PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G01S 15/06 A1

(11) International Publication Number: WO 90/07721

(43) International Publication Date: 12 July 1990 (12.07.90)

(21) International Application Number: PCT/US89/05720

(22) International Filing Date: 27 December 1989 (27.12.89)

(30) Priority data:
294,538 9 January 1989 (09.01.89) US

(71) Applicant: MOTOROLA, INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

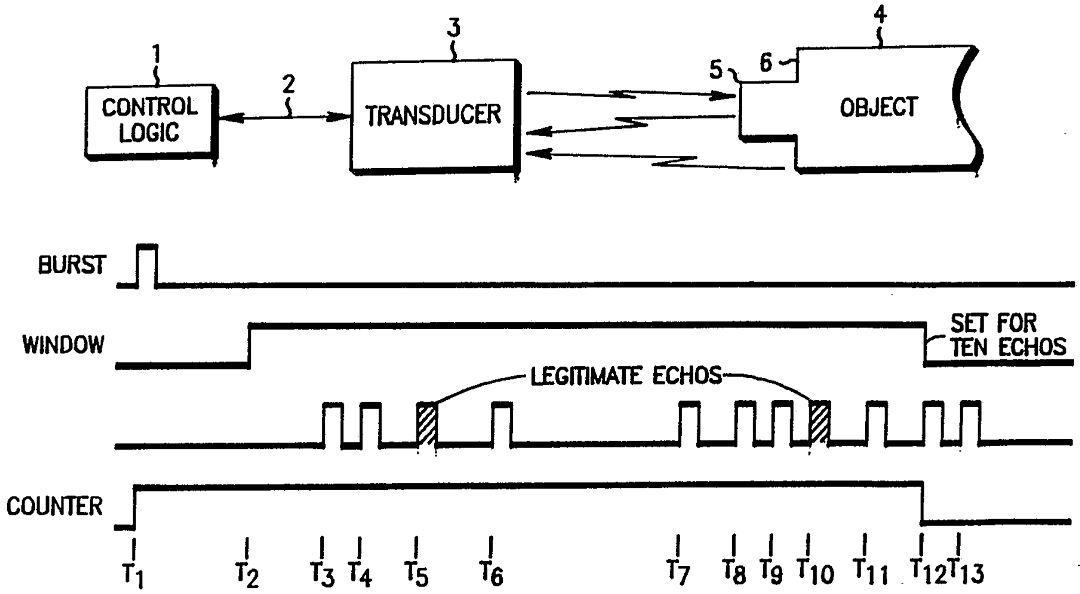
(72) Inventor: CAPURKA, Zbynek, Antonin ; 573 Geri Court, Palatine, IL 60067 (US).

(74) Agents: PARMELEE, Steven, G. et al.; Motorola, Inc., Intellectual Property Dept., 1303 East Algonquin Road, Schaumburg, IL 60196 (US).

(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent).

Published
With international search report.

(54) Title: SYSTEM FOR MEASURING POSITION OF AN OBJECT USING ELECTRONIC OR ULTRASONIC DEVICES WHERE THE OBJECT CONTAINS A REFERENCE REFLECTOR FOR TEMPERATURE COMPENSATION



(57) Abstract

A system for measuring the position of a moving object (4; 304) including transceiver means (1-3; 301) for sending signals to and receiving signals reflected from both a moving object surface (5; 305) and a reference object surface (6; 306) maintaining a known, fixed distance from the moving object surface, wherein by processing the signals sent and received, the position of the moving object can be determined while the effects of temperature on the speed of sound, frequency changes, false echoes and erroneous signals are minimized or eliminated.

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.

AT	Austria	ES	Spain	MG	Madagascar
AU	Australia	FI	Finland	ML	Mali
BB	Barbados	FR	France	MR	Mauritania
BE	Belgium	GA	Gabon	MW	Malawi
BF	Burkina Fasso	GB	United Kingdom	NL	Netherlands
BG	Bulgaria	HU	Hungary	NO	Norway
BJ	Benin	IT	Italy	RO	Romania
BR	Brazil	JP	Japan	SD	Sudan
CA	Canada	KP	Democratic People's Republic of Korea	SE	Sweden
CF	Central African Republic			SN	Senegal
CG	Congo	KR	Republic of Korea	SU	Soviet Union
CH	Switzerland	LI	Liechtenstein	TD	Chad
CM	Cameroon	LK	Sri Lanka	TG	Togo
DE	Germany, Federal Republic of	LU	Luxembourg	US	United States of America
DK	Denmark	MC	Monaco		

SYSTEM FOR MEASURING POSITION OF AN OBJECT USING ELECTRONIC OR ULTRASONIC DEVICES WHERE THE OBJECT CONTAINS A REFERENCE REFLECTOR FOR TEMPERATURE COMPENSATION

TECHNICAL FIELD

This invention relates generally to a system for measuring the position of a moving object and, more particularly, to a system for measuring the position of a moving object using electronic or ultrasonic devices.

BACKGROUND

Conventional echo ranging techniques have been used to detect the presence of, determine the position of, and measure the distance of moving objects. In such systems, ultrasonic waves, having a predetermined frequency, are transmitted towards and are reflected by the moving object. Additionally, these systems may further employ a stationary reference at a fixed distance from the transmitter. This stationary reference is operative to reflect the transmitted waves. The position of the moving object is then calculated by comparing the elapsed time of the reflections from the stationary reference to the elapsed time of the reflections from the moving object.

Such systems are subject to the effects of false echoes and other unwanted signals because the window to read the target reflection must be large enough to accommodate the full range of the distance measured. A need therefore exists to reduce the window necessary to read the target reflection and thereby minimize or eliminate the effects of false echos.

SUMMARY OF THE INVENTION

The needs expressed above are substantially met through the use of the system disclosed herein. This system discloses the use of a reference which moves with and maintains a fixed, known distance from the target. Because the target and reference move together at a fixed distance from each other, a definite relation in time is established between the signals reflected by the target and those signals reflected by the reference. Thus, in processing the signals received, the system searches for a definite relation in time between two reflections. These two reflections must agree as to the known distance between the target and reference. False reflections can be detected and disregarded, if the timing does not agree with the known distance between the target and reference.

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a block diagram illustrating an embodiment of the present invention.

Figs. 2 and 3 are timing diagrams of the signals as processed in the disclosed invention.

Fig. 4 is a cross sectional illustration of one embodiment of the disclosed invention for use in a suspension height sensor.

DESCRIPTION OF THE DRAWINGS

Referring to figure 1, which is a block diagram illustrating an embodiment of the proposed invention, a signal emanating from electronic circuitry in the control logic (1) travels through a connector (2) to a transducer (3) causing ultrasonic signals to emanate from the transducer (3) toward a moving object (4). The moving object (4) has associated with it at least two reflective surfaces (5 and 6) which reflective surfaces (5 and 6) maintain a known, fixed distance from each other.

An ultrasonic signal emanating from the transducer (3) hits a first reflective surface (5) and is reflected back toward the transducer (3). The signal reflected by the first reflective surface (5) is then sent through the connector (2) to the control logic (1) wherein a counter registers a time value representative of the time between the transmission and reception of the reflected signal from the first reflective surface (5). The ultrasonic signal emanating from the transducer (3) also hits a second reflective surface (6) on the moving object (4) and is reflected back to the transducer (3). The signal reflected by the second reflective surface (6) is then sent through the connector (2) to the control logic (1) wherein a counter registers a time value representative of the time between the transmission and reception of the reflected signal from the second reflective surface (6). The time value of the signal reflected by the first reflective surface (5) is compared to the time value of the signal reflected by the second reflective surface (6) by comparison circuitry in the control logic (1). As the first and second reflective surfaces (5 and 6) maintain a fixed, known distance from each other, by processing the time values obtained from the signals reflected by the first and second reflective surfaces (5 and 6) false echoes can be eliminated and the remaining valid reflections can be used to determine the position of the moving object.

The control logic comprises electronic transmitting circuitry to transmit the original signal and electronic receiving circuitry to receive the signal. The control logic also may include processing circuitry, counters, shift registers, a sequencer and ranging logic connected to a read only memory ROM containing instructions which manage the overall operation of the control logic. The functions of the control logic can be built into an integrated circuit or microprocessor as appropriate.

Figs. 2 and 3 are timing diagrams of the transmission and reception of signals in the proposed invention.

Referring to Fig. 2, a phase/frequency burst is emitted (T_1). Upon emission of the burst, a counter begins counting the time for the burst to be reflected. Initially, there is the possibility that multiple reflections of the burst will be received by our system and that some of those reflections are false. At the time (T_2) associated with minimum target distance, a window is opened in the system to receive reflections of the modulation burst (such reflections are depicted as occurring at times T_3 - T_{12}). This window is programmed initially to remain open until it receives ten reflections. (The window may be programmed initially to remain open for a set time or to remain open to receive a set number of reflections as desired or appropriate.) The counter registers a time value for each of the reflections ($T_3 - T_{12}$). By processing the time values ($T_3 - T_{12}$) of all possible pairs of the reflections and comparing each pair to the known, fixed distance between the target and reference, the approximate position of legitimate reflections for the reference and target can be predicted and subsequent windows can be opened accordingly to read only those legitimate reflections, as shown further in figure 3.

Referring to Fig. 3, a subsequent phase/frequency burst is emitted (at time T_1). Upon emission of the burst, one counter begins counting the time for the burst to be reflected by the target and returned, and a second counter begins counting the time for the burst to be reflected by the reference and returned. At the time (T_2) associated with the minimum or predicted target distance, a window is opened in the circuit to receive the modulation burst reflected by the target. When the reflected burst returns (at time T_3), the window closes and the first counter stops. A delay period programmed to reflect the known distance between the target and the reference begins (T_3) and ends (T_4) when the window is opened in the circuit to receive the modulation burst reflected by the reference. Upon receiving the reflected modulation burst (at time T_5), the window closes and the second counter stops. The distance to the target can be processed using the contents of the counters and the known distance between the reference and the target. If desired and where appropriate, a single counter can be used if the counts are transferred to registers. In this timing diagram, the reference and target are interchangeable.

Fig. 4 illustrates a practical embodiment of the disclosed invention as a vehicle height sensor. In this embodiment, the circuit described in Fig. 1 (301) is secured to the upper portion of a housing (302) connected to a vehicle or an upper portion of a vehicle suspension member. The circuit (301) transmits acoustical signals to areas within the housing (302) and receives reflective echoes therefrom. The housing can be a hollow oblong tube or other structure, as appropriate to the application. A lower housing (303) comprises an insert (304) into the upper housing (302). This lower housing (303) is connected to a lower portion of a vehicle suspension member and is operative to move within the upper housing (302) in direct relation to the movement of the lower portion of the vehicle suspension member to the upper portion of the vehicle suspension member or the vehicle itself. The insert (304) of the lower housing (303) is constructed to provide two reflective surfaces (305 and 306) to the acoustical signals from the circuit (301). The reflective surfaces (305 and 306) maintain a fixed, known distance from each other during the movement of the insert (304) within the upper housing (302).

In the embodiment described, acoustical signals are transmitted by the circuit (301) and subsequently received from a first reflective surface (305) and then a second reflective surface (306). By processing the signals received, the height of the attached suspension member of the vehicle can be determined. Such information can be used then to increase or decrease the height of a vehicle's suspension or the damping effect of a vehicle's shock absorbers in response to road conditions and vehicle load.

What is claimed is:

1. A system for determining the position of a known moving object including:

a) first means, separate from the moving object, for sending signals to and receiving reflected signals from the moving object;

b) a first reflective surface associated and moving with the moving object;

c) a second reflective surface associated and moving with the moving object and maintaining a known, fixed distance from said first reflective surface;

d) second means coupled to said first means for:

i) determining a first value of time related to the time between said first means sending a signal to the moving object and receiving at least one reflection of said signal from the moving object;

ii) determining a second value of time between sending said signal to the moving object and receiving at least one additional reflection of said signal;

iii) using said first and second values of time and said known fixed distance to facilitate identification of valid signal reflections by said first and second surfaces and using time values for identified valid signal reflections from said first and second surfaces, and said known fixed distance, for determining a position of the moving object with respect to said first means.

2. The system as set forth in claim 1, wherein the first means for sending and receiving signals is an ultrasonic transceiver.

3. The system as set forth in claim 1 wherein said second means determines a proper time difference relationship, in accordance with said known fixed distance, which should exist between said first and second time values if said one and said one additional reflections are caused by reflections of said signal by said first and second reflective surfaces.

4. The system as set forth in claim 1 wherein said second means opens at least one time window during which reflections of said signal from said second reflective surface are expected to be received.

5. The system as set forth in claim 4 wherein the opening of said at least one time window is determined, at least in part, by said fixed distance.

6. The system as set forth in claim 5 wherein said time window is opened after reception of said at least one reflection by said second means.

7. The system as set forth in claim 1 wherein said first and second reflective surfaces are carried by said moving object and said first means is closer to said first surface than said second surface.

8. A device for sensing vehicle suspension height, including:

a) a hollow, oblong structure with an open end, said structure being secured to a vehicle;

b) first means for sending and receiving signals in said hollow, oblong structure and secured to said hollow, oblong structure;

c) an insert into said hollow, oblong structure, said insert comprising at least two reflective surfaces with each reflective surface being a fixed known distance from each other, and each reflective surface being operative to reflect a signal from said first means back to said first means through said hollow, oblong structure;

d) said insert being secured to a vehicle suspension member and operative to move within said hollow, oblong structure in direct relation to the movement of the vehicle suspension member to the vehicle; and

e) electronic means connected to said first means for determining and comparing the length of time between said first means sending a signal to and receiving reflected signals from each of the reflective surfaces of said insert and utilizing such lengths of time and said known fixed distance between said reflective surfaces to determine the height of the suspension member.

9. The device as set forth in claim 8, wherein, the first means for sending and receiving signals is an

ultrasonic transceiver, and wherein said electronic means utilizes said known fixed distance to determine a proper time relationship which should exist between reception of reflected signals by said first means if said reflected signals correspond to reflections of said signal by each of said two reflective surfaces of said insert.

10. The device as set forth in claim 9 wherein said electronic means includes means for setting up a time window, after reception of a reflected signal by said first means from one of said reflective surfaces, during which reception of a reflected signal by said first means from another of said reflected surfaces is expected.

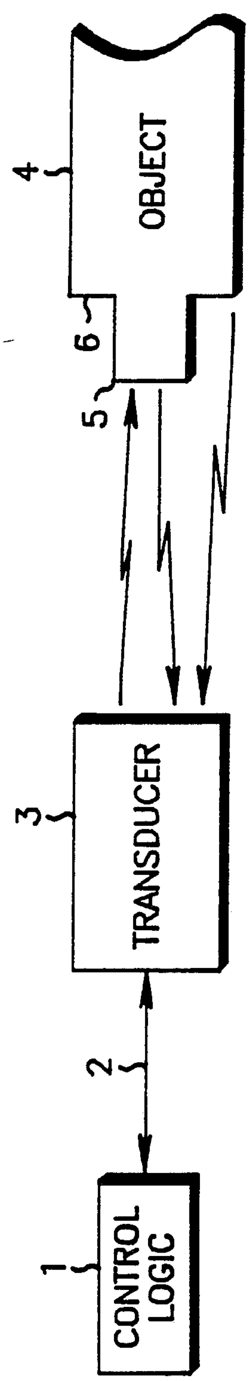

1
CONTROL LOGIC
2
3
TRANSDUCER
4
OBJECT
5
6

FIG. 1

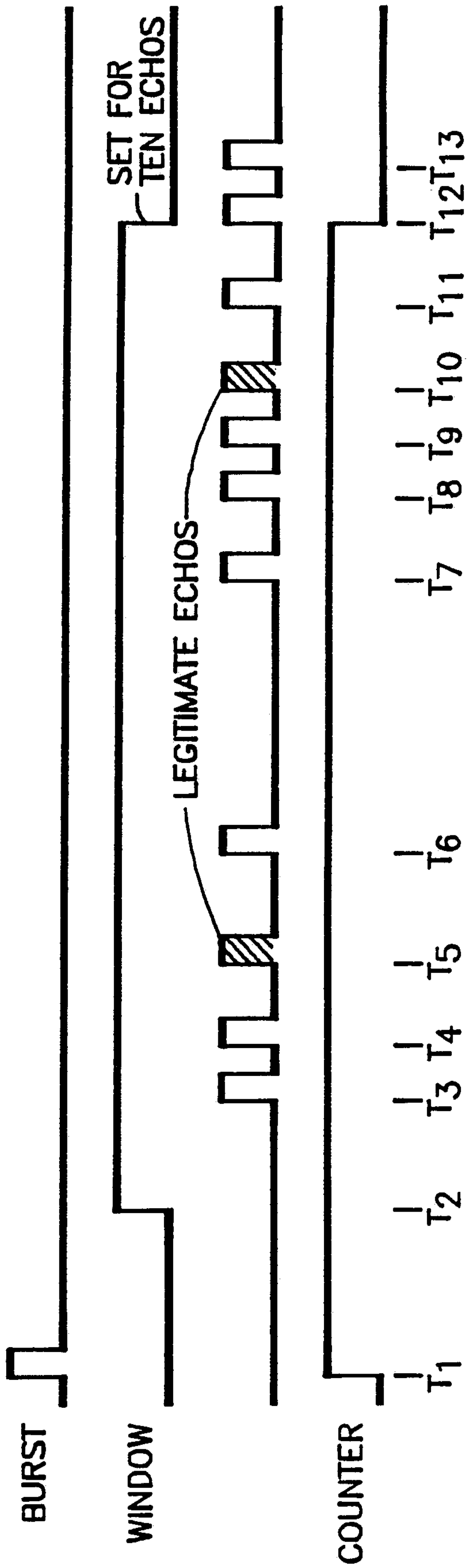

BURST
WINDOW
COUNTER
SET FOR TEN ECHOS
LEGITIMATE ECHOS
T_1
T_2
T_3
T_4
T_5
T_6
T_7
T_8
T_9
T_{10}
T_{11}
T_{12}
T_{13}

FIG. 2

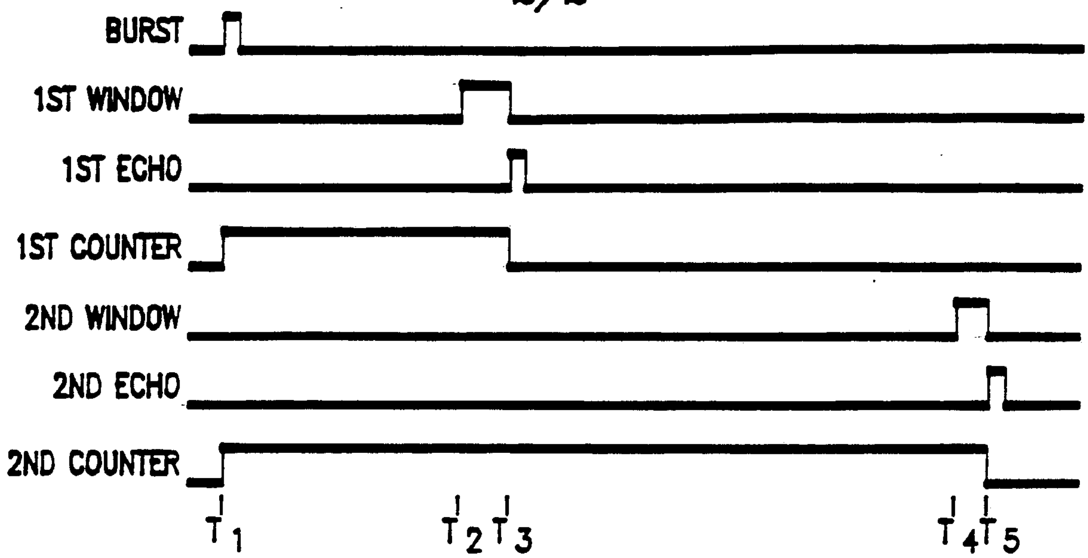

BURST
1ST WINDOW
1ST ECHO
1ST COUNTER
2ND WINDOW
2ND ECHO
2ND COUNTER
T1
T2
T3
T4
T5

FIG.3

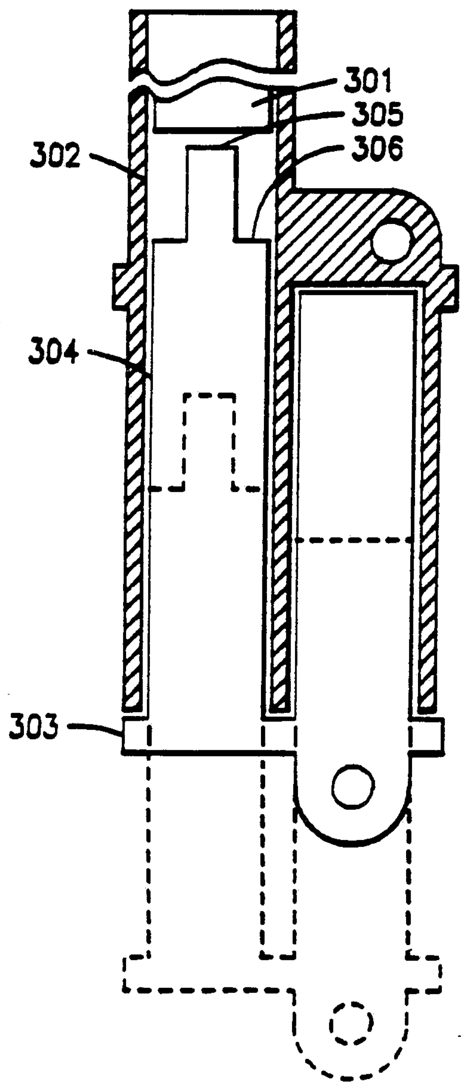

301
305
306
302
304
303

FIG.4

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/05720

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5] G01S 15/06
U.S. CL. 367/99

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S. CL.	367/87, 95, 96, 99, 902 340/933

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X Y	US,A 4,543,649 (Head et al.) 24 September 1985 See Figure 4	1-7 8-10
A Y	US,A Re26,826 (Nolan) 17 March, 1970 See Figure 1	1-7 8-10
A	US,A 4,542,652 (Reuter et al.) 24 September 1985	1-10
A	US,A 4,576,286 (Buckley et al.) 18 March 1986	1-10
A	US,A 4,634,947 (Magori) 06 January 1987	1-10
A	US,A 4,713,798 (Kay) 15 December 1987	1-10
A	US,A 4,739,860 (Kobayashi et al.) 26 April 1988	1-10

* Special categories of cited documents: [10]

"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

"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

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
13 February 1990 (13.02.90)	16 APR 1990
International Searching Authority	**Signature of Authorized Officer**
ISA/US	for TOD SWANN Ngoc Ho Nguyen HO NGUYEN

Form PCT/ISA/210 (second sheet) (Rev.11-87)