



US009410408B2

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

(10) **Patent No.:** **US 9,410,408 B2**  
(45) **Date of Patent:** **Aug. 9, 2016**

(54) **ELECTRICAL HEATING OF OIL SHALE AND HEAVY OIL FORMATIONS**

(71) Applicant: **SCHLUMBERGER TECHNOLOGY CORPORATION**, Sugar Land, TX (US)

(72) Inventors: **Brian Oliver Clark**, Sugar Land, TX (US); **Robert L. Kleinberg**, Cambridge, MA (US); **Nikita V. Seleznev**, Cambridge, MA (US)

(73) Assignee: **SCHLUMBERGER TECHNOLOGY CORPORATION**, Sugar Land, TX (US)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 337 days.

(21) Appl. No.: **13/795,832**

(22) Filed: **Mar. 12, 2013**

(65) **Prior Publication Data**  
US 2014/0262221 A1 Sep. 18, 2014

(51) **Int. Cl.**  
**E21B 43/24** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **E21B 43/2401** (2013.01)

(58) **Field of Classification Search**  
CPC ..... E21B 43/16; E21B 43/24  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,782,465 A 1/1974 Bell et al.  
3,948,319 A 4/1976 Pritchett

4,037,655 A	7/1977	Carpenter	
4,199,025 A	4/1980	Carpenter	
4,228,853 A *	10/1980	Harvey et al.	166/248
4,926,941 A	5/1990	Glandt et al.	
7,322,409 B2	1/2008	Wittle et al.	
8,196,658 B2	6/2012	Miller et al.	
2006/0151166 A1	7/2006	Montgomery et al.	
2009/0008079 A1	1/2009	Zazovsky et al.	
2010/0101793 A1 *	4/2010	Symington et al.	166/302
2011/0277992 A1	11/2011	Grimes	
2013/0255936 A1 *	10/2013	Geilikman et al.	166/248

**OTHER PUBLICATIONS**

Gurevich et al., "Modeling elastic wave velocities and attenuation in rocks saturated with heavy oil," Geophysics, Jul.-Aug. 2008, vol. 73(4): pp. E115-E122.

(Continued)

*Primary Examiner* — William P Neuder

(74) *Attorney, Agent, or Firm* — Kenneth L. Kincaid

(57) **ABSTRACT**

A method (and system) is provided that enhances production of hydrocarbons from a subterranean formation by identifying at least one target interval of the subterranean formation that is in proximity to a pay interval, wherein the at least one target interval has an electrical resistance less than electrical resistance of the pay interval. A plurality of electrodes are placed in positions spaced apart from one another and adjacent the at least one target interval. Electrical current is injected into the target interval by supplying electrical signals to the plurality of electrodes. The electrical current injected into the at least one target interval passes through at least a portion of the at least one target interval in order to heat the at least one target interval and heat the pay interval by thermal conduction for enhancement of production of hydrocarbons from the pay interval.

**21 Claims, 10 Drawing Sheets**

