US006141625A

United States Patent [19]

Smith et al.

[11] **Patent Number: 6,141,625**

[45] **Date of Patent: Oct. 31, 2000**

[54] **VISCOMETER MODULE WITH CRYSTAL RESONATOR-TYPE SENSOR**

[75] Inventors: **Ronald L. Smith**, Troy; **Mark Lovik**, Chatham, both of Ill.

[73] Assignee: **DICKEY-john Corporation**, Auburn, Ill.

[21] Appl. No.: **09/090,363**

[22] Filed: **Jun. 4, 1998**

Related U.S. Application Data

[63] Continuation-in-part of application No. 08/871,272, Jun. 9, 1997, abandoned.

[51] **Int. Cl.**[7] **G01N 9/00**

[52] **U.S. Cl.** **702/50**; 73/54.01

[58] **Field of Search** ..... 702/50, 54, 56, 702/103; 73/1.02, 32 A, 40.5 A, 75.5, 54.01, 54.02, 54.41, 64.53

[56] **References Cited**

U.S. PATENT DOCUMENTS

4,065,959	1/1978	Richardson	73/56
4,484,468	11/1984	Gau et al.	73/60
4,741,200	5/1988	Hammerle	73/54
4,783,987	11/1988	Hager et al.	73/32 A
5,198,716	3/1993	Godshall et al.	310/349
5,201,215	4/1993	Granstaff et al.	73/54.41
5,365,778	11/1994	Sheen et al.	73/54.41
5,416,448	5/1995	Wessendorf	331/116 R
5,503,003	4/1996	Brookfield	73/54.32
5,526,287	6/1996	French	364/550
5,541,855	7/1996	Enzler et al.	364/552
5,734,098	3/1998	Kraus et al.	73/61.62
5,741,961	4/1998	Martin et al.	73/32 R
5,798,452	8/1998	Martin et al.	73/32 R
5,827,952	10/1998	Mansure et al.	73/61.45
5,839,094	11/1998	French	702/91

FOREIGN PATENT DOCUMENTS

WO 97/49980 12/1997 WIPO .

OTHER PUBLICATIONS

"Viscosity—Part 1," *Measurements & Control,* Sep. 1994, pp. 114–119.

"Viscosity—Part 2," *Measurements & Control,* Oct. 1994, pp. 70–75

"Viscosity—Part 3," *Measurements & Control,* Dec. 1994, pp. 69–73.

S.J. Martin et al., "Characterization Of A Quartz Crystal Microbalance With Simultaneous Mass And Liquid Loading," *Analytical Chemistry,* vol. 63, No. 20, Oct. 15, 1991, pp. 2272–2281.

S. Bruckenstein et al., "Dual Quartz Crystal Microbalance Oscillator Circuit. Minimizing Effects Due To Liquid Viscosity, Density, And Temperature," *Analytical Chemistry,* vol. 66, No. 11, Jun. 1, 1994, pp. 1847–1852.

"Monitoring Corrosivity In The Atmosphere With A QCM," *J. Electrochem. Soc.,* 1996, 143.

W. Lee et al., "Depletion Layer Effects On The Response Of The Electrochemical Quartz Crystal Microbalance," *Analytical Chemistry,* vol. 65, No. 22, Nov. 15, 1993, pp. 3232–3237.

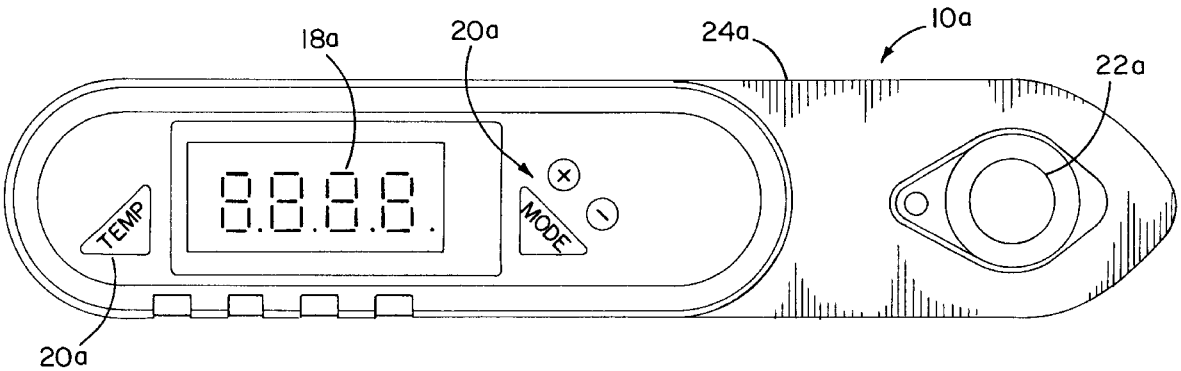
J. Redepenning et al., "Osteoblast Attachment Monitored With A Quartz Crystal Microbalance," *Analytical Chemistry,* vol. 65, No. 23, Dec. 1, 1993, pp. 3378–3381.

A.C. Hillier et al., "Scanning Electrochemical Mass Sensitivity Mapping Of The Quartz Crystal Microbalance In Liquid Media," *Analytical Chemistry,* vol. 64, No. 21, Nov. 1, 1992, pp. 2539–2554.

(List continued on next page.)

Primary Examiner—Patrick Assouad
Attorney, Agent, or Firm—Katten Muchin Zavis

[57] **ABSTRACT**

A portable viscometer includes an instrument body having an electrical control circuit disposed therein and sensor probe for immersion into a fluid to be analyzed. The sensing probe includes a crystal resonator-type sensor and a temperature sensor that provide sensing signals to the electrical control circuit indicative of fluid viscosity. The resultant viscosity is displayed and/or stored.

8 Claims, 10 Drawing Sheets