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United States Patent	12385501
Kind Code	B2
Date of Patent	August 12, 2025
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Tensioned support post and other molten metal devices

Abstract

A vertically-elongated member, which is preferably a support post used in a molten metal pump, includes a ceramic tube and tensioning structures to add a compressive load to the tube along its longitudinal axis. This makes the tube less prone to breakage. Another vertically-elongated member, such as a support post, includes one or more reinforcement members to help alleviate breakage. A device, such as a pump, used in a molten metal bath includes one or more of such vertical members.

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Appl. No.:	**18/753675**
Filed:	**June 25, 2024**

Prior Publication Data

Document Identifier	Publication Date
US 20240344528 A1	Oct. 17, 2024

Related U.S. Application Data

continuation parent-doc US 18139936 20230426 US 12031550 child-doc US 18753675
continuation parent-doc US 17496229 20211007 US 11976672 20240507 child-doc US 18139936
continuation parent-doc US 16195678 20181119 US 11149747 20211019 child-doc US 17496229
us-provisional-application US 62588090 20171117

Publication Classification

Int. Cl.: **F04D29/60** (20060101); **F04D29/043** (20060101); F04D7/00 (20060101)

U.S. Cl.:

CPC **F04D29/605** (20130101); **F04D29/043** (20130101); F04D7/00 (20130101); F05B2240/60 (20130101); F05B2240/90 (20130101)

Field of Classification Search

CPC: F04D (29/605); F04D (29/042); F04D (7/065); F05B (2240/90)

USPC: 248/677; 415/216.1

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5435982	12/1994	Wilkinson	N/A	N/A
5436210	12/1994	Wilkinson et al.	N/A	N/A
5443572	12/1994	Wilkinson et al.	N/A	N/A
5454423	12/1994	Tsuchida et al.	N/A	N/A
5468280	12/1994	Areaux	N/A	N/A
5470201	12/1994	Gilbert et al.	N/A	N/A
5484265	12/1995	Horvath et al.	N/A	N/A
5489734	12/1995	Nagel et al.	N/A	N/A
5491279	12/1995	Robert et al.	N/A	N/A
5494382	12/1995	Kloppers	N/A	N/A
5495746	12/1995	Sigworth	N/A	N/A
5505143	12/1995	Nagel	N/A	N/A
5505435	12/1995	Laszlo	N/A	N/A
5509791	12/1995	Turner	N/A	N/A
5511766	12/1995	Vassilicos	N/A	N/A
5520422	12/1995	Friedrich	N/A	N/A
5537940	12/1995	Nagel et al.	N/A	N/A
5543558	12/1995	Nagel et al.	N/A	N/A
5555822	12/1995	Loewen et al.	N/A	N/A
5558501	12/1995	Wang et al.	N/A	N/A
5558505	12/1995	Mordue et al.	N/A	N/A
5571486	12/1995	Robert et al.	N/A	N/A
5585532	12/1995	Nagel	N/A	N/A
5586863	12/1995	Gilbert et al.	N/A	N/A
5591243	12/1996	Colussi et al.	N/A	N/A
5597289	12/1996	Thut	N/A	N/A
5613245	12/1996	Robert	N/A	N/A
5616167	12/1996	Eckert	N/A	N/A
5622481	12/1996	Thut	N/A	N/A
5629464	12/1996	Bach et al.	N/A	N/A
5634770	12/1996	Gilbert et al.	N/A	N/A
5640706	12/1996	Nagel et al.	N/A	N/A
5640707	12/1996	Nagel et al.	N/A	N/A
5640709	12/1996	Nagel et al.	N/A	N/A
5655849	12/1996	McEwen et al.	N/A	N/A
5660614	12/1996	Waite et al.	N/A	N/A

5662725	12/1996	Cooper	N/A	N/A
5676520	12/1996	Thut	N/A	N/A
5678244	12/1996	Shaw et al.	N/A	N/A
5678807	12/1996	Cooper	N/A	N/A
5679132	12/1996	Rauenzahn et al.	N/A	N/A
5685701	12/1996	Chandler et al.	N/A	N/A
5690888	12/1996	Robert	N/A	N/A
5695732	12/1996	Sparks et al.	N/A	N/A
5716195	12/1997	Thut	N/A	N/A
5717149	12/1997	Nagel et al.	N/A	N/A
5718416	12/1997	Flisakowski et al.	N/A	N/A
5735668	12/1997	Klein	N/A	N/A
5735935	12/1997	Areaux	N/A	N/A
5741422	12/1997	Eichenmiller et al.	N/A	N/A
5744093	12/1997	Davis	N/A	N/A
5744117	12/1997	Wilkinson et al.	N/A	N/A
5745861	12/1997	Bell et al.	N/A	N/A
5755847	12/1997	Quayle	N/A	N/A
5758712	12/1997	Pederson	N/A	N/A
5772324	12/1997	Falk	N/A	N/A
5776420	12/1997	Nagel	N/A	N/A
5785494	12/1997	Vild et al.	N/A	N/A
5842832	12/1997	Thut	N/A	N/A
5846481	12/1997	Tilak	N/A	N/A
5858059	12/1998	Abramovich et al.	N/A	N/A
5863314	12/1998	Morando	N/A	N/A
5866095	12/1998	McGeever et al.	N/A	N/A
5875385	12/1998	Stephenson et al.	N/A	N/A
5935528	12/1998	Stephenson et al.	N/A	N/A
5944496	12/1998	Cooper	N/A	N/A
5947705	12/1998	Mordue et al.	N/A	N/A
5948352	12/1998	Jagt et al.	N/A	N/A
5951243	12/1998	Cooper	N/A	N/A
5961285	12/1998	Meneice et al.	N/A	N/A
5963580	12/1998	Eckert	N/A	N/A
5992230	12/1998	Scarpa et al.	N/A	N/A
5993726	12/1998	Huang	N/A	N/A
5993728	12/1998	Vild	N/A	N/A
6007313	12/1998	Sigel	417/424.1	F04D 29/0413
6019576	12/1999	Thut	N/A	N/A
6027685	12/1999	Cooper	N/A	N/A
6036745	12/1999	Gilbert et al.	N/A	N/A
6074455	12/1999	van Linden et al.	N/A	N/A
6082965	12/1999	Morando	N/A	N/A
6093000	12/1999	Cooper	N/A	N/A
6096109	12/1999	Nagel et al.	N/A	N/A
6113154	12/1999	Thut	N/A	N/A
6123523	12/1999	Cooper	N/A	N/A
6152691	12/1999	Thut	N/A	N/A

6168753	12/2000	Morando	N/A	N/A
6187096	12/2000	Thut	N/A	N/A
6199836	12/2000	Rexford et al.	N/A	N/A
6217823	12/2000	Vild et al.	N/A	N/A
6231639	12/2000	Eichenmiller	N/A	N/A
6250881	12/2000	Mordue et al.	N/A	N/A
6254340	12/2000	Vild et al.	N/A	N/A
6270717	12/2000	Tremblay et al.	N/A	N/A
6280157	12/2000	Cooper	N/A	N/A
6293759	12/2000	Thut	N/A	N/A
6303074	12/2000	Cooper	N/A	N/A
6345964	12/2001	Cooper	N/A	N/A
6354796	12/2001	Morando	N/A	N/A
6358467	12/2001	Mordue	N/A	N/A
6364930	12/2001	Kos	N/A	N/A
6371723	12/2001	Grant et al.	N/A	N/A
6398525	12/2001	Cooper	N/A	N/A
6439860	12/2001	Greer	N/A	N/A
6451247	12/2001	Mordue et al.	N/A	N/A
6457940	12/2001	Lehman	N/A	N/A
6457950	12/2001	Cooper et al.	N/A	N/A
6464458	12/2001	Vild et al.	N/A	N/A
6474962	12/2001	Allen et al.	N/A	N/A
6495948	12/2001	Garrett, III	N/A	N/A
6497559	12/2001	Grant	N/A	N/A
6500228	12/2001	Klingensmith et al.	N/A	N/A
6503292	12/2002	Klingensmith et al.	N/A	N/A
6524066	12/2002	Thut	N/A	N/A
6533535	12/2002	Thut	N/A	N/A
6551060	12/2002	Mordue et al.	N/A	N/A
6562286	12/2002	Lehman	N/A	N/A
6656415	12/2002	Kos	N/A	N/A
6679936	12/2003	Quackenbush	N/A	N/A
6689310	12/2003	Cooper	N/A	N/A
6709234	12/2003	Gilbert et al.	N/A	N/A
6716147	12/2003	Hinkle et al.	N/A	N/A
6723276	12/2003	Cooper	N/A	N/A
6805834	12/2003	Thut	N/A	N/A
6843640	12/2004	Mordue et al.	N/A	N/A
6848497	12/2004	Sale et al.	N/A	N/A
6869271	12/2004	Gilbert et al.	N/A	N/A
6869564	12/2004	Gilbert et al.	N/A	N/A
6881030	12/2004	Thut	N/A	N/A
6887424	12/2004	Ohno et al.	N/A	N/A
6887425	12/2004	Mordue et al.	N/A	N/A
6902696	12/2004	Klingensmith et al.	N/A	N/A
7037462	12/2005	Klingensmith et al.	N/A	N/A
7074361	12/2005	Carolla et al.	N/A	N/A
7083758	12/2005	Tremblay	N/A	N/A
7131482	12/2005	Vincent et al.	N/A	N/A

7157043	12/2006	Neff	N/A	N/A
7204954	12/2006	Mizuno	N/A	N/A
7273582	12/2006	Mordue	N/A	N/A
7279128	12/2006	Kennedy et al.	N/A	N/A
7326028	12/2007	Morando	N/A	N/A
7402276	12/2007	Cooper	N/A	N/A
7470392	12/2007	Cooper	N/A	N/A
7476357	12/2008	Thut	N/A	N/A
7481966	12/2008	Mizuno	N/A	N/A
7497988	12/2008	Thut	N/A	N/A
7507365	12/2008	Thut	N/A	N/A
7507367	12/2008	Cooper	N/A	N/A
7543605	12/2008	Morando	N/A	N/A
7731891	12/2009	Cooper	N/A	N/A
7771171	12/2009	Mohr	N/A	N/A
7784999	12/2009	Lott	N/A	N/A
7841379	12/2009	Evans	N/A	N/A
7896617	12/2010	Morando	N/A	N/A
7906068	12/2010	Cooper	N/A	N/A
8075837	12/2010	Cooper	N/A	N/A
8110141	12/2011	Cooper	N/A	N/A
8137023	12/2011	Greer	N/A	N/A
8142145	12/2011	Thut	N/A	N/A
8178037	12/2011	Cooper	N/A	N/A
8328540	12/2011	Wang	N/A	N/A
8333921	12/2011	Thut	N/A	N/A
8337746	12/2011	Cooper	N/A	N/A
8361379	12/2012	Cooper	N/A	N/A
8366993	12/2012	Cooper	N/A	N/A
8409495	12/2012	Cooper	N/A	N/A
8440135	12/2012	Cooper	N/A	N/A
8444911	12/2012	Cooper	N/A	N/A
8449814	12/2012	Cooper	N/A	N/A
8475594	12/2012	Bright et al.	N/A	N/A
8475708	12/2012	Cooper	N/A	N/A
8480950	12/2012	Jetten et al.	N/A	N/A
8501084	12/2012	Cooper	N/A	N/A
8524146	12/2012	Cooper	N/A	N/A
8529828	12/2012	Cooper	N/A	N/A
8535603	12/2012	Cooper	N/A	N/A
8580218	12/2012	Turenne et al.	N/A	N/A
8613884	12/2012	Cooper	N/A	N/A
8714914	12/2013	Cooper	N/A	N/A
8753563	12/2013	Cooper	N/A	N/A
8840359	12/2013	Vick et al.	N/A	N/A
8899932	12/2013	Tetkoskie et al.	N/A	N/A
8915830	12/2013	March et al.	N/A	N/A
8920680	12/2013	Mao	N/A	N/A
9011761	12/2014	Cooper	N/A	N/A
9017597	12/2014	Cooper	N/A	N/A

9034244	12/2014	Cooper	N/A	N/A
9057376	12/2014	Thut	N/A	N/A
9057377	12/2014	Thut	N/A	N/A
9074601	12/2014	Thut	N/A	N/A
9080577	12/2014	Cooper	N/A	N/A
9108224	12/2014	Schererz et al.	N/A	N/A
9108244	12/2014	Cooper	N/A	N/A
9156087	12/2014	Cooper	N/A	N/A
9193532	12/2014	March et al.	N/A	N/A
9205490	12/2014	Cooper	N/A	N/A
9234520	12/2015	Morando	N/A	N/A
9273376	12/2015	Lutes et al.	N/A	N/A
9328615	12/2015	Cooper	N/A	N/A
9377028	12/2015	Cooper	N/A	N/A
9382599	12/2015	Cooper	N/A	N/A
9383140	12/2015	Cooper	N/A	N/A
9388925	12/2015	Juarez	N/A	N/A
9409232	12/2015	Cooper	N/A	N/A
9410744	12/2015	Cooper	N/A	N/A
9422942	12/2015	Cooper	N/A	F04D 29/043
9435343	12/2015	Cooper	N/A	N/A
9464636	12/2015	Cooper	N/A	N/A
9470239	12/2015	Cooper	N/A	N/A
9476644	12/2015	Howitt et al.	N/A	N/A
9481035	12/2015	Cooper	N/A	N/A
9481918	12/2015	Vild et al.	N/A	N/A
9482469	12/2015	Cooper	N/A	N/A
9494366	12/2015	Thut	N/A	N/A
9506129	12/2015	Cooper	N/A	N/A
9506346	12/2015	Bright et al.	N/A	N/A
9532670	12/2016	Vanessen	N/A	N/A
9566645	12/2016	Cooper	N/A	N/A
9581388	12/2016	Cooper	N/A	N/A
9587883	12/2016	Cooper	N/A	N/A
9632670	12/2016	Wu	N/A	N/A
9643247	12/2016	Cooper	N/A	N/A
9657578	12/2016	Cooper	N/A	N/A
9855600	12/2017	Cooper	N/A	N/A
9862026	12/2017	Cooper	N/A	N/A
9903383	12/2017	Cooper	N/A	N/A
9909808	12/2017	Cooper	N/A	N/A
9920767	12/2017	Klain et al.	N/A	N/A
9920787	12/2017	Paul	N/A	F16C 33/1045
9925587	12/2017	Cooper	N/A	N/A
9951777	12/2017	Morando et al.	N/A	N/A
9970442	12/2017	Tipton	N/A	N/A
9982945	12/2017	Cooper	N/A	N/A
10052688	12/2017	Cooper	N/A	N/A
10072897	12/2017	Cooper	N/A	N/A

10126058	12/2017	Cooper	N/A	N/A
10126059	12/2017	Cooper	N/A	N/A
10138892	12/2017	Cooper	N/A	N/A
10195664	12/2018	Cooper et al.	N/A	N/A
10267314	12/2018	Cooper	N/A	F04D 7/065
10274256	12/2018	Cooper	N/A	N/A
10302361	12/2018	Cooper	N/A	N/A
10307821	12/2018	Cooper	N/A	N/A
10309725	12/2018	Cooper	N/A	N/A
10322451	12/2018	Cooper	N/A	N/A
10345045	12/2018	Cooper	N/A	N/A
10352620	12/2018	Cooper	N/A	N/A
10428821	12/2018	Cooper	N/A	N/A
10458708	12/2018	Cooper	N/A	N/A
10465688	12/2018	Cooper	N/A	N/A
10562097	12/2019	Cooper	N/A	N/A
10570745	12/2019	Cooper	N/A	N/A
10641270	12/2019	Cooper	N/A	F04D 29/628
10641279	12/2019	Cooper	N/A	N/A
10675679	12/2019	Cooper	N/A	N/A
11020798	12/2020	Cooper	N/A	N/A
11098719	12/2020	Cooper	N/A	N/A
11098720	12/2020	Cooper	N/A	F04D 29/628
11103920	12/2020	Cooper	N/A	N/A
11130173	12/2020	Cooper	N/A	N/A
11149747	12/2020	Cooper	N/A	F04D 29/605
11167345	12/2020	Cooper	N/A	N/A
11185916	12/2020	Cooper	N/A	N/A
11286939	12/2021	Cooper	N/A	N/A
11358216	12/2021	Cooper	N/A	N/A
11358217	12/2021	Cooper	N/A	N/A
11391293	12/2021	Cooper	N/A	N/A
11471938	12/2021	Fontana	N/A	N/A
11519414	12/2021	Cooper	N/A	N/A
12031550	12/2023	Cooper	N/A	F04D 29/043
2001/0000465	12/2000	Thut	N/A	N/A
2002/0089099	12/2001	Denning	N/A	N/A
2002/0102159	12/2001	Thut	N/A	N/A
2002/0146313	12/2001	Thut	N/A	N/A
2002/0185789	12/2001	Klingensmith et al.	N/A	N/A
2002/0185790	12/2001	Kilgensmith	N/A	N/A
2002/0185794	12/2001	Vincent	N/A	N/A
2003/0047850	12/2002	Areaux	N/A	N/A
2003/0075844	12/2002	Mordue et al.	N/A	N/A
2003/0082052	12/2002	Gilbert et al.	N/A	N/A
2003/0151176	12/2002	Ohno	N/A	N/A
2003/0201583	12/2002	Klingensmith	N/A	N/A
2004/0050525	12/2003	Kennedy et al.	N/A	N/A
2004/0076533	12/2003	Cooper	N/A	N/A
2004/0096330	12/2003	Gilbert	N/A	N/A

2004/0115079	12/2003	Cooper	N/A	N/A
2004/0245684	12/2003	Kojo	N/A	N/A
2004/0262825	12/2003	Cooper	N/A	N/A
2005/0013713	12/2004	Cooper	N/A	N/A
2005/0013714	12/2004	Cooper	N/A	N/A
2005/0013715	12/2004	Cooper	N/A	N/A
2005/0053499	12/2004	Cooper	N/A	N/A
2005/0077730	12/2004	Thut	N/A	N/A
2005/0081607	12/2004	Patel et al.	N/A	N/A
2005/0116398	12/2004	Tremblay	N/A	N/A
2006/0180963	12/2005	Thut	N/A	N/A
2006/0198725	12/2005	Thut	N/A	N/A
2007/0253807	12/2006	Cooper	N/A	N/A
2008/0163999	12/2007	Hymas et al.	N/A	N/A
2008/0202644	12/2007	Grassi	N/A	N/A
2008/0211147	12/2007	Cooper	N/A	N/A
2008/0213111	12/2007	Cooper	N/A	N/A
2008/0230966	12/2007	Cooper	N/A	N/A
2008/0253905	12/2007	Morando et al.	N/A	N/A
2008/0304970	12/2007	Cooper	N/A	N/A
2008/0314548	12/2007	Cooper	N/A	N/A
2009/0054167	12/2008	Cooper	N/A	N/A
2009/0140013	12/2008	Cooper	N/A	N/A
2009/0269191	12/2008	Cooper	N/A	N/A
2010/0104415	12/2009	Morando	N/A	N/A
2010/0200354	12/2009	Yagi et al.	N/A	N/A
2011/0133374	12/2010	Cooper	N/A	N/A
2011/0135457	12/2010	Cooper	N/A	N/A
2011/0140318	12/2010	Reeves et al.	N/A	N/A
2011/0140319	12/2010	Cooper	N/A	N/A
2011/0140619	12/2010	Lin	N/A	N/A
2011/0142603	12/2010	Cooper	N/A	N/A
2011/0142606	12/2010	Cooper	N/A	N/A
2011/0148012	12/2010	Cooper	N/A	N/A
2011/0163486	12/2010	Cooper	N/A	N/A
2011/0210232	12/2010	Cooper	N/A	N/A
2011/0220771	12/2010	Cooper	N/A	N/A
2011/0227338	12/2010	Pollack	N/A	N/A
2011/0303706	12/2010	Cooper	N/A	N/A
2012/0003099	12/2011	Tetkoskie	N/A	N/A
2012/0163959	12/2011	Morando	N/A	N/A
2013/0105102	12/2012	Cooper	N/A	N/A
2013/0142625	12/2012	Cooper	N/A	N/A
2013/0214014	12/2012	Cooper	N/A	N/A
2013/0224038	12/2012	Tetkoskie et al.	N/A	N/A
2013/0292426	12/2012	Cooper	N/A	N/A
2013/0292427	12/2012	Cooper	N/A	N/A
2013/0299524	12/2012	Cooper	N/A	N/A
2013/0299525	12/2012	Cooper	N/A	N/A
2013/0306687	12/2012	Cooper	N/A	N/A

2013/0334744	12/2012	Tremblay	N/A	N/A
2013/0343904	12/2012	Cooper	N/A	N/A
2014/0008849	12/2013	Cooper	N/A	N/A
2014/0041252	12/2013	Vild et al.	N/A	N/A
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2014/0252697	12/2013	Rauch	N/A	N/A
2014/0252701	12/2013	Cooper	N/A	N/A
2014/0261800	12/2013	Cooper	N/A	N/A
2014/0263482	12/2013	Cooper	N/A	N/A
2014/0265068	12/2013	Cooper	N/A	N/A
2014/0271219	12/2013	Cooper	N/A	N/A
2014/0363309	12/2013	Henderson et al.	N/A	N/A
2015/0069679	12/2014	Henderson et al.	N/A	N/A
2015/0184311	12/2014	Turenne	N/A	N/A
2015/0192364	12/2014	Cooper	N/A	N/A
2015/0217369	12/2014	Cooper	N/A	N/A
2015/0219111	12/2014	Cooper	N/A	N/A
2015/0219112	12/2014	Cooper	N/A	N/A
2015/0219113	12/2014	Cooper	N/A	N/A
2015/0219114	12/2014	Cooper	N/A	N/A
2015/0224574	12/2014	Cooper	N/A	N/A
2015/0252807	12/2014	Cooper	N/A	N/A
2015/0285557	12/2014	Cooper	N/A	N/A
2015/0285558	12/2014	Cooper	N/A	N/A
2015/0323256	12/2014	Cooper	N/A	N/A
2015/0328682	12/2014	Cooper	N/A	N/A
2015/0328683	12/2014	Cooper	N/A	N/A
2016/0031007	12/2015	Cooper	N/A	N/A
2016/0040265	12/2015	Cooper	N/A	N/A
2016/0047602	12/2015	Cooper	N/A	N/A
2016/0053762	12/2015	Cooper	N/A	N/A
2016/0053814	12/2015	Cooper	N/A	N/A
2016/0082507	12/2015	Cooper	N/A	N/A
2016/0089718	12/2015	Cooper	N/A	N/A
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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) This application is a continuation of, and claims priority to U.S. patent application Ser. No. 18/139,936, filed Apr. 26, 2023 and entitled “Tensioned Support Post and Other Molten Metal Devices,” which is a continuation of, and claims priority to U.S. patent application Ser. No. 17/496,229, filed Oct. 7, 2021 and entitled “Tensioned Support Post and Other Molten Metal Devices,” which is a continuation of, and claims priority to U.S. patent application Ser. No. 16/195,678 (Now U.S. Pat. No. 11,149,747), filed Nov. 19, 2018, and entitled “Tensioned Support Posts and Other Molten Metal Devices” which claims priority to U.S. Provisional Application 62/588,090, filed Nov. 17, 2017, and entitled “Tensioned Support Post and Other Molten Metal Devices,” each of the disclosures of which are incorporated herein by reference. This Application incorporates by reference U.S. application Ser. No. 15/406,515 (now U.S. Pat. No. 10,267,314), filed Jan. 13, 2017, and entitled “Tensioned Support Shaft and Other Molten Metal Devices,” to the extent such application does not conflict with the present disclosure.

FIELD
(1) The invention relates to tensioned support posts and other components, such as a reinforced support post that may be used in pumps for pumping molten metal.
BACKGROUND
(2) As used herein, the term “molten metal” means any metal or combination of metals in liquid form, such as aluminum, copper, iron, zinc, and alloys thereof. The term “gas” means any gas or combination of gases, including argon, nitrogen, chlorine, fluorine, Freon, and helium, which are released into molten metal.
(3) Known molten-metal pumps include (a) a pump base (also called a housing or casing), (b) one or more inlets (an inlet being an opening in the housing to allow molten metal to enter a pump

chamber), (c) a pump chamber of any suitable configuration, which is an open area formed within the housing, (d) a discharge, which is a channel or conduit of any structure or type communicating with the pump chamber (in an axial pump the chamber and discharge may be the same structure or different areas of the same structure) and that leads from the pump chamber to (e) an outlet, which is an opening formed in the exterior of the housing through which molten metal exits the casing. An impeller, also called a rotor, is mounted at least partially in the pump chamber and is connected to a drive system. The drive shaft is typically (a) an impeller shaft having one end connected to the impeller and the other end connected to a coupling, and (b) a motor shaft having one end connected to a motor (such as an electric, hydraulic, or pneumatic motor) and the other end connected to the coupling. Often, the impeller (or rotor) shaft is comprised of graphite and/or ceramic (such as silicon carbide), the motor shaft is comprised of steel, and the coupling is comprised of steel.

(4) As the motor turns the drive shaft, the drive shaft turns the impeller and the impeller pushes molten metal out of the pump chamber, through the discharge, out of the outlet and into the molten metal bath. Most molten metal pumps are gravity fed, wherein gravity forces molten metal through the inlet and into the pump chamber as the impeller pushes molten metal out of the pump chamber.

(5) Some molten metal pumps do not include a base or support posts and are sized to fit into a structure by which molten metal is pumped. Most pumps have a metal platform, or superstructure, that is either supported by a plurality of support posts attached to the pump base, or supported by another structure if there is no pump base. The motor is positioned on the superstructure, if a superstructure is used.

(6) This application incorporates by reference the portions of the following documents that are not inconsistent with this disclosure: U.S. Pat. No. 4,598,899, issued Jul. 8, 1986, to Paul V. Cooper, U.S. Pat. No. 5,203,681, issued Apr. 20, 1993, to Paul V. Cooper, U.S. Pat. No. 5,308,045, issued May 3, 1994, to Paul V. Cooper, U.S. Pat. No. 5,662,725, issued Sep. 2, 1997, to Paul V. Cooper, U.S. Pat. No. 5,678,807, issued Oct. 21, 1997, to Paul V. Cooper, U.S. Pat. No. 6,027,685, issued Feb. 22, 2000, to Paul V. Cooper, U.S. Pat. No. 6,124,523, issued Sep. 26, 2000, to Paul V. Cooper, U.S. Pat. No. 6,303,074, issued Oct. 16, 2001, to Paul V. Cooper, U.S. Pat. No. 6,689,310, issued Feb. 10, 2004, to Paul V. Cooper, U.S. Pat. No. 6,723,276, issued Apr. 20, 2004, to Paul V. Cooper, U.S. Pat. No. 7,402,276, issued Jul. 22, 2008, to Paul V. Cooper, U.S. Pat. No. 7,470,392, issued Dec. 30, 2008, to Paul V. Cooper, U.S. Pat. No. 7,507,367, issued Mar. 24, 2009, to Paul V. Cooper, U.S. Pat. No. 7,906,068, issued Mar. 15, 2011, to Paul V. Cooper, U.S. Pat. No. 8,075,837, issued Dec. 13, 2011, to Paul V. Cooper, U.S. Pat. No. 8,110,141, issued Feb. 7, 2012, to Paul V. Cooper, U.S. Pat. No. 8,178,037, issued May 15, 2012, to Paul V. Cooper, U.S. Pat. No. 8,337,746, issued Dec. 25, 2012, to Paul V. Cooper, U.S. Pat. No. 8,361,379, issued Jan. 29, 2013, to Paul V. Cooper, U.S. Pat. No. 8,366,993, issued Feb. 5, 2013, to Paul V. Cooper, U.S. Pat. No. 8,409,495, issued Apr. 2, 2013, to Paul V. Cooper, U.S. Pat. No. 8,440,135, issued May 15, 2013, to Paul V. Cooper, U.S. Pat. No. 8,444,911, issued May 21, 2013, to Paul V. Cooper, U.S. Pat. No. 8,449,814, issued May 28, 2013, to Paul V. Cooper, U.S. Pat. No. 8,475,708, issued Jul. 2, 2013, to Paul V. Cooper, U.S. Pat. No. 8,501,084, issued Aug. 6, 2013, to Paul V. Cooper, U.S. patent application Ser. No. 12/895,796, filed Sep. 30, 2010, to Paul V. Cooper, U.S. patent application Ser. No. 13/791,952, filed Mar. 9, 2013, to Paul V. Cooper, U.S. Pat. No. 8,529,828, issued Sep. 10, 2013, to Paul V. Cooper, U.S. Pat. No. 8,535,603 issued Sep. 17, 2013, to Paul V. Cooper, U.S. Pat. No. 8,613,884, issued Dec. 24, 2013 to Paul V. Cooper, U.S. Pat. No. 8,714,914, issued May 6, 2014 to Paul V. Cooper, U.S. Pat. No. 8,753,563, issued Jun. 17, 2014, to Paul V. Cooper, U.S. Pat. No. 9,011,761, issued Apr. 21, 2015, to Paul V. Cooper, U.S. Pat. No. 9,017,597, issued Apr. 28, 2015, to Paul V. Cooper, U.S. Pat. No. 9,034,244, issued May 19, 2015, to Paul V. Cooper, U.S. Pat. No. 9,080,577, issued Jul. 14, 2015, to Paul V. Cooper, U.S. Pat. No. 9,108,244, issued Aug. 18, 2015, to Paul V. Cooper, U.S. Pat. No. 9,156,087, issued Oct. 13, 2015, to Paul V. Cooper, U.S. Pat. No. 9,205,490, issued Dec. 8, 2015, to Paul V. Cooper, U.S. Pat. No. 9,328,615, issued May 3, 2016 to Paul V. Cooper, U.S. Pat. No. 9,377,028, issued Jun. 28, 2016, to Paul V. Cooper, U.S. Pat. No. 9,382,599,

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(7) Three basic types of pumps for pumping molten metal, such as molten aluminum, are utilized: circulation pumps, transfer pumps and gas-release pumps. Circulation pumps are used to circulate the molten metal within a bath, thereby generally equalizing the temperature of the molten metal. Circulation pumps may be used in any vessel, such as in a reverberatory furnace having an external well. The well is usually an extension of the charging well, in which scrap metal is charged (i.e., added).

(8) Standard transfer pumps are generally used to transfer molten metal from one structure to another structure such as a ladle or another furnace. A standard transfer pump has a riser tube connected to a pump discharge and supported by the superstructure. As molten metal is pumped it is pushed up the riser tube (sometimes called a metal-transfer conduit) and out of the riser tube, which generally has an elbow at its upper end, so molten metal is released into a different vessel from which the pump is positioned. Alternate transfer pumping systems can pump molten metal upwards to a launder, which can greatly eliminate turbulence and resulting dross.

(9) Gas-release pumps, such as gas-injection pumps, circulate molten metal while introducing a gas into the molten metal. In the purification of molten metals, particularly aluminum, it is frequently desired to remove dissolved gases such as hydrogen, or dissolved metals, such as magnesium. As is known by those skilled in the art, the removing of dissolved gas is known as “degassing” while the removal of magnesium is known as “demagging.” Gas-release pumps may be used for either of both of these purposes or for any other application for which it is desirable to introduce gas into molten metal.

(10) Gas-release pumps generally include a gas-transfer conduit having a first end that is connected to a gas source and a second end submerged in the molten metal bath. Gas is introduced into the first end and is released from the second end into the molten metal. The gas may be released downstream of the pump chamber into either the pump discharge or a metal-transfer conduit extending from the discharge, or into a stream of molten metal exiting either the discharge or the metal-transfer conduit. Alternatively, gas may be released into the pump chamber or upstream of the pump chamber at a position where molten metal enters the pump chamber. The gas may also be released into any suitable location in a molten metal bath.

(11) Molten metal pump casings and rotors often employ a bearing system comprising ceramic rings wherein there are one or more rings on the rotor that align with rings in the pump chamber (such as rings at the inlet and outlet) when the rotor is placed in the pump chamber. The purpose of the bearing system is to reduce damage to the soft, graphite components, particularly the rotor and pump base, during pump operation.

(12) Generally, a degasser (also called a rotary degasser) includes (1) an impeller shaft having a first end, a second end and a passage for transferring gas, (2) an impeller, and (3) a drive source for rotating the impeller shaft and the impeller. The first end of the impeller shaft is connected to the drive source and to a gas source and the second end is connected to the impeller.

(13) Generally a scrap melter includes an impeller affixed to an end of a drive shaft, and a drive source attached to the other end of the drive shaft for rotating the shaft and the impeller. The movement of the impeller draws molten metal and scrap metal downward into the molten metal bath in order to melt the scrap. A circulation pump is preferably used in conjunction with the scrap melter to circulate the molten metal in order to maintain a relatively constant temperature within the molten metal.

(14) The materials forming the components that contact the molten metal bath should remain

relatively stable in the bath. Structural refractory materials, such as graphite or ceramics, that are resistant to disintegration by corrosive attack from the molten metal may be used. As used herein “ceramics” or “ceramic” refers to any oxidized metal (including silicon) or carbon-based material, excluding graphite, or other ceramic material capable of being used in the environment of a molten metal bath. “Graphite” means any type of graphite, whether or not chemically treated. Graphite is particularly suitable for being formed into pump components because it is (a) soft and relatively easy to machine, (b) not as brittle as ceramics and less prone to breakage, and (c) less expensive than ceramics.
(15) Ceramic, however, is more resistant to corrosion by molten aluminum than graphite. It would therefore be advantageous to develop vertical members used in a molten metal device that are comprised of ceramic, but less costly than solid ceramic members, and less prone to breakage than normal ceramic.
SUMMARY
(16) Devices are disclosed that have increased resistance to breakage. One device comprises at least one tension rod positioned inside an outer core. The tension rod and optionally other structures apply tension (or compressive force) to the outer core in order to make it more resistant to breakage. In this disclosure, the tension rod is preferably tightened by in part using a molten metal pump superstructure (also called a platform) that supports the motor. All or most of the outer core is on the side of the superstructure opposite the surface on which the pump is positioned.
(17) The tension rod may be affixed to the outer core by being affixed to a first block of material at the top of the outer core, and affixed to a second block of material at the bottom of the outer core. When the tension rod is tightened, it draws the first block and the second block together which applies axial compressive force to the outer core.
(18) The outer core can be compressed in any suitable manner. If the first block and second block are utilized, the tension rod may be affixed to each by a bolt or other device attached to, and preferably having an area at least about 30% to 150% greater than the cross-sectional area of the tension rod. The bolt or other device could be inside or outside of the first block and/or second block.
(19) A device according to this disclosure, such as a support post or impeller shaft, includes an outer core made of structural refractory material, such as graphite, graphitized carbon, clay-bonded graphite, carbon-bonded graphite, silicon carbide, ceramics, or the like. The outer core has a first end and a second end and the tension rod includes a first end and a second end. At least one end of the tension rod can extend beyond and terminate outside of the one end of the outer core. Either the first end or the second end of the tension rod, or both, can be tightened against a superstructure. This puts the outer core under compression, and makes the outer core more resistant to breakage. By using the system of the invention, it is also possible to use a thinner cross-sectional outer core wall, thereby reducing material costs.
(20) Also disclosed is a device, such as a support post, for use in molten metal that includes a reinforcement section to strengthen the device and help alleviate breakage.
(21) Also disclosed are molten metal pumps that include one or more devices disclosed herein.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a side, partial cross-sectional view of a support post according to this disclosure.
(2) FIG. **2** is a side, partial cross-sectional view of the support post of FIG. **1** being mounted to a pump superstructure.
(3) FIG. **2**B is an optional bottom portion of the support post of FIGS. **1** and **2**.
(4) FIG. **2**C is a top view of the bottom portion of the support post of FIG. **2**B.

(5) FIG. **2**D is a cross-sectional view taken along lines D-D of FIG. **2**C.
(6) FIG. **2**E is a cross-sectional view taken along lines E-E of FIG. **2**C.
(7) FIG. **3** is a side view of an alternate support post according to this disclosure.
(8) FIG. **4** is a side, cross-sectional view of the support post of FIG. **3**.
(9) FIG. **5** is a top view of the support post of FIG. **3**.
(10) FIG. **6** is a partial, side view of the support post of FIG. **3** without the outer casing.
(11) FIG. **7** is a partial, side view of the support post of FIG. **3** without the outer casing.
(12) FIG. **8** is a top view of the support post of FIG. **6**.
(13) FIG. **9** is a close up view of detail B of FIG. **7**.
(14) FIG. **10** is a side view taken along lines A-A of FIG. **7**.
(15) FIG. **11** is a bottom view of the support post of FIGS. **6** and **7**.
(16) FIG. **11**A is an end view of the support post of FIG. **11**.
(17) FIG. **12** is a cross-sectional side view of the support post of FIG. **11** taken along lines E-E.
(18) FIG. **13** is a side view of an alternate support post according to this disclosure.
(19) FIG. **14** is an exploded view of the support post of FIG. **13**.
(20) FIG. **15** is a top view of the support post of FIG. **13**.
(21) FIG. **16** is a cross-sectional, partial side view of the support post of FIG. **15** taken along lines A-A.
(22) FIG. **17** is a close-up view of detail B shown in FIG. **16**.
(23) FIG. **18** is a close-up view of detail C shown in FIG. **16**.
(24) FIG. **19** is a side view of the base of the support post of FIGS. **3** and **6**.
(25) FIG. **20** is a top view of the base of FIG. **19**.
(26) FIG. **21** is a cross-sectional side view taken along line D-D of FIG. **20**.
(27) FIG. **22** is a cross-sectional side view taken along line E-E of FIG. **20**.
(28) FIG. **23** is a perspective, side view of an outer core according to this disclosure.
(29) FIG. **24** is a top view of the outer core of FIG. **23**.
(30) FIG. **25** is a side, cross-sectional view of the outer core taken along line F-F of FIG. **24**.
(31) FIG. **26** is a perspective side view of a tension rod according to this disclosure.
(32) FIG. **27** is a partial, side view of the tension rod of FIG. **26**.
(33) FIG. **28** is a perspective, top view of a support post top according to this disclosure.
(34) FIG. **29** is a top view of the support post top of FIG. **28**.
(35) FIG. **30** is a side, cross-sectional view taken along line G-G of FIG. **29**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

(36) For any device described herein, any of the components that contact the molten metal are preferably formed by a material that can withstand the molten metal environment. Preferred materials are oxidation-resistant graphite and ceramic, such as silicon carbide.
(37) FIG. **1** shows a support post **10** in accordance with aspects of the disclosure. Shaft has an outer core **50** that has axial tension applied to it to make outer core **50** more resistant to breakage. Similar techniques, however, may be used to tension rotor shafts or other elongate molten metal pump components. Shaft **10** has a tension rod **20**, a top support block **30**, a bottom support block **60**, an outer core **50**, and a bottom **70**.
(38) Tension rod **20** is preferably comprised of steel and has a body **24**, a first end **24** and a second end **26**. As shown, tension rod **20** is threaded along about 5% to 25% of its length starting at first end **24** and moving upward, and along about 10% to 25% of its length starting at second end **26** and moving downward. The threaded portion **24**A juxtaposed end **24** is preferably configured to be threaded into a channel **64** in second end **60** and into channel **76**A in section **76**. Portion **24**A need only have sufficient threads to anchor it in second end **60** and/or section **76**. Alternatively, shaft **20** need not be threaded into second end **60** and/or section **76**, but could instead pass through them and be retained by nut **85** (or other suitable fastener) in section **76** or section **74**.
(39) Threaded portion **26**A can optionally be threaded partially into bore **39** of top block **30**. Nut **40**

and nut **120** are threaded onto portion **26**A as further described.

(40) Tension rod **20** includes a top, threaded portion **26**A that (as shown) threaded partially into top block **30**. Top block **30** has an upper portion **34**, a top surface **35**, an opening **32**, a sleeve **38**, an internal wall surface **36**, and a passage **39**. Upper portion **34** is on top of and outside of outer core **50**, and surface **36** rests on the top **52** to apply axial tension to outer core **50**. Passage **39** is configured so rod **20** can pass therethrough. Opening **32** is formed in top surface **35**, is preferably about 1.5 to 2.5 times the diameter of rod **20**, and extends into top block **30** from upper surface **35** by about 1″ to 3″, although opening **32** can be of any suitable dimension. Sleeve **38** fits inside of outer coating **50** and extends downward about 10-30% of the length (although any suitable distance would work, or top bock **30** could be stabilized in another manner) of outer coating **50** in order to stabilize top block **30** to outer coating **50**.

(41) Channels **80** and **82** are for injecting cement into the bottom of support post **20** to help connect it to a molten metal pump base in a manner known in the art. Any suitable molten metal pump base could be utilized.

(42) FIG. **2** shows the support post **10** of FIG. **1** being connected to a superstructure **100** of a molten metal pump, wherein the superstructure **100** supports the pump motor. The superstructure **100** is preferably a steel plate or platform, and is known in the art. Here, it has an opening **102** formed therethrough, a bottom surface **104**, and a top surface **106**. To add additional tension to outer core **50**, a compression spring **110** and nut **120** are positioned on tension rod **20** above surface **106**. Nut **120** is then tightened, which ultimately tightens surface **35** of top block **30** against bottom surface **104**. Spring **110** need not be used but it or a similar flexible structure is preferred.

(43) Outer core **50** could instead be comprised of graphite and/or blocks **30** and **60** could be comprised of ceramic. Further, any of sections **72**, **74**, **76** could be comprised of graphite or ceramic.

(44) FIGS. **3-5** show an alternate support post **200** with graphite core **210** and an outer ceramic (preferably silicon carbide) core **250**. Alternatively, core **210** could be comprised of ceramic and/or outer core **250** could be comprised of graphite. A reinforcement member **300** is positioned in graphite core **210**. In this embodiment outer core **250** is optional. Further, there may be more than one reinforcement member at either one end, or both ends of core **210**. Or core **210** could have a single reinforcement member at each end or that extends therethrough or substantially therethrough.

(45) As shown, the reinforcement member **300** is positioned in a manner, and is comprised of a material, such that it helps prevent the core **210** from breaking. Reinforcement member **300** is preferably comprised of steel, has a length of about 10% to 35%, or 15%-25% of the length of core **210**, or a length of about 8″ to 12″, 10″ to 16″, or 12″ to 16″, and the cylindrical with a diameter about 1/10″, ⅛″, ⅙″, ¼″ or ½″, or about 10%-30% the diameter of portion **214** of core **210**.

(46) Core **210** has a top end **212**, a bottom end **214**, a top section **212**A, a bottom section **214**A, and a central portion **216**. A bore **220** is formed in core **210** and extends from end **214**, preferably through bottom section **214**A and partially into section **216**. As shown, bore **220** is formed in the center of core **210**, although it could be off center.

(47) Reinforcement member **300** is positioned in bore **220** and may be secured by cement. Member **300** has a first end **302** that is preferably tapered and a second end **304**. As shown, second end **304** is wider than the body portion **306**. A cap **230** is positioned over second end **304** and preferably cemented in place to prevent molten metal from contacting reinforcement member **300**. All or part of body portion **306** may be threaded so that member **300** is threaded into bore **220**. As shown in FIG. **12**, reinforcement member has a smaller-diameter portion **306**A that is threaded. Portion **306**A is threaded into smaller diameter portion **220**A of bore **220**. Larger diameter bore portion **220**B receives second end **204**.

(48) Bores **250** and **252** are for connecting first end **212** of support post **200** to a support post clamp preferably positioned above the superstructure of a molten metal pump.

(49) Some non-limiting examples of the disclosure are as follows:
(50) Example 1: A component for use in a molten metal pump, the component comprising: an outer core constructed of graphite or ceramic; a tension rod positioned partially inside the outer core, wherein the tension rod has a first end and a second end, and is configured to apply an axial compressive force to the outer core in order to make the outer core less susceptible to breakage; wherein the first end of the tension rod extends beyond the outer core and has an axially-compressive component positioned thereon, the axially-compressive component positioned against the outer core to place an axial-compressive force on the outer core.
(51) Example 2: The component of example 1, wherein the tension rod has a first end and a second end, the outer core has a first end and a second end, and at least one of the first end or second end of the tension rod extends beyond either the first end or second end of the outer core.
(52) Example 3: The component of example 2, wherein either the first end or the second end of the outer core has a cap, and the end of the tension rod that extends beyond the end of the outer core is tightened against the cap.
(53) Example 4: The component of example 1, wherein the tension rod comprises at least one elongate, metal rod.
(54) Example 5: The component of example 4, wherein the tension rod is comprised of steel.
(55) Example 6: The component of example 1 that is a molten metal pump
(56) support post.
(57) Example 7: The component of example 1, wherein the tension rod is secured in the outer core by cement.
(58) Example 8: The component of example 7, wherein the tension rod is bonded to the outer core by the cement.
(59) Example 9: The component of example 1, wherein the outer core comprises graphite.
(60) Example 10: The component of example 1, wherein the outer core comprises silicon carbide.
(61) Example 11: The component of example 1, wherein the outer core comprises material harder than graphite.
(62) Example 12: The component of example 1, wherein the second end of the tension rod is inside of the outer core.
(63) Example 13: The component of example 1, wherein the first end of the tension rod is threaded and the first axially-compressive component is a nut threaded onto the tension rod and tightened against the outer core.
(64) Example 14: The component of example 1 that further includes a second axially-compressive component on the second end of the tension rod.
(65) Example 15: The component of example 1, wherein the second end of the tension rod is threaded and that further comprises a second axially-compressive component at the second end of the tension rod.
(66) Example 16: The component of example 15, wherein the second end of the tension rod is threaded and the second axially-compressive component is a nut threaded into the second end.
(67) Example 17: The component of example 13, wherein the nut is hexagonal.
(68) Example 18: The component of example 16, wherein the nut is hexagonal.
(69) Example 19: The component of example 1 that further comprises a first support block at the first end of the outer core.
(70) Example 20: The component of example 19, wherein the second axially-compressive component is positioned inside of the second support block.
(71) Example 21: The component of example 19, wherein the first support block has a narrow portion positioned inside of the outer core and an enlarged portion that presses against at least part of the wall of the outer core.
(72) Example 22: The component of example 20, wherein the second support block has an extension positioned inside of the outer core and an enlarged portion that presses against at least

part of the wall of the outer core to provide axially-compressive force to the outer core.
(73) Example 23: The component of example 1, wherein the second end of the extension rod extends beyond a stationary plate and a third axially-compressive component is positioned on the second end of the extension rod on a side of the stationary plate opposite the outer core, and the third axially-compressive component is compressed to the stationary plate.
(74) Example 24: The component of example 23, wherein the stationary plate is a molten metal pump superstructure.
(75) Example 25: The component of example 23 that includes a compression device between the third axially-compressive component and the stationary plate.
(76) Example 26: The component of example 25, wherein the compression device is a spring.
(77) Example 27: The component of example 19, wherein the first support block is comprised of graphite.
(78) Example 28: The component of example 22, wherein the second support block is comprised of graphite.
(79) Example 29: The component of example 20 that further includes a cap at the second end distal to the second axially-compressive component.
(80) Some other non-limiting examples of the disclosure follow:
(81) Example 1: A support post comprising an elongated body having a longitudinal axis and a height, a first end configured to connect to a superstructure and a second end configured to connect to a pump base, wherein the second end comprises at least one reinforcement section configured to make the second end resistant to breakage.
(82) Example 2: The support post of example 1, wherein the at least one reinforcement section is elongated and has a longitudinal axis.
(83) Example 3: The support post of example 2, wherein the longitudinal axis of the at least one reinforcement section is aligned with the longitudinal axis of the support post.
(84) Example 4: The support post of example 1, wherein the support post is comprised of graphite and the at least one reinforcement section is comprised of one or more of the group consisting of: silicon carbide and steel.
(85) Example 5: The support post of example 1, wherein the at least one reinforcement section is completely surrounded by the material of the support post so the reinforcement section is configured not to contact molten metal.
(86) Example 6: The support post of example 1, wherein the at least one reinforcement section is less than 50% of the height of the support post.
(87) Example 7: The support post of example 1, wherein the at least one reinforcement section is between 15%-35% of the height of the support post.
(88) Example 8: The support post of example 1, wherein the at least one reinforcement section is between 15%-25% of the height of the support post.
(89) Example 9: The support post of example 1, wherein the at least one reinforcement section has a cross-sectional area that is between ¼ and 1/10 the cross-sectional area of the second end of the support post.
(90) Example 10: The support post of example 1, wherein the at least one reinforcement section has a cross-sectional area that is between ⅕ and ⅛ the cross-sectional area of the second end of the support post.
(91) Example 11: The support post of example 1, wherein the support post has a bore in its second end and the at least reinforcement section is positioned in the bore.
(92) Example 12: The support post of example 11 that further includes cement in the bore to anchor the at least one reinforcement section.
(93) Example 13: The support post of example 1 that further includes a ceramic outer cover.
(94) Example 14: The support post of example 1 that is cylindrical.
(95) Example 15: The support post of example 1, wherein the reinforcement section is cylindrical.

(96) Example 16: The support post of example 1, wherein the second end includes a first portion having a first diameter, and a second portion having a second diameter, wherein the second diameter is less than the first diameter.
(97) Example 17: The support post of example 1, wherein the second end includes a first portion having a first cross-sectional area, and a second portion having a second cross-sectional area is less than the first cross-sectional area.
(98) Example 18: The support post of example 16, wherein the at least one reinforcement section is positioned partially in the first portion and partially in the second portion.
(99) Example 19: The support post of example 17, wherein the reinforcement section is positioned partially in the first portion and partially in the second portion.
(100) Example 20: The support post of example 1 that is cylindrical with a center and the reinforcement section is positioned in the center.
(101) Example 21: The support post of example 1 that further includes one or more channels in the second end, wherein the channels are configured to receive cement.
(102) Example 22: The support post of example 1, wherein the first end is configured to fit into a coupling.
(103) Example 23: The support post of example 11 that further includes a plug at a second tip of the support post, wherein the plug is configured to cover the bore.
(104) Example 24: The support post of example 1 that includes a single reinforcement section.
(105) Example 25: The support post of example 1, wherein the at least one reinforcement section is concrete, positioned in a bore inside of the second end of the support post.
(106) Example 26: The support post of example 1, wherein the at least one reinforcement section extends the length of the support post.
(107) Example 27: The support post of example 1, wherein the at least one reinforcement section has an outer surface including threads, wherein the at least one reinforcement section is threadingly received in the support post.
(108) Example 28: The support post of example 27, wherein the threads are received in the support post at its first diameter and first cross-sectional area.
(109) Example 29: The support post of example 27, wherein the at least one reinforcement section has a length and the threads extend along the entire length.
(110) Example 30: The support post of example 27, wherein the at least one reinforcement section has a length and the threads extend at least 50% of the length.
(111) Example 31: The support post of example 27, wherein the at least one reinforcement section has a length and the threads extend at least 25% of the length.
(112) Example 32: The support post of example 1 that has one or more air-relief grooves.
(113) Example 33: The support post of example 32 that has two air-relief grooves.
(114) Example 34: The support post of example 16, wherein the second diameter is between 3.5″ and 4.5″.
(115) Example 35: The support post of example 16, wherein the second portion has a height of between 6.0″ and 7.0″.
(116) Example 36: The support post of example 1, wherein the reinforcement section has a diameter of between 0.75″ and 1.25″.
(117) Having thus described different embodiments, other variations and embodiments that do not depart from the spirit of this disclosure will become apparent to those skilled in the art. The scope of the claims is thus not limited to any particular embodiment, but is instead set forth in the claims and the legal equivalents thereof. Unless expressly stated in the written description or claims, the steps of any method recited in the claims may be performed in any order capable of yielding the desired product. No language in the specification should be construed as indicating that any non-claimed limitation is included in a claim. The terms “a” and “an” in the context of the following

claims are to be construed to cover both the singular and the plural, unless otherwise indicated herein.

Claims

1. A component for use in a molten metal pump, the component comprising: an inner core and an outer core; and a tension rod positioned inside the inner core, wherein the tension rod has a first end that is threaded and has a length of 25% or less than a length of the inner core and has a second end that is threaded and has a length that is 25% or less than the length of the inner core, and the tension rod is configured to apply an axial compressive force to the inner core.
2. The component of claim 1, wherein the first end of the tension rod extends beyond the outer core and has an axially-compressive component positioned thereon, the axially-compressive component positioned against the outer core to place an axial-compressive force on the outer core.
3. The component of claim 1, wherein the second end of the tension rod is threaded and that further comprises a third axially-compressive component at the second end of the tension rod.
4. The component of claim 3, wherein the third axially-compressive component is positioned inside of a support block.
5. The component of claim 4, wherein the support block has an extension positioned inside of the outer core and an enlarged portion that presses against at least part of the wall of the outer core to provide axially-compressive force to the outer core.
6. The component of claim 1, wherein the outer core has a first end and a second end, and at least one of the first end or second end of the tension rod extends beyond either the first end or second end of the outer core.
7. The component of claim 6, wherein either the first end or the second end of the outer core has a cap, and each end of the tension rod that extends beyond the end of the outer core is tightened against the cap.
8. The component of claim 1, wherein the tension rod comprises at least one elongate, metal rod.
9. The component of claim 1, wherein the tension rod is comprised of steel.
10. The component of claim 1 that is a molten metal pump support post.
11. The component of claim 1, wherein the outer core comprises graphite.
12. The component of claim 1, wherein the outer core comprises silicon carbide.
13. The component of claim 1, wherein the outer core comprises material harder than graphite.
14. The component of claim 1, wherein the first end of the tension rod is threaded and the first axially-compressive component is a nut threaded onto the tension rod and tightened against the outer core.
15. The component of claim 1, wherein the inner core has one or more bores that are configured to receive the tension rod.
16. The component of claim 1, wherein the second end of the extension rod extends beyond a stationary plate and a second axially-compressive component is positioned on the second end of the extension rod on a side of the stationary plate opposite the outer core, and the second axially-compressive component is compressed to the stationary plate.
17. The component of claim 16, wherein the stationary plate is a molten metal pump superstructure.
18. The component of claim 16 that includes a compression device between the second axially-compressive component and the stationary plate.
19. The component of claim 18, wherein the compression device is a spring.
20. The component of claim 19 that further includes a cap at the second end distal to the second axially-compressive component.