US006169397B1

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

(10) **Patent No.: US 6,169,397 B1**
(45) **Date of Patent: Jan. 2, 2001**

(54) **DAMPED SUPERCONDUCTING COIL SYSTEM HAVING A MULTITURN, PLANAR GEOMETRY SUPERCONDUCTING COIL AND SHUNT RESISTORS ELECTRICALLY CONNECTING SUCCESSIVE COIL TURNS**

(75) Inventors: **Andrew Harvey Steinbach**, Paris (FR); **Martin Emile Huber**, Louisville; **Ronald Hajime Ono**, Boulder, both of CO (US)

(73) Assignees: **University Technology Corp.**, Boulder, CO (US); **National Institute of Standards and Technology**, Gaithersburg, MD (US)

(*) Notice: Under 35 U.S.C. 154(b), the term of this patent shall be extended for 0 days.

(21) Appl. No.: **09/133,470**

(22) Filed: **Aug. 13, 1998**

Related U.S. Application Data

(60) Provisional application No. 60/055,564, filed on Aug. 13, 1997.

(51) **Int. Cl.**[7] **G01R 33/02**; G01R 33/035; H01L 21/00; H01L 39/22

(52) **U.S. Cl.** **324/248**; 505/846

(58) **Field of Search** 324/248–244; 505/845, 846–874; 327/527, 528; 257/31

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,319,307	6/1994	Simmonds	324/248
5,656,937	8/1997	Cantor	324/248

OTHER PUBLICATIONS

Keene, Mark, Nicholas Exon, Julian Satchell, Richard Humphreys, Nigel Chew and Karan Lander, "HTS SQUID Magnetometers with Intermediate Flux Transformers," IEEE Transactions on Applied Superconductivity, 1996.

Cantor, Robin, "DC SQUIDS: Design, Optimization and Practical Applications," *SQUID Sensors: Fundamentals, Fabrication and Applications,* H. Weinstock (ed.), Netherlands: Kluwer Academic Publishers, 1996, pp. 179–233.

Ryhanen, Tapani, Heikki Seppa, Risto Ilmoniemi, and Jukka Knuutila, "Squid Magnetometers for Low–Frequency Applications," Journal of Low Temperature Physics, vol.76, Nos. 5/6, 1989, 287–386.

Enpuku, K., R. Cantor and H. Koch, "Resonant Properties of a DC SQUID Coupled to a Multiturn Input Coil," IEEE Transactions on Applied Superconductivity, vol. 3, No.1, 1993, 1858–1861.

Enpuku, K., K. Yoshida and S. Kohjiro, "Noise Characteristics of a DC SQUID with a Resistively Shunted Inductance," J. Appl. Phys., vol. 60, No. 12, 1986, 4218–4223.

Sauvageau, J.E., C.J. Burroughs, P.A.A. Booi, M.W. Cromar, S.P. Benz and J.A. Koch, "Superconducting Integrated Circuit Fabrication with Low Temperature ECR–Based PECVD SiO_2 Dialectic Films," IEEE Transactions on Applied Superconductivity, vol. 5, No. 2, 1995, 2303–2309.

Ketchen, M.B., "DC SQUIDS 1980: The State of the Art," IEEE Transactions on Magnetics, vol. 17, No. 1, 1981, 387–394.

Jaycox, J.M., and M.B. Ketchen, "Planar Coupling Scheme for Ultra Low Noise DC SQUIDs," IEEE Transactions on Magnetics, vol. 17, No. 1, 1981, 400–403.

Primary Examiner—Jay Patidar
(74) *Attorney, Agent, or Firm*—Jennifer L. Bales; Macheledt Bales & Johnson LLP

(57) **ABSTRACT**

The operation of a planar geometry superconducting coil used in conjunction with a ground plane is improved by intracoil damping. This damping reduces coil resonances. The improvement consists of an intracoil shunt, which damps the resonances of the coil by connecting each turn, or loop, of the multiturn/multiloop coil with resistors. One example of a planar geometry superconducting coil which is effectively damped according to the present invention is the input coil to a superconducting quantum interference device (SQUID). The intracoil shunt may be added to the SQUID at the same time in the SQUID fabrication as the junction shunts.

24 Claims, 10 Drawing Sheets