptance range narrower than the first, first and second storage means for the value carriers and a transport system arranged to
15 transport value carriers from the opening means to the measuring unit, from the measuring unit to one of the opening means, said first storage means and second storage means, in dependence on the output of the decision means and from the second storage means back
20 to the opening means, the arrangement being such that only those value carriers for which each parameter falls within the corresponding first acceptance range are stored in the first and second storage means and only those value carriers for which each parameter
25 falls within the corresponding second acceptance range

are stored in the second storage means.

15 15. Apparatus according to claim 14, wherein,
from the outlet of the measuring unit and via a
routing element, the transport system is arranged to
5 - transport a non-acceptable value carrier directly
back to the opening,
- direct an acceptable value carrier that is not to be
re-used to the first storage means, and
- direct an acceptable value carrier that is to be
10 available for re-use to said second storage means.

16. Apparatus according to claim 14 or 15,
further comprising a data store for storing the
characteristic values of the acceptance ranges.

15 17. Apparatus according to claim 16, arranged to
accept and return a plurality of types of value
carrier, the measurements in the measuring unit
serving also to identify the type of value carrier,
the type-specific characteristic values of the
acceptance ranges being stored in the data store and
20 the accepted value carriers being stored in separate,
type-specific first or second storage means.

18. Apparatus according to any one of claims 13

to 17, wherein the one or more parameters measured by the measuring unit are indicative of the authenticity of the banknote.

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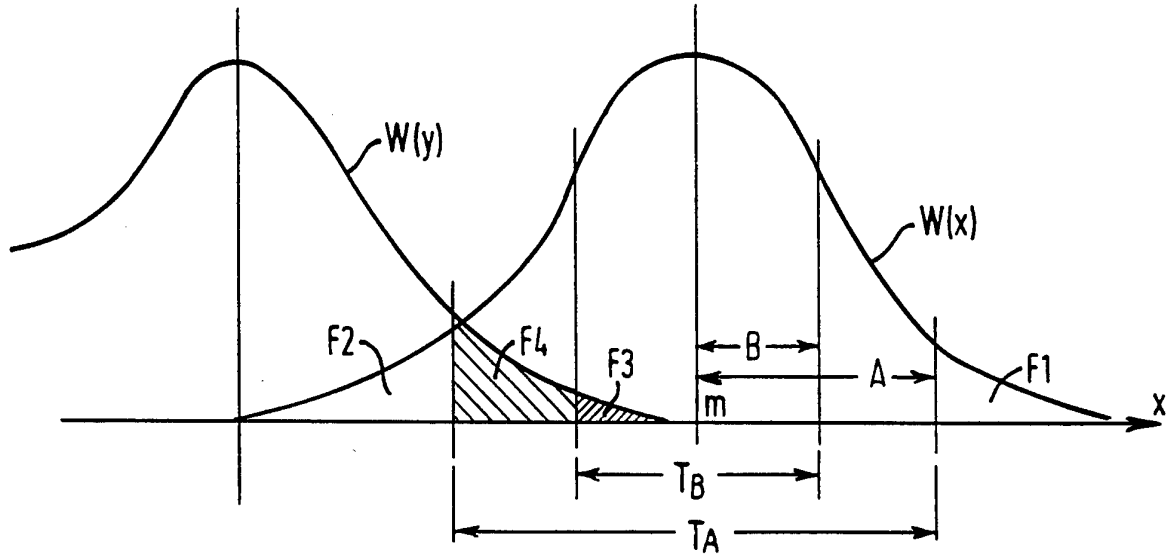


FIG. 1

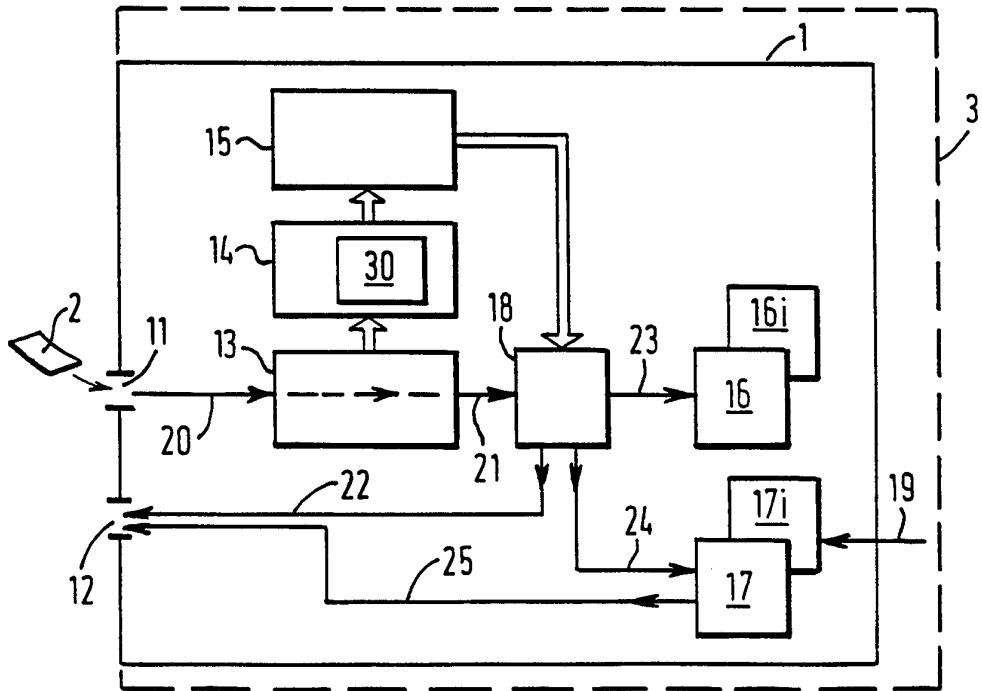


FIG. 2

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 94/00184

A. CLASSIFICATION OF SUBJECT MATTER

IPC 5 G07D13/00 G07D5/00

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 5 G07D G07F

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	GB,A,2 100 906 (LAUREL BANK MACHINE) 6 January 1983 see abstract; claims; figure 4 see page 4, line 3 - line 15 ---	1,4, 11-15,18
A	US,A,5 076 441 (A. GERLIER) 31 December 1991 cited in the application see abstract; figures 1,2 see column 1, line 64 - column 2, line 47 ---	1-4, 10-16,18
A	WO,A,92 10816 (MARS) 25 June 1992 see abstract; claims; figures 1-3 ---	1,4,5, 10-18
A	EP,A,0 155 126 (MARS) 18 September 1985 see abstract; claims; figure 4 ---	1,4-17
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Patent family members are listed in annex.

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Date of the actual completion of the international search

20 October 1994

Date of mailing of the international search report

- 8. 11. 94

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP,A,0 473 106 (HITACHI) 4 March 1992 -----	

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No PCT/IB 94/00184
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