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(54) **MECHANICAL PROCESSING OF HIGH ASPECT RATIO METALLIC TUBING AND RELATED TECHNOLOGY**

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F16L 9/02 (2006.01)

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CPC ***F16L 9/02*** (2013.01)

(58) **Field of Classification Search**
USPC ..... 138/177, 178, DIG. 5, DIG. 11; 428/586
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,343,890 A 3/1944 Dewald
2,788,994 A * 4/1957 van de Wateren F16L 5/022 285/192
2,999,552 A * 9/1961 Fox E21B 17/16 138/177
3,232,638 A * 2/1966 Hollander E21B 17/16 138/109
3,303,859 A 2/1967 Ackermann et al.
3,382,565 A 5/1968 Binkley
3,574,917 A 4/1971 Miyazaki
3,668,916 A 6/1972 Ledebur
3,718,017 A 2/1973 Blackburn
3,915,291 A 10/1975 Vogts
4,090,382 A 5/1978 Schott
4,134,430 A * 1/1979 Mukasa F16L 9/00 138/109

(Continued)

FOREIGN PATENT DOCUMENTS

CN 202861228 U 4/2013
DE 4343820 A1 6/1995
JP 2003088924 A 3/2003

OTHER PUBLICATIONS

U.S. Appl. No. 14/749,500, filed Jun. 24, 2015, Raghavan et al.

(Continued)

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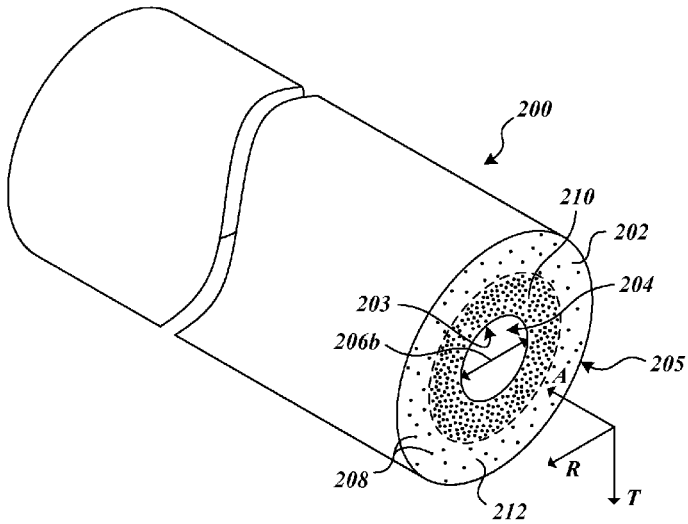
(57) **ABSTRACT**

Tubes for use in ultrahigh pressure devices, and associated systems and methods of manufacture are disclosed herein. In one embodiment, a metal tube includes an elongate bore having a circular transverse cross-sectional shape. The metal tube also includes an elongate wall extending around the bore and having an annular transverse cross-sectional shape with an inner surface closest to the bore, an outer surface furthest from the bore, and a wall thickness extending from the inner surface to the outer surface. An inner portion of the wall is under swage-autofrettage-induced overall compressive stress.

17 Claims, 11 Drawing Sheets