(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 May 2001 (25.05.2001)

PCT

(10) International Publication Number
WO 01/36951 A3

(51) International Patent Classification[7]: G01N 22/00

(21) International Application Number: PCT/US00/31851

(22) International Filing Date:
20 November 2000 (20.11.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/166,445 19 November 1999 (19.11.1999) US

(71) Applicant: **RHINO ANALYTICS, LLC** [US/US]; 13740 Research Boulevard, Suite M5, Austin, TX 78750 (US).

(72) Inventors: **JEAN, Buford, Randall**; 1051 Red Bud Lane, Austin, TX 78664 (US). **WHITEHEAD, Frederick, Lynn**; 9435 Singing Quail Drive, Austin, TX 78758 (US). **DANIEWICZ, John, Lee**; 10807 Bonaparte Bend, Austin, TX 78750 (US).

(74) Agent: **KLINGER, Robert, C.**; Jackson Walker, LLP, Suite 600, 2435 North Central Expressway, Richardson, TX 75080 (US).

(81) Designated States *(national)*: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW.

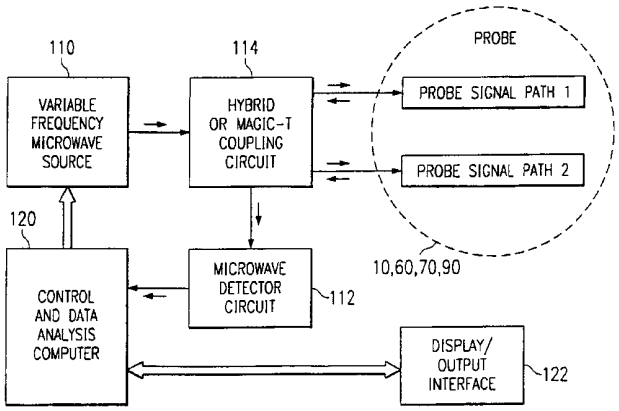
(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

(88) Date of publication of the international search report:
20 June 2002

[Continued on next page]

(54) Title: INTERFEROMETRIC MICROWAVE SENSOR



(57) Abstract: A novel microwave sensor (10, 60, 70, 90, 200, 250, 280) provides low-cost, robust measurement of the electrical properties of fluid substances. The sensor is suitable for use in an industrial vessel or pipe and employs parallel electrical transmission paths (12, 14) that differ in electrical or physical length. The electrical length of each transmission path, which may be a two-way path caused by placing a reflective element in each path, is further determined by the electrical properties of the material under test. The frequency (f) of the signal being applied to the sensor is varied in a known manner such that the difference in the electrical lengths (ΔL) of the transmission paths (12, 14) is caused to correspond to an odd integral multiple of a half wavelength. When the frequency is so adjusted and the signals that have traversed the transmission paths are allowed to coherently interfere with one another, then a minimum resultant signal or null is obtained. The null frequency for which a minimum signal is obtained is a direct measurement of the real part of the electrical permittivity (ε_r) of the material under test and thus provides a measurement from which material composition can be inferred. The material under test may be stationary of flowing past the probe element without affecting the characteristic of the measurement. An important application of the measurement method is that of determining the quality of steam and a preferred embodiment of such a sensor is described. Other fluid substances can be sensed using the sensor by the present inventions.

WO 01/36951 A3

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/31851

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N22/00

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 7 G01N

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, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 103 181 A (BJORNSEN BJORN G ET AL) 7 April 1992 (1992-04-07) column 3, line 26 - line 50; figures 1-27,35,36 column 10, line 17 -column 23, line 20 --- -/--	1-6, 9-12, 14-16, 20-27, 29,32, 34-38, 41-44, 46-48, 52-59,61

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in 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
19 March 2002	27/03/2002

Name and mailing address of the ISA	Authorized officer
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	Strohmayer, B

1

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 009, no. 122 (P-359), 28 May 1985 (1985-05-28) & JP 60 007347 A (NIPPON DENSO KK), 16 January 1985 (1985-01-16) abstract; figures 1,2	1-5,7, 9-12,15, 17,21-27
X	US 3 403 335 A (DEAN COUPER WILLIAM ET AL) 24 September 1968 (1968-09-24)	1-6,9, 11,12, 15,21, 23,25-27
Y	abstract; claim 1; figures 1-5 column 3, line 54,67	17,18, 28,30
X	GB 976 128 A (EURATOM) 25 November 1964 (1964-11-25) column 3, line 3 - line 39; figure 2	1-4,6,9, 11,12, 15,21, 23,25-27
X	PATENT ABSTRACTS OF JAPAN vol. 1995, no. 04, 31 May 1995 (1995-05-31) & JP 07 005122 A (KOBE STEEL LTD;OTHERS: 01), 10 January 1995 (1995-01-10) abstract; figures 1-3,5	1,5,6, 17,18, 21,23, 26,27, 32,37, 38,49, 50,53, 55,57-59
X	US 5 073 755 A (NEUFELD RICHARD D) 17 December 1991 (1991-12-17) abstract; figures 1,6 column 2, line 49 -column 3, line 17 column 4, line 10 - line 13 column 5, line 15 - line 26	1-6, 9-12,21, 23,26,27
X	US 4 996 489 A (SINCLAIR PAUL L) 26 February 1991 (1991-02-26) column 3, line 7 -column 4, line 26; figure 1	1,5,7,8, 11,12, 14,16, 21,23, 26-28,30

-/--

1

INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/US 00/31851

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	DE 27 12 600 A (INNOTEC OY) 29 September 1977 (1977-09-29) page 8, paragraph 2; claims 1,6,12; figures 1-10 page 10, paragraph 2 -page 12, paragraph 2 page 17, paragraph 2 -page 22, paragraph 1	1-12, 14-16, 20,21, 23, 26-30, 32,35, 37-44, 46-48, 52,53, 55,57-62
X	US 4 544 880 A (NAGY LOUIS L ET AL) 1 October 1985 (1985-10-01) column 4, line 1 - line 7; figure 1	1-4,11, 12
Y	GB 1 078 111 A (MICROWAVE INSTR LTD;JACK BILBROUGH) 2 August 1967 (1967-08-02) page 1, line 60 -page 2, line 9 page 2, line 57 - line 85; figures 1,2	17,18
Y	US 4 902 961 A (DE BIBHAS R ET AL) 20 February 1990 (1990-02-20) column 7, line 6 - line 14; figure 3	28,30
A	US 3 500 182 A (BILBROUGH JACK ET AL) 10 March 1970 (1970-03-10) column 4, line 23 - line 43; figures 3-7	17,18, 49,50
A	US 5 334 941 A (KING RAY J) 2 August 1994 (1994-08-02) column 2, line 57 -column 3, line 19; figure 1	1,32

1

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box I.2

Claims Nos.: 13,19,45,51

The subject matters of claims 13/45 are not clear, since they depend on claim 1/32 and refer to "said common electric connection", although no common electric connection is defined in claims 1/32.
The subject matters of claims 19/51 are not clear, since they depend on claim 1/37 and refers to "said first electrical element and said second electrical element", although no "electrical elements" are defined in claims 1/37.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter onal Application No
PCT/US 00/31851

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5103181	A	07-04-1992	AT	146881 T	15-01-1997
			AU	638217 B2	24-06-1993
			AU	4423489 A	01-05-1990
			BR	8907691 A	20-08-1991
			CA	2000223 A1	05-04-1990
			DE	68927587 D1	06-02-1997
			DE	68927587 T2	07-08-1997
			DK	58891 A	04-06-1991
			EP	0437532 A1	24-07-1991
			FI	102014 B1	30-09-1998
			JP	4500857 T	13-02-1992
			JP	3086689 B2	11-09-2000
			NO	911309 A	05-06-1991
			RU	2122722 C1	27-11-1998
			WO	9004167 A1	19-04-1990
JP 60007347	A	16-01-1985	NONE		
US 3403335	A	24-09-1968	NONE		
GB 976128	A	25-11-1964	FR	1312022 A	14-12-1962
			LU	42607 A1	29-12-1962
JP 07005122	A	10-01-1995	JP	3124413 B2	15-01-2001
US 5073755	A	17-12-1991	NONE		
US 4996489	A	26-02-1991	NONE		
DE 2712600	A	29-09-1977	FI	52406 B	02-05-1977
			FI	53364 B	30-12-1977
			FI	53365 B	30-12-1977
			DE	2712600 A1	29-09-1977
			GB	1560591 A	06-02-1980
			JP	1398676 C	07-09-1987
			JP	52138197 A	18-11-1977
			JP	62008741 B	24-02-1987
			SE	418774 B	22-06-1981
			SE	7703300 A	23-09-1977
			GB	1564194 A	02-04-1980
US 4544880	A	01-10-1985	US	4503384 A	05-03-1985
			US	4543823 A	01-10-1985
GB 1078111	A	02-08-1967	NONE		
US 4902961	A	20-02-1990	NONE		
US 3500182	A	10-03-1970	GB	1078504 A	09-08-1967
			DE	1598800 A1	07-01-1971
			FR	1484482 A	09-06-1967
			NL	6608756 A	27-12-1966
US 5334941	A	02-08-1994	NONE		