

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

EXRO TECHNOLOGIES INC.,

Petitioner,

v.

ePROPELLED, INC.,

Patent Owner.

U.S. Patent No. 7,382,103

Title: Magnetic Gearing of Permanent Magnet Brushless Motors

Case No. IPR2022-01154

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 7,382,103**

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EXHIBIT LIST

Exhibit	Description
1001	U.S. Patent No. 7,382,103 B2 to Shirazee et al.
1002	Declaration of Dr. Steven B. Leeb
1003	Curriculum Vitae of Dr. Steven B. Leeb
1004	Prosecution History of U.S. Patent No. 7,382,103
1005	Canadian Patent Application No. 02341095 A1 (“ Chen ”)
1006	U.S. Patent No. 6,853,107 B2 to Pyntikov et al. (“ Pyntikov ”)
1007	Eckart Nipp, <i>Permanent Magnet Motor Drives with Switched Stator Windings</i> , Ph.D. Dissertation, School of Electrical Engineering and Information Technology, KTH, Stockholm (1999), accessible at http://kth.diva-portal.org/smash/record.jsf?pid=diva2%3A8554&dswid=-7499 , (“ Nipp ”).
1008	U.S. Patent No. 6,727,668 B1 to Maslov et al. (“ Maslov ”)
1009	U.S. Patent No. 6,901,212 B2 to Masino (“ Masino ”)
1010	U.S. Patent No. 6,445,101 B2 to Ley
1011	U.S. Patent No. 6,329,783 B1 to Vrionis et al.
1012	U.S. Patent No. 5,912,522 to Rivera (“ Rivera ”)
1013	Declaration of Pernilla Looman regarding publication of Ex. 1007
1014	Sanath Alahakoon, <i>Digital Motion Control Techniques for Electrical Drives</i> , Ph.D. Dissertation, School of Electrical Engineering and Information Technology, KTH, Stockholm (2000), accessible at http://kth.diva-portal.org/smash/record.jsf?pid=diva2:8694
1015	Erik Nordlund and Chandur Sadarangani, “The Four-Quadrant Energy Transducer,” <i>Conference Record of the 2002 IEEE Industry Applications Conference, 37th IAS Annual Meeting</i> (Cat. No. 02CH37344), vol. 1, pp. 390-397 (2002), accessible at https://ieeexplore.ieee.org/document/1044117/citations#citations
1016	Peter Thelin, <i>Design and Evaluation of a Compact 15 kW PM Integral Motor</i> , Ph.D. Dissertation, Lappeenranta University of Technology, Stockholm (2002), accessible at http://kth.diva-portal.org/smash/record.jsf?pid=diva2:9110

1017	Tanja Heikkilä, <i>Permanent Magnet Synchronous Motor for Industrial Inverter Applications – Analysis and Design</i> , Ph.D. Dissertation, School of Computer Science, Electrical Engineering and Engineering Physics, KTH, Lappeenranta, Finland (2002), accessible at https://lutpub.lut.fi/handle/10024/31173
1018	Eckart Nipp, “Alternative to Field-Weakening of Surface-Mounted Permanent Magnet Motors for Variable-Speed Drives,” <i>Conference Record of the 1995 IEEE Industry Applications Conference Thirtieth IAS Annual Meeting</i> , vol. 1, pp. 191-198 (1995), accessible at https://ieeexplore.ieee.org/abstract/document/530301
1019	Hong Huang and Liuchen Chang, “Electrical Two-Speed Propulsion by Motor Winding Switching and Its Control Strategies for Electric Vehicles,” <i>IEEE Transactions on Vehicular Technology</i> , vol. 48, no. 2, pp. 607-618 (March 1999), accessible at https://ieeexplore.ieee.org/abstract/document/752586

I. INTRODUCTION

Petitioner Exro Technologies Inc. (“Exro”) respectfully requests *inter partes* review (“IPR”) of U.S. Patent No. 7,382,103 (Ex. 1001, “’103”), assigned to Patent Owner ePropelled Inc., and cancellation of claims 1-17.

’103 is directed to “magnetic gearing” permanent magnet (“PM”) motors. (Ex. 1001, Title). Each stator winding of the motor is made up of a plurality of winding sections. (Ex. 1001, Abstract). Switches are used to connect the winding sections in different configurations while the motor is running, including all in series, all in parallel, or in a combination of series and parallel. *Id.* The different configurations alter the speed/torque characteristics of the motor, thereby providing “magnetic gearing” of the motor. *Id.*

’103 was allowed because the prior art of record was directed to induction motors (not PM motors), which purportedly failed to teach switching winding sections such that all of the winding sections are always connected to the power source, i.e., certain configurations would result in redundant, or unused, winding sections. (Ex. 1004, 19-21, 29-37).

However, it was well-known in the art to reconfigure the connection of stator winding sections of PM motors in series, parallel, or combinations thereof to “magnetically gear” the motor. For example, **Pyntikov** and **Nipp** are both directed to magnetic gearing of PM motors by switching the configuration of the winding

sections such that they are connected all in series, all in parallel, or in combinations of both. The configuration of the switches (yellow) used to reconfigure the winding sections (blue) in '103, **Pyntikov**, and **Nipp** are indistinguishable.

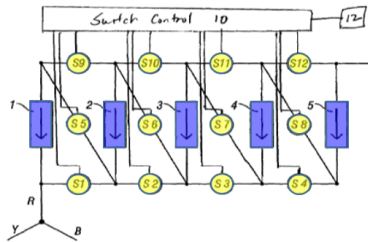


FIG. 1

Figure 1 of '103 Patent

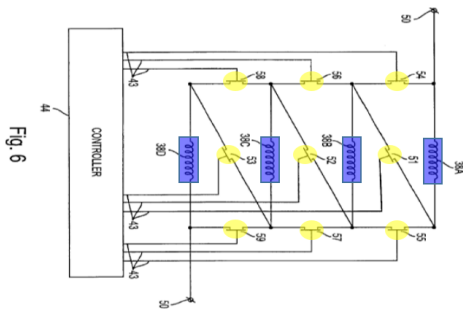


Figure 6 of Pyntikov

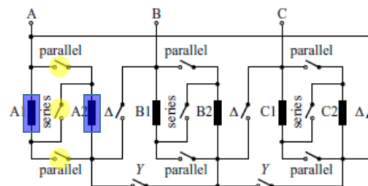


Figure 3.5.: Arrangement to switch stator windings with two parts each (A1-C2) into different configurations.

Figure 3.5 of Nipp

And both **Pyntikov** and **Nipp** disclose reconfiguration of the winding sections in series, parallel, or combinations thereof to “magnetically gear” the motor.

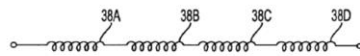


Fig. 4A

each winding section
 in series with all other
 winding sections of
 the given phase

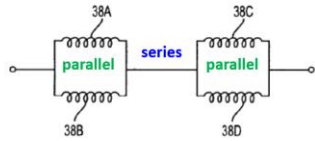


Fig. 4B

each winding section
 connected in series and parallel
 taken together

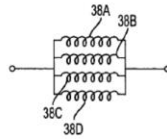
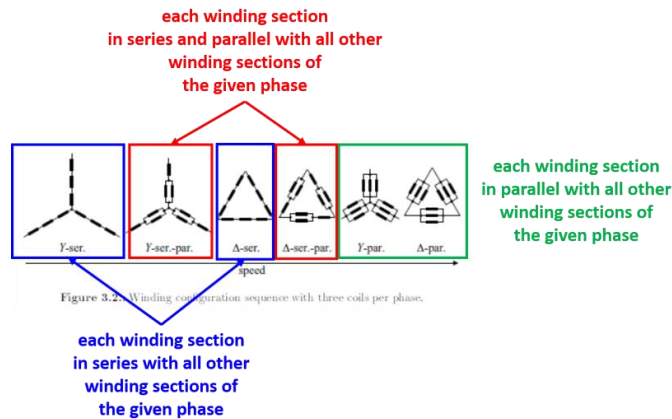


Fig. 4C

each winding section
 in parallel with all other
 winding sections of
 the given phase

Exemplary Winding Configurations Disclosed in Pyntikov



Exemplary Winding Configurations Disclosed in Nipp

Thus, '103's claims are unpatentable.

II. REQUIREMENTS FOR *INTER PARTES* REVIEW

A. Grounds for Standing

Pursuant to §42.104(a), Petitioner certifies that '103 is available for IPR and that the Petitioner is not barred or estopped from requesting IPR on the grounds identified herein.

B. Identification of Challenge

Pursuant to §42.104(b), Petitioner requests IPR and cancellation of claims 1-17 of '103 as unpatentable. '103 issued from a PCT application filed October 22, 2004, and cites a foreign priority application filed October 24, 2003, which Petitioner assumes is the priority date.¹

1. Prior Art

Ex. 1006 – U.S. Patent No. 6,853,107 (“**Pyntikov**”) issued February 8, 2005, from application 10/396,482, filed March 26, 2003, is prior art to '103 under pre-AIA 35 U.S.C. §§102(a), (e).

Ex. 1012 – U.S. Patent No. 5,912,522 (“**Rivera**”) issued June 15, 1999, from application 08/909,086, filed August 14, 1997, is prior art to the '103 under pre-AIA 35 U.S.C. §§102(a), (b), (e).

¹ The cited prior art predates '103's earliest priority date, the propriety of which, Petitioner takes no position, and reserves the right to challenge any priority claim.

Ex. 1008 – U.S. Patent No. 6,727,668 (“**Maslov**”) issued April 27, 2004, from application 10/173,610, filed June 19, 2002, is prior art to ’103 under pre-AIA 35 U.S.C. §§102(a), (e).

Ex. 1009 – U.S. Patent No. 6,901,212 (“**Masino**”) issued May 31, 2005, from application 10/170,960, filed June 13, 2002, is prior art to ’103 under pre-AIA 35 U.S.C. §§102(a), (e).

Ex. 1007 – Eckart Nipp, *Permanent Magnet Motor Drives with Switched Stator Windings*, Ph.D. Dissertation, School of Electrical Engineering and Information Technology, KTH, Stockholm (1999), (“**Nipp**”), publicly available and accessible at least as early as January 1, 2000 (Ex. 1013) (date declaration), is prior art to the ’103 under pre-AIA 35 U.S.C. §§102(a), (b). *See also* Exs. 1014-1017 (citing **Nipp**).

2. Challenges

Ground	Statute	Claim(s)	Prior Art
1	§103	1-3, 5, 8, 9, 13-17	Pyntikov
2	§103	6, 7	Pyntikov, either alone or in view of Rivera
3	§103	10, 12	Pyntikov in view of Maslov
4	§103	11	Pyntikov in view of Masino
5	§103	1-5, 8-15	Nipp

The information required by §§42.104(b)(4) and (5) is provided in §VI.

A declaration of Dr. Steven B. Leeb, an expert in the field of '103, supports this Petition. (Ex. 1002, "Leeb;" Ex. 1003).

III. BACKGROUND

A. Summary of '103

'103 relates to "magnetic gearing of permanent magnet brushless motors." (Ex. 1001, 1:7-8; Leeb, ¶96). '103 admits that permanent magnet brushless motors capable of providing variable speed outputs were well-known, explaining that the "motor characteristics are linear, generating high torque at low speeds and high speed at low torque levels." (Ex. 1001, 1:9-12, Leeb, ¶96). '103 discusses a prior art system in Canadian Patent Application No. 2341095 (Ex. 1005, "**Chen**") for varying speed and torque by using a switching circuit to reconfigure the stator windings of the motor.

Chen requires that "the stator coils of the motor must be segmented into at least two or more sections," so that "the switching circuit can then be used to change the number of coil segments which are connected to the supply." (Ex. 1001, 1:26-31). **Chen** depicts a segmented stator coil having three segments and a switching circuit to change the number of coil segments connected to the supply.²

² All emphasis/annotations added unless otherwise noted.

In contrast to known methods of varying the speed or torque by coil manipulation, **the present invention is distinguished in that all of the winding segments contribute towards the motor operation no matter which section configuration is being employed.** In this manner, **all of the available copper is utilised at all times**, thereby keeping the copper loss of the motor to a minimum.

(Ex. 1001, 2:26-32; Leeb, ¶101). The system disclosed in '103 uses switches to configure “the coil segments in series, parallel or a combination of both.” (Ex. 1001, 2:18-19; Leeb, ¶101).

'103 discloses a system that includes switches (yellow) to selectively couple the coil segments (blue) in a number of configurations. In the example shown in Figure 1, each phase of the three phase system includes five coil segments (1-5) in the winding, and twelve switches (S1-S12).

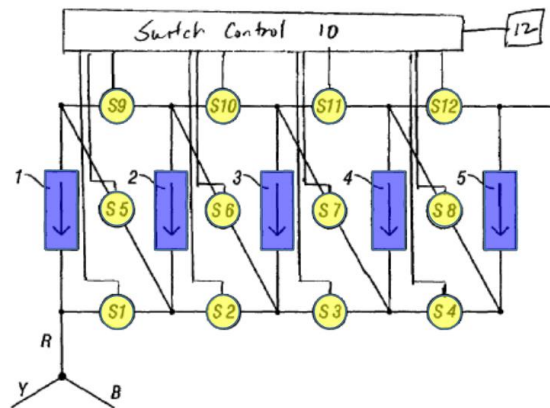


FIG. 1

(Ex. 1001, 3:59-60, Figure 1; Leeb, ¶102).

'103 describes using the switches to selectively connect the winding segments into one of three general configurations: (1) all of the winding sections connected in parallel; (2) all of the winding sections connected in series; and (3) some of the winding sections in parallel with at least one other winding section connected in series with the parallel-connected sections. (Ex. 1001, 2:43-57; Leeb, ¶103). Figures 2-6 of '103 depict the five possible configurations for connecting the five winding sections, and Figure 7 summarizes the settings for the twelve switches to implement such configurations. (Ex. 1001, Figures 2-7; Leeb, ¶103).

Figures 1, 6, and 7 of the '103 below, show that by controlling the switches, the winding sections can be connected in different configurations. For example, by turning switches S1-S4 and S9-S12 "ON," all five winding sections are connected in parallel.

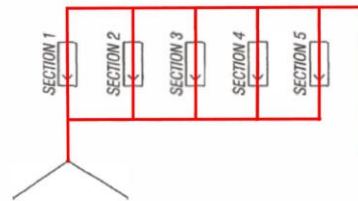
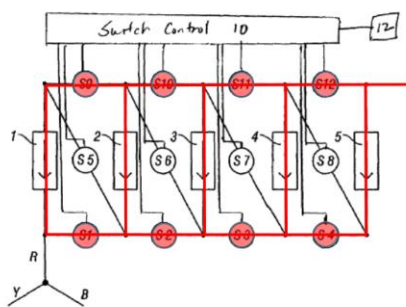


FIG. 6

	SWITCH 1	SWITCH 2	SWITCH 3	SWITCH 4	SWITCH 5	SWITCH 6	SWITCH 7	SWITCH 8	SWITCH 9	SWITCH 10	SWITCH 11	SWITCH 12
FIG 2	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF	OFF
FIG 3	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF	OFF
FIG 4	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF	OFF
FIG 5	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON	OFF
FIG 6	ON	ON	ON	ON	OFF	OFF	OFF	OFF	ON	ON	ON	ON

All Sections Connected In Series

Series/Parallel Combination

FIG. 1 All Sections Connected In Parallel

FIG. 7

(Ex. 1001, Figures 1, 6, 7, 5:31-34; Leeb, ¶¶104-106).

'103 explains that “a gearing system for the motor can be provided by operating the switches, thereby allowing the motor to generate higher torque (at low speed) and higher speed (with low torque) than would be possible with any single configuration (with limited current supply).” (Ex. 1001, 5:55-59; Leeb, ¶107). '103 depicts the different operating characteristics of the motor achievable when the switches are configured as shown in Figures 2-6.

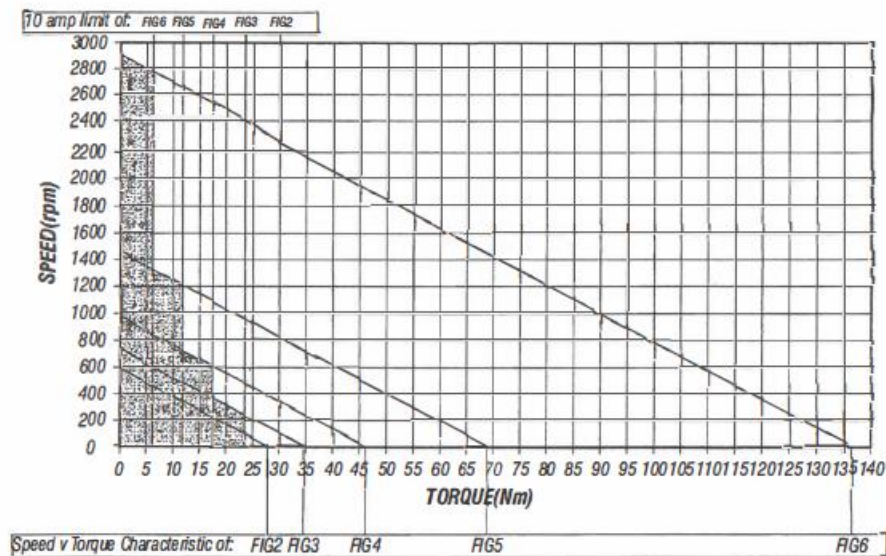


FIG. 8

(Ex. 1001, Figure 8, 3:43-44; Leeb, ¶107).

All the limitations of the challenged claims were known in the prior art. (*See infra*, §VI; *see generally* Leeb).

B. Prosecution History of '103

During prosecution of '103, the originally-submitted claims were rejected as anticipated by Ley (Ex. 1010), or obvious over Ley in view of Vrionis (Ex. 1011).

(Ex. 1004, 65-71) In response, Applicants argued that the prior art of record was not directed to a permanent magnet brushless motor. (Ex. 1004, 50-54). The Examiner issued a Final Office Action maintaining the rejections and asserting that “the recitation a permanent magnet brushless motor has not been given patentable weight because the recitation occurs in the preamble.” (Ex. 1004, 43-49). In response, the claims were amended; for example, sole independent claim 1 was amended to add limitations reciting “a stator ...” and “a rotor ... comprising at least one permanent magnet,” and amending the “switch means” limitation as follows:

~~a winding divided into a plurality of sections and~~ switch means comprising a plurality of switching devices for simultaneously selectively connecting **all of** the winding sections of the given phase winding in one of a plurality of different configurations, wherein said switching devices are disposed at opposite ends of each winding section and are arranged to connect each winding section is connected in series and/or parallel with all other winding sections of the given phase winding.

(Ex. 1004, 29).

It its remarks, Applicants distinguished the amended claims by arguing that the claims require “that **ALL** of the winding sections of a given phase are **SIMULTANEOUSLY** connected in a desired configuration during operation of the motor,” whereas the asserted prior art uses redundant windings (i.e., windings that are not connected). (Ex. 1004, 35 (emphasis in original)).

Applicants further argued that “the cited prior art fails to disclose a permanent magnet brushless motor in which the switching devices are disposed at opposite ends of each winding section of a given phase of the stator and are arranged to connect each winding section in series and/or parallel with all other winding sections of the given phase of the stator as recited in claim 1.” (Ex. 1004, 35-36).

The examiner allowed the claims based on the “amendment and arguments dated 2/6/08.” (Ex. 1004, 19-21).

IV. LEVEL OF ORDINARY SKILL

A person of ordinary skill in the art (“POSITA”) at the time of the alleged invention of ’103 would have had an undergraduate degree in electrical engineering or a related field along with at least two years of work experience in the field of electric motors. (Leeb, ¶¶38-42). More education can supplement practical experience and vice versa. (Leeb, ¶41).

V. CLAIM CONSTRUCTION

The claims of ’103 are construed “using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b).” 37 C.F.R. §42.100(b). Under that standard, the claims are construed “in accordance with the ordinary and customary meaning of such claim as understood by one of ordinary skill in the art and the prosecution history pertaining to the patent.” *Id.* The only claim terms that need to be construed are those that are necessary to resolve the

controversy. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017).

For purposes of this proceeding, Exro provides the following claim constructions. Exro believes that no express constructions of any other claim terms are material to resolving the obviousness disputes in this forum.³ (Leeb, ¶¶113-121).

A. “switch means comprising a plurality of switching devices for simultaneously connecting all of the winding sections of the given phase in one of a plurality of different configurations” (claim 1)

This limitation is drafted using “means for” language giving rise to a presumption that it invokes 35 U.S.C. § 112, ¶6. *Williamson v. Citrix Online, LLC*, 792 F.3d 1339, 1349 (Fed. Cir. 2015) (*en banc*). The inclusion of the “switching devices” language is entirely functional, so it is not sufficient to overcome the presumption that 35 U.S.C. § 112, ¶6 governs. Generic terms like “device” are “nonce words that ... ‘typically do not connote sufficiently definite structure.’” *Id.* at 1350 (citations omitted). Here, the prefix “switching” does not impart structure into the term “devices” because together, they do not describe a

³ Petitioner reserves all rights to raise claim construction and other arguments—including validity challenges under 35 U.S.C. § 112—in district court as relevant to those proceedings.

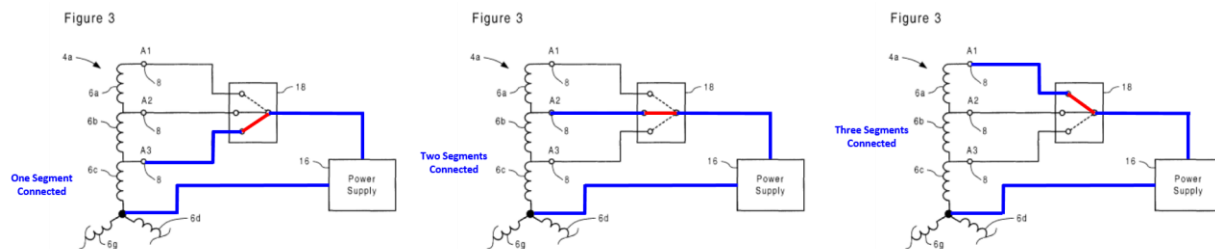
sufficiently definite structure—they merely identify the function that the devices perform. *See id.* at 1351, *see also Robert Bosch, LLC v. Snap-On Inc.*, 769 F.3d 1094, 1099 (Fed. Cir. 2014) (finding the terms “program recognition device” and “program loading device” to lack sufficiently definite structure).

The construction of a means-plus-function limitation includes two steps: first, the Court must identify the function recited in the claim, and second, the Court must determine what structure disclosed in the patent specification corresponds to the claimed function. *Williamson*, 792 F.3d at 1351.

The identified function of the “switch means” is “simultaneously connecting **all of** the winding sections of the given phase in one of a plurality of configurations.” The ’103 specification identifies as corresponding structure “switches S1 to S12 can be relays or semiconductor devices.” (Ex. 1001, 5:64-65; Figure 1, S1-S12; Leeb, ¶114). Thus, “switch means” should be construed as relays or semiconductor devices, or equivalents thereof.

The Background section of ’103 describes the possibility of having redundant (i.e., unconnected) sections of a winding in certain situations as a disadvantage, stating that “sections are redundant when running the motor during some configurations and thus copper (I^2R) losses will be higher.” (Ex. 1001, 1:57-59; Leeb, ¶115). This statement is made in reference to the configurations of the switch in the left and center versions of Figure 3 of **Chen** below, in which not all winding

sections are connected to the power supply. (Leeb, ¶115). Only in the configuration depicted in the right-most version below are all of the winding sections connected. (Leeb, ¶115).



(Ex. 1005, Figure 3; Leeb, ¶115).

’103 stresses that “the present invention is distinguished in that **all of** the winding segments contribute towards the motor operation **no matter which section configuration is being employed**. In this manner, **all of the available copper is utilised at all times**, thereby keeping the copper loss of the motor to a minimum.”

(Ex. 1001, 2:26-32; Leeb, ¶116).

During prosecution, Applicants amended claim 1 to recite that “**all of**” the winding sections are connected, and distinguished the prior art of record by arguing that the claims require “that **ALL** of the winding sections of a given phase are **SIMULTANEOUSLY** connected in a desired configuration during operation of the motor.” (Ex. 1004, 35 (emphasis in original); Leeb, ¶117).

Thus, a POSITA would understand that the functional language of the switch means (requiring that “**all of**” the winding sections be connected) means that the

switches are configured such that it is not possible to have a redundant, i.e., unconnected winding segment during operation of the motor. (Leeb, ¶118).

B. “wherein said switching devices ... are arranged to connect each winding section in series and/or parallel with all other winding sections of the given phase” (claim 1)

This “wherein” clause further limits the structure of the “switch means,” requiring that the switches be arranged to connect each winding section “in series **and/or** parallel” with all other winding sections of the given phase. The PTAB has held that such “A and/or B” claim language “covers embodiments having element A alone, element B alone, or elements A and B taken together.” *Ex parte Gross*, Appeal No. 2011-004811, Decision on Appeal (P.T.A.B. Jan. 3, 2014). ’103 states that the switch means can be “used to change magnetic gears, by changing the configuration of the coil segments in series, parallel or a combination of both.” (Ex. 1001, 2:17-19; Leeb, ¶119).

Accordingly, a POSITA would understand that this claim language means that the switches are configured such the winding sections can be connected all in series, all in parallel, or any combination of series and parallel such that all of the winding segments are in use. (Leeb, ¶120).

Thus, the “wherein” clause should be construed to further limit the structure of the “switch means” to be configured such that all of the winding sections can be

connected all in series, all in parallel, or any combination of series and parallel such that all of the winding segments are always in use. (Leeb, ¶121).

VI. DETAILED EXPLANATION OF THE GROUNDS

A. Ground 1: Pyntikov Renders Obvious Claims 1-3, 5, 8, 9, and 13-17

1. Pyntikov

Like '103, **Pyntikov** is directed to a “Multiphase Motor Having Different Winding Configurations for Respective Speed Ranges.” (Ex. 1006, Title; Leeb, ¶122). **Pyntikov** explains that—like '103—“**[a]ll winding sections for a stator element are energized throughout the motor operating speed** range but connected, through appropriate switches, in different circuit configurations for respective portions of the speed range.” (Ex. 1006, Abstract; Leeb, ¶122).

Pyntikov discloses a control circuit for implementing the various configurations of the winding sections using controllable switches. (Ex. 1006, Figure 6, 6:54-60; Leeb, ¶123). In the example below, the stator winding includes four sections (38A-38D, blue) that can be connected in various combinations of series and parallel connections using the switches (51-59, yellow).

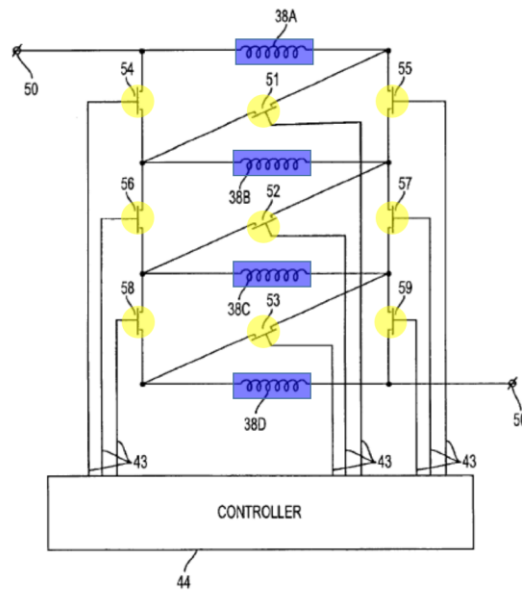


Fig. 6

(Ex. 1006, Figure 6, 6:54-60; Leeb, ¶123).

The controller in Figure 6 actuates the switches to reconfigure the winding sections based on the speed of the motor throughout the different speed ranges of operation of the machine. (Ex. 1006, 6:14-19; Leeb, ¶124). **Pyntikov** discloses an example including three different winding configurations for a motor corresponding to the start of motor operation, an increased speed range, and a yet higher speed. (Ex. 1006, Figures 4A-4C, 6:19-46; Leeb, ¶124). These three winding configurations are depicted in Figure 4A (all four winding sections connected in series), Figure 4B (windings 38A and 38B connected in parallel, and windings 38C and 38D connected in parallel, with the two parallel sets themselves connected in series), and Figure 4C (all four winding sections connected in parallel).

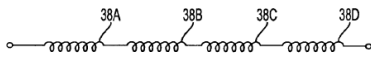


Fig. 4A

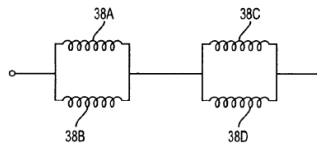


Fig. 4B

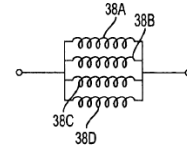


Fig. 4C

(Ex. 1006, Figures 4A-4C, 6:19-46; Leeb, ¶124). In all configurations, all four of the winding sections are connected, i.e., there are no redundant windings. (Ex. 1006, Abstract; Leeb, ¶124).

Pyntikov further discloses that—like the '103—by reconfiguring the stator windings as discussed *supra*, the motor “exhibits high efficiency operation over an extended range of speeds, that is not obtainable with only one of the configurations,” as shown below, which **Pyntikov** describes as a plot of “optimal efficiency for the motor ... obtained in each speed range.”

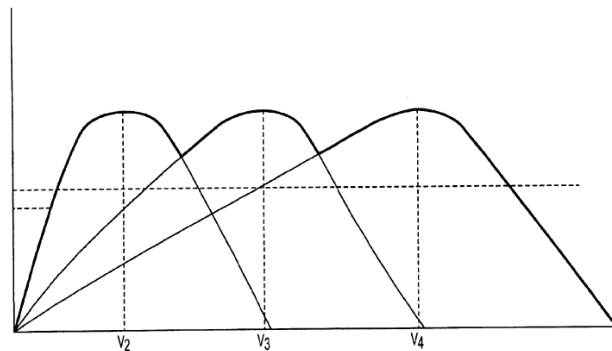


Fig. 5

(Ex. 1006, Figure 5, 6:17-18, 6:47-52; Leeb, ¶125). **Pyntikov** discloses that “a plurality of mutually exclusive sub speed ranges between startup and a maximum speed at which a motor can be expected to operate are identified, and a different configuration for circuit connection of all of the stator winding sections is designated

and energized for each sub speed range.” (Ex. 1006, 4:11-17; Leeb, ¶125).

2. Claim 1

a) “A permanent magnet brushless motor comprising:”

To the extent that the preamble of claim 1 is limiting, **Pyntikov** discloses the limitations therein. (Leeb, ¶126).

Pyntikov discloses a permanent magnet brushless motor, including a “[r]otor member 20 ... having permanent magnets 21,” and “a stator member 30,” which “comprises a plurality of electromagnet core segments.”

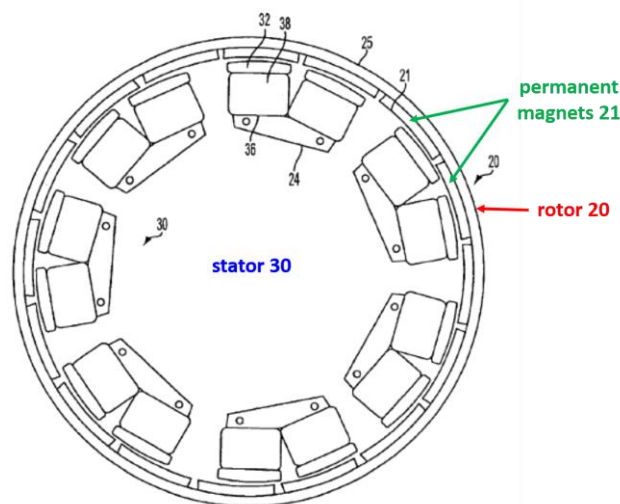


Fig. 2

(Ex. 1006, 5:35-43, Figure 2; Leeb, ¶127).

Thus, **Pyntikov** discloses “[a] permanent magnet brushless motor.” (Leeb, ¶128).

- b) “a stator comprising one or more phases, wherein at least one given phase of the stator includes a plurality of winding sections;”

Pyntikov discloses this. (Leeb, ¶129). **Pyntikov**'s PM motor has a rotor and “a **stator** member 30,” which “comprises a plurality of electromagnet core segments.” (Ex. 1006, 5:35-43, Figure 2; Leeb, ¶129). **Pyntikov** discloses the stator windings in the context of Figures 3A and 3B, which depict “alternative winding formations on a two pole core section,” noting that “all of the **stator** core segments are similarly formed.” (Ex. 1006, 5:65-6:1; Leeb, ¶129). **Pyntikov** explains that “the **winding** of each core segment **comprises four sections** identified as 38A-38D.” (Ex. 1006, 6:1-3, Figures 3A, 3B; Leeb, ¶129).

'103 admits that having a plurality of winding sections per phase was well-known in the art. In the Background section, '103 discusses **Chen**, as a motor in which speed and torque can be varied, and states that “[a] prerequisite of this technique is that the stator coils of the motor must be segmented into at least two or more sections” (Ex. 1001, 1:26-28; Leeb, ¶130). **Chen** describes a PM motor in which “[t]he **stator winding includes at least two segments** having a respective plurality of turns.” (Ex. 1005, 2:17-19; Leeb, ¶130).

Similarly, **Pyntikov** discloses that it was well known in the art to use a “plurality of individual serially connected coil sets separated by tap connections,”

such that “[e]ach respective tap is connected by a switch to a source of energization during a single corresponding speed range.” (Ex. 1006, 3:5-21; Leeb, ¶131). Using this approach, “[t]he windings thus have a different number of energized coils for each speed range.” (Ex. 1006, 3:21-22; Leeb, ¶131).

Thus, **Pyntikov** discloses “a stator comprising one or more phases, wherein at least one given phase of the stator includes a plurality of winding sections.” (Leeb, ¶132).

c) **“a rotor rotatably mounted relative to the stator and comprising at least one permanent magnet;”**

Pyntikov discloses this. (Leeb, ¶133). **Pyntikov**’s PM motor has a “[r]otor member 20 ... having permanent magnets 21,” and a stator. (Ex. 1006, 5:35-43, Figure 2; Leeb, ¶133). **Pyntikov** discloses that “[t]he rotor surrounds a stator member 30, the rotor and stator members being separated by an annular radial air gap.” (Ex. 1006, 5:40-42; Leeb, ¶133). A POSITA would have understood that during operation of the **Pyntikov** motor, the rotor member 20 rotates relative to the stator member 30. (Leeb, ¶133). **Pyntikov** provides an exemplary configuration of the rotor 20 rotatably mounted relative to the stator 30.

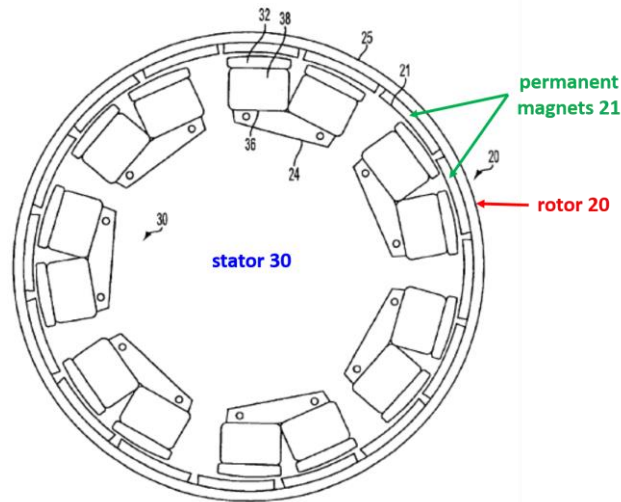


Fig. 2

(Ex. 1006, Figure 2; Leeb, ¶133).

Thus, **Pyntikov** discloses “a rotor rotatably mounted relative to the stator and comprising at least one permanent magnet.” (Leeb, ¶134).

- d) “switch means comprising a plurality of switching devices for simultaneously connecting all of the winding sections of the given phase in one of a plurality of different configurations,”

Pyntikov discloses this. (Leeb, ¶135). **Pyntikov** discloses “[a] control circuit for effecting the winding section configurations ... is shown in FIG. 6.”

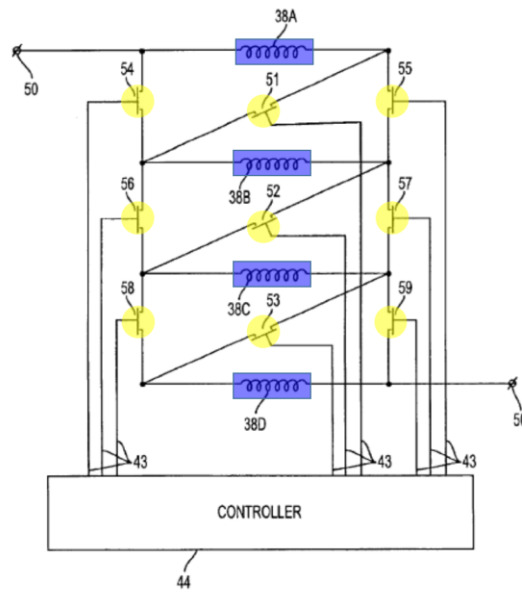


Fig. 6

(Ex. 1006, 6:54-55, Figure 6; Leeb, ¶135). **Pyntikov** explains: “[a]lthough only windings for a single stator core element are shown [in Figure 6], it would be understood that the stator may comprise any number of core elements and that the illustrated circuit is applicable to each core element.” (Ex. 1006, 6:61-65, Figure 6; Leeb, ¶135). In this example, this phase has four winding sections (38A-38D, blue), and nine switching devices (51-59, yellow) for connecting the four winding sections of the phase in either a series configuration, a parallel configuration, or a combination of series and parallel connections of the sections. (Ex. 1006, 6:66-7:41; Leeb, ¶¶135-138).

Pyntikov discloses the same arrangement of switches per winding section as disclosed in '103, as depicted below:

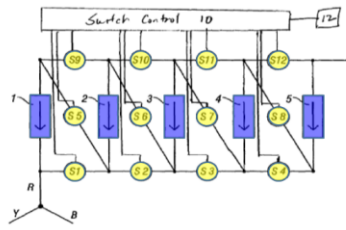


Figure 1 of '103 Patent

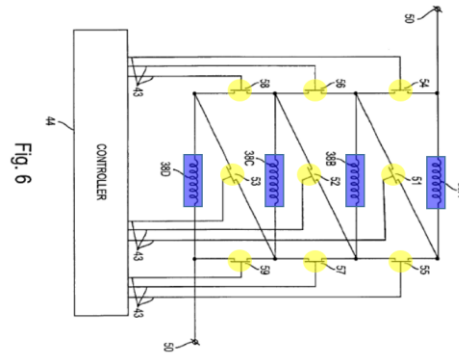


Figure 6 of Pyntikov

(Ex. 1001, Figure 1; Ex. 1006, Figure 6; Leeb, ¶139).

Pyntikov discloses “FIGS. 4A-4C illustrate different circuit configurations of the winding sections 38A-38D of each core segment for respective operating speed ranges, ... whereby optimal efficiency is obtained in each speed range, as illustrated in FIG. 5.” (Ex. 1006, 6:14-19, Figures 4A-4C, 5; Leeb, ¶¶140-143). As shown in **Pyntikov**, based on the speed of the machine, there is a sequence of three different configurations for a stator having four winding sections per phase.



Fig. 4A

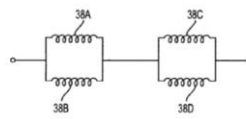


Fig. 4B

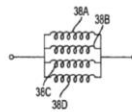


Fig. 4C

(Ex. 1006, Figures 4A-4C; Leeb, ¶¶140-143). **Pyntikov** discloses: “[a]ll winding

sections are energized throughout the motor operating speed range but connected, through appropriate ones of the switches, in different circuit configurations for respective portions of the speed range.” (Ex. 1006, 4:4-8; Leeb, ¶¶140-143).

Pyntikov discloses that the switches used to connect the winding sections in the different possible configurations “may comprise MOSFETs or other appropriate electronic devices.” (Ex. 1006, 6:57-58; Leeb, ¶144). A POSITA would have understood that a MOSFET is a well-known semiconductor electronic switch. (Leeb, ¶144).

Thus, **Pyntikov** discloses relays or semiconductor devices for simultaneously connecting all of the winding sections of a given phase in one of a plurality of configurations. (Leeb, ¶145).

- e) **“wherein said switching devices are disposed at opposite ends of each winding section and are arranged to connect each winding section in series and/or parallel with all other winding sections of the given phase.”**

Pyntikov discloses this. (Leeb, ¶146). **Pyntikov** discloses the identical position of the switches at opposite ends of each winding section, as shown below in the comparison of Figure 1 of ’103 and Figure 6 of **Pyntikov**:

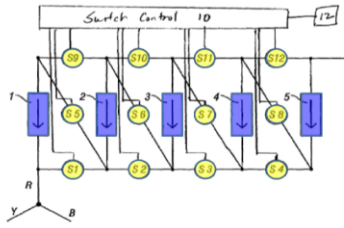


FIG. 1

Figure 1 of '103 Patent

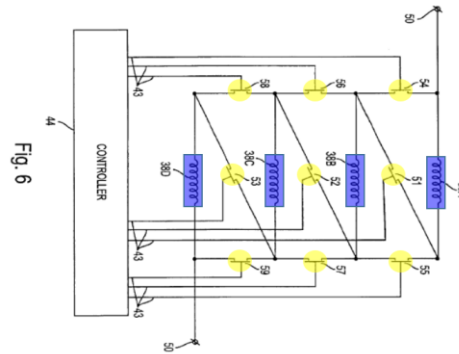


Fig. 6

Figure 6 of Pyntikov

(Ex. 1001, Figure 1; Ex. 1006, Figure 6; Leeb, ¶146).

Pyntikov discloses that when four winding sections are used, that the winding sections can be connected all in series as shown in Figure 4A, all in parallel as shown in Figure 4C, or in series and parallel combinations taken together, as shown in Figure 4B:

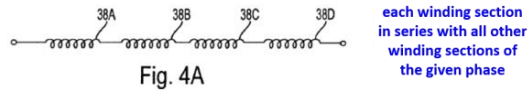


Fig. 4A

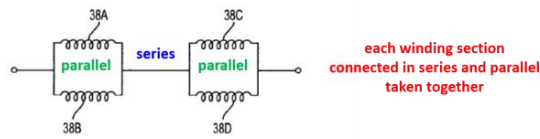


Fig. 4B

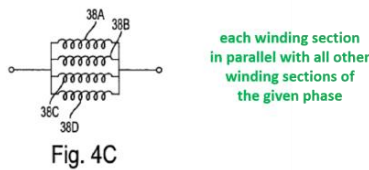


Fig. 4C

(Ex. 1006, Figures 4A-4C; Leeb, ¶147). **Pyntikov** discloses that in each possible configuration, “[a]ll winding sections are energized throughout the motor

operating speed range but connected, through appropriate ones of the switches, in different circuit configurations for respective portions of the speed range,” such that there are never any redundant stator windings. (Ex. 1006, 4:4-8; Leeb, ¶147).

Thus, **Pyntikov** discloses that the switches “are arranged to connect each winding section in series and/or parallel with all other winding sections of the given phase.” (Leeb, ¶¶148-149).

3. Claim 2: “A permanent magnet brushless motor as claimed in claim 1, wherein: the switch means is arranged to connect all of the winding sections of the given phase in parallel.”

Pyntikov discloses claim 1. **Pyntikov** discloses that “[a]s the motor reaches the next speed transition point, predetermined per the efficiency curves of FIG. 5, the controller changes the application of output control signals to the leads 43 that are connected to the control terminals of switches 54, 55, 56, 57, 58 and 59. With these switches activated, **all of the winding sections 38A-38D are connected in parallel** across the power supply terminals” in the configuration shown in Figure 4C.

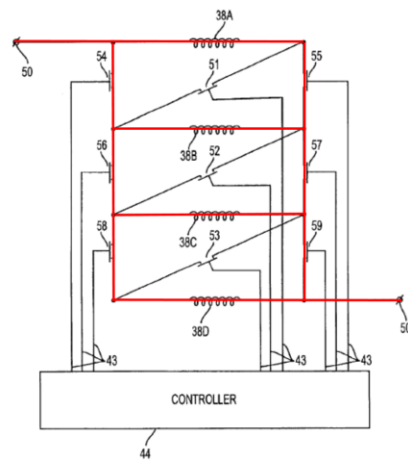


Fig. 6

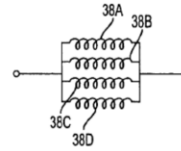


Fig. 4C

(Ex. 1006, 7:34-41, 6:36-41, Figures 6, 4C; Leeb, ¶150).

Thus, **Pyntikov** discloses switches arranged to connect all of the winding sections of the given phase in parallel. (Leeb, ¶151).

4. **Claim 3: “A permanent magnet brushless motor as claimed in claim 1, wherein: the switch means is arranged to connect all of the winding sections of the given phase in series.”**

Pyntikov discloses claim 1. **Pyntikov** discloses that “[i]n operation, at motor startup the controller outputs control signals to those leads 43 that are connected to the control terminals of switches 51, 52 and 53, thereby to connect winding sections 38A-38D in series across the power supply terminals 50” in the configuration shown in Figure 4A.

6. **Claim 8: “A permanent magnet brushless motor as claimed in claim 1, further comprising: control means for actuating the switch means to vary the connection configuration of the winding sections whilst the motor is running, in accordance with predetermined operating parameters.”**

Pyntikov discloses claim 1. **Pyntikov** discloses “a motor control system ... which further comprises the stator winding features and control elements illustrated in FIGS. 3 and 6 for dynamic reconfiguration of stator winding sections according to the present invention.”

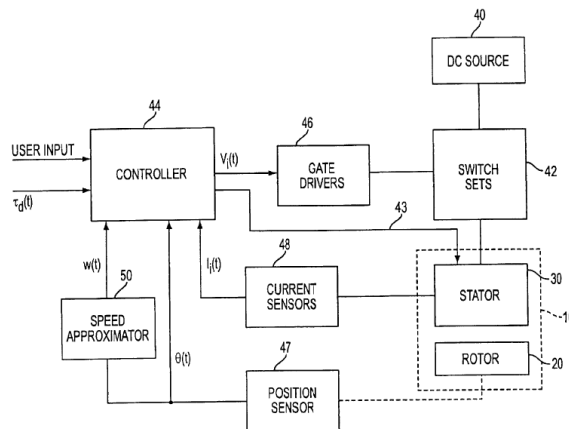


Fig. 7

(Ex. 1006, 7:52-57, Figure 7; Leeb, ¶156). **Pyntikov** discloses that the “controller 44 may have **one or more user inputs and a plurality of inputs for motor conditions sensed during operation.**” (Ex. 1006, 8:7-9; Leeb, ¶156). **Pyntikov** explains that the controller reconfigures the windings when the motor reaches certain “**speed transition points,**” which are “**predetermined** in accordance with the efficiency curves exemplified in FIG 5.” (Ex. 1006, 7:26-27, 7:34-36; Leeb, ¶156).

Thus, a POSITA would have understood that **Pyntikov** discloses a “control means for actuating the configuration of the winding sections whilst the motor is running,” and that **Pyntikov**’s controller varies the connection configuration of the winding sections in accordance with predetermined operating parameters, e.g., predetermined speed transition points. (Leeb, ¶156).

Thus, **Pyntikov** discloses a control unit that actuates the switches to vary the connection configuration of the winding sections while the motor is running based on a predetermined operating parameter of the motor. (Leeb, ¶157).

7. **Claim 9: “A permanent magnet brushless motor as claimed in claim 8, wherein: the control means is adapted to vary the connection configuration of the winding sections whilst the motor is running, in accordance with the output of means for sensing an operating parameter of the motor.”**

Pyntikov discloses claim 8. **Pyntikov** discloses that the “**controller 44** may have one or more user inputs and **a plurality of inputs for motor conditions sensed during operation.**” (Ex. 1006, 8:7-9; Leeb, ¶158). **Pyntikov** explains “the **reconfiguration of stator winding sections** may be incorporated within a motor control system that is adaptive to **control various motor parameters in response to sensed conditions** as well as user input commands.” (Ex. 1006, 7:42-46; Leeb, ¶158). ’103 describes configuring the winding connections “in accordance with the

output of means for sensing an operating parameter of the motor such as the current, voltage, **speed** or torque.” (Ex. 1001, 3:7-9; Leeb, ¶158).

Like '103, **Pyntikov** discloses in the context of Figure 7, e.g., that “[c]urrent in each phase winding can be sensed by a respective one of a plurality of current sensors 48 whose outputs are provided to controller 44.”

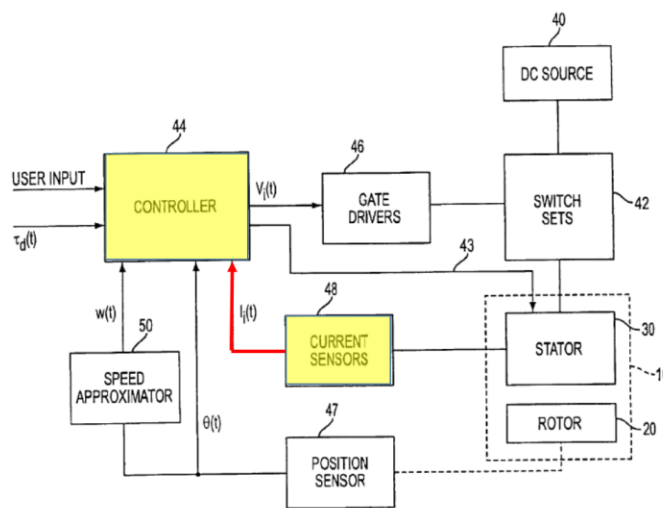


Fig. 7

(Ex. 1006, 8:9-11, Figure 7; Leeb, ¶159). **Pyntikov** explains: “[i]n operation, the controller 44 is responsive to the various inputs, including the **motor speed** to provide appropriate waveforms through switch sets 42 to terminals 50 of each stator core element or phase. The controller is also responsive to **motor speed** to activate, through lines 43, the appropriate switches of switches 51-59 to configure the connection of winding sections to correspond to the respective speed range that comprises the **sensed motor speed.**” (Ex. 1006, 8:28-35, Figure 7; Leeb, ¶159).

Thus, **Pyntikov** discloses a control unit that actuates the switches to vary the connection configuration of the winding sections while the motor is running based on an output of a sensor that senses an operating parameter of the motor. (Leeb, ¶160).

8. **Claim 13: “A permanent magnet brushless motor as claimed in claim 8, wherein: the control means comprises means for manually changing the connection configuration of the winding sections.”**

Pyntikov discloses claim 8. **Pyntikov** discloses that the “**controller** 44 may have one or more **user inputs** and a plurality of inputs for motor conditions sensed during operation.” (Ex. 1006, 8:7-9; Leeb, ¶161). ’103 states only that “means may be provided for manually changing the configuration of the winding connection.” (Ex. 1001, 3:20-21; Leeb, ¶161). This claim is drafted as a means-plus-function claim, with the recited function of “manually changing the connection configuration of the winding sections.” ’103 does not specifically identify any structure corresponding to the recited function, but a POSITA would understand that any manual input mechanism—such as a switch or a brake—could be used to provide an input to the controller to cause a change in the configuration of the winding connections. (Leeb, ¶161).

Like ’103, **Pyntikov** discloses, e.g., that “the **reconfiguration of stator winding sections may be incorporated within a motor control system that is**

adaptive to control various motor parameters in response to sensed conditions as well as **user input commands**. For example, **in a vehicle drive application, the system may respond to a user input command to regulate motor speed accordingly.**”

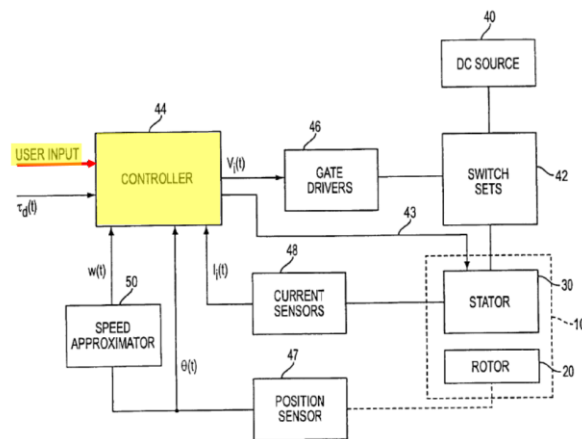


Fig. 7

(Ex. 1006, 7:42-48, Figure 7; Leeb, ¶162). A POSITA would have understood that a user input disclosed in **Pyntikov** would include the ability for a user to manually change the connection configuration of the winding sections, e.g., by simply depressing a switch. (Leeb, ¶162).

Thus, **Pyntikov** discloses a control unit that includes the ability to manually change the connection configuration of the winding sections. (Leeb, ¶163).

9. **Claim 14:** “A permanent magnet brushless motor as claimed in claim 1, wherein: all of the winding sections of the given phase are wound in parallel to each other.”

Pyntikov discloses claim 1. '103 states that the winding sections “are co-wound in parallel through the relevant stator slots of the motor,” but does not further describe the configuration. (Ex. 1001, 3:61-62; Leeb, ¶164). Like '103, **Pyntikov** discloses:

Preferably, the winding of each core segment comprises four sections identified as 38A-38D. Each section has two ends that may be connected to ends of the other sections in various circuit configurations in a manner described hereinafter. In the formation shown in FIG. 3A, each winding section comprises coils wound on both salient poles 32. Thus each section has an end connection point accessible at each pole 32 of the pole pair. FIG. 3A illustrates end connection points 38A-38D at each of the poles.

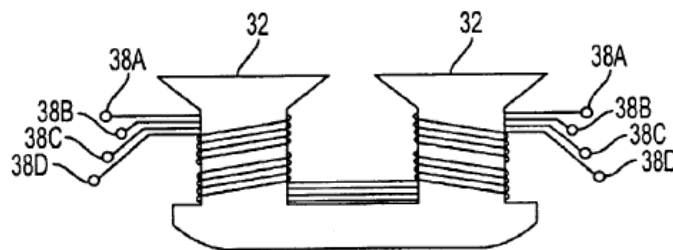


Fig. 3A

(Ex. 1006, 6:1-10, Figure 3A; Leeb, ¶164). A POSITA would have understood that the four conductors of the winding sections (38A-38D) depicted in Figure 3A of **Pyntikov** are co-wound in parallel to each other. (Leeb, ¶¶164-165).

10. **Claim 15:** “A permanent magnet brushless motor as claimed in claim 1, wherein: the winding sections of the given phase are connected such that current flows through each winding section in the same direction.”

Pyntikov discloses claim 1. '103 states in the context of Figure 1, when all of the stator winding sections 1-5 are connected in series, “the supply current flows through each series-connected section 1-5 in the same direction with respect to each section’s polar orientation (as indicated by the arrows in FIG.1).”

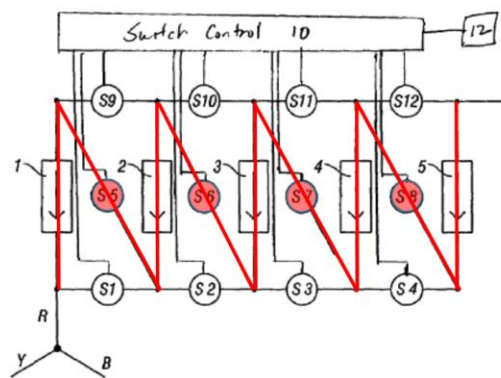


FIG. 1

(Ex. 1001, 4:15-21, Figure 1; Leeb, ¶166). Like '103, **Pyntikov** discloses the identical configuration in the context of Figure 6

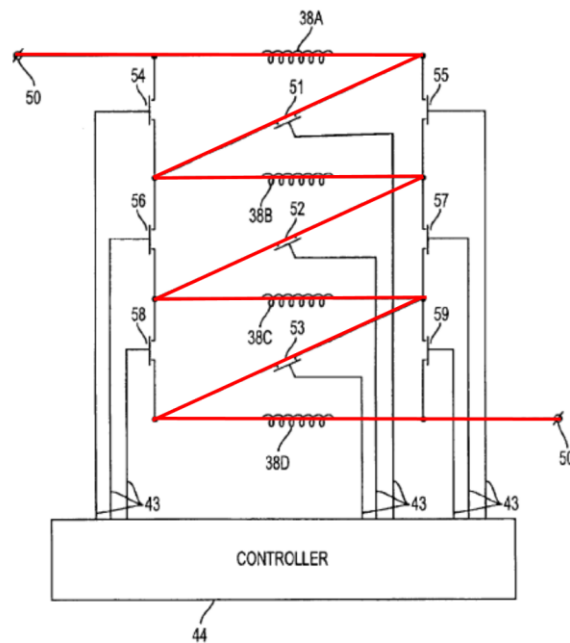


Fig. 6

(Ex. 1006, Figure 6; Leeb, ¶166). A POSITA would have understood that when the series-connected winding sections 38A-38D of **Pyntikov** are connected across a power supply at terminals 50, the current will flow through each winding section in the same direction. (Leeb, ¶166).

Thus, **Pyntikov** discloses connecting the winding sections of a given phase such that current flows through each winding section in the same direction. (Leeb, ¶167).

11. Claims 16 and 17

Pyntikov discloses claim 1. Claims 16 and 17 merely require using a different number of turns (claim 16) or a conductor having a different cross-sectional area (claim 17) for one of the winding sections. **Pyntikov** discloses that it was well

known that one approach to varying the motor topology is to **vary the number of turns** of the phase windings **or the cross-sectional area (“gauge”) of the conductor**. (Ex. 1006, 3:23-35; Leeb, ¶¶168-169).

Thus, **Pyntikov** discloses claims 16 and 17. (Leeb, ¶170).

B. Ground 2: Claims 6 and 7 are Obvious Over Pyntikov, Either Alone or in Combination with Rivera

- 1. Claim 6: “A permanent magnet brushless motor as claimed in claim 5, wherein: the voltage applied to the winding sections of the given phase is pulse-width modulated by selectively energising said switch means.”**

Pyntikov discloses claim 5. **Pyntikov** discloses that “[e]lectronically controlled pulsed energization of windings of motors offers the prospect of more flexible management of motor characteristics. By **control of pulse width, duty cycle**, and switched application of a battery source to appropriate stator windings, high functional versatility can be achieved.” (Ex. 1006, 1:35-40; Leeb, ¶¶171-172). In that passage, **Pyntikov** specifically distinguishes “switched application of a battery source” from the general options of a “control of pulse width, [and] duty cycle.” A POSITA would have understood that “switched application” of a battery source employs an external switch that selectively varies or controls the application of a battery source to the winding. (Leeb, ¶¶171-172). A POSITA would have understood **Pyntikov’s** disclosure includes the possibility of using the winding

reconfiguration switches to chop or pulse width modulate the voltage applied to each winding segment. (Leeb, ¶171-172). That is, a POSITA would have understood that **Pyntikov** discloses switching either the power source or the switches connecting the winding sections to the power source or both, and that “the voltage applied to the winding sections of the given phase is pulse-width modulated by selectively energising said switch means,” as claimed. (Leeb, ¶172).

To the extent it is argued that **Pyntikov** does not explicitly teach selectively energizing the switch means, **Rivera** discloses this. **Rivera** is entitled “Permanent Magnet Direct Current (PMDC) Machine with Integral Reconfigurable Winding Control,” and discloses a “PMDC machine concept [that] operates from a constant dc voltage source.” (Ex. 1012, Title, Abstract; Leeb, ¶173). **Rivera** discloses that in its machine, “the voltage delivered to the windings may be constant and selectable at the most convenient value to support the required machine performance. Consequently, my machine concept uses direct current without need for external power converters.” (Ex. 1012, 2:38-42; Leeb, ¶173). Like the ’103, **Rivera** discloses that its reconfigurable winding sections are controlled using switches to achieve various torque/speed performance profiles, as shown in Figure 4.

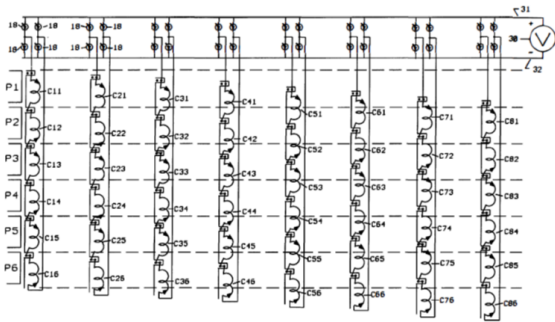


FIGURE 3A

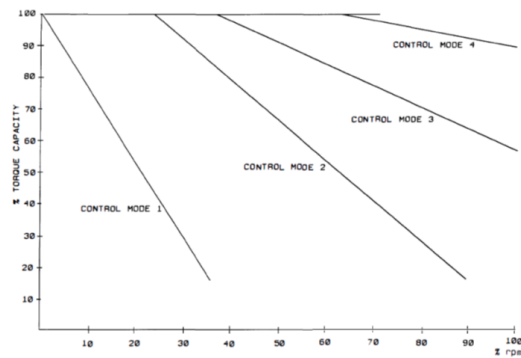


FIGURE 4

(Ex. 1012, 7:25-48, Figures 3A-3B, 4; Leeb, ¶173). That is, **Rivera** discloses that its machine “uses direct current” from a “voltage delivered to the windings” that “may be constant” (Ex. 1012, 2:38-42; Leeb, ¶173). **Rivera** repeats this later, where it discloses “my machine concept is capable of maintaining torque capacity with increasing speed while under constant or nonchanging input voltage” as opposed to prior art that “would require increasing voltage with speed to maintain torque capacity.” (Ex. 1012, 7:44-48; Leeb, ¶173). **Rivera** identifies “**pulse width modulation**” as an approach used “for motors driven by external variable voltage, variable frequency power converters.” (Ex. 1012, 1:67-2:7; Leeb, ¶173). **Rivera** discloses that its “concept uses direct current without need for external power converters.” (Ex. 1012, 2:40-42; Leeb, ¶173). A POSITA would have understood that **Rivera** has replaced external power converters that typically use PWM to control (e.g., “increase with speed”) the output voltage applied to a motor. (Leeb, ¶173). A POSITA would have understood **Rivera** as explaining that it avoids the

need for these “external power converters” by using winding reconfiguration switches that are capable of replacing the external PWM internally. (Leeb, ¶173).

Because **Rivera** uses a direct current power source, a POSITA would have understood that the controller must selectively energize the switches such that the windings are supplied with a PWM voltage. (Leeb, ¶174). **Rivera** discloses

Control systems for controlling all aspects of electric motors and generators are old and well known. A control system to control almost all aspects and functions of any given new or old type of motor is well within the skill of the art. Therefore, a control system can be provided to control the various switches of my invention. To apply such a control system to the present invention, **it is simply necessary to control the various switches ... in a way as to control the motor in any given way.**

(Ex. 1012, 10:38-47; Leeb, ¶174).

Thus, **Pyntikov**, either alone or in view of **Rivera**, discloses applying a PWM voltage to the winding sections of the given phase by selectively energizing the switches that control the winding connection configuration. (Leeb, ¶175).

2. **Claim 7: “A permanent magnet brushless motor as claimed in claim 1, further comprising: means for repeatedly actuating said switch means to change said winding sections between different connection configurations to obtain a motor characteristic intermediate that of the connection configurations between which the winding sections are repeatedly switched.”**

Pyntikov discloses claim 1. **Pyntikov**, either alone or in view of **Rivera** discloses this limitation. (Leeb, ¶176). A POSITA would have understood claim 7 to be directed to another way of describing the effect of the apparatus described *supra*, in the context of claim 6. (Leeb, ¶177). While claim 6 recites “pulse width modulated by selectively energising said switch means,” in claim 7, the “switch means” are “repeatedly actuated” as would, for example, also occur in the pulse width modulation of the voltage applied to the winding sections recited in claim 6. (Leeb, ¶177). A POSITA would have understood from basic circuit theory that “changing the winding sections between different configurations” will vary or modulate the voltage across each winding section. (Leeb, ¶177). For example, when all of the winding sections are connected in parallel, each winding section will experience the same total, maximal voltage applied to the winding array. (Leeb, ¶177). On the other hand, when all of the winding sections are connected in series, they will divide the total voltage applied to the winding array. (Leeb, ¶177). A

POSITA would have understood that switching between, for example, an “all parallel” and an “all series” configuration, would switch the voltages from a maximum voltage applied to each parallel winding section to a minimum voltage applied to each series winding section. (Leeb, ¶177). A POSITA would have understood that repeated switching, e.g., via PWM at a duty cycle that selects between one winding configuration and another, would create an average voltage across each winding section that is in between the section voltage of the two winding configurations being switched between. (Leeb, ¶177). This intermediate average voltage would cause the winding sections to draw current and produce a motor performance characteristic intermediate that of the two winding configurations being switched between. (Leeb, ¶177).

Thus, for the same reasons discussed *supra* in the context of claim 1 and claim 6, **Pyntikov**, either alone or in view of **Rivera**, discloses a “means for repeatedly actuating said switch means to change said winding sections between different connection configurations to obtain a motor characteristic intermediate that of the connection configurations between which the winding sections are repeatedly switched,” as claimed. (Leeb, ¶178).

3. Reasons to Combine

A POSITA would have been motivated in light of **Rivera** to employ a control technique in the **Pyntikov** controller wherein control of the switches is used to

generate the pulse-width modulated voltage for the windings, as claimed. (Leeb, ¶179). Such an implementation would have been a combination of familiar technologies according to known methods, and would have yielded predictable results. *See KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007).

A POSITA would have understood that **Pyntikov** and **Rivera** are in the same technical field, since they both disclose control of a PMDC machine by reconfiguring the winding sections to achieve various operating parameters for the machine. (Leeb, ¶180). It would have been a common sense approach for those skilled in the art to look to **Rivera** for further details of a controller, such as that disclosed in **Pyntikov**. (Leeb, ¶180). **Rivera** discloses that control systems were well known and that “it is simply necessary to control the various switches ... to control the motor in any given way.” (Ex. 1012, 10:38-47; Leeb, ¶180). A POSITA would have understood that using a direct current power source and controlling the switches is a matter of design choice, and as disclosed in **Rivera**, would allow a machine design “without need for external power converters.” (Ex. 1012, 2:41-42; Leeb, ¶180).

Accordingly, **Pyntikov**, either alone or in combination with **Rivera**, discloses applying a PWM voltage to the winding sections of the given phase by selectively energizing the switches that control the winding connection configuration. (Leeb, ¶181).

C. Ground 3: Claims 10 and 12 are Obvious Over Pyntikov and Maslov

- 1. Claims 10 and 12: “A permanent magnet brushless motor as claimed in claim 8, wherein: the control means is adapted to vary the connection configuration of the winding sections whilst the motor is running, ...”**

Claim 10: “... in accordance with the output of means for sensing an operating parameter of the article being driven by the motor.”

Claim 12: “...in accordance with time or an operating cycle or program.”

Pyntikov discloses claim 8. **Pyntikov** discloses that the “**controller** 44 may have one or more user inputs and **a plurality of inputs for motor conditions sensed during operation.**” (Ex. 1006, 8:7-9; Leeb, ¶¶182-183). **Pyntikov** explains “the **reconfiguration of stator winding sections** may be incorporated within a motor control system that is adaptive to **control various motor parameters in response to** sensed conditions as well as **user input commands.**” (Ex. 1006, 7:42-46; Leeb, ¶183). ’103 describes configuring the winding connections “in accordance with the output of means for sensing an operating parameter of the article being driven by the motor such as velocity,” or alternatively, “in accordance with time or an operating cycle or program. (Ex. 1001, 3:9-11, 3:17-19; Leeb, ¶183).

Like '103, **Pyntikov** discloses, e.g., that “[a]s described more fully in [Maslov, Ex. 1008], controller 44 may have one or more user inputs and a plurality of inputs for motor conditions sensed during operation.”

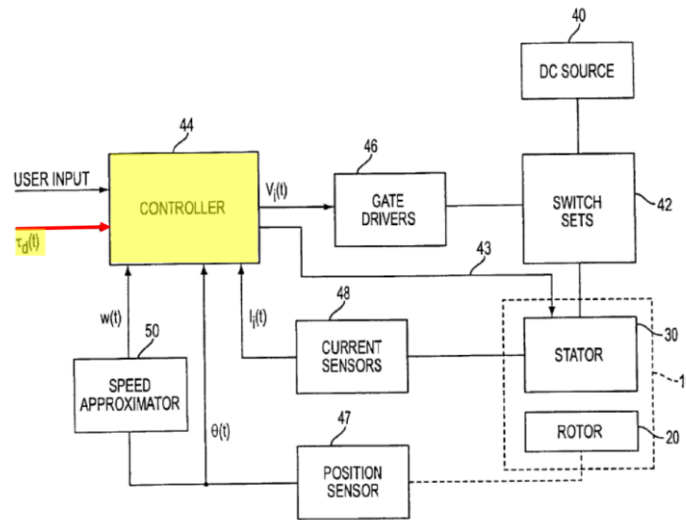


Fig. 7

(Ex. 1006, 8:6-9, Figure 7; Leeb, ¶184). **Pyntikov** incorporates **Maslov** by reference. (Ex. 1006, 1:10-17; Leeb, ¶184). Boris Maslov is a co-inventor of **Pyntikov**.

Maslov is directed to a “control system for a multiphase permanent magnet motor,” which describes the same control system included in **Pyntikov**.

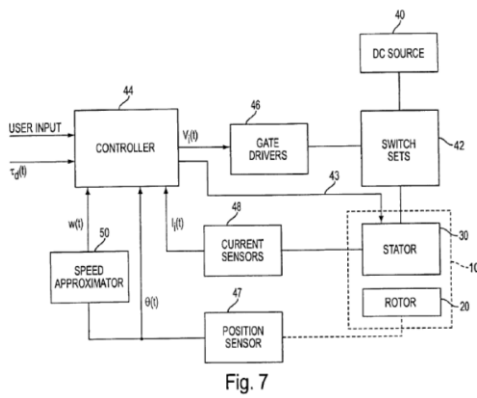


Figure 7 of Pyntikov

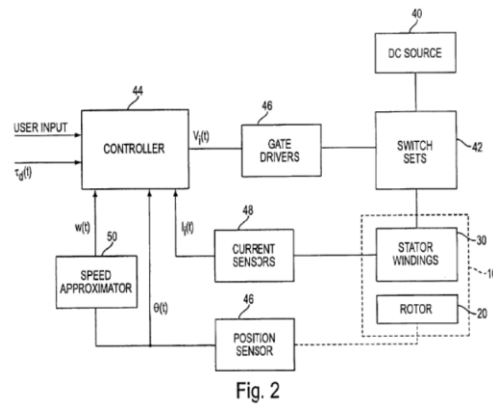


Figure 2 of Maslov

(Ex. 1006, Figure 7; Ex. 1008, Figure 2; Leeb, ¶185).

Pyntikov explains “[i]n operation, the controller 44 is responsive to the various inputs, including the motor speed to provide appropriate waveforms through switch sets 42 to terminals 50 of each stator core element or phase. The controller is also responsive to motor speed to activate, through lines 43, the appropriate switches of switches 51-59 to configure the connection of winding sections to correspond to the respective speed range that comprises the sensed motor speed.” (Ex. 1006, 8:28-35, Figure 7; Leeb, ¶186). Thus, **Pyntikov** discloses “control means for actuating the configuration of the winding sections whilst the motor is running,” and that **Pyntikov**’s controller varies the connection configuration of the winding sections in accordance with the output of a sensor that senses an operating parameter of the article being driven by the motor. (Leeb, ¶186).

To the extent Patent Owner argues **Pyntikov** does not explicitly disclose “means for sensing an operating parameter of the article being driven by the motor,”

a POSITA would have looked to **Maslov** for this. **Pyntikov** states that “in a vehicle drive application, the system may respond to a user input command to regulate motor speed accordingly. Such a system, [is] disclosed in [**Maslov**].” (Ex. 1006, 7:46-49; Leeb, ¶187).

Maslov discloses that the output of the “[r]otor position sensor 46 is connected to another input of controller 44 to provide position signals thereto.” (Ex. 1008, 3:62-64; Leeb, ¶188). “The output of the position sensor is also applied to speed approximator 50, which converts the position signals to speed signals to be applied to another input of controller 44.” (Ex. 1008, 3:64-67; Leeb, ¶188).

Maslov discloses that “[t]he motor of the present invention is suitable for use in driving a vehicle wheel of an automobile, motorcycle, bicycle, or the like,” and depicts a “cutaway drawing of the motor structure that can be housed within a vehicle, the stator rigidly mounted to a stationary shaft and surrounded by a rotor [figure element 20] for driving the wheel.”

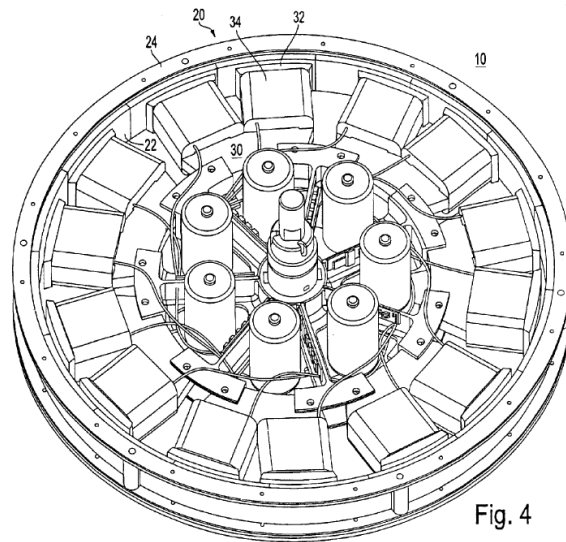


Fig. 4

(Ex. 1008, 4:33-38, Figure 4; Leeb, ¶189). A POSITA would have understood that in this embodiment of **Maslov**, the rotor is the article being driven by the motor, i.e., the speed of the rotor as sensed by the position sensor is also the speed of the article being driven by the motor. (Leeb, ¶189).

Thus, the combination of **Pyntikov** and **Maslov** discloses a control unit that actuates the switches to vary the connection configuration of the winding sections while the motor is running based on an output of a sensor that senses an operating parameter the article being driven by the motor (claim 10). (Leeb, ¶190).

Claim 12 recites that the control means can vary the connections “in accordance with time or an operating cycle or program.” As discussed *supra*, **Pyntikov** identifies **Maslov** as describing further details of its motor controller. (See Ex. 1006, 7:46-49; Leeb, ¶191).

Maslov discloses “[a] control system for a multiphase permanent magnet motor [in which] [a] **digital signal processor may be utilized that applies an algorithm** incorporating the parameters as constant values, the parameters for a particular phase being accessed for generating the appropriate control signals for energizing that phase.” (Ex. 1008, Abstract; Leeb, ¶192). A POSITA would have understood that a programmable digital signal processor runs a “**program**” to control the motor. (Leeb, ¶192).

Thus, **Pyntikov** discloses a control unit that actuates the switches to vary the connection configuration of the winding sections while the motor is running based on a **program**. (Leeb, ¶193). To the extent Patent Owner argues **Pyntikov** does not explicitly disclose varying the connection configurations of the winding sections “in accordance with time or an operating cycle or program,” a POSITA would have looked to **Maslov** for this. **Pyntikov** states that its Figure 7 depicting the motor control system is “disclosed in [**Maslov**].” (Ex. 1006, 7:53-54; Leeb, ¶193).

Pyntikov also discloses that the “present invention fulfills the above-described needs for controlling, through a plurality of operating speed ranges, a multiphase motor with optimum operating efficiency throughout the entire operating range.” (Ex. 1006, 3:62-65; Leeb, ¶194). ’103 does not disclose what “time or an operating cycle or program” entails, but explains in the context of Figure 9 that “the required range of speed and torque can easily be achieved within the current confines

using a reasonably sized direct drive brushless DC motor in accordance with this invention.”

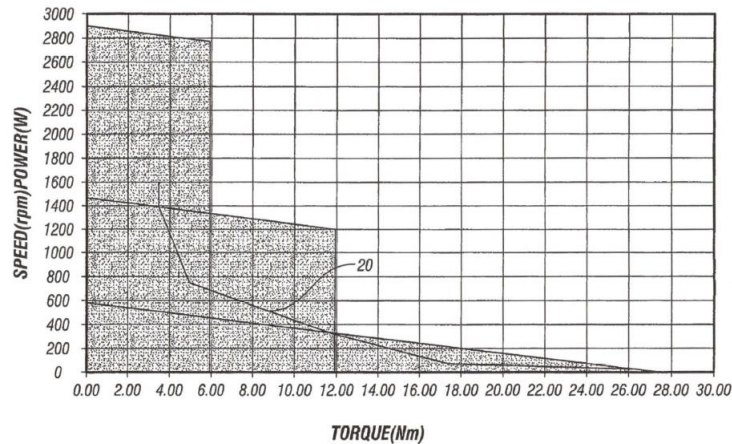


FIG. 9

(Ex. 1001, 6:12-16, Figure 9; Leeb, ¶194). A POSITA would have understood that controlling the motor “in accordance with time or an operating cycle or program” would include controlling the motor to achieve the operating characteristics throughout the operating range of the motor, as shown in Figure 9 of ’103. (Leeb, ¶194).

Like ’103, **Pyntikov** discloses that the “efficiency characteristic for motor operation with these winding section reconfigurations is represented by the bold curve in FIG. 5. This curve is a composite of the three individual curves and exhibits high efficiency operation over an extended range of speeds, that is not obtainable with only one of the configurations.”

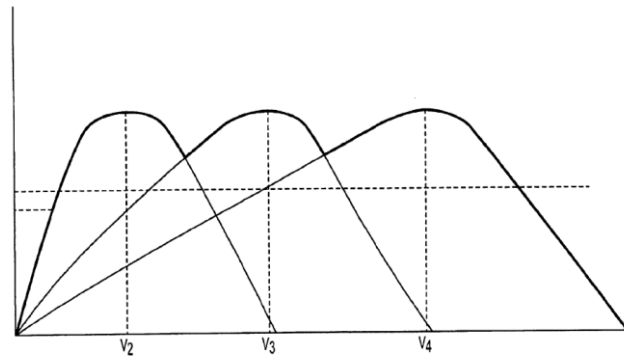


Fig. 5

(Ex. 1006, 6:48-53, Figure 5; Leeb, ¶195). Thus, a POSITA would have understood that **Pyntikov** discloses a “control means for actuating the configuration of the winding sections whilst the motor is running,” and that **Pyntikov**’s controller varies the connection configuration of the winding sections in accordance with time or an operating cycle or program. (Leeb, ¶195).

To the extent it is argued that **Pyntikov** does not explicitly teach a control means for varying the connection configurations of the winding sections in accordance with time or an operating cycle or program, a POSITA would have found it obvious to do so. (Leeb, ¶196).

Thus, the combination of **Pyntikov** and **Maslov** discloses a control unit that actuates the switches to vary the connection configuration of the winding sections while the motor is running based on time or an operating cycle or program (claim 12). (Leeb, ¶197).

2. Reasons to Combine

A POSITA would have been motivated in light of **Maslov** to employ various control techniques in the **Pyntikov** controller, such as varying the configuration of the winding sections in accordance with an operating parameter of the article being driven or in accordance with a program, as claimed. (Leeb, ¶198). Such an implementation would have been a combination of familiar technologies according to known methods, and would have yielded predictable results. *See KSR*, 550 U.S. at 416.

A POSITA would have understood that **Pyntikov** and **Maslov** are in the same technical field, since they disclose interrelated teachings of the same system, are co-assigned, and have shared inventors. (Leeb, ¶199). In addition, **Pyntikov** incorporates **Maslov** by reference. (Leeb, ¶199). Indeed, a POSITA would have understood that **Pyntikov** and **Maslov** are directed to two different aspects of the same system. Thus, it would have been a common sense approach for those skilled in the art to look to **Maslov** for further details of the controller disclosed in **Pyntikov**. (Leeb, ¶199).

Accordingly, the combination of **Pyntikov** and **Maslov** discloses the claimed features recited in claims 10 and 12. (Leeb, ¶200).

D. Ground 4: Claim 11 is Obvious Over Pyntikov and Masino

- 1. Claim 11: “A permanent magnet brushless motor as claimed in claim 8, wherein: the control means is adapted to vary the connection configuration of the winding sections of a conducting phase whilst the motor is running, in accordance with the back emf measured across a non-conducting phase or a winding section thereof.”**

Pyntikov discloses claim 8. It would have been obvious to a POSITA to configure the connection configuration of the winding sections in **Pyntikov** in accordance with the back emf measured across a non-conducting phase, as disclosed in **Masino**. (Leeb, ¶201).

Masino is directed to a “brushless, sensorless DC motor controller that uses back electromotive force values from the DC motor to selectively switch power to windings in the DC motor stator.” (Ex. 1009, 1:20-22; Leeb, ¶202). In the Background, **Masino** states, “the advent of brushless, sensorless DC motor controllers that use **Back EMF signals to indicate rotor position** has eliminated the need for commutator brushes, revolvers, and hall effect sensors to indicate the position of a rotor as it moves with respect to the stator. The **Back EMF signals** are incorporated into a feedback loop between the DC motor and the DC motor controller to correctly time the switching of power to the motor windings.” (Ex. 1009, 3:5-12; Leeb, ¶202).

Pyntikov discloses that “[r]otor position sensor 47 is connected to another input of controller 44 to provide position signals thereto. The output of the position sensor may also be applied to speed approximator 50, which converts the position signals to speed signals to be applied to another input of controller 44. Alternatively, any conventional motor speed feedback means may be utilized to provide an appropriate motor speed feedback signal to the controller.”

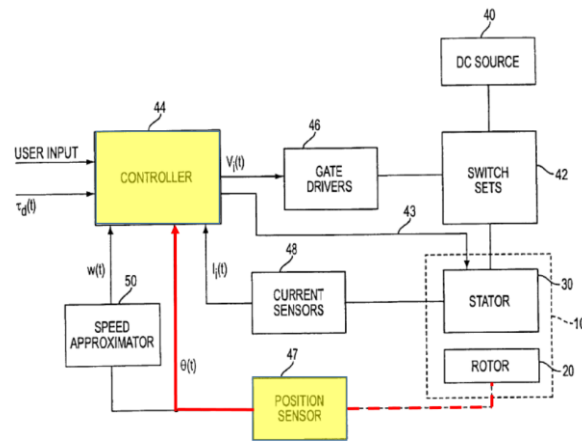


Fig. 7

(Ex. 1006, 8:14-22, Figure 7; Leeb, ¶203). A POSITA would have understood that knowledge of rotor position is a necessary input to a controller for a permanent magnet brushless motor. (Leeb, ¶203). A POSITA would have understood that it a well-known technique for determining the rotor position of a brushless DC motor was to measure the back-emf across the phase of the stator that is not energized, as disclosed in **Masino**. (Leeb, ¶203). A POSITA would have understood that it was merely a matter of design choice to use a back-emf sensor to determine the rotor

position rather than a position sensor. (Leeb, ¶203). Indeed, **Pyntikov** discloses that instead of a rotor position sensor, “[a]lternatively, any conventional motor speed feedback means may be utilized to provide an appropriate motor speed feedback signal to the controller.” (Ex. 1006, 8:19-22; Leeb, ¶203). A POSITA would have understood that the sensorless control technique disclosed by **Masino** is one such choice for determining rotor position for controlling a brushless DC motor. (Leeb, ¶203).

Thus, the combination of **Pyntikov** and **Masino** discloses a control unit that varies the connection configuration of the winding sections in accordance with the back emf measured across a non-conducting phase or winding section thereof. (Leeb, ¶204).

2. Reasons to Combine

A POSITA would have been motivated in light of **Masino** to employ a technique of measuring the back-emf of the de-energized stator phase to determine rotor position in the **Pyntikov** controller, as claimed. (Leeb, ¶205). Such an implementation would have been a combination of familiar technologies according to known methods, and would have yielded predictable results. *See KSR*, 550 U.S. at 416.

A POSITA would have understood that **Pyntikov** and **Masino** are in the same technical field relating to control of permanent magnet motors. (Leeb, ¶206). A

POSITA would have understood that to employ the well-understood techniques of **Masino** would be a matter of design choice, e.g., to create a sensorless motor controller. (Leeb, ¶206). Indeed, **Masino** discloses that “[t]he motor configuration for these brushless, sensorless DC motors remains the same as the sensed, brushless DC motors.” (Leeb, ¶206). Measuring back-emf as disclosed in **Maslov** is one of the limited number of solutions for determining rotor position for a brushless DC motor as disclosed in **Pyntikov**, and as such “a person of ordinary skill has good reason to pursue the known options within his or her technical grasp.” *KSR*, 550 U.S. at 421. Thus, it would have been a common sense approach for those skilled in the art to look to **Masino** for design choices for determining the rotor position to control the brushless DC motor disclosed in **Pyntikov**. (Leeb, ¶206).

Accordingly, the combination of **Pyntikov** and **Masino** discloses the claimed features recited in claim 11. (Leeb, ¶207).

E. Ground 5: Nipp Renders Obvious Claims 1-5 and 8-15

1. Nipp

Like '103, **Nipp** is directed to “Permanent Magnet Motor Drives with Switched Stator Windings.” (Ex. 1007, Title; Leeb, ¶208). **Nipp** explains that—like '103—“switched stator windings are a means to increase the speed range of permanent magnet motors above base speed.” (Ex. 1007, 51; Leeb, ¶208). **Nipp** explains that “series to parallel switching is possible if the phase windings are

divided into several parts. ... Even combinations of series and parallel coils may be considered.” (Ex. 1007, 51; Leeb, ¶208).

Nipp discloses an arrangement of switches to reconfigure a stator winding having two sections per phase. (Ex. 1007, Figure 3.5, 59; Leeb, ¶209). In an example, the stator winding for each phase includes two sections (e.g., A1, A2, blue) that can be connected in various combinations of series and parallel connections using the switches (yellow).

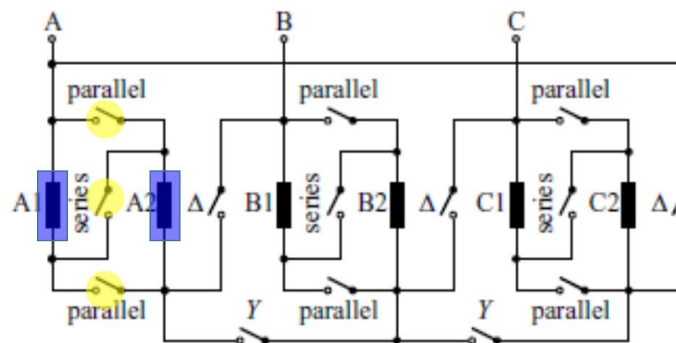


Figure 3.5.: Arrangement to switch stator windings with two parts each (A1–C2) into different configurations.

(Ex. 1007, Figure 3.5, 59; Leeb, ¶209).

The switches reconfigure the winding sections based on the speed of the motor throughout the different speed ranges of operation of the machine. (Ex. 1007, 52; Leeb, ¶210). **Nipp** discloses an example having four different winding configurations for a motor having two winding sections per phase, and another example having six different winding configurations for a motor having three winding sections per phase. The winding configurations in both examples

correspond to the operating speed of the motor. (Ex. 1007, Figures 3.1, 3.2, 52-54; Leeb, ¶210). These different winding configurations are depicted in Figure 3.1 (two winding sections per phase) and Figure 3.2 (three winding sections per phase).

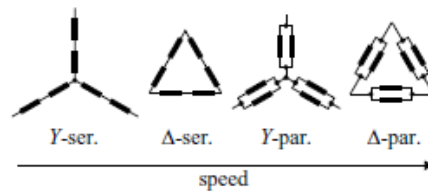


Figure 3.1.: Winding configuration sequence with two coils per phase.

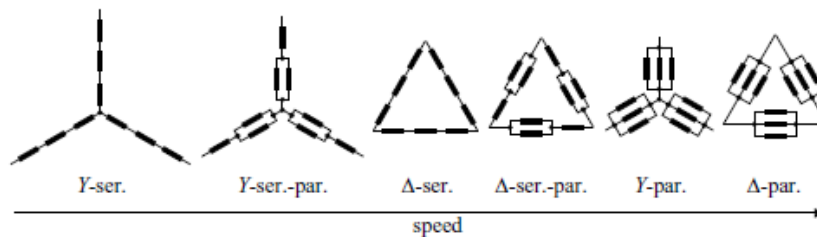


Figure 3.2.: Winding configuration sequence with three coils per phase.

(Ex. 1007, Figures 3.1, 3.2, 54; Leeb, ¶210). As shown, **Nipp** discloses switching between winding configurations being connected all in series, all in parallel, and combinations of series and parallel. (Ex. 1007, Figures 3.1, 3.2, 52-54; Leeb, ¶210). **Nipp** discloses that regardless of the configuration of the winding sections, all of windings are always connected to the power source. (Ex. 1007, Figures 3.1, 3.2, 52-54; Leeb, ¶210).

Nipp further discloses that—like '103—by reconfiguring the configuration of the stator windings as discussed *supra*, the motor exhibits an effect that “is similar to a mechanical gear switch. Therefore the arrangement can be looked upon as an

electronic gearbox.” (Ex. 1007, 56; Leeb, ¶211). **Nipp** discloses the various torque vs. speed performance for the various configurations of the switched stator windings.

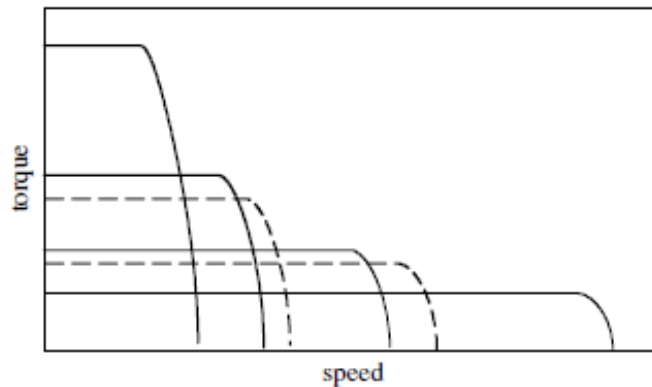


Figure 3.3.: Tractive effort curves comparison for two and three winding parts per phase. Thick lines, both solid and dashed, apply to two parts. Solid lines, both thick and thin, apply to three parts.

(Ex. 1007, Figure 3.3, 57; Leeb, ¶211).

2. Claim 1

a) “A permanent magnet brushless motor comprising:”

To the extent that the preamble of claim 1 is limiting, **Nipp** discloses the limitations therein. (Leeb, ¶212).

Nipp is entitled “Permanent Magnet Motor Drives with Switched Stator Windings.” (Ex. 1007, Title; Leeb, ¶213). **Nipp** explains that permanent magnet (“PM”) machines are “usually divided into synchronous PM machines and brushless DC (BLDC) PM machines.” (Ex. 1007, 11; Leeb, ¶213). As noted in **Nipp**, “[t]his terminology is somewhat confusing since both types have no brushes and operate in synchronous mode.” (Ex. 1007, 11; Leeb, ¶213). **Nipp** states “[o]ften the field

weakening speed range is important but difficult to obtain with **PM machines** because the induction in the direction of magnetization tends to be low. An alternative can be to switch different coils groups of the stator winding into different configurations. This is the central topic of this thesis.” (Ex. 1007, Abstract; Leeb, ¶213). The preamble—to the extent it is limiting—does not identify any particular type of PM machine, and therefore, would not be understood to be limited to a particular class of PM machines. A POSITA would have understood that ’103’s “permanent magnet brushless motor” is either a synchronous PM machine or a brushless DC PM machine because both types are permanent magnet brushless motors. (Leeb, ¶213).

Thus, **Nipp** discloses “[a] permanent magnet brushless motor.” (Leeb, ¶214).

- b) **“a stator comprising one or more phases, wherein at least one given phase of the stator includes a plurality of winding sections;”**

Nipp discloses this. (Leeb, ¶215). **Nipp** explains “the stator flux linkage can also be reduced by reducing the number of stator winding turns. This can obviously be accomplished by switching **a phase winding with two parts** from series to parallel connection.” (Ex. 1007, 40; Leeb, ¶215). **Nipp** explains “[i]ncreasing the number of winding parts requires not only more switches to perform the

reconfigurations but also complicates motor design, cabling, maintenance, installation, etc.” (Ex. 1007, 55; Leeb, ¶215).

’103 admits that having a plurality of winding sections per phase was well-known, e.g. as disclosed in **Chen**, discussed *supra* at §VI.A.2.b, which is incorporated herein by reference. (Leeb, ¶216).

In order to provide a PM motor in which the speed and torque characteristics can be varied, it was well-understood by those skilled in the art that providing a plurality of winding sections for the stator windings provides the ability to reconfigure the stator to achieve such control. (Leeb, ¶217).

Thus, **Nipp** discloses “a stator comprising one or more phases, wherein at least one given phase of the stator includes a plurality of winding sections.” (Leeb, ¶218).

c) **“a rotor rotatably mounted relative to the stator and comprising at least one permanent magnet;”**

Nipp discloses this. (Leeb, ¶219). **Nipp** explains “[t]he synchronous PM machine is characterized by a **permanent magnet excited rotor** and the operation with sinusoidal stator currents, and “[t]he BLDC PM machine is characterized by a **permanent magnet excited rotor** and the operation with square wave currents” (Ex. 1007, 11-12; Leeb, ¶219). As depicted below, **Nipp** provides exemplary

configurations of the rotor rotatably mounted relative to the stator in both a synchronous PM machine and a BLDC PM machine.

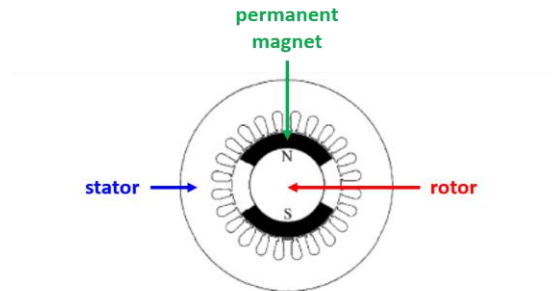


Figure 2.6.: Typical cross section example of a 2-pole synchronous PM motor.

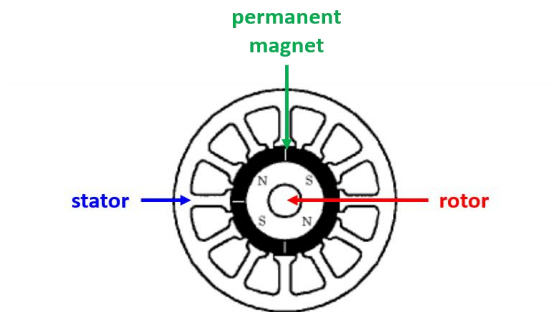


Figure 2.8.: Typical cross section example of a 4-pole BLDC motor.

(Ex. 1007, Figures 2.6, 2.8, 12-13; Leeb, ¶219).

A POSITA would have understood that in the configurations discussed above, that the rotor includes a permanent magnet and is rotatably mounted relative to the stator. (Leeb, ¶220).

Thus, **Nipp** discloses “a rotor rotatably mounted relative to the stator and comprising at least one permanent magnet.” (Leeb, ¶221).

- d) “switch means comprising a plurality of switching devices for simultaneously connecting all of the winding sections of the given phase in one of a plurality of different configurations,”

Nipp discloses this. (Leeb, ¶222). **Nipp** discloses that “[i]n figure 3.5 the complete winding switch arrangement is shown for two coils per phase.”

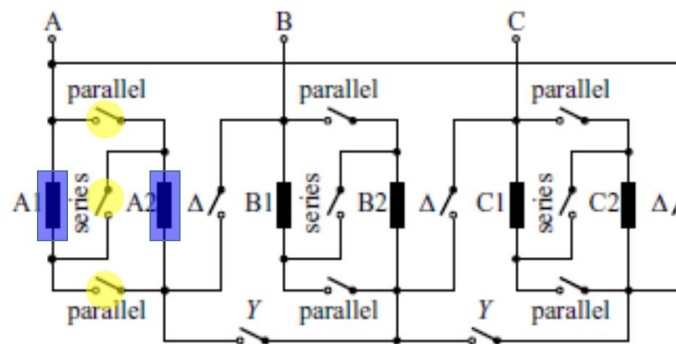


Figure 3.5.: Arrangement to switch stator windings with two parts each (A1-C2) into different configurations.

(Ex. 1007, Figure 3.5, 59; Leeb, ¶222). In this example, each given phase (e.g., phase A) includes three switching devices (yellow) for connecting the two winding sections of the phase (blue) in either a series configuration, or a parallel configuration. (Ex. 1007, Figure 3.5, 59; Leeb, ¶222). In this example, if the series switch is closed and the two parallel switches are open, all of the winding sections for phase A are connected in series, as illustrated below.

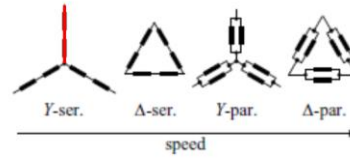
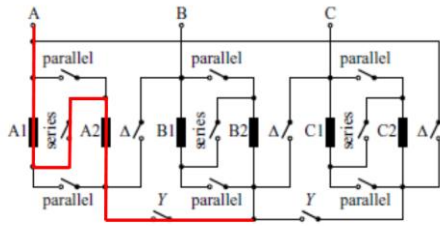


Figure 3.1.: Winding configuration sequence with two coils per phase.

(Ex. 1007, Figures 3.1, 3.5, 54, 59; Leeb, ¶222).

Nipp discloses the same arrangement of switches per winding section as disclosed in '103, as depicted below:

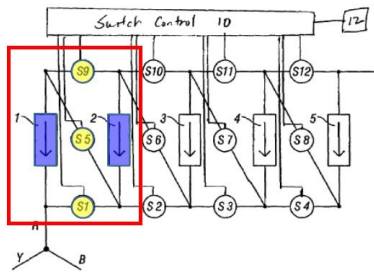


FIG. 1

Figure 1 of '103 Patent

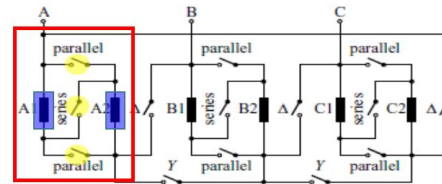


Figure 3.5.: Arrangement to switch stator windings with two parts each (A1-C2) into different configurations.

Figure 3.5 of Nipp

(Ex. 1001, Figure 1; Ex. 1007, Figure 3.5, 59; Leeb, ¶¶223-224).

Nipp discloses the sequences of configuration of the winding sections for stators having both two and three winding sections based on the changes in the machine parameters. (Ex. 1007, Figure 3.5, 59; Leeb, ¶225). As **Nipp** shows, based on the speed of the machine, there is a sequence of four different configurations for a stator having two winding sections per phase, and a sequence of six different configurations for a stator having three winding sections per phase.

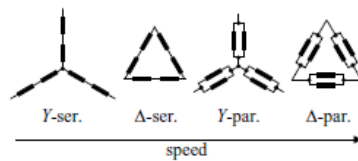


Figure 3.1.: Winding configuration sequence with two coils per phase.

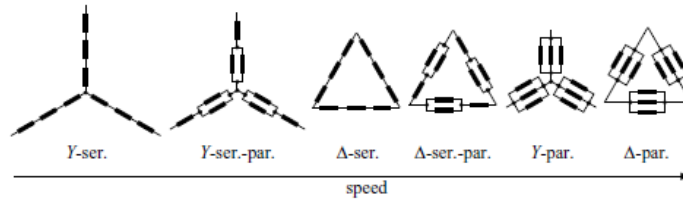


Figure 3.2.: Winding configuration sequence with three coils per phase.

(Ex. 1007, Figures 3.1, 3.2, -54; Leeb, ¶225). All of the winding sections are always connected regardless of the configurations. (Ex. 1007, Figures 3.1, 3.2, 54; Leeb, ¶225).

Nipp discloses that the switches used to connect the winding sections in the different possible configurations can be either electro-mechanical switches or semiconductor switches. (Ex. 1007, 59-61; Leeb, ¶¶223-226).

Thus, **Nipp** discloses relays or semiconductor devices for simultaneously connecting all of the winding sections of a given phase in one of a plurality of configurations. (Leeb, ¶227).

- e) “wherein said switching devices are disposed at opposite ends of each winding section and are arranged to connect each winding section in series and/or parallel with all other winding sections of the given phase.”

Nipp discloses this. (Leeb, ¶228). **Nipp** discloses the identical position of the switches at opposite ends of each winding section, as shown below in the comparison of Figure 1 of '103 and Figure 3.5 of **Nipp**:

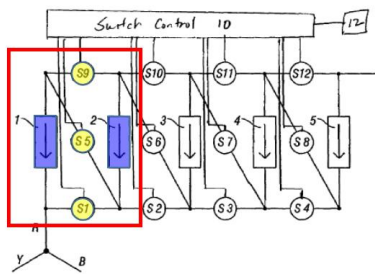


FIG. 1

Figure 1 of '103 Patent

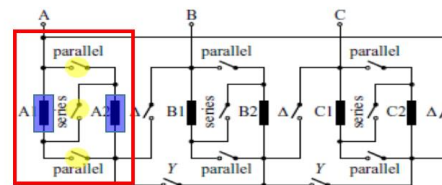


Figure 3.5.: Arrangement to switch stator windings with two parts each (A1-C2) into different configurations.

Figure 3.5 of Nipp

(Ex. 1001, Figure 1; Ex. 1007, Figure 3.5, 59; Leeb, ¶228).

Nipp discloses that when two winding sections are used, that the winding sections can be connected all in series, or all in parallel, as shown in Figure 3.1:

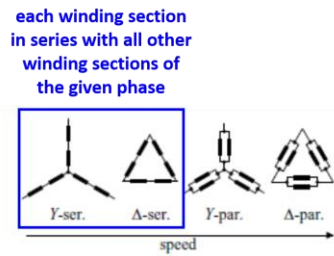


Figure 3.1.: Winding configuration sequence with two coils per phase.

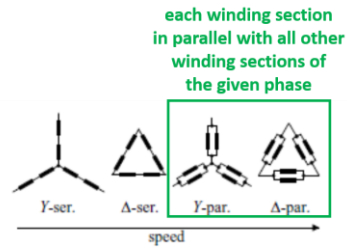


Figure 3.1.: Winding configuration sequence with two coils per phase.

(Ex. 1007, Figure 3.1, 54; Leeb, ¶229).

And when three winding sections are used, the winding sections can be connected all in series, all in parallel, or in series and parallel combinations taken together, as shown in Figure 3.2:

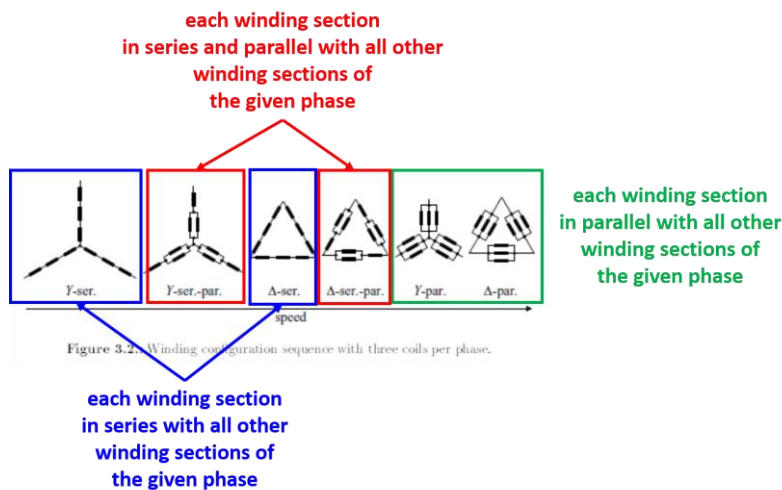


Figure 3.2.: Winding configuration sequence with three coils per phase.

(Ex. 1007, Figure 3.2, 54; Leeb, ¶230). **Nipp** discloses that in every possible configuration of the winding sections—regardless of how many sections are used per phase—all of the winding sections are used such that there are no redundant or unused stator windings. (Ex. 1007, Figures 3.1, 3.2, 52-57; Leeb, ¶230).

Thus, **Nipp** discloses that the switches “are arranged to connect each winding section in series and/or parallel with all other winding sections of the given phase.” (Leeb, ¶¶231-232).

3. **Claim 2: “A permanent magnet brushless motor as claimed in claim 1, wherein: the switch means is arranged to connect all of the winding sections of the given phase in parallel.”**

Nipp discloses claim 1. **Nipp** discloses that if the series switch is open and the two parallel switches are closed, all of the winding sections for phase A are connected in parallel.

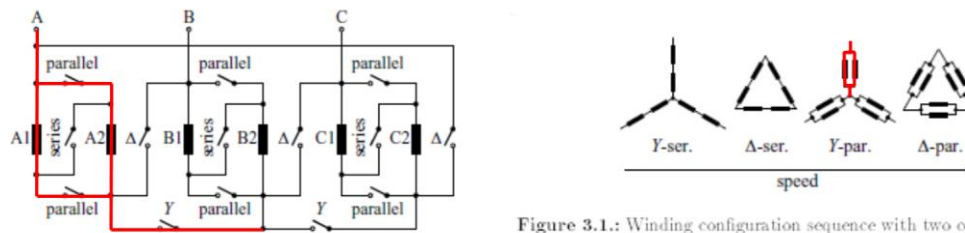


Figure 3.1.: Winding configuration sequence with two coils per phase.

(Ex. 1007, Figures 3.1, 3.5, 54, 59; Leeb, ¶233). Figure 3.1 of **Nipp** depicts configurations where all of the winding sections of the given phase are connected in parallel.

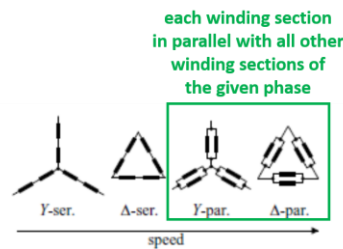


Figure 3.1.: Winding configuration sequence with two coils per phase.

(Ex. 1007, Figure 3.1, 54; Leeb, ¶233).

Thus, **Nipp** discloses switches arranged to connect all of the winding sections of the given phase in parallel. (Leeb, ¶234).

4. **Claim 3: “A permanent magnet brushless motor as claimed in claim 1, wherein: the switch means is arranged to connect all of the winding sections of the given phase in series.”**

Nipp discloses claim 1. **Nipp** discloses that if the series switch is closed and the two parallel switches are open, all of the winding sections for phase A are connected in series, as illustrated below.

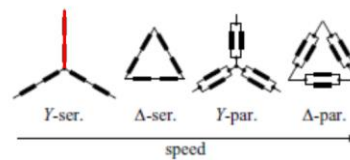
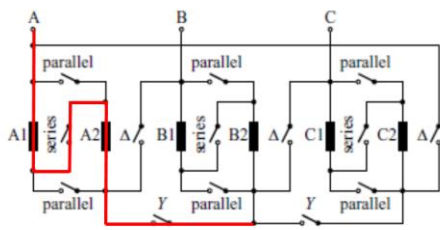


Figure 3.1.: Winding configuration sequence with two coils per phase.

(Ex. 1007, Figures 3.1, 3.5, 54, 59; Leeb, ¶235). Figure 3.1 of **Nipp** depicts configurations where all of the winding sections of the given phase are connected in series.

each winding section
in series with all other
winding sections of
the given phase

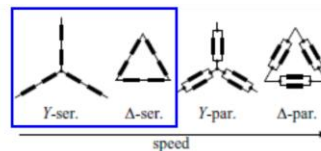


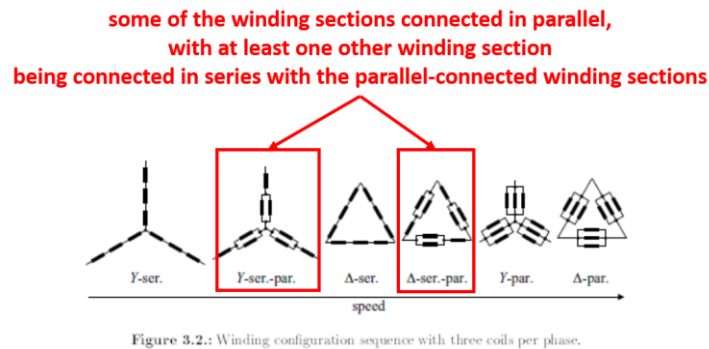
Figure 3.1.: Winding configuration sequence with two coils per phase.

(Ex. 1007, Figure 3.1, 54; Leeb, ¶235).

Thus, **Nipp** discloses switches arranged to connect all of the winding sections of the given phase in series. (Leeb, ¶236).

5. **Claim 4: “A permanent magnet brushless motor as claimed in claim 1, wherein: the switch means is arranged to connect some of the winding sections of the given phase in parallel, with at least one other winding section of the given phase being connected in series with the parallel-connected winding sections.”**

Nipp discloses claim 1. Figure 3.2 of **Nipp** depicts configurations where some of the winding sections are connected in parallel, with at least one other winding section of the phase being connected in series with the parallel-connected winding sections.



(Ex. 1007, Figure 3.2, 54; Leeb, ¶237).

Thus, **Nipp** discloses claim 4. (Leeb, ¶238).

6. **Claim 5: “A permanent magnet brushless motor as claimed in claim 1, wherein: the voltage applied to the winding sections of the given phase is pulse-width modulated.”**

Nipp discloses claim 1. **Nipp** discloses that “[i]n accordance with the state of the art a solid state, **pulse width modulated**, voltage source power inverter is assumed,” and “[s]ince a high switching frequency is anyway necessary it is preferable to utilize asynchronous **pulse width modulation (PWM)** strategies” to control the phase currents. (Ex. 1007, 27; Leeb, ¶239).

Thus, **Nipp** discloses using a PWM voltage applied to the winding sections of the given phase. (Leeb, ¶240).

7. **Claim 8: “A permanent magnet brushless motor as claimed in claim 1, further comprising: control means for actuating the switch means to vary the connection configuration of the winding sections whilst the motor is running, in accordance with predetermined operating parameters.”**

Nipp discloses claim 1. **Nipp** discloses that “digital control is state of the art for variable speed drives [and] [m]ostly micro-controllers or digital signal processors (DSP) are used.” (Ex. 1007, 30; Leeb, ¶241). **Nipp** provides an exemplary schematic depicting a system for controlling a PM motor drive with winding switches.

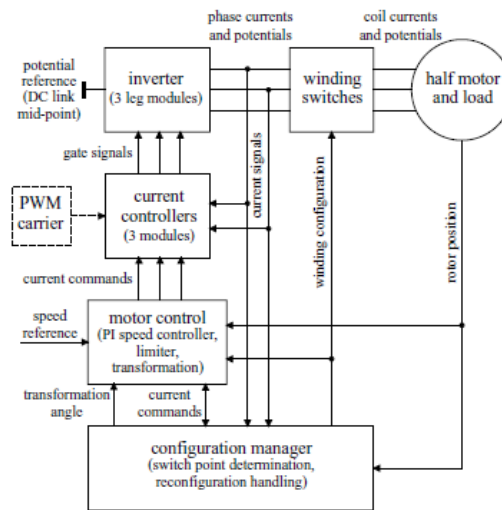


Figure 2.26.: Modular simulation system for PM motor drive with switched stator windings.

(Ex. 1007, Figure 2.26, 45; Leeb, ¶241). **Nipp** discloses that the “simplest choice for the winding switches are electro-mechanical switches, i.e. contactors,” and that the “contactors were actuated from the DSP via relays.” (Ex. 1007, 141; Leeb, ¶241). Thus, a POSITA would have understood that **Nipp** discloses a “control means for actuating the configuration of the winding sections whilst the motor is running.” (Leeb, ¶241).

Nipp further discloses that “[a]n important issue is to determine appropriate instants when to change the winding configuration,” which **Nipp** refers to as the “switch points.” (Ex. 1007, 63-64; Leeb, ¶242). **Nipp** concludes: “[a]n obvious approach is to **calculate the base speeds for all configurations, store them in the DSP, and switch when those predefined points are reached.**” (Ex. 1007, 63; Leeb, ¶242). A POSITA would understand that a stored base speed of the motor for

determining which winding configuration to select is a “predetermined operating parameter” of the motor. (Leeb, ¶242).

Thus, **Nipp** discloses claim 8. (Leeb, ¶243).

8. Claims 9 and 10: “A permanent magnet brushless motor as claimed in claim 8, wherein: the control means is adapted to vary the connection configuration of the winding sections whilst the motor is running, in accordance with ...”

a) Claim 9: “... the output of means for sensing an operating parameter of the motor.”

Nipp discloses claim 8. **Nipp** discloses that “[a]n obvious approach is to calculate the base speeds for all configurations, store them in the DSP, and switch when these predefined points are reached.” (Ex. 1007, 63; Leeb, ¶244). **Nipp** discloses that the “the actual rotor speed ... in revolutions per minute is obtained by derivation of the angular position,” as determined from the output of the position sensor. (Ex. 1007, 22; Leeb, ¶244). A POSITA would have understood that the predefined points for switching the connection configurations of the winding sections are determined in accordance with the output of the position sensor that senses the rotor position. (Leeb, ¶244).

Thus, **Nipp** discloses a control unit that actuates the switches to vary the connection configuration of the winding sections while the motor is running based

on the output of a sensor that senses the rotor position, which is an operating parameter of the motor. (Leeb, ¶245).

b) Claim 10: “... the output of means for sensing an operating parameter of the article being driven by the motor.”

Nipp discloses claim 8. ’103 describes configuring the winding connections “in accordance with the output of means for sensing an operating parameter of the article being driven by the motor such as velocity.” (Ex. 1001, 3:9-11; Leeb, ¶246).

Nipp discloses that “PM machines are today used for numerous applications, ranging from motors in watches to direct driven wind power generators ... and ship propulsion drives.” (Ex. 1007, 1; Leeb, ¶247). A POSITA would understand that in a direct drive PM machine, the speed of the rotor is the same as the speed of the article being driven. (Leeb, ¶¶247).

Nipp provides an exemplary schematic depicting a system for controlling a PM motor drive with winding switches.

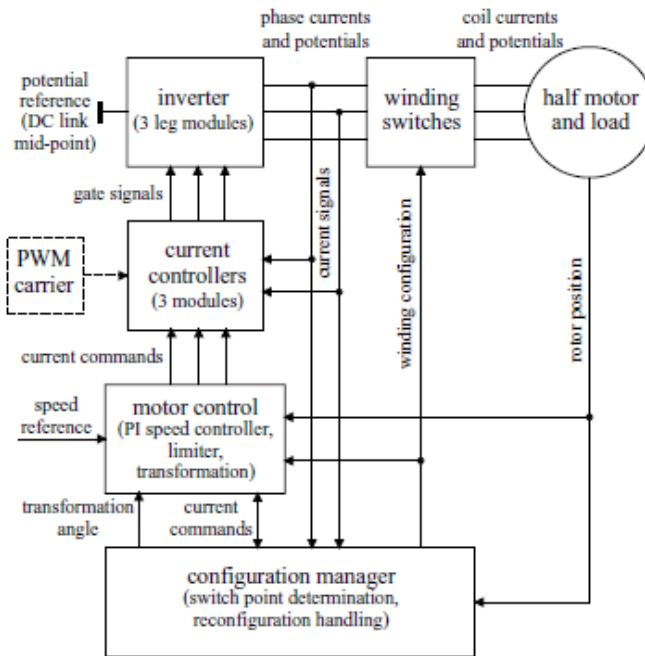


Figure 2.26.: Modular simulation system for PM motor drive with switched stator windings.

(Ex. 1007, Figure 2.26, 45; Leeb, ¶248). A POSITA would understand that **Nipp’s** controller receives a sensed rotor position, from which the rotor speed is determined, which in a direct drive implementation, is the same as the speed of the article being driven by the motor. (Leeb, ¶248). Thus, a POSITA would have understood that **Nipp** discloses a “control means for actuating the configuration of the winding sections whilst the motor is running,” and that **Nipp’s** controller varies the connection configuration of the winding sections in accordance with the output of a sensor that senses an operating parameter of the article being driven by the motor such as its speed. (Leeb, ¶248).

Thus, **Nipp** discloses claim 10. (Leeb, ¶249).

9. **Claim 11: “A permanent magnet brushless motor as claimed in claim 8, wherein: the control means is adapted to vary the connection configuration of the winding sections of a conducting phase whilst the motor is running, in accordance with the back emf measured across a non-conducting phase or a winding section thereof.”**

Nipp discloses claim 8. In Section 2.6 entitled “Motor control,” **Nipp** discloses that one of the control parameters for the motor—rotor position—can be estimated in a brushless DC motor (“BLDC”) by measuring the induced voltage of the stator winding that is current free, and that “the property of BLDC motors, that always one stator winding is current free, can be advantageous as the induced voltage in this phase may be measured.” (Ex. 1007, 33; Leeb, ¶250). **Nipp** discloses that by measuring the voltage across the non-conducting phase, an algorithm could be utilized to estimate the rotor position in lieu of a mechanical encoder. (Ex. 1007, 32-33; Leeb, ¶250). A POSITA would have understood that measuring the voltage across the non-conducting phase of a BLDC determines the back emf, from which the position of the rotor can be determined. (Leeb, ¶250). **Nipp** discloses that “[i]nverter-fed synchronous PM and BLDC motors require some kind of rotor position feedback to control the phase current synchronously with the revolution of the rotor.” (Ex. 1007, 11; Leeb, ¶250).

Thus, **Nipp** discloses a control unit that varies the connection configuration of the winding sections in accordance with the back emf measured across a non-conducting phase or winding section thereof. (Leeb, ¶251).

10. **Claim 12: “A permanent magnet brushless motor as claimed in claim 8, wherein: the control means is adapted to vary the connection configuration of the winding sections whilst the motor is running, in accordance with time or an operating cycle or program.”**

Nipp discloses claim 8. **Nipp** discloses that “[a]n important issue is to determine appropriate instants when to change the winding configuration,” which **Nipp** refers to as the “switch points.” (Ex. 1007, 63-64; Leeb, ¶252). **Nipp** discloses that “[a]n obvious approach is to calculate the base speeds for all configurations, store them in the DSP, and switch when those predefined points are reached.” (Ex. 1007, 63; Leeb, ¶252). A POSITA would have understood that the DSP in **Nipp** is running a “**program**” that is used to control the motor. (Leeb, ¶252). Section 5.2.6 of **Nipp**, entitled “Control software” discloses details of the **program**, explaining that “a digital signal processor hosted by a PC was used for the motor control and thus two **programs** were needed.” (Ex. 1007, 151-154; Leeb, ¶252).

Thus, **Nipp** discloses a control unit that actuates the switches to vary the connection configuration of the winding sections while the motor is running based on a program. (Leeb, ¶253).

The '103 does not disclose what “time or an operating cycle or program” entails, but explains in the context of Figure 9 that “the required range of speed and torque can easily be achieved within the current confines using a reasonably sized direct drive brushless DC motor in accordance with this invention.”

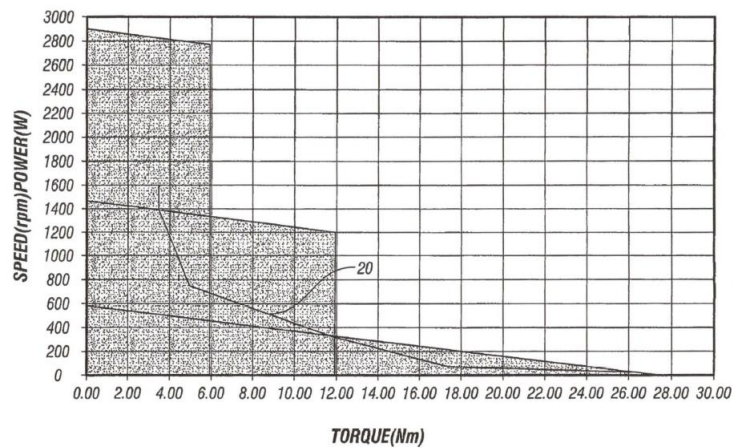


FIG. 9

(Ex. 1001, 6:12-16, Figure 9; Leeb, ¶254). A POSITA would have understood that controlling the motor “in accordance with time or an operating cycle or program” would include controlling the motor to achieve the operating characteristics throughout the operating range of the motor. (Leeb, ¶254).

Like '103, **Nipp** discloses that for different winding configurations, different motor characteristics can be achieved, such that “the effect is similar to that of a mechanical gear shift which is why this system can be seen as an *electronic gearbox*.” (Ex. 1007, 41; Leeb, ¶255). **Nipp** discloses the “[c]orresponding tractive effort curves” in Figure 2.24:

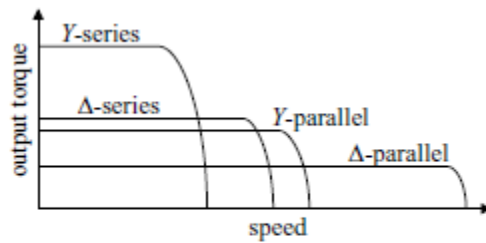


Figure 2.24.: Qualitative torque versus speed curves of a PM motor drive with two winding parts per phase.

(Ex. 1007, 40-41, Figure 2.24; Leeb, ¶255). Thus, a POSITA would have understood that **Nipp** discloses a “control means for actuating the configuration of the winding sections whilst the motor is running,” and that **Nipp**’s controller varies the connection configuration of the winding sections in accordance with time or an operating cycle or program. (Leeb, ¶255).

Thus, **Nipp** discloses claim 12. (Leeb, ¶256).

11. **Claim 13: “A permanent magnet brushless motor as claimed in claim 8, wherein: the control means comprises means for manually changing the connection configuration of the winding sections.”**

Nipp discloses claim 8. ’103 states only that “means may be provided for manually changing the configuration of the winding connection.” (Ex. 1001, 3:20-21; Leeb, ¶257). This claim is drafted as a means-plus-function claim, with the recited function of “manually changing the connection configuration of the winding sections.” ’103 does not specifically identify any structure corresponding to the recited function, but a POSITA would understand that any manual input

mechanism—such as a switch or a brake—could be used to provide an input to the controller to cause a change in the configuration of the winding connections. (Leeb, ¶257).

Nipp discloses in the section entitled “Braking capability,” that the connection configuration of the winding sections can be used for braking the motor, explaining that “switched stator windings ... allows switching to a configuration for a lower than actual speed when braking.” (Ex. 1007, 65; Leeb, ¶258). **Nipp** discloses the braking performance that is achievable using different winding configurations.

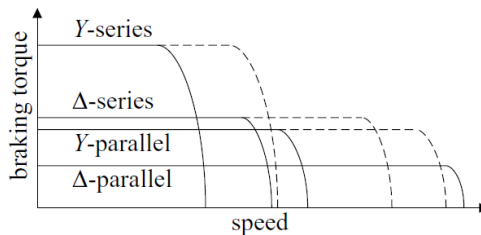


Figure 3.9.: Normal (solid lines) and increased (dashed lines) braking performance of a drive with switched stator windings.

(Ex. 1007, Figure 3.9, 66; Leeb, ¶258). A POSITA would have understood that a brake is a manual user input. (Leeb, ¶258).

Thus, **Nipp** discloses a control unit that includes the ability to manually change the connection configuration of the winding sections. (Leeb, ¶259).

- 12. Claim 14: “A permanent magnet brushless motor as claimed in claim 1, wherein: all of the winding sections of the given phase are wound in parallel to each other.”**

Nipp discloses claim 1. **Nipp** discloses that “[t]o achieve an entirely symmetric field **all coils of one phase must be wound parallel** in the same slots.” (Ex. 1007, 56; Leeb, ¶260).

Accordingly, a POSITA would have understood that **Nipp** discloses winding all of the winding section of the phase in parallel to each other. (Leeb, ¶261).

- 13. Claim 15: “A permanent magnet brushless motor as claimed in claim 1, wherein: the winding sections of the given phase are connected such that current flows through each winding section in the same direction.”**

Nipp discloses claim 1. '103 states that when all of the stator winding sections 1-5 are connected in series, “the supply current flows through each series-connected section 1-5 in the same direction with respect to each section’s polar orientation (as indicated by the arrows in FIG.1).”

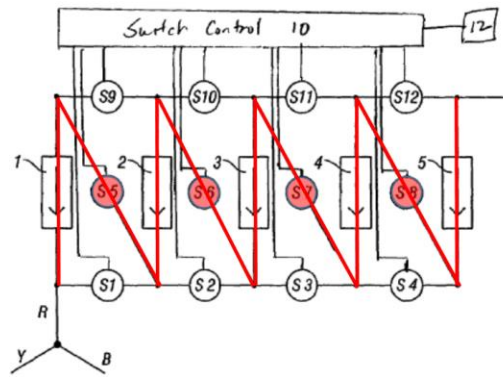


FIG. 1

(Ex. 1001, 4:15-21, Figure 1; Leeb, ¶262). Like '103, **Nipp** discloses the same switch configuration in the context of Figure 3.5:

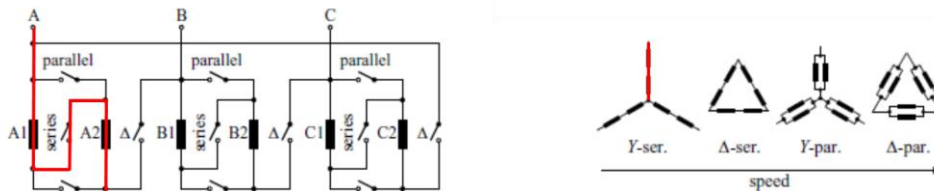


Figure 3.1.: Winding configuration sequence with two coils per phase.

(Ex. 1007, Figures 3.1, 3.5, 54, 59; Leeb, ¶262). A POSITA would have understood that when the series-connected winding sections in **Nipp** as depicted above are connected across a power supply at A, the current will flow through each winding section in the same direction. (Leeb, ¶262).

Thus, **Nipp** discloses claim 15. (Leeb, ¶263).

VII. SECONDARY CONSIDERATIONS

Petitioner is unaware of evidence of secondary considerations relevant to the challenged claims.

VIII. THE BOARD SHOULD NOT EXERCISE ITS DISCRETION TO DENY INSTITUTION

A. The *Fintiv* Factors Do Not Support Discretionary Denial of Institution Under §314(a)

The co-pending proceeding in district court does not warrant the exercise of discretion under §314(a) based on the six factors set forth in *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 (P.T.A.B. Mar. 20, 2020). 1: The district court proceeding is in its infancy. Exro intends to move for stay pending the outcome in this proceeding after this Petition is filed. 2: A trial date has not yet been set in the D. Mass. case, and no scheduling order has been issued. 3: The D. Mass. case is in its infancy, and the Court has not yet set an initial case management conference. 4: The district court case will likely involve multiple invalidity defenses, e.g., under §112, as well as defenses under §§102 and 103 based on ePropelled's infringement theories, which are not at issue here. 5: The parties to this proceeding and the district court case are the same. 6: As set forth in this Petition, the merits of the asserted grounds are very strong. This IPR proceeding will provide an efficient alternative

to having to litigate the same invalidity grounds in district court. In considering all of these factors, the Board should not exercise its discretion to deny institution.

B. §325(d) Discretion Does Not Apply

No other proceedings involving the '103 have been brought before or are currently pending before the Patent Office. None of the asserted prior art references (**Pyntikov, Rivera, Maslov, Masino, and Nipp**) were before the Examiner during prosecution. Thus, the same or substantially the same prior art or arguments have not been previously presented to the Patent Office and denial of institution under §325(d) is not warranted.

IX. MANDATORY NOTICES

A. Real Parties-In-Interest

The real parties-in-interest are Exro Technologies Inc., Exro Technologies USA, Inc., Exro Vehicle Systems Inc., and DPM Technologies Inc.

B. Related Matters

The '103 is currently the subject of litigation in *ePropelled, Inc. v. Exro Technologies Inc.*, No. 1:22-cv-10090-LTS (D. Mass.).

C. Lead and Back-Up Counsel, and Service Information

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Petitioner consents to electronic service of documents to the e-mail addresses of the counsel identified above.

X. CONCLUSION

For the reasons set forth above, Petitioner has shown a reasonable likelihood that the challenged claims are unpatentable. Accordingly, Petitioner requests review and cancellation of each challenged claim. The undersigned authorizes the Office to charge any required fees to Deposit Account No. 50-3111.

Respectfully submitted,

Dated: June 15, 2022

/Thomas J. Fisher/

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CERTIFICATE OF COMPLIANCE

The undersigned hereby certifies that this Petition for *Inter Partes* Review complies with the type-volume limitations of 37 C.F.R. §42.24. As calculated by the word count feature of Microsoft Word®, it contains 13,813 words, excluding any table of contents, table of authorities, mandatory notices under §42.8, certificate of service or word count, or appendix of exhibits or claim listing.

/Thomas J. Fisher/
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Lead Counsel for Petitioner

CERTIFICATE OF SERVICE

The undersigned hereby certifies that on June 15, 2022, a true and correct copy of the foregoing PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,382,103 and EXHIBITS 1001-1019 were served via Overnight Federal Express at the following address of record as listed on PAIR for the subject patent:

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