



US009410787B2

(12) **United States Patent**
Raab et al.

(10) **Patent No.:** **US 9,410,787 B2**
(45) **Date of Patent:** **Aug. 9, 2016**

(54) **PORTABLE COORDINATE MEASUREMENT MACHINE HAVING A BEARING ASSEMBLY WITH AN OPTICAL ENCODER**

USPC 33/1 PT, 503
See application file for complete search history.

(71) Applicant: **FARO Technologies, Inc.**, Lake Mary, FL (US)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Simon Raab**, Santa Barbara, CA (US);
Marc M. Barber, Deltona, FL (US)

2,906,179 A 9/1959 Bower
3,531,868 A 10/1970 Stevenson

(Continued)

(73) Assignee: **FARO TECHNOLOGIES, INC.**, Lake Mary, FL (US)

FOREIGN PATENT DOCUMENTS

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 16 days.

DE 2711593 A1 9/1978
DE 3527128 A1 1/1987

(Continued)

(21) Appl. No.: **14/524,073**

OTHER PUBLICATIONS

(22) Filed: **Oct. 27, 2014**

Blais, F., "Review of 20 Years of Range Sensor Development", Journal of Electronic Imaging, 13, 1, 2004, vol. 13 (1)/231. Jan. 2004. 15 Pages.

(65) **Prior Publication Data**

(Continued)

US 2015/0192399 A1 Jul. 9, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/412,744, filed on Mar. 6, 2012, now Pat. No. 8,931,182, which is a continuation of application No. 13/412,705, filed on Mar. 6, 2012, now Pat. No. 8,595,948, which is a

(Continued)

(51) **Int. Cl.**
G01B 5/008 (2006.01)
B25J 9/16 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **G01B 5/008** (2013.01); **B25J 9/1692** (2013.01); **G01B 7/008** (2013.01); **G01B 11/005** (2013.01);

(Continued)

(58) **Field of Classification Search**
CPC G01D 5/3473; G01B 5/008

Primary Examiner — G. Bradley Bennett

(74) *Attorney, Agent, or Firm* — Cantor Colburn LLP

(57) **ABSTRACT**

A portable articulated arm coordinate measurement machine having an articulated arm that includes a first arm connected to a second arm segment by a connecting segment. An assembly is provided having a first pair of bearings and a first optical encoder and a second pair of bearings and a second optical encoder. The first optical encoder includes a first patterned disk and a first read head. The second optical encoder includes a second patterned disk and a second read head. The first and second patterned disks are both fixed with respect to the connecting segment. An electronic circuit is operably coupled to the first read head and the second read head, the electronics being configured to determine three-dimensional coordinates of the probe based at least in part on a first angle and a second angle measured by the first and second optical encoders.

7 Claims, 64 Drawing Sheets

