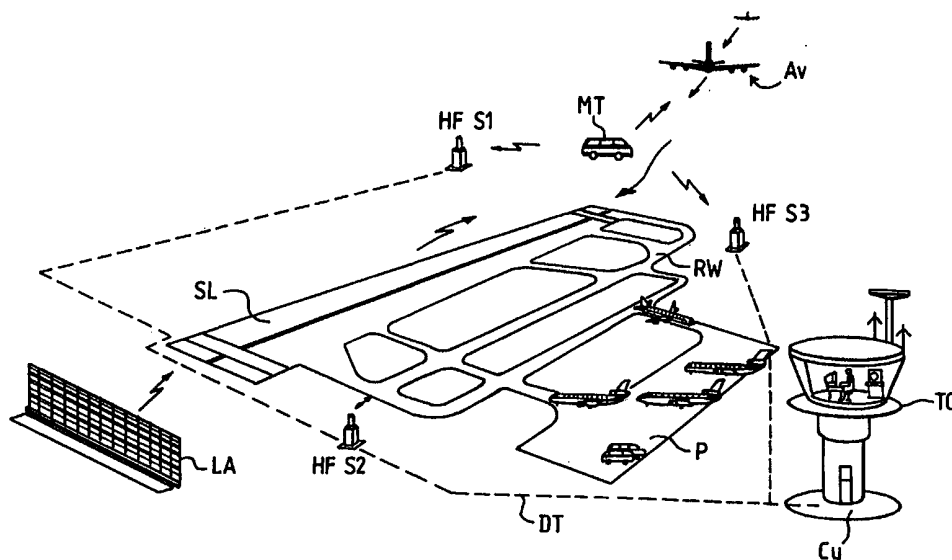




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : G01S 1/02	A1	(11) International Publication Number: WO 00/48015 (43) International Publication Date: 17 August 2000 (17.08.00)
(21) International Application Number: PCT/EP00/01323 (22) International Filing Date: 8 February 2000 (08.02.00) (30) Priority Data: 199 04 842.8 8 February 1999 (08.02.99) DE (71) Applicant (for all designated States except US): AIRSYS NAVIGATION SYSTEMS GMBH [DE/DE]; Lorenzstrasse 10, D-70435 Stuttgart (DE). (72) Inventors; and (75) Inventors/Applicants (for US only): FRANKE, Erich [DE/FR]; Thomson-CSF Propriété Intellectuelle, Dept. Brevets, 13, av. du Prés. Salvador Allende, F-94117 Arcueil Cedex (FR). KLEIBER, Herbert [DE/FR]; Thomson-CSF Propriété Intellectuelle, Département Brevets, 13, avenue du Président Salvador Allende, F-94117 Arcueil Cedex (FR). (74) Agent: LUCAS, Laurent; Thomson-CSF Propriété Intellectuelle, Dépt. Brevets, 13, avenue du Président Salvador Allende, F-94117 Arcueil Cedex (FR).		(81) Designated States: AU, CA, NO, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>

(54) Title: SURVEILLANCE SYSTEM FOR TERRESTRIAL NAVIGATIONAL AND AIRPORT LANDING SYSTEMS

**(57) Abstract**

The invention deals with a surveillance system for terrestrial navigational and landing systems, in which the navigational signals being transmitted for aeroplanes or other airborne objects by the navigational and airport landing systems are received and evaluated by a ground-based receiving and control facility. In this system: the receiving and control facility is equipped with a plurality of additional receiving stations; these additional receiving stations operate in the frequency range of the navigational signals; the additional receiving stations are arranged geographically distributed within the transmitting range of the navigational or airport landing system; the signals recorded by the additional receiving stations are forwarded to a central evaluating unit.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

SURVEILLANCE SYSTEM FOR TERRESTRIAL NAVIGATIONAL AND AIRPORT LANDING SYSTEMS

5 The invention relates to a surveillance system for terrestrial navigational and airport landing systems.

Such navigational and landing systems are used in civil and military air travel, both for position and course fixing and for helping aeroplanes to land.

10

Examples of navigational systems for position and course fixing include so-called VOR (Very High Frequency Omnidirectional Range) and DVOR (Doppler VOR) rotating radio beacons, which are predominantly employed in civil applications, and the TACAN system which is predominantly used in military applications.

15

Also included in this category are distance measuring installations such as DME (Distance Measuring Equipment), and beacon systems such as NDMs (Non-Directional Beacons).

20

Examples of landing systems include the widely used instrument landing system ILS and the comparatively new microwave landing system MLS. Components in landing systems further include systems based on differential GPS (correction data transmission).

25

All the systems cited above entail installing transmitting stations on the ground which transmit corresponding signals; the signals are received on board the aeroplanes, evaluated in the navigational equipment for position and course fixing, and utilised in the landing aid facilities for determining localisation and angle of approach.

30

International authorities such as the ICAO standardise certain operating parameters throughout the world.

Safety aspects naturally play a defining role in determining these operating parameters, i.e. particularly in the case of the transmitting stations it is necessary

to adopt measures that guarantee the maximum degree of safety both with regard to the construction of the transmitting stations and with regard to the operation thereof.

5 Such safety-related measures are laid down by the aforementioned ICAO international authority in the so-called International Standards and Recommended Practices. Where the integrity of the transmitted signals is at issue, then for example certain surveillance systems are provided such as the known Far Field Monitor (FFM) for the aforesaid ILS instrument landing system.
10 This FFM (far field monitor) monitors the technical quality of the localising information in the final phase of the landing approach.

This type of known surveillance system principally monitors, and if necessary corrects, those faults that are contained in the transmitted signal itself.

15 In addition to such faults or signal distortions that occur within the system itself, other influences coming from outside also appear which can result in the signals here designated overall as navigational signals either being unable to be evaluated in the aeroplane or else - and this may have more serious
20 consequences - leading to false evaluation results. Possible sources of such external faults may for example be radio transmitters, or the deliberate broadcasting of differential GPS data in the VHF band, or transmitters of other radio-communication services, which for example due to their own operating malfunctions broadcast interference signals in frequency ranges that are within
25 range of the operating frequency of the navigational or landing system. However, because as a rule such transmitters are fixed installations, the fact that they broadcast publicly means that their operating data are known and are readily identifiable, and systematic technical and organisational rectification of the problem is possible.

30 Far more dangerous faults or falsifications of the navigational signals may be caused by transmitters that are only introduced periodically into the geographical vicinity of the navigational or airport landing systems and operated there. For

present purposes it is immaterial whether the perturbation or falsification of the navigational signal is due to a malfunction or to an intentional transmission.

5 Existing known surveillance systems for navigational and airport landing systems do not provide for systematic monitoring of such perturbations and are therefore not suitable either.

10 It is therefore the object of the present invention to create a surveillance system for terrestrial navigational and airport landing systems in which the navigational signals for aeroplanes or other airborne objects transmitted by the navigational and airport landing systems are received and evaluated by a ground-based receiving and control facility; it should also be possible to use said surveillance system effectively when faults or falsifications of the last-named type occur.

15 The measures cited in Claim 1 are proposed in order to accomplish this object.

20 The advantage of this solution lies in the fact that the additional receiving stations and their geographical distribution enable position-fixing of the rogue transmitter using *per se* known methods, such as for example the hyperbolic sectioning method or the like, and the central evaluating unit, which in any case operates with conventional digital signal processing methods for the FFM mentioned in the introduction, such as for example FFT (Fast Fourier Transform) algorithms, is in addition able to identify the rogue signals.

25 For maximum simplicity and reliability of the co-operation between the additional receiving stations and the central evaluating unit, one embodiment of the invention provides for proceeding in accordance with the features of Claim 2. Because the transmitting data of the system's own transmitters and any stationary rogue transmitters are known in the central evaluating unit, it is possible in accordance with the features of Claim 3 to ascertain the geographical co-ordinates of the unknown rogue transmitter. Claim 4 sets out how the content of the transmitting signal from the unknown rogue transmitter is evaluated.

30

According to a further embodiment of the invention corresponding to Claim 5, it is advantageous that with central evaluation there is the possibility of selecting suitable counter-measures by comparing the navigational signal and the rogue signal.

5

Further details and advantages of the invention may be taken from the description which follows of an exemplifying embodiment.

Figure 1 shows a schematic view of the geographical distribution of the additional receiving stations in the vicinity of an airport.

10

Figure 2 shows the block diagram of the functional units of the surveillance system.

Figure 1 shows a view of an airport with its essential elements such as take-off and landing strip SL, access roads RW to the take-off and landing strip SL, parking area P, and tower TO. At the lower edge of Figure 1 the transmitting antenna LA of the airport landing system is shown. Distributed geographically around the airport are the additional receiving stations HF S1, HF S2 and HF S3. MT identifies a picture of a vehicle symbolising a rogue transmitter MT which is only temporarily in operation and/or mobile. Lastly Av denotes an aeroplane which is in the process of making its landing approach and is receiving the signals transmitted by the transmitters LA and MT.

20

It has not been deemed necessary here to separately depict a rotating radio beacon (VOR; DVOR) or beacon system used for position and course fixing, since such a depiction cannot be expected to provide any additional information in terms of an understanding of the invention.

25

The line of dashes DT represents the link used for data transmission between the individual additional receiving stations HF S1, HF S2 and HF S3 and the central evaluating unit CU, with the central evaluating unit in this example being spatially associated with the tower TO. The antenna station LA is used to

30

transmit to the aeroplane, which is to say in this case the aeroplane Av, the landing signals needed for landing, e.g. ILS landing signals, which contain information about the approach heading and/or angle of approach. Assuming that at the same time the mobile transmitter MT is also transmitting signals in the frequency range of the ILS landing signals and of a corresponding strength, it must be expected that the signals received in the aeroplane Av will be disrupted. Depending on the type of signals being transmitted by the mobile transmitter MT, this disruption will either result in the aeroplane's on-board receiving instruments being unable to evaluate the landing signals from the ILS system or in the evaluation giving false results, which in certain circumstances would be far worse.

In accordance with the invention, however, the landing signal from the ILS landing station which is being disrupted by the mobile transmitter MT is received not only by the receiving instruments on board the aeroplane Av, and if appropriate by the instruments (not shown) of the FFM far field monitor described in the introduction, but also by the additional receiving stations HF S1, HF S2 and HF S3 installed in a geographically distributed manner.

Three such additional receiving stations HF S(1...3) are represented in the example shown. As a rule the use of conventional position fixing methods calls for at least three spatially separately positioned sensors in order to obtain unambiguous evaluations. Just how many such sensors or - as here - additional receiving stations HF S1 to HF Sn actually are employed depends on other parameters, as does their exact spatial arrangement.

Such parameters for example include the extent and geometry of the airport, the number and layout of the approach areas, topography and density of the built-up environment, and the necessary so-called safety level (for example as laid down by the ICAO).

However, it is not necessary to fully cover all possible parameters in order to understand the invention.

Figure 2 is a block diagram representing the functional units of the surveillance system that are crucial to the invention.

5 The spatially distributed additional receiving stations HF S1 to HF Sn set up within the operating range of the navigational or airport landing system consist essentially of the receiving antenna EA, the actual HF receiving section EM and the output unit D Ex (1 to n). The HF receiving section EM is made up of amplifiers, filters, mixers and synthesisers. The mode of operation of such a
10 receiving section EM with its aforementioned elements is known and is not the subject of the invention, therefore a detailed explanation is not given here.

The signals received in this way are processed at the output in such a way in a suitably configured evaluating unit D Ex and provided with the necessary
15 additional information that the central evaluating unit CU is supplied with the information needed for position fixing and classification. Obviously the processing operation in the evaluating unit must also take account of the technology and the transmission characteristics of the DT link between the additional receiving equipment HF S (1...n).

20 Evaluation of the signals recorded by the individual additional receiving stations HFS (1...n) takes place in the central evaluating unit CU. This evaluating unit has essentially three important functional units within the framework of the invention, which in Figure 2 are likewise represented in block diagram form.
25 Used for the actual evaluation of the signal are firstly the Loc unit provided for position fixing, and the Class unit for classifying the received signals. In the Dis-AL unit the output from the Loc and Class units, possibly together with other criteria/information, is then combined and evaluated in such a way that as a
30 result an alarm is triggered, for example in the flight management, and/or further safety measures can be taken.

In Figure 2 the additional receiving stations - as shown - are individually linked to the central evaluating unit CU, and this enables the geographical allocation of the

output signals of the outputs DEx 1 to n to be readily performed by means of the respective connections In 1 to In n. In the case of a single link DT as in Figure 1, it is necessary to first of all prime the output signals with information. Further typical data relevant for position fixing are the time of reception, the duration of the signal and its measurement. As the position-fixing method it is, for example, possible to use the hyperbolic sectioning method already mentioned in the introduction, which is considered to be advantageous in terms of its cost and the integrability of its circuits. In general terms the choice of the position-fixing method is also determined by its detection speed, its position-fixing accuracy and its ability to simultaneously fix the positions of a plurality of signal sources. The above criteria are of course inseparably bound up with the function of classifying the signal or signals.

In addition, the Class unit evaluates the signal strength, the temporal characteristics of the signal, the frequency spectrum, carrier frequency, modulation frequencies and the degree of modulation. With the conventional digital signal processing method, using the FFT (Fast Fourier Transform) algorithms, it is possible to detect and evaluate the rogue signals in the frequency band of the radio channel utilised for the navigation and for the landing system. By additionally taking into account the operating parameters of the respective navigational and/or landing system it can then be decided whether the disturbances found are of an intensity and type likely to disrupt the proper reception and evaluation of the wanted signal.

Depending on this decision, with the help of the Dis-AL functional unit the necessary measures are then initiated in the technical field or by calling security personnel.

Because all the receiving and evaluating units whose objectives and mode of operation have been cited above are present either in full or in part in a different scenario, e.g. in the cited FFM system, a further advantage of the surveillance system according to the invention is the option to integrate the use of these pre-existing facilities. This also means that it is possible for the surveillance function

of the system in accordance with the invention to be expanded to other frequency ranges with transparency of financial outlay.

CLAIMS

1. Surveillance system for terrestrial navigational and landing systems, in which the navigational signals being transmitted for aeroplanes (Av) or other airborne objects by the navigational and airport landing systems are received and evaluated by a ground-based receiving and control facility, characterised in that:
 - the receiving and control facility is equipped with a plurality of additional receiving stations (HF S1, HF S2, HF S3),
 - these additional receiving stations operate in the frequency range of the navigational signals,
 - the additional receiving stations are arranged geographically distributed within the transmitting range of the navigational or airport landing system,
 - the signals recorded by the additional receiving stations are forwarded to a central evaluating unit (CU).
2. Surveillance system according to claim 1, characterised in that the signals recorded by the additional receiving stations are given additional identification codes before being forwarded to the central evaluating unit.
3. Surveillance system according to claim 2, characterised in that the signals recorded by the additional receiving stations are evaluated in relation to the location of their transmitter.
4. Surveillance system according to claim 2, characterised in that the signals recorded by the additional receiving stations are evaluated in relation to their type, duration and content.
5. Surveillance system according to claim 1, characterised in that in the event of detecting a disruption to the wanted signal, the central evaluating unit transmits a corresponding alarm signal to initiate suitable measures in each case.

6. Surveillance system according to claims 1 to 5, characterised in that existing receiving and control station facilities, for example far field monitor systems, are expanded to take over the additional surveillance functions.

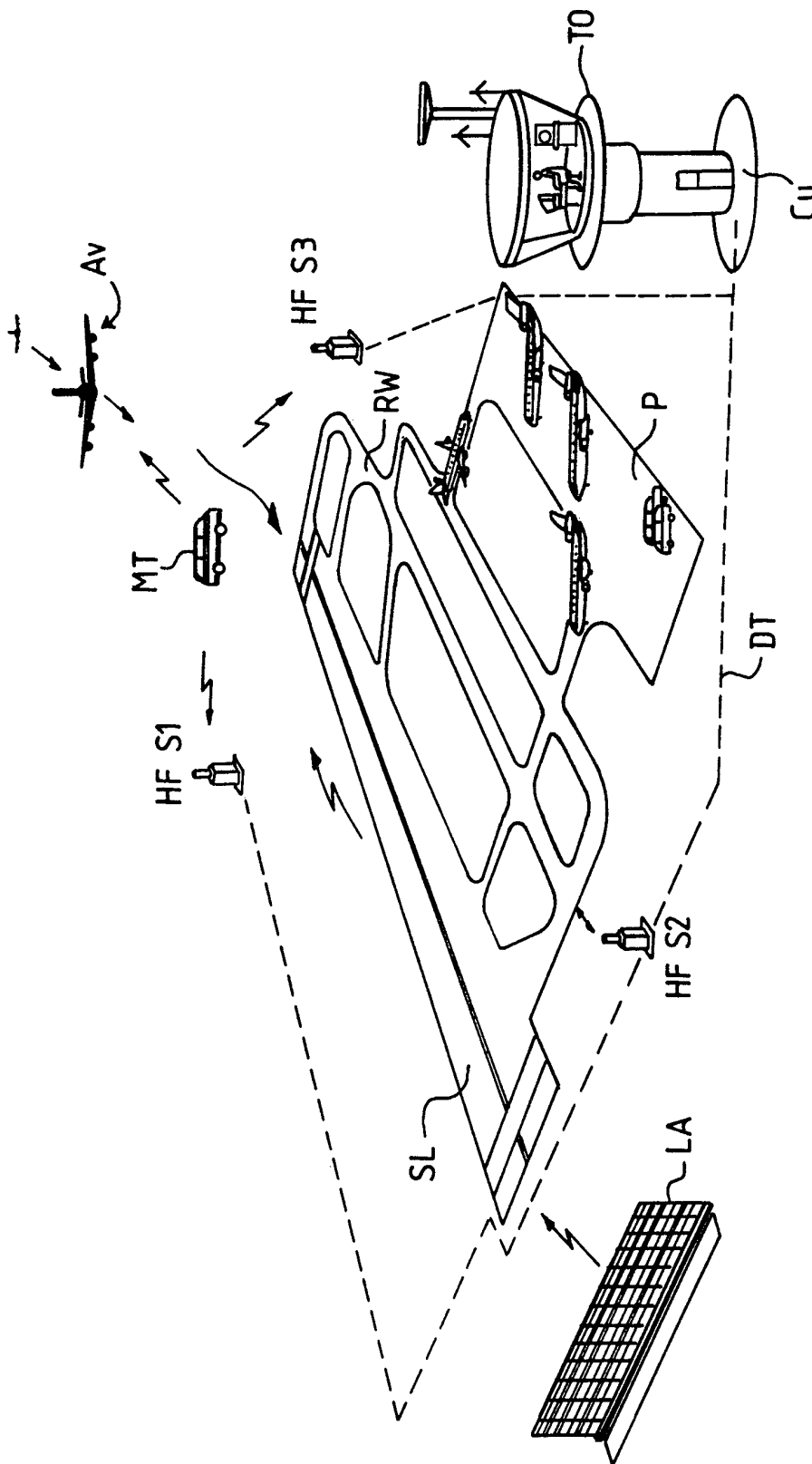


FIG.1

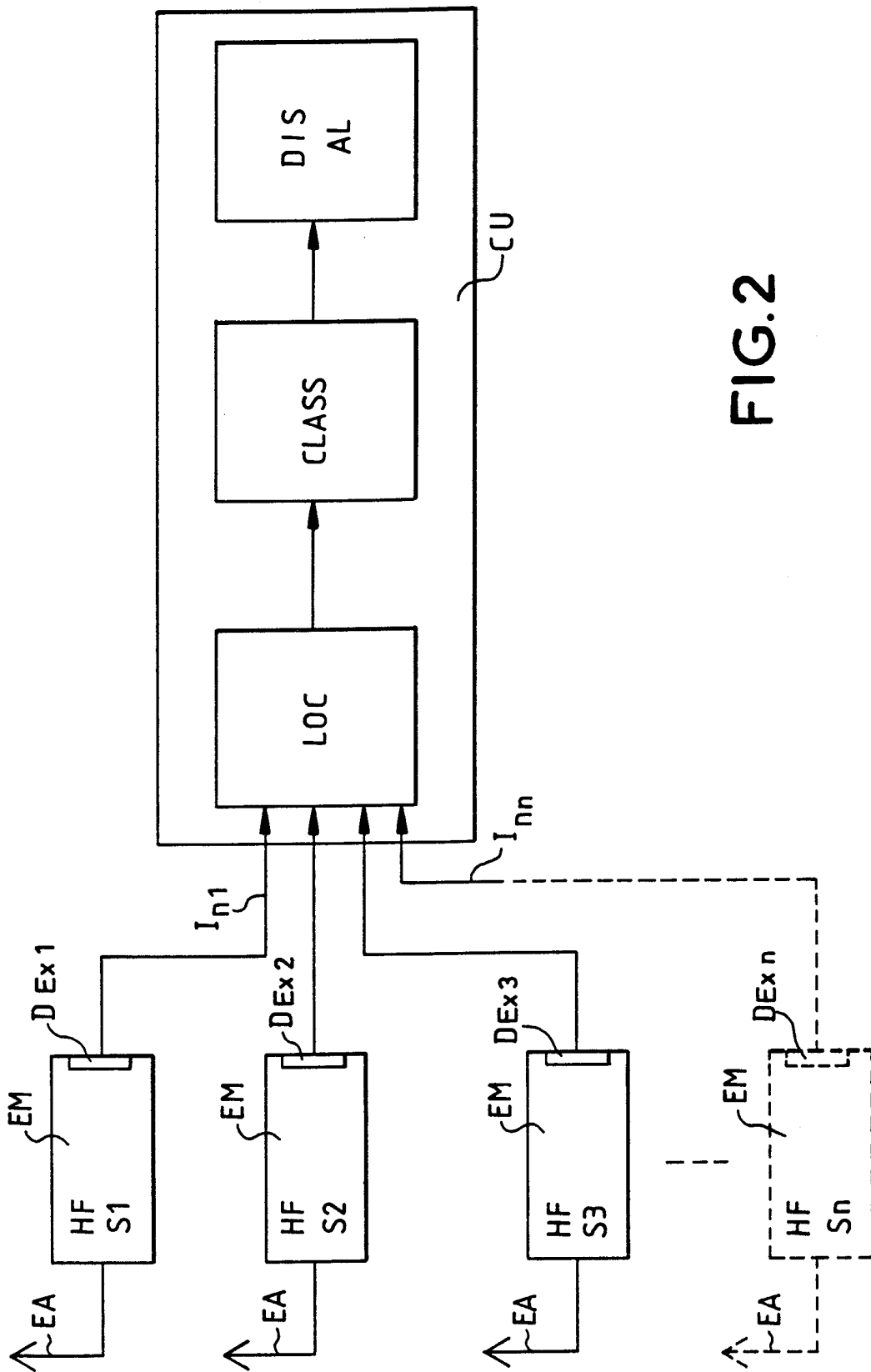


FIG.2

INTERNATIONAL SEARCH REPORT

Int. Application No PCT/EP 00/01323

A. CLASSIFICATION OF SUBJECT MATTER IPC 7 G01S1/02				
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 7 G01S				
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) EPO-Internal				
C. DOCUMENTS CONSIDERED TO BE RELEVANT				
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X	US 4 333 081 A (HOEFGEN GUENTER) 1 June 1982 (1982-06-01) column 2, line 39 -column 4, line 4 -----	1-5		
X	US 4 414 632 A (MURRELL ROBERT A) 8 November 1983 (1983-11-08) column 5, line 36 -column 6, line 6 -----	1,5		
X	GB 1 398 005 A (TULL AVIATION CORP) 18 June 1975 (1975-06-18) page 1, line 88 -page 2, line 95 -----	1,5		
X	US 3 818 476 A (COULTER J ET AL) 18 June 1974 (1974-06-18) column 4, line 17 -column 6, line 2 -----	1,5		
<input type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.				
* Special categories of cited documents : <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;"> *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 </td> <td style="width: 50%; border: none; vertical-align: top;"> *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 </td> </tr> </table>			*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
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 30 June 2000	Date of mailing of the international search report 10/07/2000			
Name and mailing address of the ISA 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	Authorized officer Haffner, R			

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/EP 00/01323

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4333081 A	01-06-1982	DE 2924847 A	22-01-1981
		AU 536847 B	24-05-1984
		AU 5927280 A	08-01-1981
		CA 1147038 A	24-05-1983
		FR 2459485 A	09-01-1981
		GB 2052911 A, B	28-01-1981
		IT 1193949 B	31-08-1988
		JP 1250792 C	14-02-1985
		JP 56031658 A	31-03-1981
		JP 59025983 B	22-06-1984
		NL 8003433 A	23-12-1980
		NO 801760 A, B,	22-12-1980
		US 4414632 A	08-11-1983
GB 1398005 A	18-06-1975	AR 203263 A	29-08-1975
		AU 475219 B	12-08-1976
		AU 4971972 A	06-06-1974
		BE 792277 A	30-03-1973
		CA 972090 A	29-07-1975
		CH 565422 A	15-08-1975
		DD 102839 A	20-12-1973
		DE 2258187 A	14-06-1973
		FR 2164322 A	27-07-1973
		IL 40903 A	31-08-1975
		IT 971520 B	10-05-1974
		JP 48066387 A	11-09-1973
		NL 7214890 A	08-06-1973
		NO 139940 B	26-02-1979
		SE 403873 B	04-09-1978
		US 3820074 A	25-06-1974
		ZA 7208210 A	26-06-1974
		US 3818476 A	18-06-1974
AU 5724973 A	09-01-1975		
BE 801429 A	15-10-1973		
CA 1006250 A	01-03-1977		
CH 560393 A	27-03-1975		
DE 2332322 A	10-01-1974		
FR 2191124 A	01-02-1974		
GB 1388239 A	26-03-1975		
IT 989479 B	20-05-1975		
JP 49052994 A	23-05-1974		
NL 7308722 A	02-01-1974		
SE 386745 B	16-08-1976		