



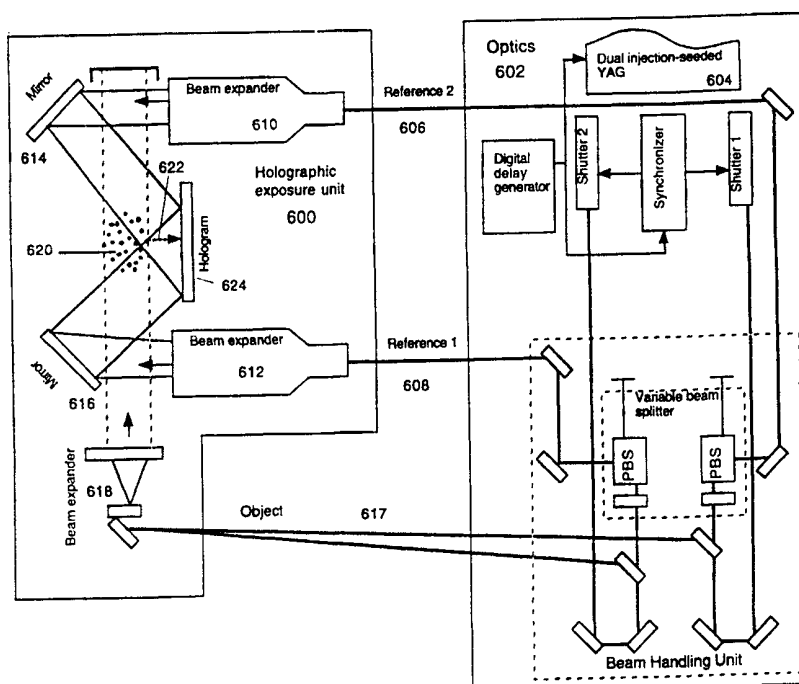
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁷ : G03H 1/04, 1/28, G01P 5/00		A3	(11) International Publication Number: WO 00/03308
			(43) International Publication Date: 20 January 2000 (20.01.00)
(21) International Application Number: PCT/US99/15449			(81) Designated States: CA, JP, MX, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).
(22) International Filing Date: 9 July 1999 (09.07.99)			
(30) Priority Data: 60/092,298 10 July 1998 (10.07.98) US			
(71) Applicant: KANSAS STATE UNIVERSITY RESEARCH FOUNDATION [US/US]; 1500 Hayes Drive, Manhattan, KS 66502-5068 (US).			
(72) Inventors: PU, Ye; 1410 Watson Place #12, Manhattan, KS 66502 (US). MENG, Hui; 3818 Emerald Circle, Manhattan, KS 66503 (US).			
(74) Agents: BALES, Jennifer, L. et al.; Macheledt Bales & Johnson LLP, Mountain View Plaza, 1520 Euclid Circle, Lafayette, CO 80026-1250 (US).			Published <i>With international search report.</i>
			(88) Date of publication of the international search report: 13 April 2000 (13.04.00)

(54) Title: PARTICLE IMAGE VELOCIMETRY APPARATUS AND METHODS

(57) Abstract

The proposed holographic particle image velocimetry (HPIV) system employs holograms of two time-separated particle fields, illuminated by separate reference beams (606, 608) on a single recording medium (624). 90-degree scattering is utilized for the object wave, in order to improve N.A. and resolve the third dimension of the hologram. The proposed HPIV system then uses substantially the same optical geometry for the reconstruction process. A CCD camera (702) is utilized to extract particle subimages, thin slice by thin slice, and a standard centroid-finding algorithm is applied to extract centroid locations for each volume. The concise cross correlation (CCC) algorithm for extracting velocity vector fields from the centroid data is an important enabling feature of the proposed system. Correlations are calculated between subsets of centroids representing the images or cubes, and velocity vectors are computed from the individual correlations. Higher spatial resolution can also be obtained by pairing particle centroids individually.



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			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 99/15449

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 G03H1/04 G03H1/28 G01P5/00

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 G03H G01P

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.
X	US 5 548 419 A (ADRIAN RONALD J ET AL) 20 August 1996 (1996-08-20) cited in the application column 4, line 50 -column 9, line 12 figures 1-5	1-3,5-7
A	US 5 532 814 A (CHA SOYOUNG S) 2 July 1996 (1996-07-02) column 3, line 22 -column 4, line 29	1-3,5-7
A	EP 0 436 125 A (EZEL INC) 10 July 1991 (1991-07-10) page 2, line 16 - line 36	4,8,9

☐ Further documents are listed in the continuation of box C.

☒ 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

18 January 2000

Date of mailing of the international search report

24/01/2000

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

Krametz, E

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 99/15449

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5548419	A	20-08-1996	NONE	
US 5532814	A	02-07-1996	NONE	
EP 0436125	A	10-07-1991	JP 2815118 B	27-10-1998
			JP 3175364 A	30-07-1991
			DE 69004064 D	25-11-1993
			DE 69004064 T	17-02-1994
			US 5249136 A	28-09-1993