



**United States Patent**  
**Özgür et al.**

(10) Patent No.: **US 10,377,231 B2**  
(45) Date of Patent: **Aug. 13, 2019**

(54) **MAGNET-ASSISTED BALL DRIVE**

(71) Applicant: **ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE (EPFL)**, Lausanne (CH)

(72) Inventors: **Ayberk Özgür**, Lausanne (CH); **Séverin Lemaignan**, Plymouth (GB); **Wafa Jahal**, Lausanne (CH); **Francesco Mondada**, Bussigny (CH); **Pierre Dillenbourg**, Giverny (CH)

(73) Assignee: **ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE (EPFL)**, Lausanne (CH)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 198 days.

(21) Appl. No.: **15/648,425**

(22) Filed: **Jul. 12, 2017**

(65) **Prior Publication Data**  
US 2019/0016213 A1 Jan. 17, 2019

(51) **Int. Cl.**  
**B60K 1/704** (2006.01)  
**B60B 19/14** (2006.01)  
**B60B 19/00** (2006.01)  
**B60K 7/00** (2006.01)

(52) **U.S. CL.**  
**CPC** ..... **B60K 1/7043** (2013.01); **B60B 19/003** (2013.01); **B60B 19/14** (2013.01); **B60K 7/0007** (2013.01); **B60B 29/00931** (2013.01); **B60K 2007/00045** (2013.01); **B60K 2007/00067** (2013.01); **B60Y 2200/40** (2013.01)

(58) **Field of Classification Search**  
CPC ..... **B60K 1/7043**; **B60K 7/0007**; **B60K 2007/00045**; **B60B 19/003**; **B60B 19/14**; **B60B 29/00931**; **B60Y 2200/40**  
See application file for complete search history.

**References Cited**

**U.S. PATENT DOCUMENTS**

4,700,381 A	10/1987	Tibbals, Jr.	473,594
4,785,891 A	11/1988	von Wackelmann	473,594
5,190,504 A *	3/1993	Scatterday	A63D 21/00189
5,660,596 A *	8/1997	Rocheffort	A63D 5/08
7,891,445 B1	2/2011	McKinley et al.	473/118
8,459,383 B1	6/2013	Burget	Aug
8,660,660 B2 *	12/2013	Aug	B60B 19/14
			701/22

(Continued)

**OTHER PUBLICATIONS**

Chen et al., "Design and implementation of a ball-driven omnidirectional spherical robot", *Mechanism and Machine Theory*, vol. 68, 2013, pp. 35-48.

(Continued)

**Primary Examiner**—Anne Marie M. Boehler  
**Assistant Examiner**—Marlon A. Ace  
**(74) Attorney, Agent, or Firm**—Maschoff Brennan

**ABSTRACT**  
The present invention concerns a magnet-assisted ball drive. The drive comprises a ball and a drive element in contact with the ball. The drive element is arranged to be rotated around its axis of rotation to drive the ball. The ball and the drive element each comprise magnetic material such that at least one of the ball and the drive element comprises a magnet to generate a magnetic pulling force to pull the ball and the drive element against each other.

**18 Claims, 4 Drawing Sheets**

