**CONTAINS CONFIDENTIAL – ATTORNEYS' EYES ONLY INFORMATION**

**IN THE UNITED STATES DISTRICT COURT**
**FOR THE DISTRICT OF CONNETICUT**

| | | |
|---|---|---|
| CHAPCO, INC. and SAMSARA FITNESS, LLC, | ) | |
| Plaintiffs, | ) | Civil Action No. 3:15-cv-1665 (JCH) |
| vs. | ) | March 2, 2017 |
| WOODWAY USA, INC., | ) | |
| Defendant. | ) | |

# EXPERT REPORT OF KIM B. BLAIR, Ph.D.

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I, Kim B. Blair, Ph.D., hereby make the following disclosure pursuant to Fed. R. Civ. P. 26(a)(2).

## I. SUMMARY OF OPINIONS

1. I have been asked by Woodway USA, Inc. ("Woodway") to express an opinion on whether the TrueForm Runner Treadmills manufactured, offered for sale, sold, and used by Chapco, Inc. ("Chapco") and Samsara Fitness, LLC ("Samsara") infringe U.S. Patent Nos. 8,986,169 ("the '169 patent) and 9,039,580 ("the '580 patent")[1] and to comment on certain other technical issues in the case.

2. As discussed in more detail below and explained in Exhibits E and F, annexed hereto, I have arrived at the following opinions:

(a) The Original TrueForm Runner Treadmills literally infringe claims 11-16 of the '169 patent;

(b) The Original and Redesigned TrueForm Runner Treadmills literally infringe claims 1, 4-6, 10-14, 18-20, and 25 of the '580 patent; and

(c) The Technogym SkillMill product likely infringes at least independent claims 1, 11, and 19 of the '580 patent.

## II. QUALIFICATIONS

3. Enabling innovation at the intersection of technology and sports, I have extensive experience utilizing advanced technologies to enhance all aspects of the sporting experience. As the Founder of STI&E Consulting and previously as the Vice President of Business Development and Operations and the Manager of the Sports Engineering Practice at Cooper Perkins, Inc. and the Founding Director of the Sports Innovation Program at MIT (now

[1] Copies of the '169 and '580 patents are annexed to this Report as Exhibits A and B, respectively.

STE@M), I lead the development of new products as well as technologies for sport performance analyses from early formulation of product concepts to final prototype design and testing.

4. Many of my projects have won awards, including MIT departmental awards, conference best paper awards, and international ispo Academic Challenge design awards.

5. My work enjoys extensive media coverage, including features in Forbes, The Boston Globe, Outside Magazine, and GQ, and programs by CNN, The NewsHour, The Discovery Channel, NPR, and local network affiliates.

6. I provide a wide variety of consulting services to the sports industry, including leading product development projects, conducting performance testing of existing and prototype products, and creating innovative concepts aimed at enhancing the experience for sports spectators.

7. In addition, as a member of the board of advisors for emerging companies, I provide expertise on business and strategic planning, technology assessment and development, strategic alliances, and raising capital.

8. A recognized expert in innovation and sport technology, I have spoken at the Lemelson Foundation, the Boston Museum of Science, IDEAS Boston 2004, The International Congress on Technological and Social Innovation in Sport (Spain), The University of Nebraska, Purdue University, The University of Illinois, Rutgers University, Rochester Polytechnic Institute, The University of London, Loughborough University (UK), the SGMA International Business Intelligence, Tufts University, and the MIT Center for Innovation and Product Development.

9. I have served as a technical advisor for the United States Olympic Committee, on the advisory board for the SGMA Sport + Technology Convergence Conference, and as a member of the Golf Digest Academic Advisory Panel.

10. Prior to founding STI&E and my work with Cooper Perkins, I was the President and Founder of Sports Innovation Group LLC, a lecturer in the MIT Aeronautics and Astronautics Department, serving as the lead instructor for a capstone experimental projects course, co-developer of a junior level advanced dynamics course, and instructor in a graduate structural dynamics and vibrations course.

11. Previously, I was a senior scientist and management team member at Moldyn, Inc., an organization applying aerospace analysis techniques to the fields of biomechanics and computational chemistry. I also served as an aerospace engineer at the NASA Johnson Space Center.

12. My professional affiliations include serving as Secretary, President, and Past-President of the International Sports Engineering Association as well as serving as member of the editorial board for the Journal of Sports Engineering and Technology and reviewer for the Journal of Sports Engineering.

13. I have served on the scientific committees for several editions of The Engineering of Sport Conference and the Asia Pacific Conference on Sports Technology. In addition, I recently served as a Session Chair for the 11th International Conference on Engineering of Sport.

14. I am also a lead user of sports and fitness products having trained for and competed in more than 100 endurance events, including the US National Triathlon Championships, World Triathlon Championship Qualifier, and the Hawaii Ironman World

Championships. I am the past president and current board member of Team Psycho, a New England-based elite triathlon team.

15. Born and raised in Nebraska, I earned a B.A. in Psychology and a B.S. in Mechanical Engineering at the University of Nebraska. At Purdue University, I earned a M.S. in Mechanical Engineering and a Ph.D. in Aeronautics and Astronautics. In 2005, the University of Nebraska awarded me an Alumni Achievement Award.

16. Of particular relevance to this case, I have contributed to the design and development of fitness equipment such as the KoKo Smartrainer, I am a co-inventor of a wearable device for assessing running form (US 20130041617), and I have served as an expert witness on a number of patent litigation cases related to sports equipment, most recently four cases involving treadmills. Over the years, I have attended a number of trade shows that feature fitness equipment including the SGMA Super Show, Club Industry East, Interbike, and ispo.

17. I am generally familiar with patents and review patent disclosures regularly.

18. My curriculum vitae is attached as Exhibit C. It includes a listing of all publications I have authored or co-authored during my career.

## III. TESTIMONY AND FEES

19. I have testified in lawsuits and been accepted as an expert in state and federal courts. More specifically, in the past four years, I have testified as an expert by deposition in the following matters:

- Case No.: 09-12102 – Warrior Sports, Inc. vs. Dickinson Wright, P.L.L.C. (E.D. Mich.);
- Case No.: C.A. No. 1:10-cv-00195-RJS-DBP – Icon Health and Fitness Inc. vs. Park City Entertainment, Inc. (D. Utah); and
- Case No.: 2013 Civ. 01276 – Speedfit LLC v. Woodway USA, Inc. (E.D.N.Y.).

20. The compensation for my time spent in working on issues in this case is $450 per hour. I am also compensated for my expenses in relation to this matter. My compensation is not dependent on or related in any manner to the outcome of the current litigation. I have no financial interest whatsoever in the outcome of the litigation.

## IV. MATERIALS REVIEWED

21. In my study of this matter and in forming my opinions disclosed herein, I have relied on my own experience and education as well as information learned through discussions with Woodway personnel, and from examining the '169 and '580 patents, the '169 and '580 patents' file histories, including the referenced priority patent application, the materials identified in Exhibit D, certain deposition testimony from this case, documents produced during discovery, and the materials cited in this Report. I relied on these materials to varying degrees; some very much and some not at all.

22. Although I am not a lawyer, I have been advised about certain aspects of the law, which I have set forth in my Report where pertinent.

## V. BACKGROUND AND SUMMARY OF THE PATENTS AND ASSERTED CLAIMS

23. In reaching my opinions about the infringement of the '169 and '580 patents expressed herein, and about the importance of the inventions described in these claims, I studied a number of prior art patents/references to come to an understanding of the background that preceded the inventions in the '169 and '580 patents. In addition, I have met with and spoken with one of the inventors, Nicholas Oblamski, to discuss the inventions in detail.

24. As I understand it, Woodway has been building and selling manual or non-motorized treadmills since at least the mid-1990s, including the TRAMP and FORCE treadmills,[2] which complement its line of motorized treadmills.[3]

25. While the concept of a manual treadmill has been in the public domain for centuries,[4] one of the problems that has never been solved is how to handle the unpredictable movement of the running belt, particularly when the running surface is curved.

26. A critical challenge with a curved, motorless treadmill is to ensure the safety of the user. When a curved, motorless treadmill is being used as intended, it requires free rolling of the running belt. However, when a user is trying to mount or dismount, the running belt can move in the forward and backward direction. Because it is common for a user to enter the treadmill from the rear, when a user steps on the rear of the treadmill, the user's weight may cause the belt to unexpectedly rotate forward (the reverse of the normal operating direction of the running belt). Depending on how quickly and where the user mounts the treadmill, the running belt may move in the forward or backward direction, creating an extreme safety hazard. The unpredictable belt movement may startle the user, create a temporary feeling of loss of control, or even cause a user to fall.

27. The patents-in-suit describe design improvements and novel safety enhancements to a curved, manually operated treadmill.

28. The '169 patent is entitled "Manual Treadmill and Methods of Operating the Same." The '169 patent issued on March 24, 2015, from U.S. Patent Application No. 14/243,716, which was filed on April 2, 2014. The named inventors are Douglas G. Bayerlein,

[2] Deposition of Douglas Bayerlein, December 14, 2016 , pp. 35, 37, 50-51.
[3] Deposition of Douglas Bayerlein, December 14, 2016, pp. 31-35.
[4] http://www.attendly.com/the-ancient-and-surprising-history-of-the-treadmill (noting that manual treadmills have been in existence since at least the 1st century AD, when Roman engineers fitted the Polyspastos Crane with a human powered tread wheel).

Vance E. Emons, Nicholas A. Oblamski, Scott D. Hoerig, Matthew J. Zank, Robert L. Zimpel, and Joel W. Richards. The '169 patent is assigned to Woodway.

29. The '580 patent is also entitled "Manual Treadmill and Methods of Operating the Same." The '580 patent issued on May 26, 2015, from U.S. Patent Application No. 14/656,942, which was filed on March 13, 2015. The named inventors are Douglas G. Bayerlein, Vance E. Emons, Nicholas A. Oblamski, Scott D. Hoerig, Matthew J. Zank, Robert L. Zimpel, and Joel W. Richards. The '580 patent is assigned to Woodway.

30. Both the '169 and '580 patents claim a curved, manual treadmill that, among other things, requires "a safety device" that prevents the running belt from moving in both the forward and backward directions. In the asserted claims of the '169 patent, the safety device cooperates with the rear shaft of the rear shaft assembly to permit rotation of the rear shaft (and therefore the running belt which is disposed about the front and rear shafts) in only one direction. The asserted claims of the '580 patent are a broader application of the safety mechanism and require that the safety device is coupled to at least one of the front shaft or the rear shaft.

31. Woodway has been manufacturing and selling its non-motorized CURVE treadmills, which embody the inventions of the '169 and '580 patents, since 2009. Since the 2009 launch, Woodway has introduced various models and sizes in this product line.

**Woodway's Innovative CURVE Treadmills**

| | | |
|---|---|---|
| | | |
| **CURVE Treadmill** | **CURVE Trainer Treadmill** | **CURVE XL Treadmill** |

32. It is my understanding that Woodway is asserting claims 11-16 of the '169 patent against Chapco and Samsara. These claims are reproduced below.[5]

| **Claim** | |
|---|---|
| 11 | A manually operated treadmill comprising:<br><br>a frame supported on a substantially horizontal surface;<br><br>a front shaft assembly supported by the frame and comprising:<br><br>a front shaft; and<br><br>at least one front running belt pulley supported by the front shaft;<br><br>a rear shaft assembly supported by the frame and spaced a distance from the front shaft and comprising:<br><br>a rear shaft; and<br><br>at least one rear running belt pulley supported by the rear shaft;<br><br>a running belt supported at least in part by the front shaft assembly and the rear shaft assembly, |

[5] It is my understanding that Woodway filed a Request for Certificate of Correction Pursuant to 37 C.F.R. § 1.323 with the United States Patent and Trademark Office to correct minor typographical and clerical errors. Woodway proposed, and the United States Patent and Trademark Office adopted, certain corrections, which are not subject to reasonable debate based on consideration of the claim language, the specification, and the prosecution history. The Certificate of Correction issued on March 29, 2016. The additions as a result of the Certificate of Correction are shown in underline; the deletion is shown in strikethrough.

| Claim | |
|---|---|
| | the running belt including<br><br>a front belt portion adjacent the front shaft assembly,<br><br>a rear belt portion adjacent the rear shaft assembly, and<br><br>a central belt portion intermediate the front belt portion and the rear belt portion,<br><br>the front belt portion and the rear belt portion being positioned vertically higher than a lowest point found in the central belt portion to form a curved running surface upon which a user of the treadmill may walk or run,<br><br>wherein gravitational force acting upon weight of the user's body on the running belt relative to the lowest point of the running belt causes rotation of the running belt, front shaft, and the rear shaft without the aid of a motor;<br><br>a safety device cooperating with the rear shaft to permit rotation of the rear shaft in only one direction; and<br><br>at least one bearing rail having a plurality of bearings rotatably coupled to the at least one bearing rail and forming a top profile,<br><br>the top profile defined by<br>a front profile portion adjacent the front shaft assembly,<br><br>a rear profile portion adjacent the rear shaft assembly, and<br><br>a central profile portion intermediate the front profile portion and the rear profile portion,<br><br>the central profile portion having a concave curve, and<br><br>the front profile portion and the ~~profile~~ rear profile portion being continuations of the concave curve;<br><br>wherein the running surface of the running belt is supported by the top profile of the at least one bearing rail such that the running surface substantially corresponds to the shape of the top profile of the at least one bearing rail. |
| 12 | The manually operated treadmill of claim **11,**<br><br>the at least one bearing rail extending along the frame and longitudinally aligned with one of the at least one front running belt pulley and one of the at least one rear running belt pulley. |

| **Claim** | |
|---|---|
| | |
| 13 | The manually operated treadmill of claim **12,**<br><br>wherein the running belt comprises a plurality of laterally extending slats. |
| 14 | The manually operated treadmill of claim **13,** wherein:<br><br>the front shaft assembly comprises a second front running belt pulley supported by the front shaft and spaced laterally from the at least one front running belt pulley;<br><br>the rear shaft assembly comprises a second rear running belt pulley supported by the rear shaft and spaced laterally from the at least one rear running belt pulley;<br><br>the at least one bearing rail further comprises a second bearing rail having a plurality of bearings forming a top profile matching the top profile of the first of the at least one bearing rail,<br><br>the second bearing rail being longitudinally aligned with the second front running belt pulley and the second rear running belt pulley;<br><br>the running belt comprises a first endless belt and a second endless belt, wherein the first endless belt is supported by the at least one front running belt pulley, the first of the at least one bearing rail, and the at least one rear running belt pulley, and wherein the second endless belt is supported by the second front running belt pulley, the second bearing rail, and the second rear running belt pulley; and<br><br>the plurality of laterally extending slats extend between the first endless belt and the second endless belt. |
| 15 | The manually operated treadmill of claim **14,**<br><br>wherein the rear <u>profile</u> portion of the at least one bearing rail is positioned and shaped to provide a smooth transition for the running belt from the at least one bearing rail onto the at least one rear running belt pulley. |
| 16 | The manually operated treadmill of claim **11,**<br><br>wherein the safety device comprises a one-way bearing. |

33. It is also my understanding that Woodway is asserting claims 1, 4-6, 10-14, 18-20, and 25 of the '580 patent against Chapco and Samsara. These claims are reproduced below.

| **Claim** | |
|---|---|
| 1 | A manually powered treadmill comprising: |

| **Claim** | |
|---|---|
| | a frame having a front end and a rear end positioned opposite the front end;<br><br>a front shaft rotatably coupled to the frame at the front end;<br><br>a rear shaft rotatably coupled to the frame at the rear end;<br><br>a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;<br><br>a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;<br><br>a running belt supported by the first bearing rail and the second bearing rail and disposed about the front shaft and the rear shaft, wherein the running belt follows a curved running surface; and<br><br>a safety device coupled to at least one of the front shaft and the rear shaft,<br><br>wherein the safety device is structured to substantially prevent rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of the at least one of the front shaft and the rear shaft in a second rotational direction opposite the first rotational direction. |
| 4 | The manually powered treadmill of claim **1,**<br>wherein each one of the first and second bearing rails are attached longitudinally to the frame between the front shaft and the rear shaft. |
| 5 | The manually powered treadmill of claim **1,**<br><br>wherein each one of the first bearing rail and the second bearing rail define in part a top profile corresponding to the curved running surface. |
| 6 | The manually powered treadmill of claim **1,**<br><br>wherein the safety device includes a one-way bearing. |
| 10 | The manually powered treadmill of claim **1,**<br><br>further comprising a handrail attached to the frame and structured to provide a support structure for the user of the manually powered treadmill. |
| 11 | A manually powered treadmill, comprising:<br><br>a frame having a front end and a rear end positioned opposite the front end; |

| **Claim** | |
|---|---|
| | a front shaft attached to the frame adjacent the front end;<br><br>a rear shaft attached to the frame adjacent the rear end;<br><br>a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;<br><br>a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;<br><br>a running belt at least partially disposed about the front shaft and the rear shaft and at least partially supported by the first bearing rail and the second bearing rail,<br><br>wherein the running belt includes<br><br>a front belt portion proximate the front end,<br><br>a rear belt portion proximate the rear end, and<br><br>a central belt portion intermediate the front and rear belt portions,<br><br>wherein the central belt portion is positioned vertically closer to a ground surface supporting the frame than the front and rear belt portions such that the running belt follows a curved running surface; and<br><br>a safety device for substantially preventing rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of the at least one of the front shaft and the rear shaft in a second rotational direction opposite the first rotational direction. |
| 12 | The manually powered treadmill of claim **11,**<br><br>wherein the safety device includes a one-way bearing. |
| 13 | The manually powered treadmill of claim **11,**<br><br>further comprising a pair of wheels mounted to the frame,<br><br>wherein the pair of wheels are mounted so that the pair of wheels are not in contact with the ground surface when the manually powered treadmill is in an operating position. |
| 14 | The manually powered treadmill of claim **11,** |

| Claim | |
|---|---|
| | further comprising support feet coupled to the frame,<br><br>wherein the support feet are vertically adjustable to adjust an incline of the manually powered treadmill relative to the ground surface. |
| 18 | The manually powered treadmill of claim **11,**<br><br>wherein each of the first and second bearing rails are attached longitudinally to the frame between the front shaft and the rear shaft. |
| 19 | A manually powered treadmill, comprising:<br><br>a frame having a front end and a rear end;<br><br>a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;<br><br>a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;<br><br>a handrail attached to the frame and structured to provide a support structure for a user of the manually powered treadmill;<br><br>a pair of wheels mounted to the frame,<br><br>wherein the pair of wheels are mounted so that the pair of wheels are not in contact with a ground surface when the manually powered treadmill is in an operating position;<br><br>at least two support feet coupled to the frame,<br><br>wherein the support feet are vertically adjustable to adjust an incline of the manually powered treadmill relative to the ground surface;<br><br>a running belt supported by the first and second bearing rails,<br><br>wherein the running belt follows a curved running surface; and<br><br>a safety device coupled to the frame and operatively coupled to the running belt,<br><br>wherein the safety device is structured to substantially prevent movement of the running belt in a first direction and permit movement of the running belt in a second direction opposite the first direction. |
| 20 | The manually powered treadmill of claim **19,** |

| Claim | |
|---|---|
| | further comprising a sensor configured to acquire data indicative of a speed of the running belt. |
| 25 | A method, comprising:<br><br>providing a manually powered treadmill,<br><br>the manually powered treadmill having a frame with a front end and rear end;<br><br>providing a first bearing rail and a second bearing rail, the first and second bearing rails each comprising a plurality of bearings and extending longitudinally on the frame,<br><br>wherein the first and second bearing rails define a curved top profile;<br><br>disposing a running belt on the plurality of bearings of the first bearing rail and the second bearing rail such that the running belt follows a top curved running surface corresponding to the curved top profile of the first and second bearing rails;<br><br>permitting movement of the running belt in a first direction; and<br><br>substantially preventing movement of the running belt in a second direction opposite the first direction. |

## VI. LAW OF INFRIGNEMENT

34. In forming my opinions, I have been asked to assume that certain legal principles apply to Woodway's claims of infringement against Chapco and Samsara. Counsel for Woodway has provided me with the current (last edited July 2016) version of the Model Patent Jury Instructions published by the Federal Circuit Bar Association, and I have taken guidance from those form instructions on matters that relate to my opinions expressed herein. If there is some change in the applicable law to which I am alerted, or if the Court adopts some substantially different instructions for the jury to follow, I will reconsider my opinions accordingly. Also, if there is some change in the applicable substantive law between the time of this Report and any future expert testimony, my opinions may change as well.

35. I understand that each of the patent claims asserted by Woodway is made up of multiple limitations or elements. In order for an accused device to infringe a patent claim, I understand that each element of that patent claim must be found in the particular accused device, either literally or when alleged, equivalently. If one or more of a claim's elements are not found in the accused device, then that accused device does not infringe the claim.

36. I understand that some patent claims may "depend from" or "be dependent upon" other claims in the same patent. These dependent claims are understood to include all of the limitations that are found in the claim or claims from which they depend. Therefore, if a dependent claim depends from another claim that is not infringed by an accused device, then the dependent claim also is not infringed by the accused device.

## VII. THE COURT'S CLAIM CONSTRUCTION ORDER

37. I understand that the Court has defined certain terms and phrases that appear in the asserted claims of the '169 and '580 patents and that, in reading and applying the patent claims, I am to apply the Court's definitions. Below is a summary of the terms and phrases construed by the Court.

| **Disputed Term/Phrase** | **Chapco's and Samsara's Construction** | **Woodway's Construction** | **Court's Construction** |
|---|---|---|---|
| Frame | A structure distinct from the bearing rails. | Plain and ordinary meaning. | No further construction necessary. |
| Bearing Rail | A running belt retention system that is a structure distinct from the frame and configured to help achieve the desired shape of the running surface. | Plain and ordinary meaning. | A rail with bearings whose top profile corresponds to the shape of the running surface. |

| **Disputed Term/Phrase** | **Chapco's and Samsara's Construction** | **Woodway's Construction** | **Court's Construction** |
|---|---|---|---|
| A safety device cooperating with the rear shaft | A safety device mechanically connected to the rear shaft. | Plain and ordinary meaning. | A safety device adjoined to the rear shaft. |
| Coupled | The joining of two members directly or indirectly. | The joining of two members directly or indirectly. | The joining of two members directly or indirectly. |
| Rotatably coupled | Each part is connected in such a way to permit rotation of one entire element relative to the other element. | Plain and ordinary meaning. | No further construction necessary. |
| A bearing rail having a plurality of bearings rotatably coupled to the at least one bearing rail | At least one bearing rail having more than one bearing connected to the bearing rail in such a way that each bearing can rotate relative to the bearing rail. | Plain and ordinary meaning. | No further construction necessary. |
| Running belt | A structure different from the endless belts that follows the profile of the bearing rails. | Plain and ordinary meaning. | No further construction necessary. |
| Running Surface | Section of the running belt in between the front and rear shafts intended for contact with the user's foot. | Plain and ordinary meaning. | The portion of the running belt upon which a user could place their foot during normal operation.<br><br>or<br><br>The portion of the running belt upon which a user could place part of their foot. |
| Left side member and | The left side of the | Should not be | The court declines to |

| Disputed Term/Phrase | Chapco's and Samsara's Construction | Woodway's Construction | Court's Construction |
|---|---|---|---|
| right side member | frame and the right side of the frame. | construed. | construe this term. |

38. My analysis is based on the specific constructions adopted by the Court, and where the Court ruled that no further construction was necessary, I understand that I am to apply the ordinary and customary meaning to those claim terms and phrases as understood by a person of ordinary skill in the art at the time of the invention, in the context of the relevant patent-in-suit.

39. In defining a "person of ordinary skill in the art," I have been advised to consider factors such as the educational level and years of experience not only of the persons who have developed the Woodway CURVE treadmills that practice the claimed inventions of the patents-in-suit, but also of others working in the pertinent art; the types of problems encountered in the art; the teachings of the prior art; patents and publications of other persons or companies; and the sophistication of the technology. I understand that a person of ordinary skill in the art is not a specific, real individual, but rather a hypothetical individual having the qualities reflected by the factors discussed above. I have assessed the level of ordinary skill in the art based upon my nearly 20 years working in the sport technology industry along with my experience, education, and training.

40. In order to determine who one of ordinary skill in the art is, I found it necessary to first define what that "art" is. It is my understanding that the art in question relates to designing manual treadmills. In my opinion, one of ordinary skill in the art of designing manual treadmills would have a bachelor of science degree in mechanical engineering or at least two years of

experience in the treadmill industry, including experience and knowledge of the design, construction, testing, and operation of manual treadmills.

## VIII. INFRINGEMENT ANALYSIS

### A. Chapco and Samsara Accused Products

41. As I understand the record, there are three models of the TrueForm Runner Treadmill: the Low Rider, Enduro, and Performance, with the only difference between these models being their relative size and shape and arrangement of the handrails; the size and dimensions of the treadmill base is the same for each model.[6] Images of the three models of the TrueForm Runner treadmill are depicted below.

[6] Deposition of Jeremiah Rabe, October 18, 2016, pp. 30-31; 30(b)(6) Deposition of Chapco, October 20, 2016, p. 98, Ex. 84; see also Exhibit G attached hereto.

42. From the TrueForm Runner's introduction until "late March 2015,"[7] the TrueForm Runner Treadmills had what I will call an "Original" configuration. I understand that Chapco/Samsara treadmill with Serial Number 100106, which has been disassembled and photographed for the purposes of this case, is representative of an Original TrueForm Runner Treadmill. I have inspected these photographs for the purposes of my analysis.

43. Sometime after late March 2015, Chapco/Samsara redesigned the Original TrueForm Runner and began manufacturing, offering for sale, selling, and using what I will call a "Redesigned" TrueForm Runner Treadmill. I understand that Chapco/Samsara treadmill with Serial Number 100950, which has also been dissembled and photographed for the purposes of this case, is representative of a Redesigned TrueForm Runner Treadmill.[8] I have also inspected these photographs for the purposes of my analysis. I understand that Chapco and Samsara continue to offer the Redesigned TrueForm Runner Treadmill.

44. During discovery, Chapco provided CAD prints of the TrueForm Runner Treadmills at various stages of assembly/disassembly.[9]

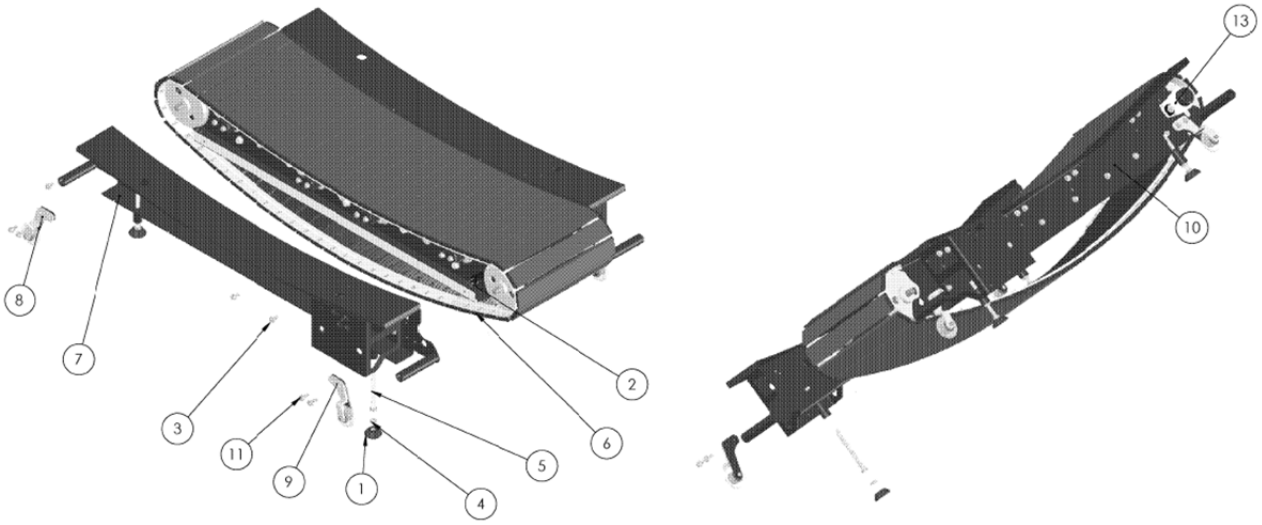
[7] 30(b)(6) Deposition of Chapco, October 20, 2016, pp. 158-159.
[8] The disassembled Original and Redesigned TrueForm Runner Treadmills have not been altered, modified, or otherwise changed relative to the as-sold units.
[9] 30(b)(6) Deposition of Chapco, October 20, 2016, pp. 131-143, Exs. 34-37.

**Exhibit 37, SAM0005704**[10]

[10] Attached hereto as Exhibit H.

**Exhibit 36, SAM0005701**[11]

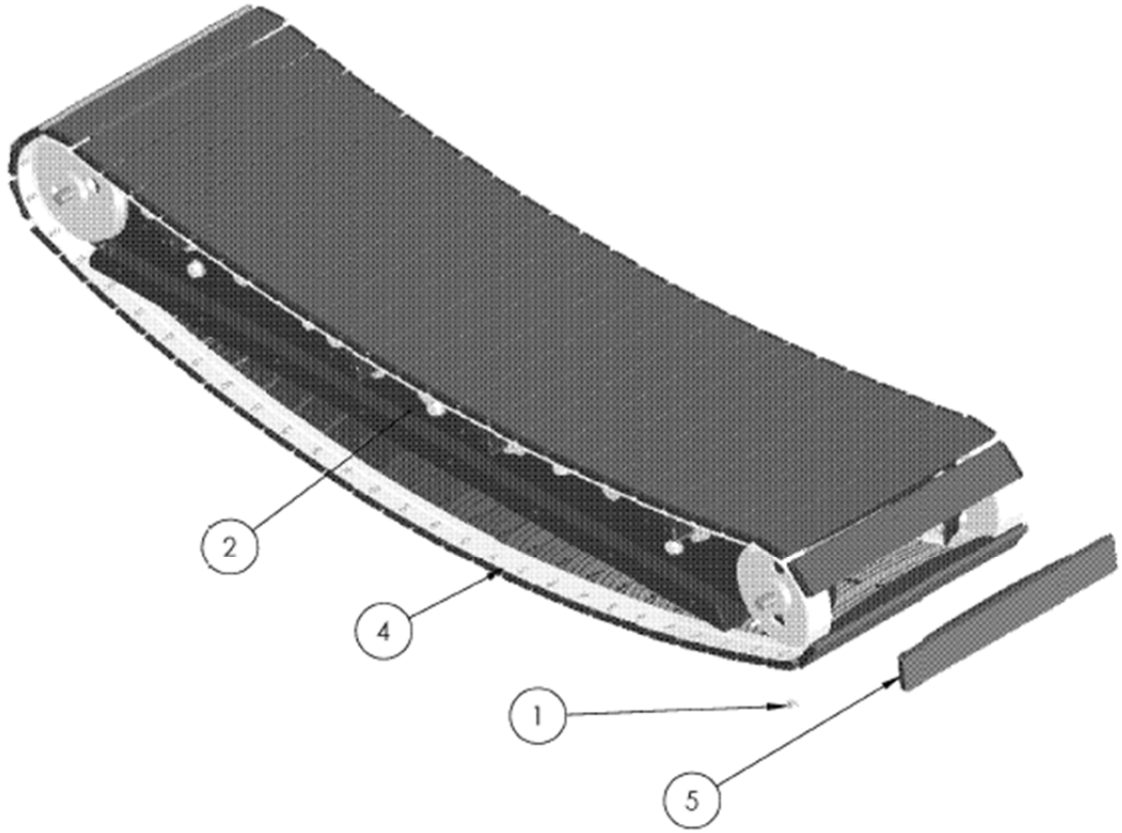
| ITEM | QTY. | PART NUMBER | REV | DESCRIPTION |
|---|---|---|---|---|
| 1 | 4 | 50609 | | FOOT, MOUNTING, 1/2-13, NEOPRENE, 150-600# |
| 2 | 1 | 90096A540 | | SCREW, HEX, 1/4-20 X .75, TYPE F, ZINC PLATED |
| 3 | 32 | 90096A622 | | SCREW, HEX, 3/8-16 X .75, TYPE F, ZINC PLATED |
| 4 | 8 | 91078A222 | | NUT, HEX, JAM, 1/2-13, GRADE 2, ZINC |
| 5 | 4 | 95475A738 | | STUD, THREADED, 1/2-13 X 6", STEEL, ZINC |
| 6 | 1 | S007-A00958_S2 | | TREADMILL, ASSEMBLY, STAGE 2 |
| 7 | 1 | S007-A01239 | H | FRAME, SIDE, WELDMENT RIGHT |
| 8 | 2 | S007-A03086 | C | WHEEL, MOUNT, ASSEMBLY |
| 9 | 2 | S007-A03086 | C | WHEEL, MOUNT, ASSEMBLY |
| 10 | 1 | S007-A01239 | H | FRAME, SIDE, WELDMENT LEFT |
| 11 | 8 | 90096A624 | | SCREW, HEX, 3/8-16 X 1, TYPE F, ZINC PLATED |
| 12 | 1 | S007-D03833 | - | TENSION TOOL 3/4 ASSY |
| 13 | 1 | S007-A03894 | 3 | ONE WAY BEARING ASSY |



[11] Attached hereto as Exhibit I.

**Exhibit 35, SAM0005698**[12]

| ITEM | QTY. | PART NUMBER | REV | DESCRIPTION |
|---|---|---|---|---|
| 1 | 228 | 96562A240 | | SCREW, PAN #2, 10-24 X .375, 18-8 SST, PATCH |
| 2 | 1 | S007-A00958_S1 | | TREADMILL, ASSEMBLY, STAGE 1 |
| 3 | 1 | S007-A02491 | A | HOUSING, ROLLBACK BEARING, BACK ASSEMBLY |
| 4 | 2 | S007-D00943 | G | BELT, TREADMILL |
| 5 | 57 | S007-D02744 | A | TREAD, TREADMILL, W/ OVERMOLD |




FLAT BLANK DATA

COMMENTS:

CHAPCO INCORPORATED

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/64
ANG: MACH ± .5° BEND ± .5°
TWO PLACE DECIMAL ± .010
THREE PLACE DECIMAL ± .005

MATERIAL

FINISH

CLIENT

PROJECT TRUEFORM

TREADMILL ASSEMBLY STAGE 2

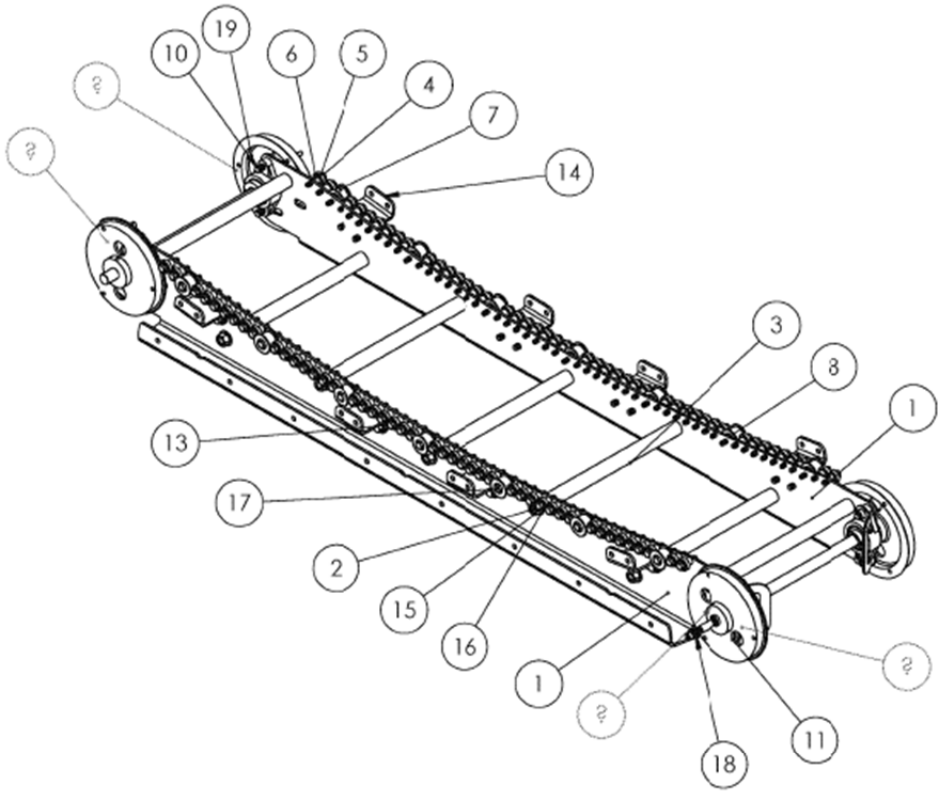
SIZE B | PART NO. S007-A00958_S2 | REV. -

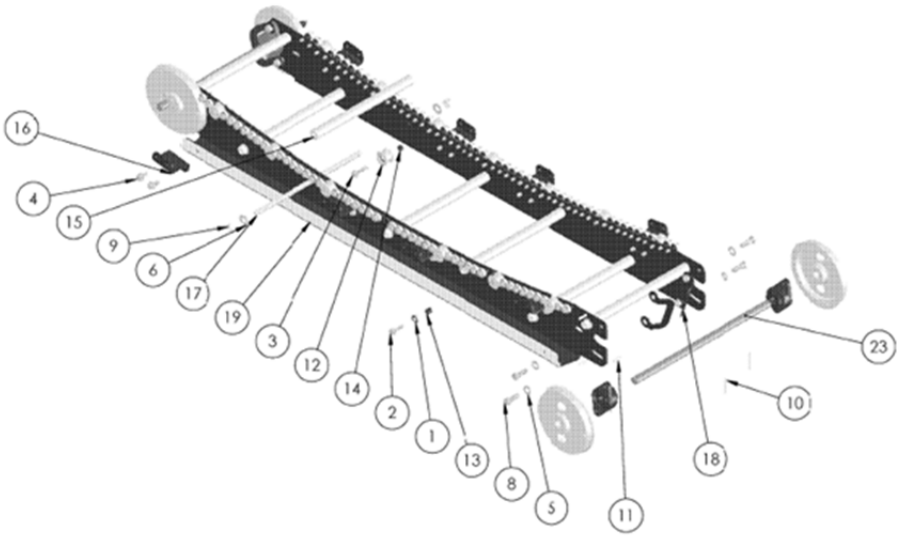
ASSY NAME: | DRAWN BY: BDC | DRAW DATE: 7/25/2012 | CHECKED BY: | CHECKED DATE: | SCALE: 1:8 | WEIGHT: 128.7 | SHEET 1 OF 1 | CHAPCO REV.

FILE PATH: \\Chapcon\cadd-cam\CADD\TRUEFORM\S007\TREADMILL\TOP LEVEL\S007-A00958_S2

[12] Attached hereto as Exhibit J.

**Exhibit 34, SAM0005694**[13]




| | | |
|---|---|---|
| FLAT BURN DATA | CHAPCO | TRUEFORM |
| COMMENTS: | DIMENSIONS ARE IN INCHES<br>TOLERANCES:<br>FRACTIONALS 1/64<br>ANG: MACH ±.5° BEND ±.5°<br>TWO PLACE DECIMAL ±.010<br>THREE PLACE DECIMAL ±.005 | TREADMILL ASSEMBLY STAGE 1 |
| ASSY NAME: | DRAWN BY: BOC DRAW DATE: 7/25/2012 CHECKED BY: CHECKED DATE: | B S007-A00958_S1 - |

[13] Attached hereto as Exhibit K.

45. As I understand it and from my review of the evidence, the only material difference between the Original and Redesigned TrueForm Runner Treadmills is the location of the "One Way Bearing Assy," which is Item 13 as indicated in the Stage 3 Assembly print above.[14] In the Original TrueForm Runner Treadmill, the "One Way Bearing Assy" was located on the rear shaft of the treadmill.[15] Mr. Rabe, a Chapco engineer, testified that the "One Way Bearing Assy" was moved sometime in 2015 to the front shaft of the treadmill to "avoid a patent issue."[16] To effectuate the change, Chapco swapped the locations of the front and rear shafts.[17]

**B. Claim Charts for the '169 and '580 Patents**

46. I have analyzed and compared the representative Original and Redesigned TrueForm Runner Treadmills to the construed claims of the '169 and '580 patents. These comparisons are expressed in the form of claim charts, which are attached to this Report. Exhibits E and F detail how each and every claim limitation of the asserted claims of the '169 and '580 patents are literally met.

47. Based on my analysis discussed herein and as set forth in Exhibit E, I believe the Original TrueForm Runner Treadmills literally infringe claims 11-16 of the '169 patent.

48. Based on my analysis discussed herein and as set forth in Exhibit F, I believe the Original and Redesigned TrueForm Runner Treadmills literally infringe claims 1, 4-6, 10-14, 18-20, and 25 of the '580 patent.

[14] 30(b)(6) Deposition of Chapco, October 20, 2016, pp. 137-140, 158-159.
[15] Deposition of Jeremiah Rabe, October 18, 2016, pp. 31-34.
[16] Deposition of Jeremiah Rabe, October 18, 2016, p. 34.
[17] 30(b)(6) Deposition of Chapco, October 20, 2016, pp. 158-159, Exs. 34, 44.

### C. Technogym SkillMill Product

49. I understand that sometime in 2016, fitness equipment manufacturer, Technogym, introduced the SkillMill product, which is a piece of "functional training equipment" that has a curved, manual treadmill component.[18] Technogym's SkillMill product is depicted below.

50. Based on my review of the information made available to me, the SkillMill product likely infringes at least independent claims 1, 11, and 19 of the '580 patent, reproduced below.

| Claim 1 | Claim 11 | Claim 19 |
|---|---|---|
| A manually powered treadmill comprising:<br><br>a frame having a front end | A manually powered treadmill, comprising:<br><br>a frame having a front end | A manually powered treadmill, comprising:<br><br>a frame having a front end |

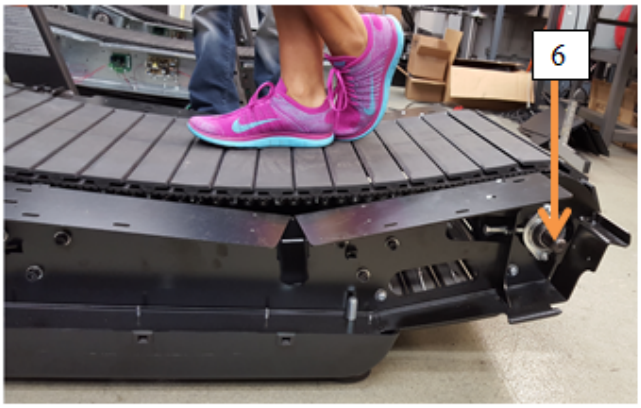
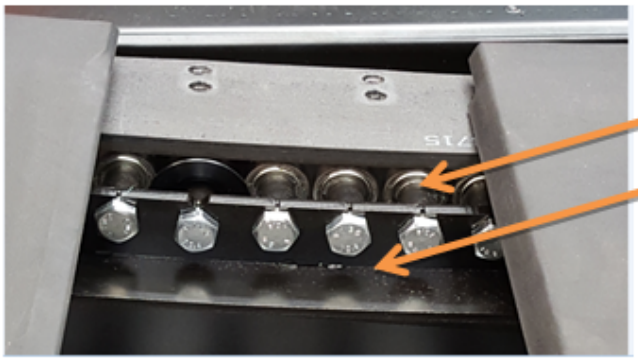
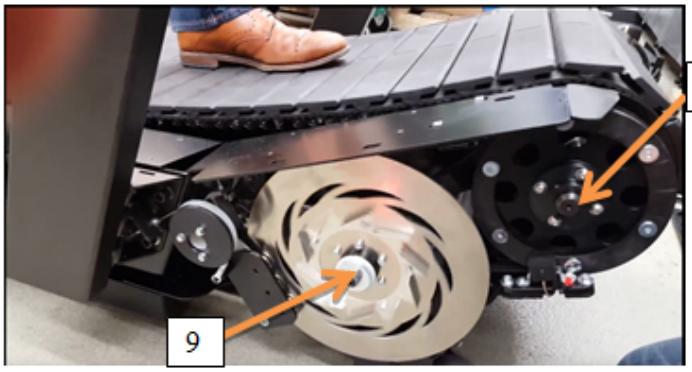
[18] http://www.technogym.com/us/products/functional-flexibility/skillmill.html; Deposition of Douglas Bayerlein, December 14, 2016, pp. 233-234.

| Claim 1 | Claim 11 | Claim 19 |
|---|---|---|
| and a rear end positioned opposite the front end;<br><br>a front shaft rotatably coupled to the frame at the front end;<br><br>a rear shaft rotatably coupled to the frame at the rear end;<br><br>a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;<br><br>a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;<br><br>a running belt supported by the first bearing rail and the second bearing rail and disposed about the front shaft and the rear shaft, wherein the running belt follows a curved running surface; and<br><br>a safety device coupled to at least one of the front shaft and the rear shaft, wherein the safety device is structured to substantially prevent rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of the at least one of the front shaft and the rear shaft in a second rotational direction opposite the first rotational direction. | and a rear end positioned opposite the front end;<br><br>a front shaft attached to the frame adjacent the front end;<br><br>a rear shaft attached to the frame adjacent the rear end;<br><br>a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;<br><br>a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;<br><br>a running belt at least partially disposed about the front shaft and the rear shaft and at least partially supported by the first bearing rail and the second bearing rail, wherein the running belt includes a front belt portion proximate the front end, a rear belt portion proximate the rear end, and a central belt portion intermediate the front and rear belt portions, wherein the central belt portion is positioned vertically closer to a ground surface supporting the frame than the front and rear belt portions such that the running belt follows a curved running surface; | and a rear end;<br><br>a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;<br><br>a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;<br><br>a handrail attached to the frame and structured to provide a support structure for a user of the manually powered treadmill;<br><br>a pair of wheels mounted to the frame, wherein the pair of wheels are mounted so that the pair of wheels are not in contact with a ground surface when the manually powered treadmill is in an operating position;<br><br>at least two support feet coupled to the frame, wherein the support feet are vertically adjustable to adjust an incline of the manually powered treadmill relative to the ground surface;<br><br>a running belt supported by the first and second bearing rails, wherein the running belt follows a curved running surface; |

| Claim 1 | Claim 11 | Claim 19 |
|---|---|---|
| | and<br><br>a safety device for substantially preventing rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of the at least one of the front shaft and the rear shaft in a second rotational direction opposite the first rotational direction. | and<br><br>a safety device coupled to the frame and operatively coupled to the running belt, wherein the safety device is structured to substantially prevent movement of the running belt in a first direction and permit movement of the running belt in a second direction opposite the first direction. |

51. As is apparent from a review of the claim language, these independent claims require a safety device as well as various other components of a curved, manual treadmill. While each and every element recited in the claim language must be present for the SkillMill to infringe, the infringement analysis appears to primarily hinge on the "safety device" element. The below annotated photographs illustrate how the SkillMill product likely meets each and every claim limitation in claims 1, 11, and 19 of the '580 patent.

| Technogym SkillMill Product | Legend |
|---|---|
| <br> | 1 – Manually powered treadmill<br><br>2 – Handrail<br><br>3 – Running belt with a curved running surface<br><br>4 – Frame<br><br>5 – Front shaft<br><br>6 – Rear shaft<br><br>7 – Bearing rail<br><br>8 – Bearings<br><br>9 – Safety device<br><br>10 – Wheels |

| Technogym SkillMill Product | Legend |
|---|---|
|  <br>  <br>  | 1 – Manually powered treadmill<br>2 – Handrail<br>3 – Running belt with a curved running surface<br>4 – Frame<br>5 – Front shaft<br>6 – Rear shaft<br>7 – Bearing rail<br>8 – Bearings<br>9 – Safety device<br>10 – Wheels |

## IX. RESERVATIONS

52. I have been advised by counsel for Woodway that the parties in the litigation are under a continuing obligation to supplement any discovery that has been provided during this

litigation. Therefore, because new materials or information may become available which could further support or modify the conclusions that I have reached to date, I expressly reserve the right to amend, expand, add, supplement, change, alter, or otherwise modify my opinions. Any changes or necessary amplification of my opinions and conclusions will be addressed in supplemental reports or testimony, which I reserve the right to provide.

53. Further, I reserve the right to consider and comment on any expert reports or statements and testimony of any Chapco and/or Samsara expert(s) in this matter.

54. If I am called to testify, I expect and intend to use exhibits and demonstratives relating to the subject matter of my testimony. These exhibits and demonstratives may include portions of the materials included in this report (and Exhibits hereto) as well as diagrams, models, photographs, or physical samples of the structures described in those items. Portions of these documents may be enlarged, colored, or otherwise adapted to illustrate my opinions. I may also rely on claim charts, demonstrative exhibits, and summaries that have not yet been prepared.

## X. SIGNATURE

I hereby certify under the penalty of perjury that the foregoing is true and correct to the best of my knowledge.

Date: March 2, 2017

Kim B. Blair, Ph.D.

Exhibit A

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

(10) **Patent No.: US 8,986,169 B2**
(45) **Date of Patent: Mar. 24, 2015**

(54) **MANUAL TREADMILL AND METHODS OF OPERATING THE SAME**

(71) Applicant: **Woodway USA, Inc.**, Waukesha, WI (US)

(72) Inventors: **Douglas G. Bayerlein**, Oconomowoc, WI (US); **Vance E. Emons**, Hartland, WI (US); **Nicholas A. Oblamski**, Waukesha, WI (US); **Scott D. Hoerig**, Brookfield, WI (US); **Matthew J. Zank**, Milwaukee, WI (US); **Robert L. Zimpel**, Menomonee Falls, WI (US); **Joel W. Richards**, Wauwatosa, WI (US)

(73) Assignee: **Woodway USA, Inc.**, Waukesha, WI (US)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/243,716**

(22) Filed: **Apr. 2, 2014**

(65) **Prior Publication Data**

US 2014/0213419 A1 Jul. 31, 2014

**Related U.S. Application Data**

(63) Continuation of application No. 13/235,065, filed on Sep. 16, 2011, which is a continuation-in-part of application No. PCT/US2010/027543, filed on Mar. 16, 2010.

(60) Provisional application No. 61/161,027, filed on Mar. 17, 2009.

(51) **Int. Cl.**
***A63B 22/02*** (2006.01)
***A63B 21/005*** (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ..... ***A63B 22/02*** (2013.01); ***A63B 21/0053*** (2013.01); ***A63B 21/157*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC . A63B 22/02; A63B 69/0028; A63B 69/0035
USPC ..... 482/2, 23, 37, 51–52, 54–56, 69–71, 482/79; 119/700; 434/247, 255
IPC ..... A63B 22/02
See application file for complete search history.

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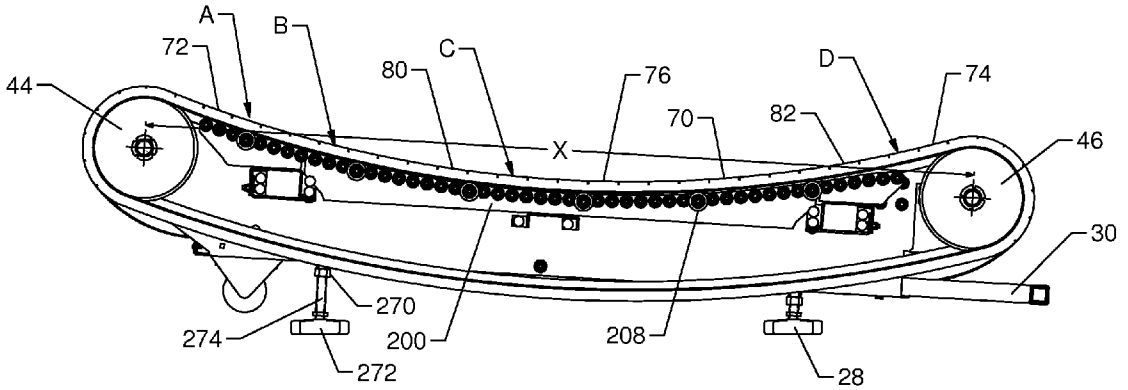
(Continued)

*Primary Examiner* — Oren Ginsberg
(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

A manually operated treadmill is provided. The treadmill includes a treadmill frame, a front shaft rotatably coupled to the treadmill frame, a rear shaft rotatably coupled to the treadmill frame, a running belt including a contoured running surface upon which a user of the treadmill may run, wherein the running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running belt to rotate about the front shaft and the rear shaft without the rotation of the running belt being generated by a motor, and a one-way bearing assembly configured to prevent rotation of the running surface of the running belt in one direction.

**16 Claims, 20 Drawing Sheets**



(51) **Int. Cl.**
***A63B 21/00*** (2006.01)
*A63B 22/00* (2006.01)

(52) **U.S. Cl.**
CPC ..... *A63B22/0285* (2013.01); *A63B 2021/0054* (2013.01); *A63B 2021/0055* (2013.01); *A63B 2022/0017* (2013.01); *A63B 2230/06* (2013.01); *A63B 2230/75* (2013.01)
USPC ..... **482/54**

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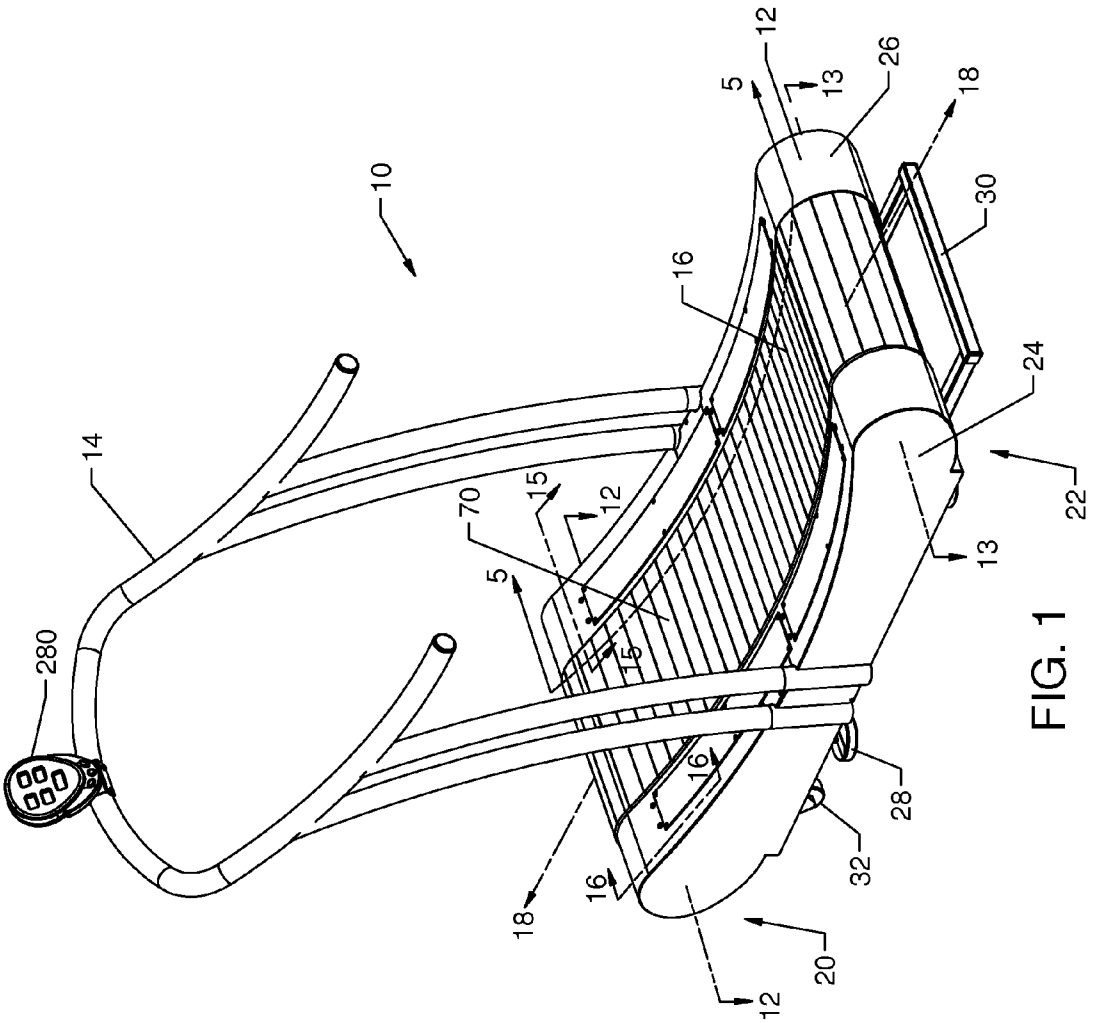
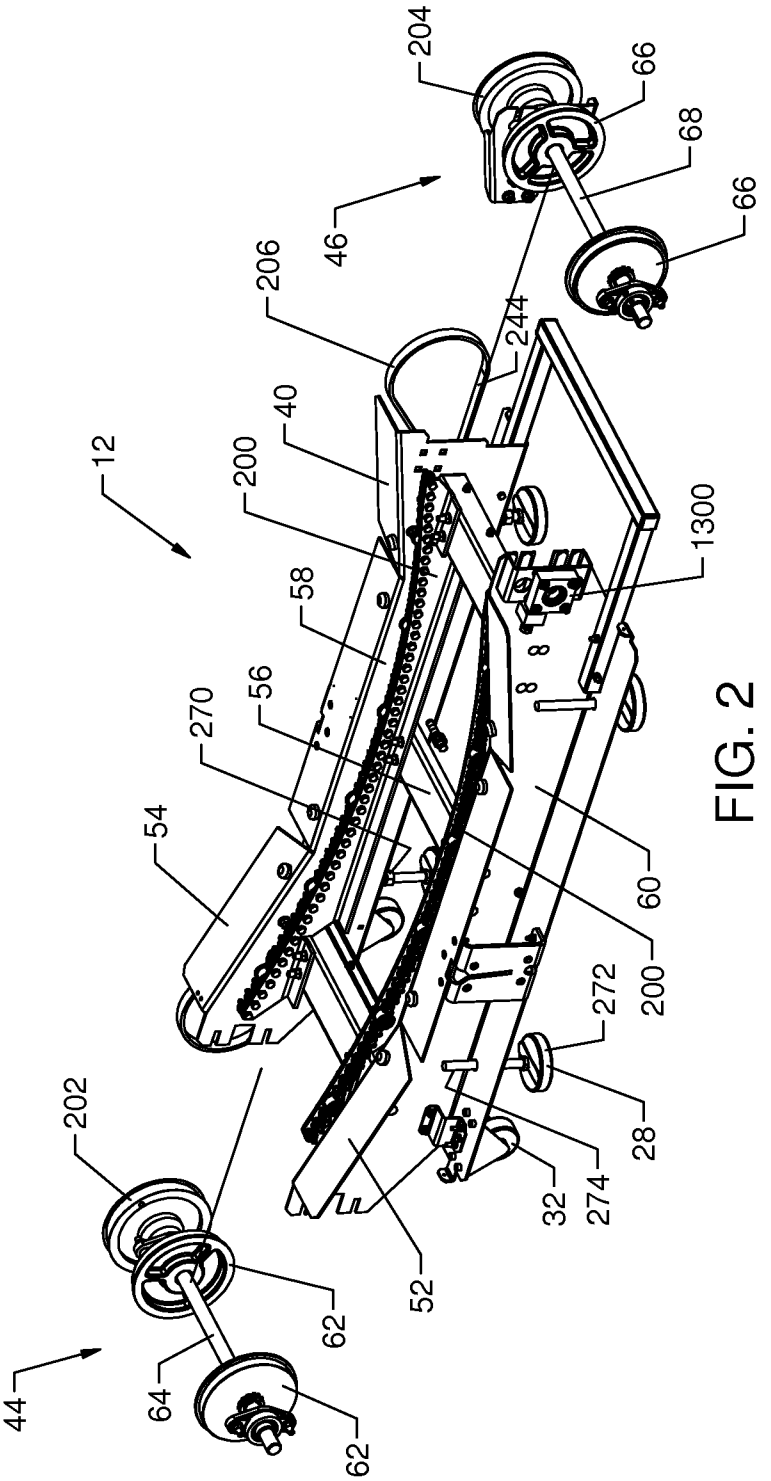



FIG. 1


204
66
68
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46
206
244
40
200
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1300
58
56
270
54
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200
272
28
274
32
52
202
62
64
62
44

FIG. 2

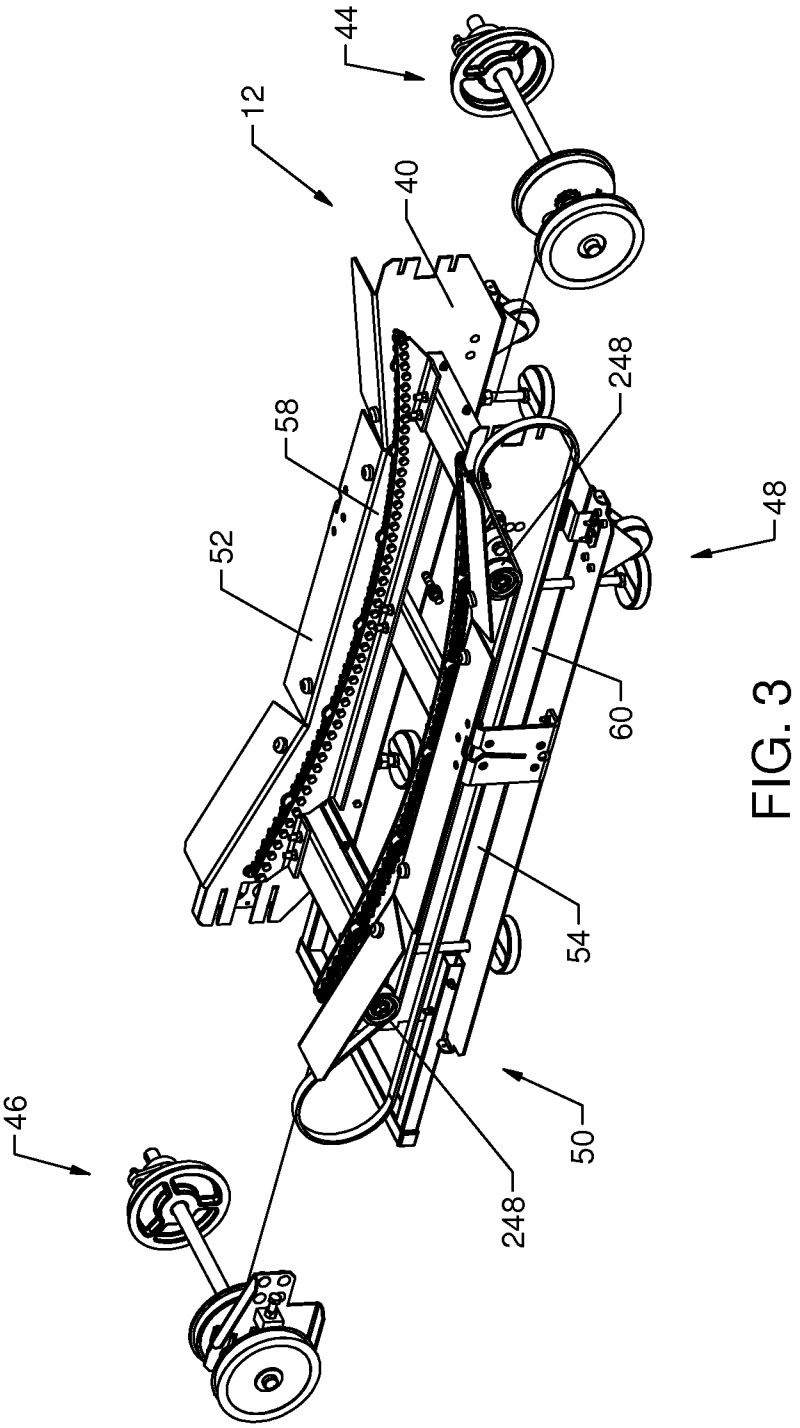



FIG. 3

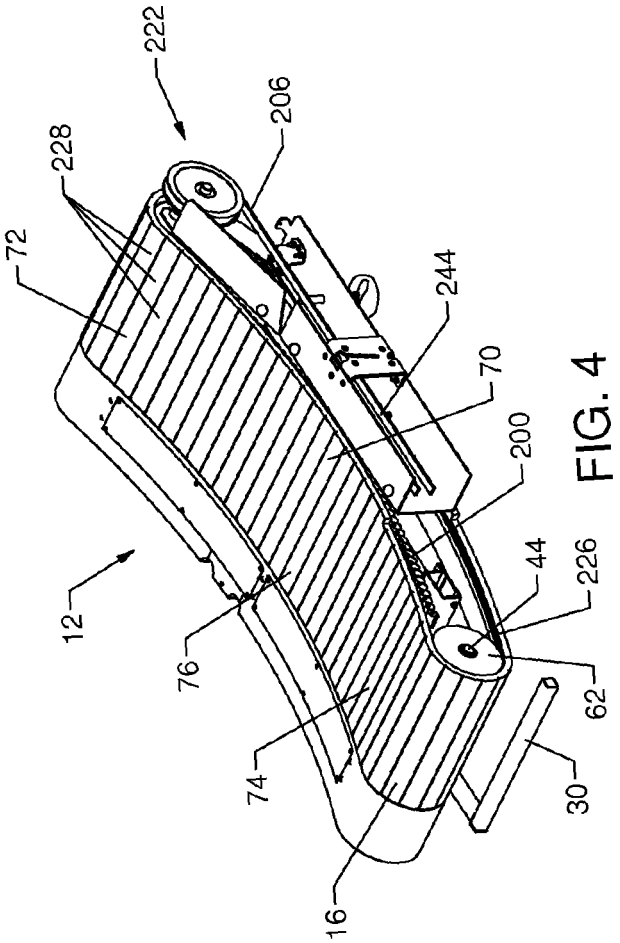

222
206
228
72
244
70
200
44
226
62
12
76
74
30
16

FIG. 4

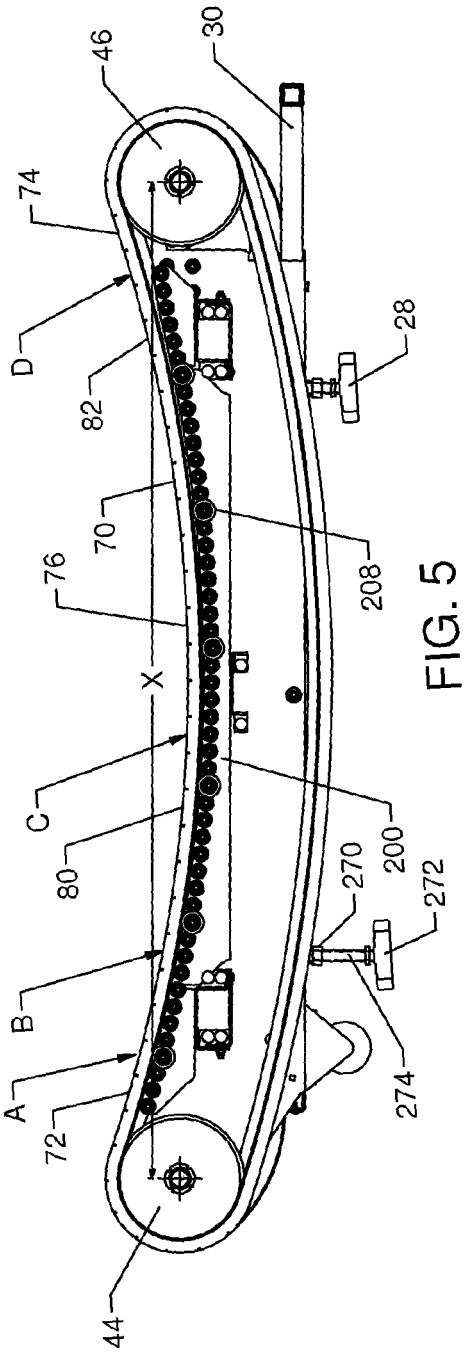

46
30
74
D
28
82
70
208
76
X
C
200
80
270
272
B
A
72
274
44

FIG. 5

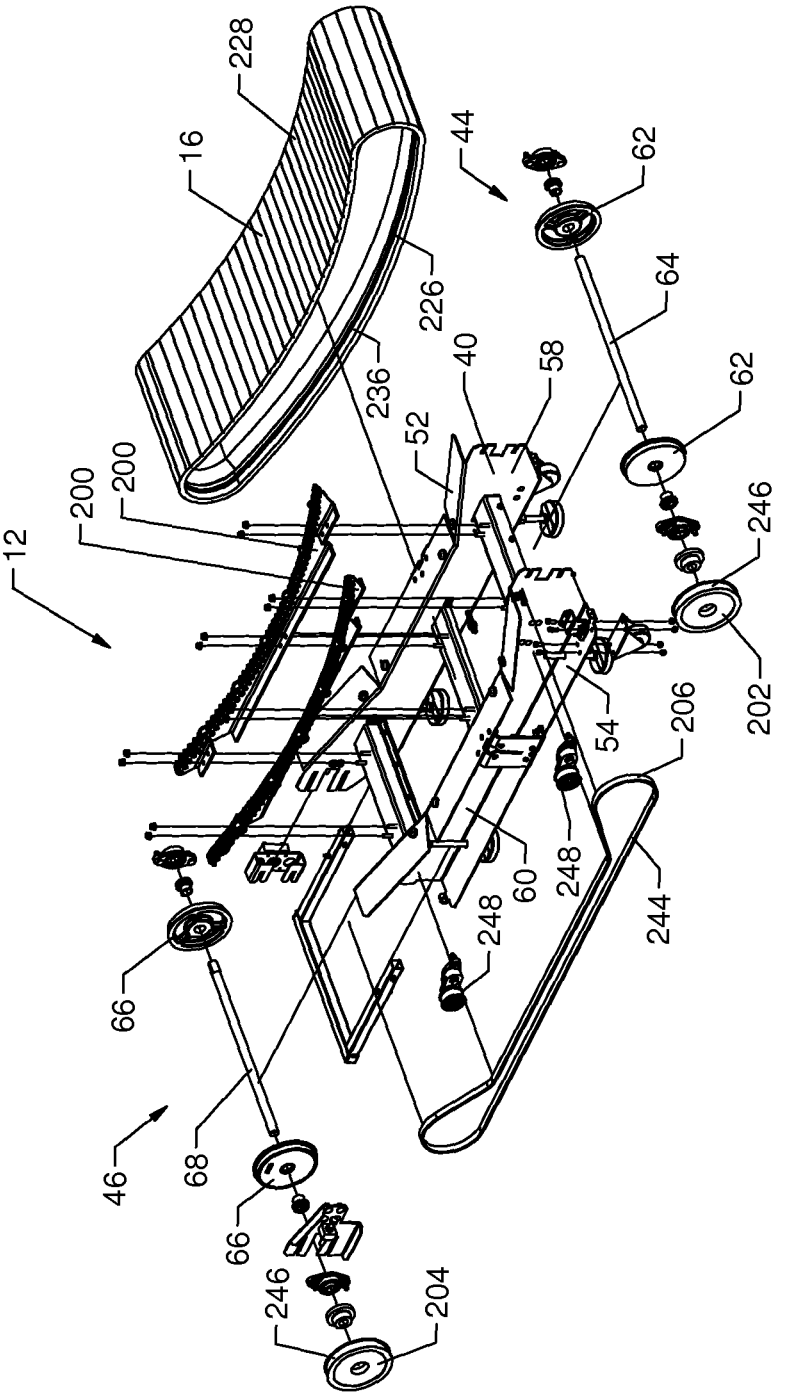

228
16
44
62
64
226
236
40
58
62
52
200
200
246
12
202
206
54
60
248
248
244
66
68
46
66
246
204

FIG. 6

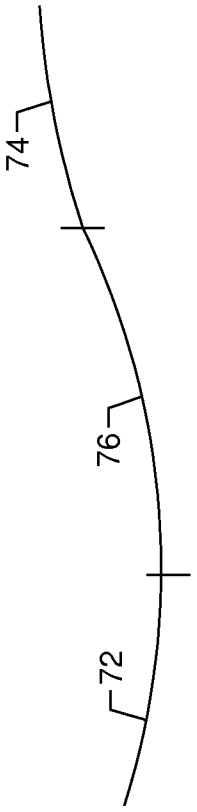



FIG. 7a

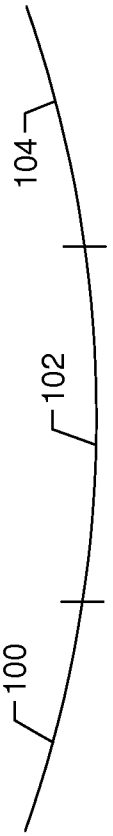



FIG. 7b

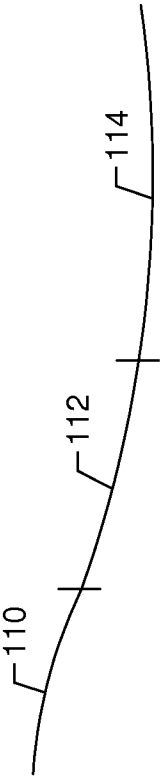



FIG. 7c

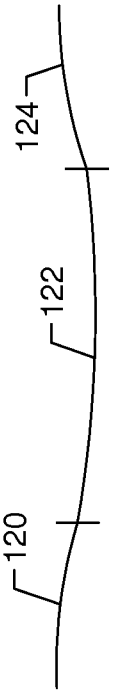



FIG. 7d

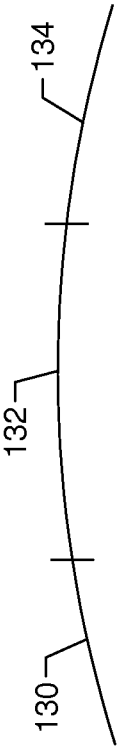



FIG. 7e

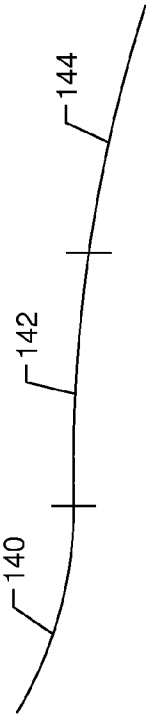



FIG. 7f

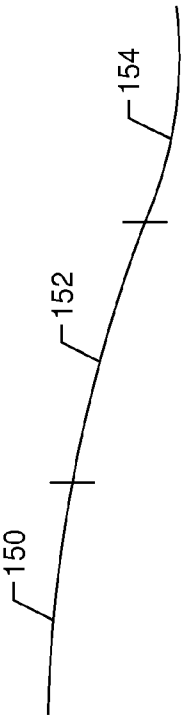



FIG. 7g

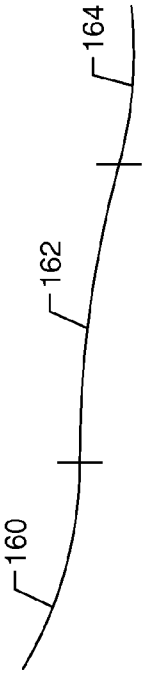



FIG. 7h

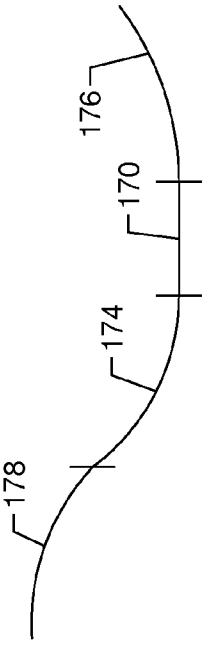



FIG. 7i

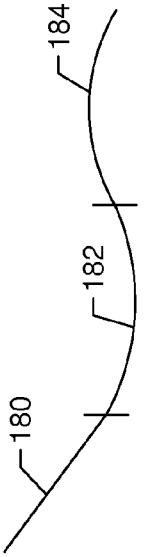



FIG. 7j

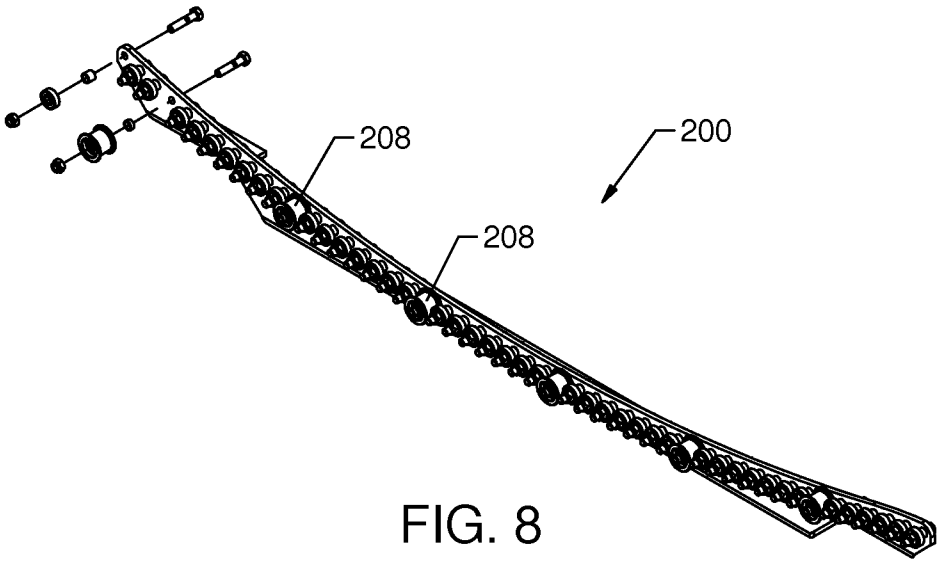



FIG. 8

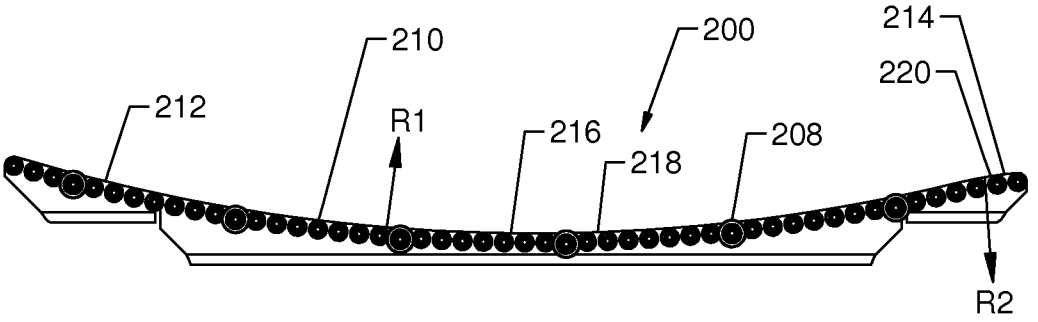



FIG. 9

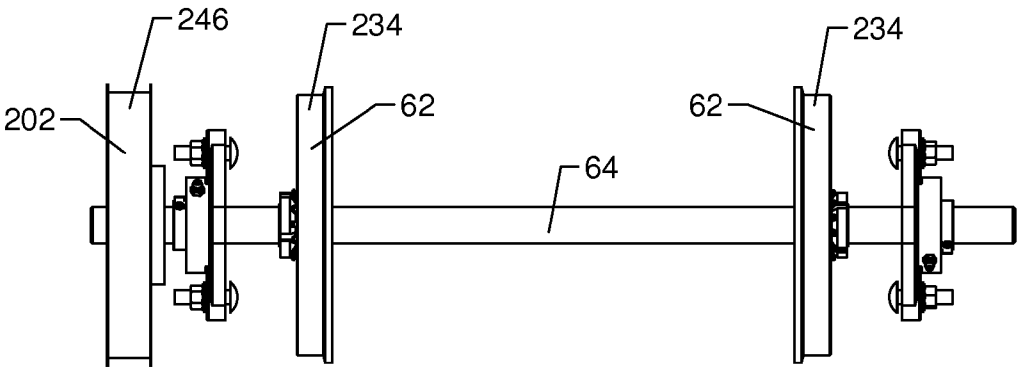



FIG. 10

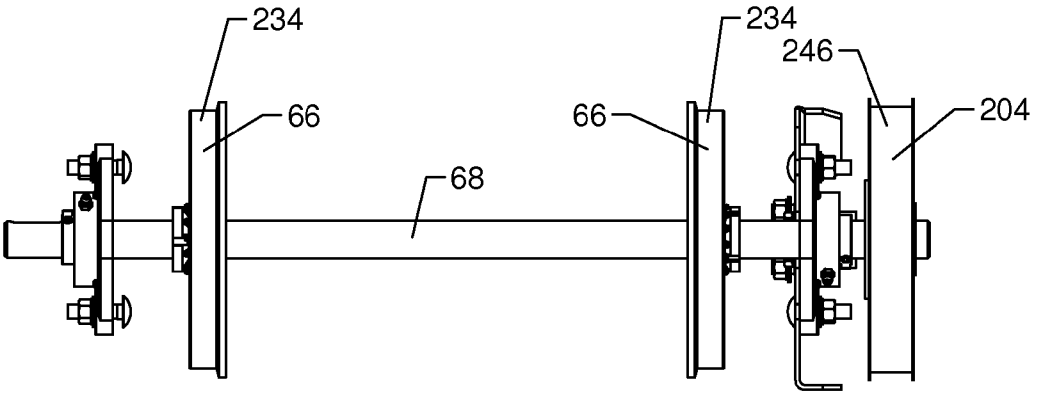
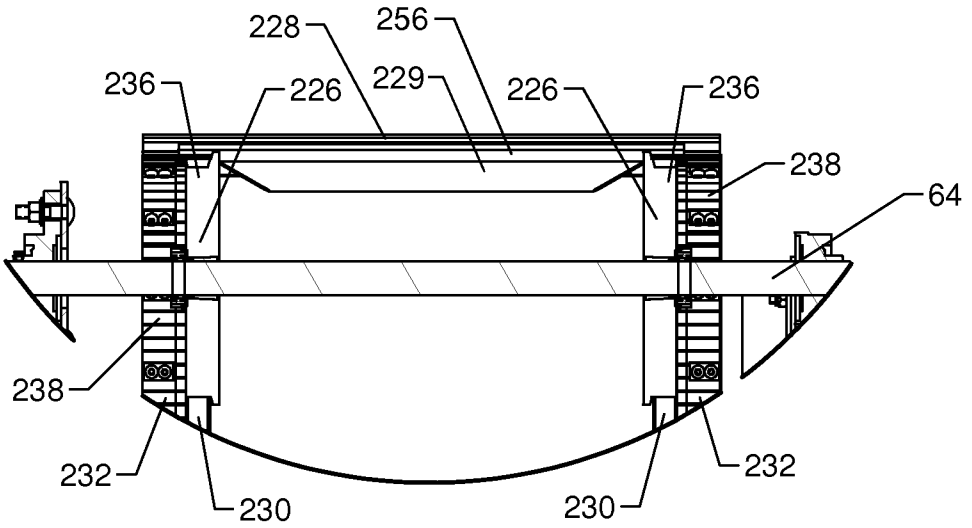



FIG. 11


228
256
236
226
229
226
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238
64
238
232
230
230
232

FIG. 12

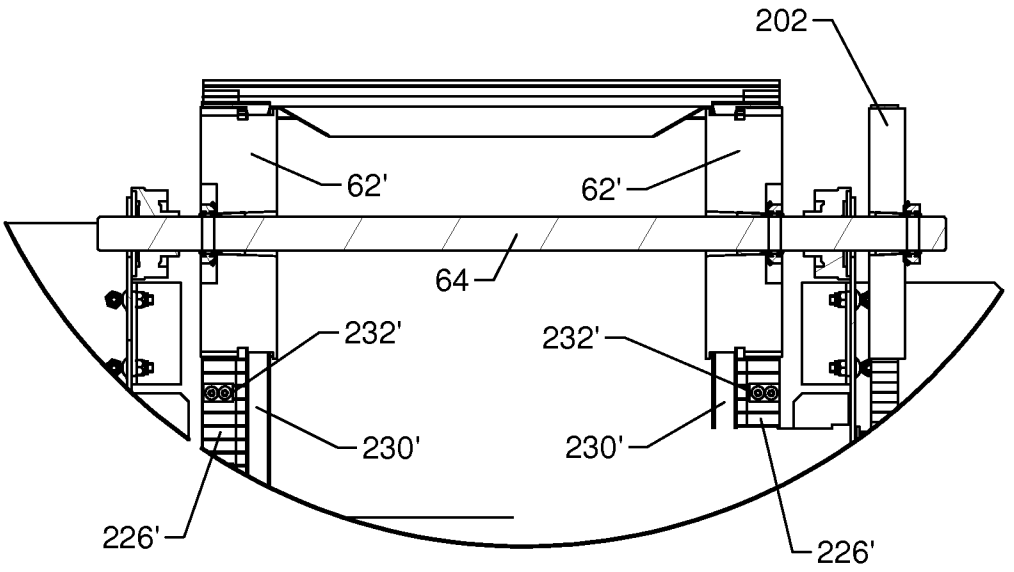
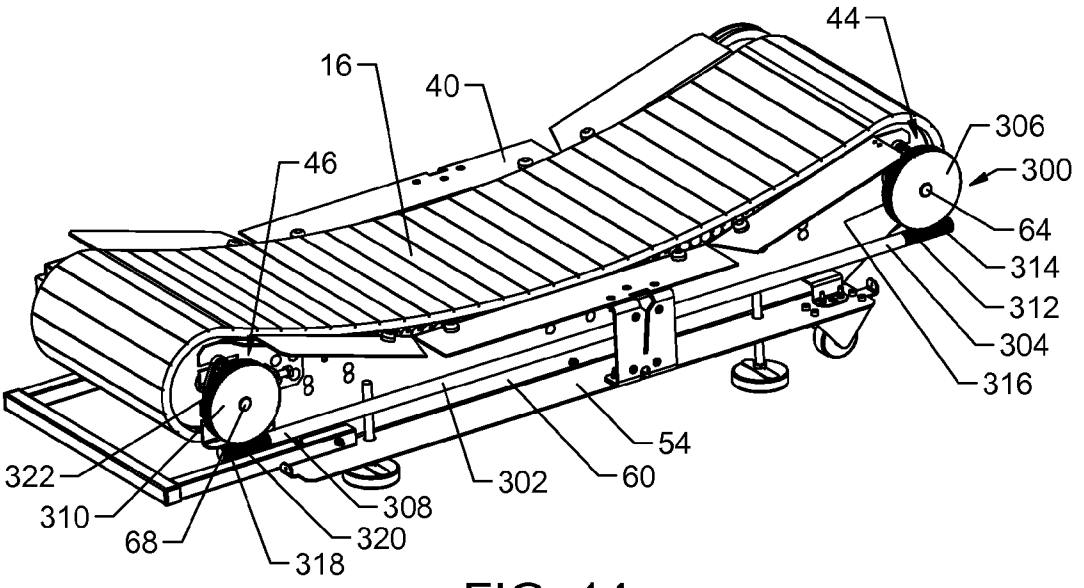

202
62'
62'
64
232'
232'
230'
230'
226'
226'

FIG. 13


44
16
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306
46
300
64
314
312
304
316
54
322
302
60
310
308
68
320
318

FIG. 14

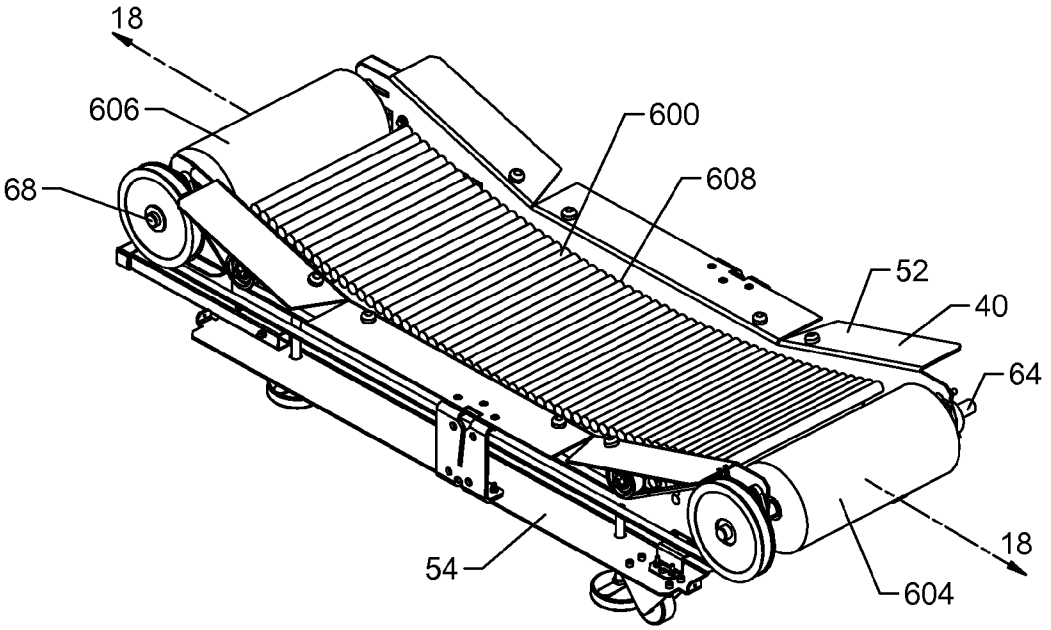
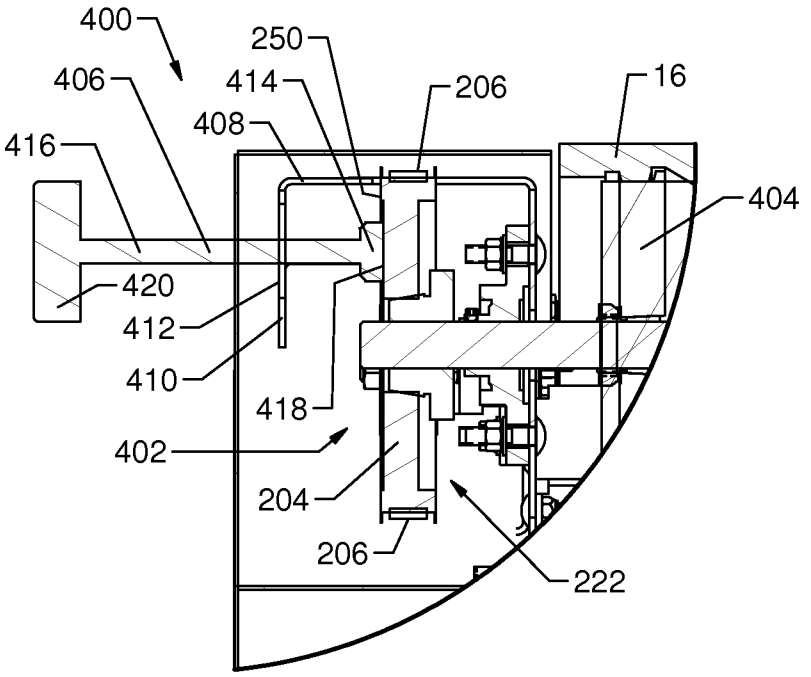

18
606
600
68
608
52
40
64
18
54
604

FIG. 17


400
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406
414
206
16
408
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404
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412
410
418
402
204
206
222

FIG. 15

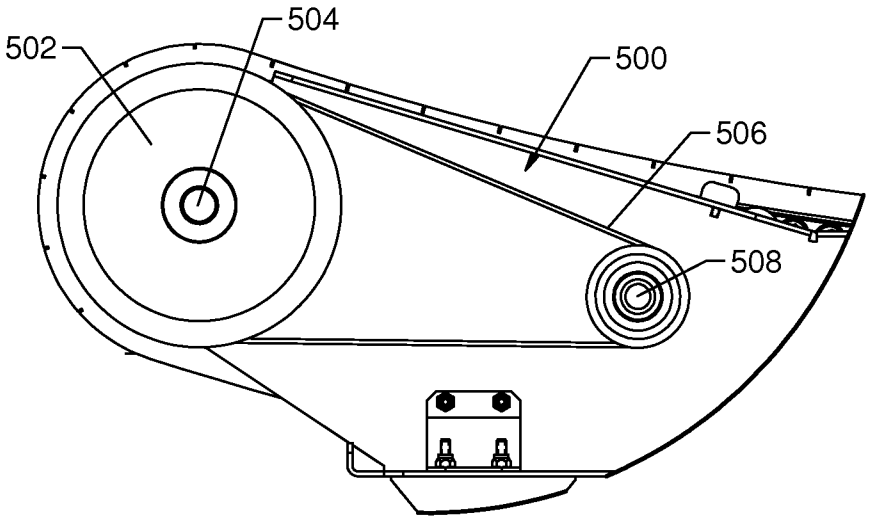

504
502
500
506
508

FIG. 16

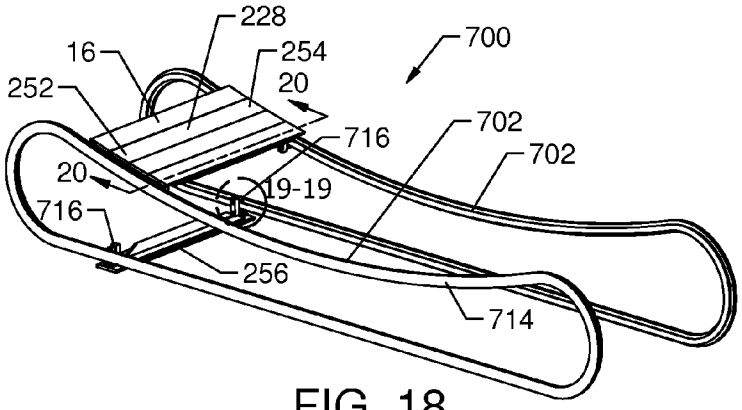



FIG. 18

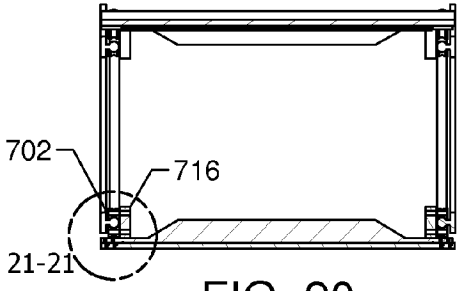



FIG. 20

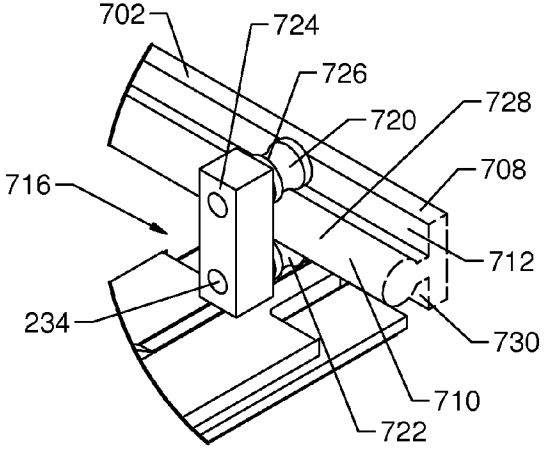



FIG. 19

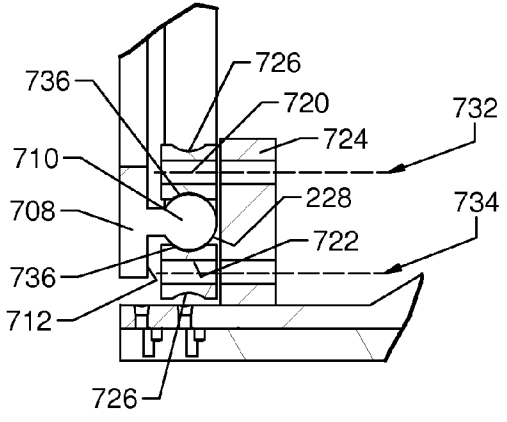



FIG. 21

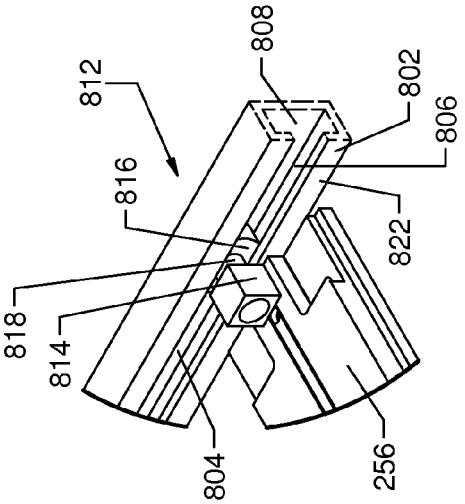



FIG. 23

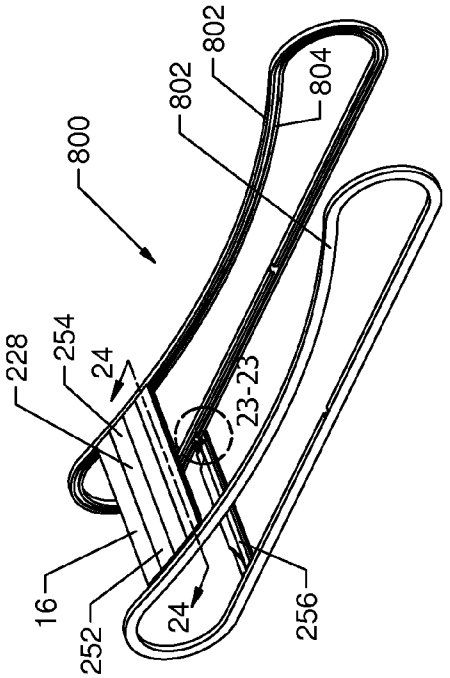



FIG. 22

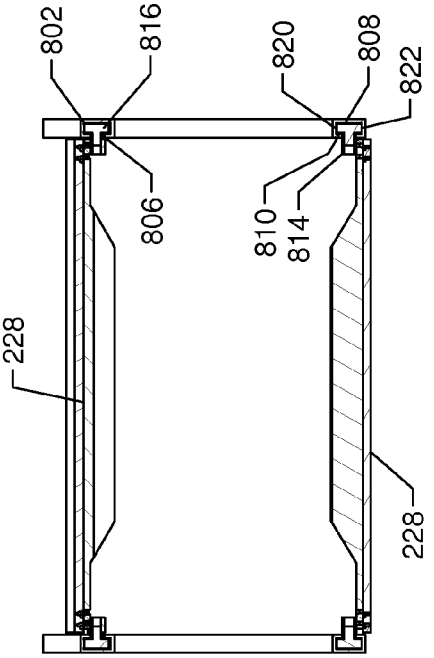



FIG. 24

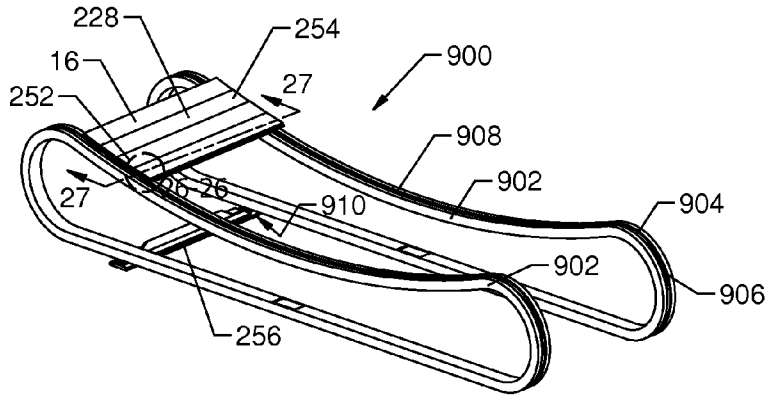



FIG. 25

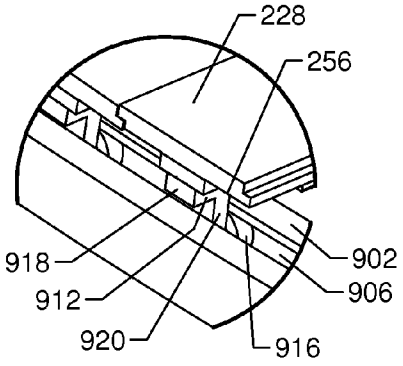



FIG. 26

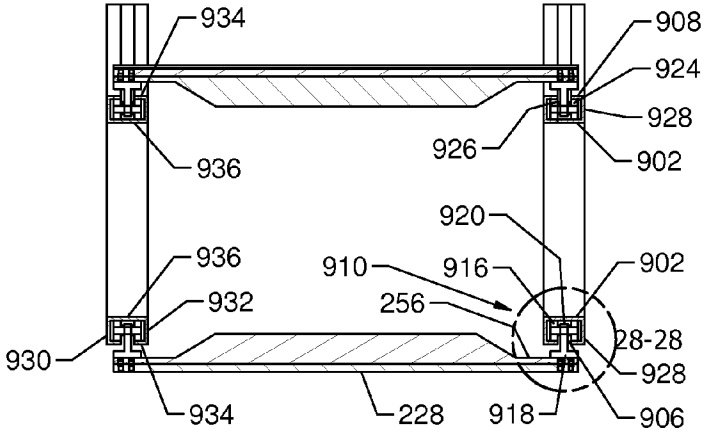



FIG. 27

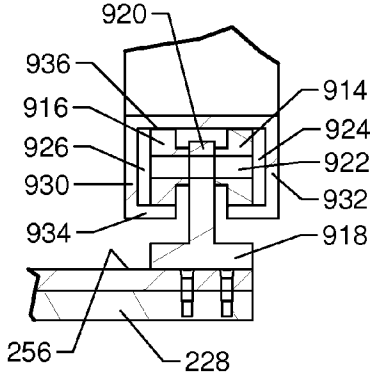



FIG. 28

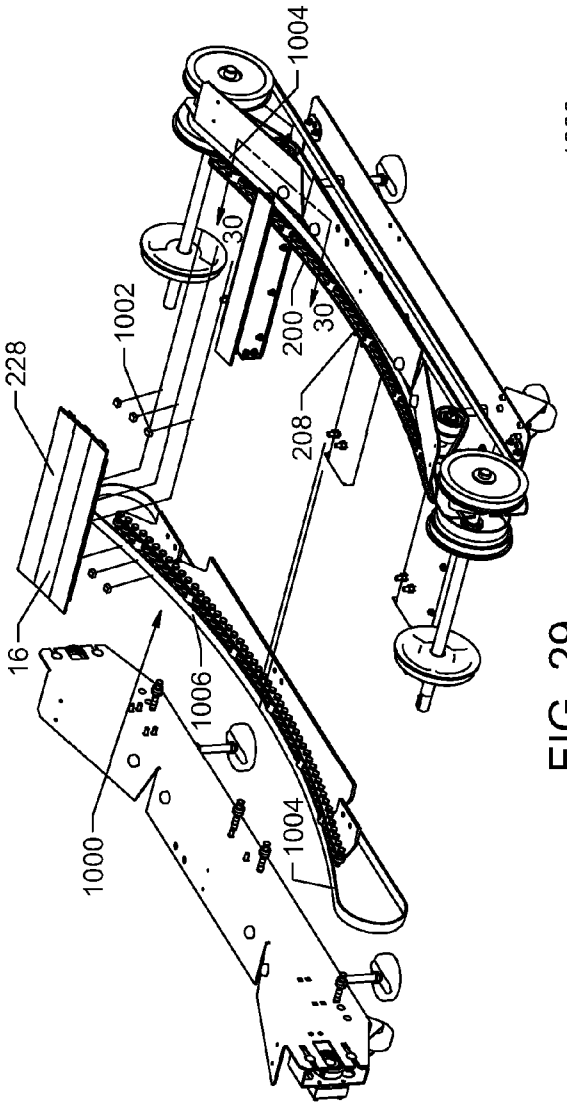

1004
30
1002
200
30
228
208
16
1006
1000
1004

FIG. 29

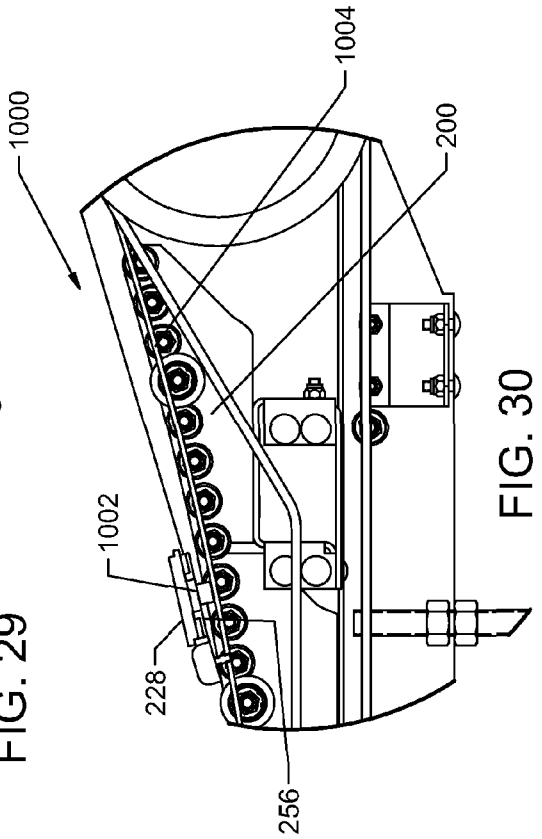

1000
1004
200
1002
228
256

FIG. 30

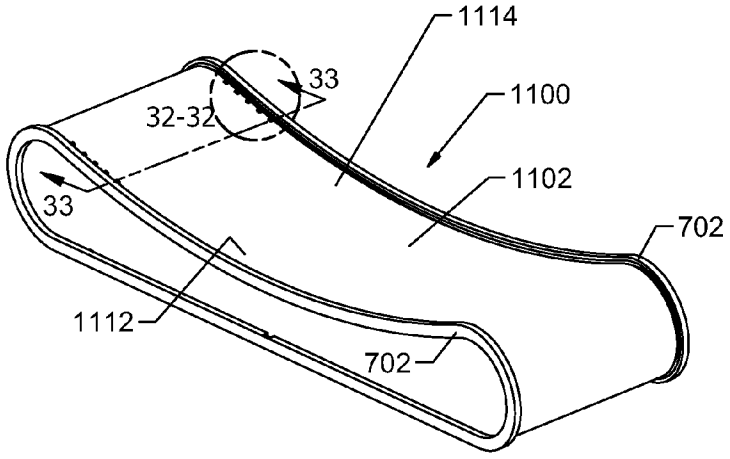



FIG. 31

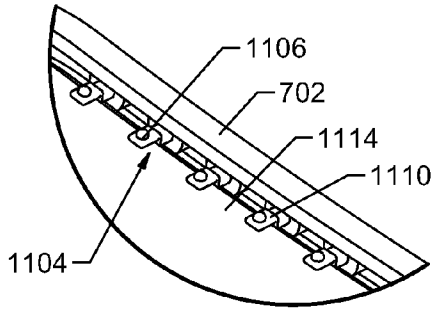



FIG. 32

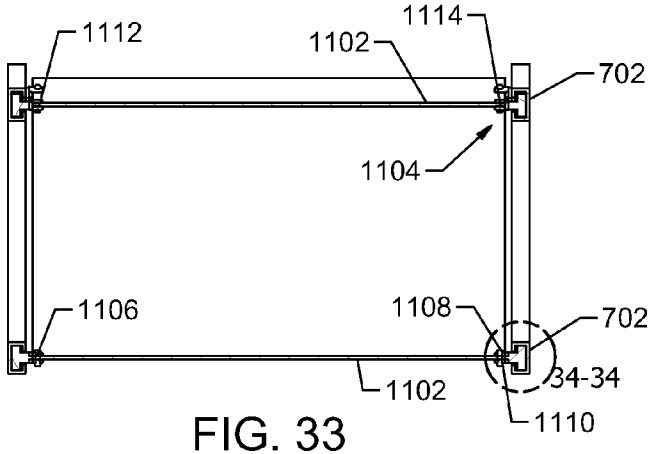



FIG. 33

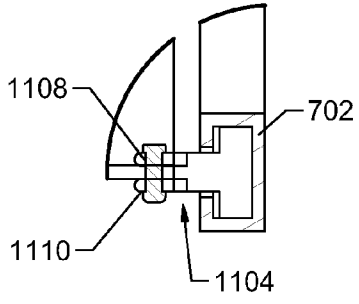



FIG. 34

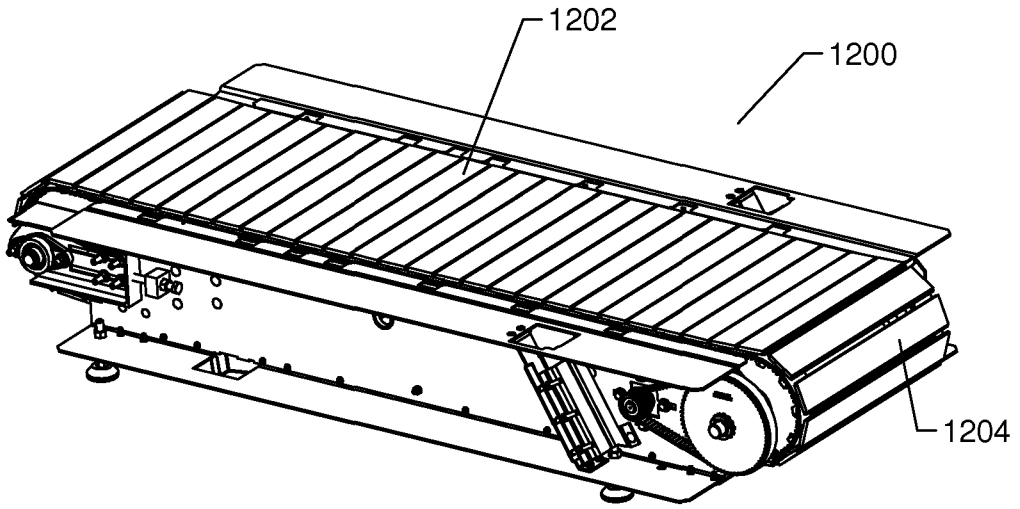



FIG. 35

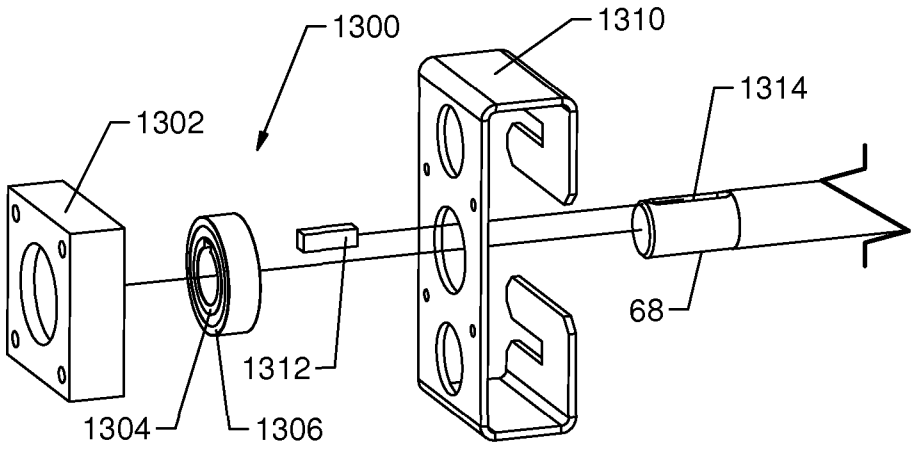
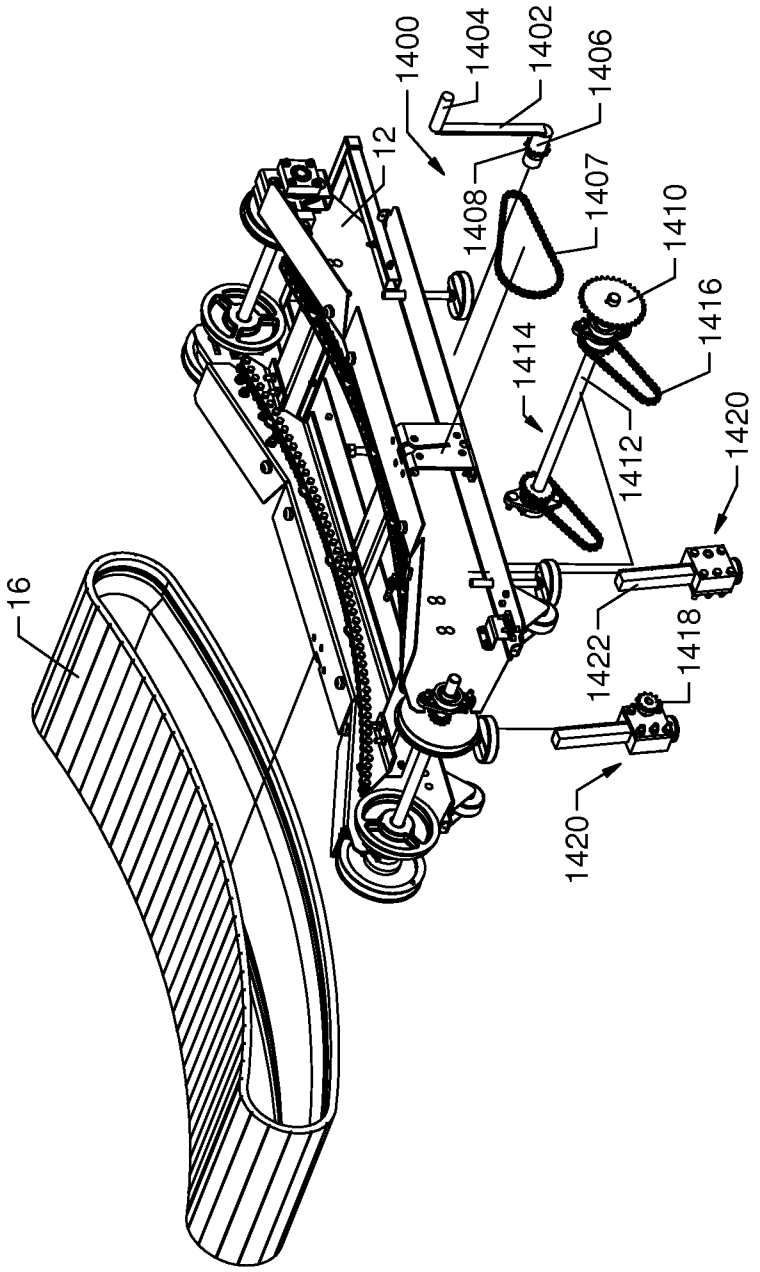



FIG. 36


1400
1404
1402
1406
12
1408
1407
1410
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1420
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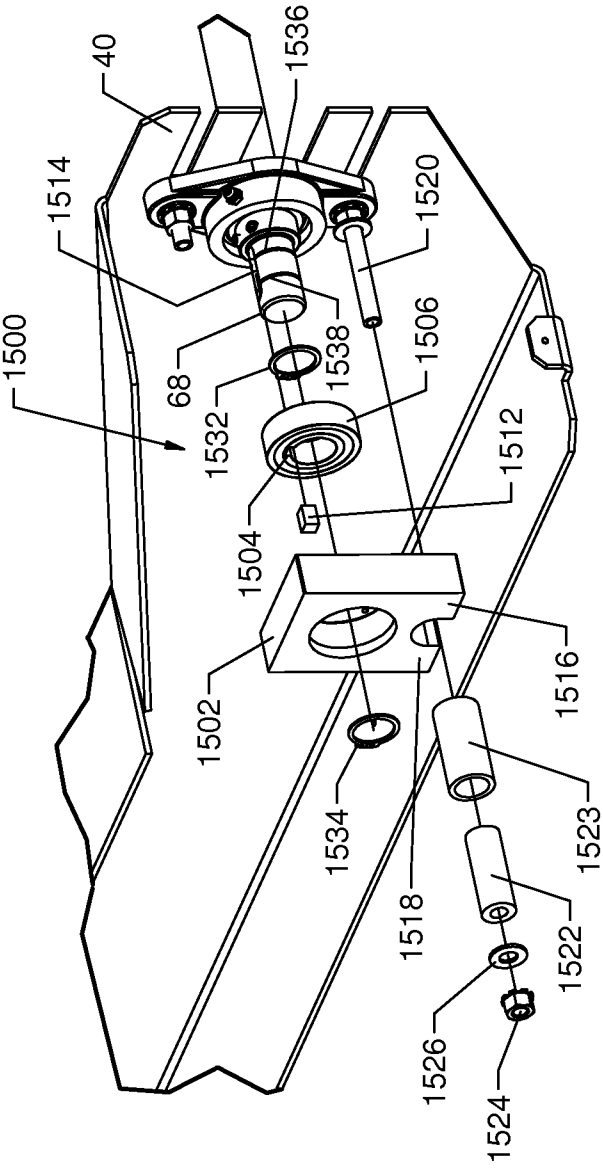
1420

FIG. 37


40
1536
1514
1520
1500
68
1538
1506
1532
1512
1504
1516
1502
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1523
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1524

FIG. 38

# MANUAL TREADMILL AND METHODS OF OPERATING THE SAME

## CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application claims the benefit of priority as a continuation of U.S. patent application Ser. No. 13/235,065, filed Sep. 16, 2011, which is a continuation-in-part of prior international Application No. PCT/US10/27543, filed Mar. 16, 2010, which claims priority to U.S. Provisional Application Ser. No. 61/161,027, filed Mar. 17, 2009, all of which are incorporated herein by reference in their entireties.

## BACKGROUND

The present invention relates generally to the field of treadmills. More specifically, the present invention relates to manual treadmills. Treadmills enable a person to walk, jog, or run for a relatively long distance in a limited space. It should be noted that throughout this document, the term "run" and variations thereof (e.g., running, etc.) in any context is intended to include all substantially linear locomotion by a person. Examples of this linear locomotion include, but are not limited to, jogging, walking, skipping, scampering, sprinting, dashing, hopping, galloping, etc.

A person running generates force to propel themselves in a desired direction. To simplify this discussion, the desired direction will be designated as the forward direction. As the person's feet contact the ground (or other surface), their muscles contract and extend to apply a force to the ground that is directed generally rearward (i.e., has a vector direction substantially opposite the direction they desire to move). Keeping with Newton's third law of motion, the ground resists this rearwardly directed force from the person, resulting in the person moving forward relative to the ground at a speed related to the force they are creating.

To counteract the force created by the treadmill user so that the user stays in a relatively static fore and aft position on the treadmill, most treadmills utilize a belt that is driven by a motor. The motor operatively applies a rotational force to the belt, causing that portion of the belt on which the user is standing to move generally rearward. This force must be sufficient to overcome all sources of friction, such as the friction between the belt and other treadmill components in contact therewith and kinetic friction, to ultimately rotate the belt at a desired speed. The desired net effect is that, when the user is positioned on a running surface of the belt, the forwardly directed velocity achieved by the user is substantially negated or balanced by the rearwardly directed velocity of the belt. Stated differently, the belt moves at substantially the same speed as the user, but in the opposite direction. In this way, the user remains at substantially the same relative position along the treadmill while running. It should be noted that the belts of conventional, motor-driven treadmills must overcome multiple, significant sources of friction because of the presence of the motor and configurations of the treadmills themselves.

Similar to a treadmill powered by a motor, a manual treadmill must also incorporate some system or means to absorb or counteract the forward velocity generated by a user so that the user may generally maintain a substantially static position on the running surface of the treadmill. The counteracting force driving the belt of a manual treadmill is desirably sufficient to move the belt at substantially the same speed as the user so that the user stays in roughly the same static position on the running surface. Unlike motor-driven treadmills, however, this force is not generated by a motor.



## SUMMARY

One embodiment of the disclosure relates to a manually operated treadmill comprising a treadmill frame having a front end and a rear end opposite the front end, a front shaft rotatably coupled to the treadmill frame at the front end, a rear shaft rotatably coupled to the treadmill frame at the rear end, a running belt including a curved running surface upon which a user of the treadmill may run, and a one-way bearing assembly coupled to at least one of the front shaft and the rear shaft, wherein the one-way bearing assembly prevents rotation of at least one of the front shaft and the rear shaft in one direction and permits rotation of at least one of the front shaft and the rear shaft in the opposite direction to restrict rotation of the running belt in a single direction. The running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running surface of the running belt to move from the front shaft toward the rear shaft. The treadmill is configured to allow the user to manually control the speed of the running belt and to facilitate maintenance of a contour of the curved running surface.

Another embodiment of the disclosure relates to a manually operated treadmill comprising a treadmill frame, a front shaft rotatably coupled to the treadmill frame, a rear shaft rotatably coupled to the treadmill frame, a running belt including a contoured running surface upon which a user of the treadmill may run, wherein the running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running belt to rotate about the front shaft and the rear shaft without the rotation of the running belt being generated by a motor, and a one-way bearing assembly configured to prevent rotation of the running surface of the running belt in one direction.

Another embodiment of the disclosure relates to a manually operated treadmill comprising a frame supported on a substantially horizontal surface, a front shaft assembly supported by the frame and comprising a front shaft and at least one front running belt pulley supported by the front shaft, a rear shaft assembly supported by the frame a spaced distance from the front shaft and comprising a rear shaft and at least one rear running belt pulley supported by the rear shaft, a running belt supported at least in part by the front shaft assembly and the rear shaft assembly, and a one-way bearing assembly cooperating with one of the front shaft and the rear shaft to permit rotation of said one of the front shaft and the rear shaft in only one direction. The running belt includes a front portion adjacent the front shaft assembly, a rear portion adjacent the rear shaft assembly, and a central portion intermediate the front portion and the rear portion, the front portion and the rear portion being positioned vertically higher than a lowest point found in the central portion to form a non-planar running surface upon which a user of the treadmill may walk or run, wherein gravitational force acting upon weight of the user's body on the running belt relative to the lowest point of the running belt causes rotation of the running belt, front shaft, and the rear shaft without the aid of a motor.

Another embodiment of the disclosure relates to a manually operated treadmill comprising a treadmill frame having a front end and a rear end opposite the front end, a front shaft rotatably coupled to the treadmill frame at the front end, a rear shaft rotatably coupled to the treadmill frame at the rear end, and a running belt including a curved running surface upon

which a user of the treadmill may run. The running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running surface of the running belt to move from the front shaft toward the rear shaft. The treadmill is configured to control the speed of the running belt to facilitate the maintenance of the contour of the curved running surface.

Another embodiment of the disclosure relates to a manually operated treadmill comprising a treadmill frame, a front support member rotatably coupled to the treadmill frame, a rear support member rotatably coupled to the treadmill frame, a running belt including a curved running surface upon which a user of the treadmill may run, wherein the running belt is supported by the front support member and the rear support member, and a synchronizing system configured to cause the front support member and the rear support member to rotate at substantially the same speeds. The force generated by the user causes rotation of the front support member and the rear support member and also causes the running belt to rotate relative to the treadmill frame.

Another embodiment of the disclosure relates to manually operated treadmill comprising a treadmill frame, a running belt including a running surface upon which a user of the treadmill may run, a front support member rotatably coupled to the treadmill frame, the front support member comprising the forwardmost support for the running belt, a rear support member rotatably coupled to the treadmill frame, the rear support member comprising the rearwardmost support for the running belt. The running surface comprises at least in part a complex curve located intermediate the front support member and the rear support member and incorporating a minimum of two geometric configurations.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an exemplary embodiment of a manual treadmill having a non-planar running surface.

FIG. **2** is a left-hand partially exploded perspective view of a portion of the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **3** is a right-hand partially exploded perspective view of a portion of the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **4** is a perspective view of the right-hand side of the manual treadmill of FIG. **1** with a portion of the rear of the treadmill cut-away to show a portion of the arrangement of elements.

FIG. **5** is a cross-sectional view of a portion of the manual treadmill taken along line **5-5** of FIG. **1**.

FIG. **6** is an exploded view of a portion of the manual treadmill of FIG. **1** having the side panels and handrail removed.

FIG. **7***a* is a side schematic view of the profile of the running surface of the manual treadmill according to an exemplary embodiment.

FIGS. **7***b*-**7***j* are sides schematic views of alternative profiles of the running surfaces of manual treadmills according to alternative exemplary embodiments.

FIG. **8** is a partially exploded, perspective view of a bearing rail for the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **9** is a side elevation view of the bearing rail of FIG. **6**.

FIG. **10** is a top elevation view of a front shaft assembly for the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **11** is a top elevation view of a rear shaft assembly for the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **12** is a partial, cross-sectional view of the manual treadmill taken along line **12-12** of FIG. **1**.

FIG. **13** is an alternative exemplary embodiment of the partial, cross-sectional view of the manual treadmill similar to FIG. **12**.

FIG. **14** is a perspective view of an alternative embodiment of a synchronizing system integrated into a manual treadmill.

FIG. **15** is a partial, cross-sectional view of a manual treadmill including an exemplary embodiment of a braking system taken along line **15-15** of FIG. **4**.

FIG. **16** is a partial, cross-sectional view of a manual treadmill including another exemplary embodiment of a braking system taken along line **16-16** of FIG. **4**.

FIG. **17** is a perspective side view of a portion of the manual treadmill according to the exemplary embodiment shown in FIG. **1** including a plurality of rollers used in place of bearing rails.

FIG. **18** is a side perspective view of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **19** is a detail view of the track system of FIG. **18** taken along line **19-19**.

FIG. **20** is a partial cross-sectional view of the track system of FIG. **18** taken along line **20-20**.

FIG. **21** is a detail view of the track system of FIG. **20** taken along line **21-21**.

FIG. **22** is a side perspective view of another exemplary embodiment of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **23** is a detail view of the track system of FIG. **22** taken along line **23-23**.

FIG. **24** is a partial cross-sectional view of the track system of FIG. **18** taken along line **24-24**.

FIG. **25** is a side perspective view of another exemplary embodiment of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **26** is a detail view of the track system of FIG. **25** taken along a line **26-26**.

FIG. **27** is a partial cross-sectional view of the track system of FIG. **25** taken along line **27-27**.

FIG. **28** is a detail view of the track system of FIG. **27** taken along line **28-28**.

FIG. **29** is a partially exploded, right-hand perspective view of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **30** is a detail view of the track system of FIG. **29** taken along line **30-30**.

FIG. **31** is a side perspective view of another exemplary embodiment of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **32** is a detail view of the track system of FIG. **31** taken along a line **32-32**.

FIG. **33** is a partial cross-sectional view of the track system of FIG. **31** taken along a line **33-33**.

FIG. **34** is a detail view of the track system of FIG. **32** taken along a line **34-34**.

FIG. **35** is a perspective view of an exemplary embodiment of a manual treadmill according to another embodiment having a substantially planar running surface.

FIG. **36** is a perspective view of a one-way bearing for the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **37** is a left-hand partially exploded perspective view of a portion of the manual treadmill according to the exemplary embodiment shown in FIG. **1** including an incline adjustment system.

FIG. **38** is a perspective view of a one-way bearing for the manual treadmill shown in FIG. **1**, according to another embodiment.

## DETAILED DESCRIPTION

Referring to FIG. **1**, a manual treadmill **10** generally comprises a base **12** and a handrail **14** mounted to the base **12** as shown according to an exemplary embodiment. The base **12** includes a running belt **16** that extends substantially longitudinally along a longitudinal axis **18**. The longitudinal axis **18** extends generally between a front end **20** and a rear end **22** of the treadmill **10**; more specifically, the longitudinal axis **18** extends generally between the centerlines of a front shaft and a rear shaft, which will be discussed in more detail below.

A pair of side panels **24** and **26** (e.g., covers, shrouds, etc.) are preferably provided on the right and left sides of the base **12** to effectively shield the user from the components or moving parts of the treadmill **10**. The base **12** is supported by multiple support feet **28**, which will be described in greater detail below. A rearwardly extending handle **30** is provided on the rear end of the base **12** and a pair of wheels **32** are provided at the front of the base **12**, however, the wheels **32** are mounted so that they are generally not in contact with the ground when the treadmill is in an operating position. The user can easily move and relocate the treadmill **10** by lifting the rear of the treadmill base **12** a sufficient amount so that the multiple support feet **28** are no longer in contact with the ground, instead the wheels **32** contact the ground, thereby permitting the user to easily roll the entire treadmill **10**. It should be noted that the left and right-hand sides of the treadmill and various components thereof are defined from the perspective of a forward-facing user standing on the running surface of the treadmill **10**.

Referring to FIGS. **2-6**, the base **12** is shown further including a frame **40**, a front shaft assembly **44** positioned near a front end **48** of the frame **40**, and a rear shaft assembly **46** positioned near the rear end **50** of frame **40**, generally opposite the front end **48**. Specifically, the front shaft assembly **44** is coupled to the frame **40** at the front end **48**, and the rear shaft assembly **46** is coupled to the frame **40** at the rear end **50** so that the frame supports these two shaft assemblies.

The frame **40** comprises longitudinally-extending, opposing side members, shown as a left-hand side member **52** and a right-hand side member **54**, and one or more lateral or cross-members **56** extending between and structurally connecting the side members **52** and **54** according to an exemplary embodiment. Each side member **52**, **54** includes an inner surface **58** and an outer surface **60**. The inner surface **58** of the left-hand side member **52** is opposite to and faces the inner surface **58** of the right-hand side member **54**. According to other exemplary embodiments, the frame may have substantially any configuration suitable for providing structure and support for the manual treadmill.

Similar to most motor-driven treadmills, the front shaft assembly **44** includes a pair of front running belt pulleys **62** interconnected with, and preferably directly mounted to, a shaft **64**, and the rear shaft assembly **46** includes a pair of rear running belt pulleys **66** interconnected with, and preferably directly mounted to, a shaft **68**. The front and rear running belt pulleys **62**, **66** are configured to facilitate movement of the running belt **16**. The running belt **16** is disposed about the front and rear running belt pulleys **62**, **66**, which will be discussed in more detail below. As the front and rear running belt pulleys **62**, **66** are preferably fixed relative to shafts **64** and **68**, respectively, rotation of the front and rear running belt pulleys **62**, **66** causes the shafts **64**, **68** to rotate in the same direction. The front and rear running belt pulleys **62**, **66** are formed of a material sufficiently rigid and durable to maintain shape under load. Preferably, the material is of a relatively light weight so as to reduce the inertia of the pulleys **62**, **66**. The pulleys **62**, **66** may be formed of any material having one or more of these characteristics (e.g., metal, ceramic, composite, plastic, etc.). According to the exemplary embodiment shown, the front and rear running belt pulleys **62**, **66** are formed of cast aluminum. According to another embodiment, the front and rear running belt pulleys **62**, **66** are formed of a glass-filled nylon, for example, Grivory® GV-5H Black 9915 Nylon Copolymer available from EMS-GRIVORY of Sumter, S.C. 29151, which may save cost and reduce the weight of the pulleys **62**, **66** relative to metal pulleys. To prevent a static charge due to operation of the treadmill **10** from building on a pulley **62**, **66** formed of electrically insulative materials (e.g., plastic, composite, etc.), an antistatic additive, for example Antistat 10124 from Nexus Resin Group of Mystic, Conn. 06355, maybe may be blended with the GV-5H material.

As noted above, the manual treadmill disclosed herein includes a force translation system that incorporates a variety of innovations to translate the forward force created by the user into rotation of the running belt and permit the user to maintain a substantially static fore and aft position on the running belt while running. One of the ways to translate this force is to configure the running belt **16** to be more responsive to the force generated by the user. For example, by minimizing the friction between the running belt **16** and the other relevant components of the treadmill **10**, more of the force the user applies to the running belt **16** to propel themselves forward can be utilized to rotate the running belt **16**.

Another way to counteract the user-generated force and convert or translate it into rotational motion of the running belt **16** is to integrate a non-planar running surface, such as non-planar running surface **70**. Depending on the configuration, non-planar running surfaces can provide a number of advantages. First, the shape of the non-planar running surface may be such that, when a user is on the running surface, the force of gravity acting upon the weight of the user's body helps rotate the running belt. Second, the shapes may be such that it creates a physical barrier to restrict or prevent the user from propelling themselves off the front end **20** of the treadmill **10** (e.g., acting essentially as a stop when the user positions their foot thereagainst, etc.). Third, the shapes of some of the non-planar running surfaces can be such that it facilitates the movement of the running belt **16** there along (e.g., because of the curvature, etc). Accordingly, the force the user applies to the running belt is more readily able to be translated into rotation of the running belt **16**.

As seen in FIGS. **1** and **4-5**, the running surface **70** is generally non-planar and shown shaped as a substantially complex curve according to an exemplary embodiment. The running surface can be generally divided up into three general

regions each having a particular geometric configuration, the front portion **72**, which is adjacent to the front shaft assembly **44**, the rear portion **74**, which is adjacent to the rear shaft assembly **46**, and the central portion **76**, which is intermediate the front portion **72** and the rear portion **74**. In the exemplary embodiment seen in FIGS. **1** and **4**, the running surface **70** includes a substantially concave curve **80** and a substantially convex curve **82**. At the front portion **72** of the running surface **70**, the relative height or distance of the running surface **70** relative to the ground is generally increasing moving forward along the longitudinal axis **18** from the central portion **76** toward the front shaft assembly **44**. This increasing height configuration provides one structure to translate the forward running force generated by the user into rotation of the running belt **16**. To initiate the rotation of the running belt **16**, the user places her first foot at some point along the upwardly-inclined front portion **72** of the running surface **70**. As the weight of the user is transferred to this first foot, gravity exerts a downward force on the user's foot and causes the running belt **16** to move (e.g., rotate, revolve, advance, etc.) in a generally clockwise direction as seen in FIG. **1** (or counter-clockwise as seen in FIG. **4**). As the running belt **16** rotates, the user's first foot will eventually reach the lowest point in the non-planar running surface **70** found in the central portion **76**, and, at that point, gravity is substantially no longer available as a counteracting source to the user's forward running force. Assuming a typical gait, at this point the user will place her second foot at some point along the upwardly-inclined front portion **72** of the running belt **16** and begin to transfer weight to this foot. Once again, as weight shifts to this second foot, gravity acts on the user's foot to continue the rotation of the running belt **16** in the clockwise direction as seen in FIG. **1**. This process merely repeats itself each and every time the user places her weight-bearing foot on the running belt **16** at any position vertically above the lowest point of central portion **76** of the running surface **70** of the of the running belt **16**. The upwardly-inclined front portion **72** of the running belt **16** also acts substantially as a physical stop, reducing the chance the user can inadvertently step off the front end **20** of the treadmill **10**.

A user can generally utilize the force translation system of the treadmill **10** to control the speed of the treadmill **10** by the relative placement of her weight-bearing foot along the running belt **16** of the base **12**. Generally, the rotational speed of the running belt **16** increases as greater force is applied thereto in the rearward direction. The generally upward-inclined shape of the front portion **72** thus provides an opportunity to increase the force applied to the running belt **16**, and, consequently, to increase the speed of the running belt **16**. For example, by increasing her stride and/or positioning her weight-bearing foot vertically higher on the front portion **72** relative to the lowest portion of the running belt **16**, gravity will exert a greater and greater amount of force on the running belt **16** to drive it rearwardly. In the configuration of the running belt **16** seen in FIG. **1**, this corresponds to the user positioning her foot closer to the front end **20** of the treadmill **10** along the longitudinal axis **18**. This results in the user applying more force to the running belt **16** because gravity is pulling her mass downward along a greater distance when her feet are in contact with the front portion **72** of the running surface **70**. As a result, the relative rotational speed of the running belt **16** and the relative running speed the user experiences is increased. Accordingly, the force translation system is adapted to convert a variable level of force generated by the user into a variable speed of rotation of the belt.

FIG. **5** illustrates a number of possible locations where a user may position her feet. A-C indicate locations along the front portion **72** of the running surface **70** where a user may place their weight bearing foot. When the user positions her weight bearing foot at location A, she will be running with greater speed than if her weight bearing foot was positioned at locations B or C based upon the fact that the force of gravity is able to have a greater effect as the user's weight bearing foot moves from location A towards the rear of the non-planar running surface **70** as the running belt **16** rotates. At location A, gravity is able to have the greatest impact on the user so that the greatest amount of force is translated into rotation of the running belt **16**. A user can decrease her relative running speed by positioning her weight bearing foot at locations B or C. As location B is relatively higher along the front portion **72** than C, gravity is able to exert a greater force on the user and the running belt **16** than if the user's weight bearing foot was positioned at location C.

Another factor which will increase the speed the user experiences on the treadmill **10** is the relative cadence the user assumes. As the user increases her cadence and places her weight-bearing foot more frequently on the upwardly extending front portion **72**, more gravitational force is available to counteract the user-generated force, which translates into greater running speed for the user on the running belt **16**. It is important to note that speed changes in this embodiment are substantially fluid, substantially instantaneous, and do not require a user to operate electromechanical speed controls. The speed controls in this embodiment are generally the user's cadence and relative position of her weight-bearing foot on the running surface. In addition, the user's speed is not limited by speed settings as with a driven treadmill.

In the embodiment shown in FIGS. **1-6**, gravity is also utilized as a means for slowing the rotational speed of the running belt. At a rear portion **74** of the running surface **70**, the distance of the running surface **70** relative to the ground generally increases moving rearward along the longitudinal axis **18** from the lowest point in the non-planar running surface **70**. As each of the user's feet move rearward during her stride, the rear portion **74** acts substantially as a physical stop to discourage the user from moving too close to the rear end of the running surface. To this point, the user's foot has been gathering rearward momentum while moving from the front portion **72**, into the central portion **76**, and toward the rear portion **74** of the running surface **70**. Accordingly, the user's foot is exerting a significant rearwardly-directed force on the running belt **16**. Under Newton's first law of motion, the user's foot would like to continue in the generally rearward direction. The upwardly-inclined rear portion **74**, interferes with this momentum and provides a force to counter the rearwardly-directed force of the user's foot by providing a physical barrier. As the user's non-leading foot moves up the incline (see position D in FIG. **5**), the running surface **70** provides a force that counters the force of the user's foot, absorbing some of the rearwardly-directed force from the user and preventing it from being translated into increasing speed of the running belt **16**. Also, gravity acts on the user's weight bearing foot as it moves upward, exerting a downwardly-directed force on the user's foot that the user must counter to lift their foot and bring it forward to continue running. In addition to acting as a stop, the rear portion **74** provides a convenient surface for the user to push off of when propelling themselves forward, the force applied by the user to the rear portion **74** being countered by the force the rear portion **74** applies to the user's foot.

One benefit of the manual treadmill according to the innovations described herein is positive environmental impact. A manual treadmill such as that disclosed herein does not utilize electrical power to operate the treadmill or generate the rota-

tional force on the running belt. Therefore, such a treadmill can be utilized in areas distant from an electrical power source, conserve electrical power for other uses or applications, or otherwise reduce the "carbon footprint" associated with the operation of the treadmill **10**.

A manual treadmill according to the innovations disclosed herein can incorporate one of a variety of shapes and complex contours in order to translate the user's forward force into rotation of the running belt or to provide some other beneficial feature or element. FIG. **7***a* generally depicts the curve defined by the running surface **70** of the exemplary embodiment shown in FIG. **1**, specifically, substantially a portion of a curve defined by a third-order polynomial. The front portion **72** and the central portion **76** define a concave curve and the rear portion **74** of the running surface **70** defines a convex curve. As the central portion **76** of the running surface **70** transitions to the rear portion **74**, the concave curve transitions to the convex curve. In the embodiment shown, the curvature of the front portion **72** and the central portion **76** is substantially the same; however, according to other exemplary embodiments, the curvature of the front portion **72** and the central portion **76** may differ. Please note, the description of the running surfaces as concave and convex provided herein is related to the relative curve which the user's foot would experience on the running surface **70**.

FIGS. **7***b*-**7***h* illustrate the side profiles of some exemplary non-planar, contoured running surfaces according to the innovations disclosed herein, each including a front portion, a central portion, and a rear portion. Each portion has a particular geometric configuration that is concave, convex, or linear; collectively, the portions define the non-planar running surface. For example, FIG. **7***b* shows an exemplary embodiment of the profile of a non-planar surface including a concave front portion **100**, a concave central portion **102**, and a concave rear portion **104** according to an exemplary embodiment. In this embodiment, the front portion **100**, central portion **102**, and rear portion **104** each have different curvatures. According to other exemplary embodiments, one or more of the front, central, and rear portions may have the same curvature.

FIG. **7***c* shows an exemplary embodiment of the profile of a non-planar surface including a convex front portion **110**, a concave central portion **112**, and a concave rear portion **114** according to an exemplary embodiment. Once again, this embodiment incorporates a smooth transition between the different curvatures of the front, central, and rear portions.

FIG. **7***d* shows an exemplary embodiment of the profile of a non-planar surface including a convex front portion **120**, a concave central portion **122**, and a convex rear portion **124** according to an exemplary embodiment. In this embodiment, the front portion **120** and the rear portion **122** have different curvatures, but these curvatures may be the same according to other exemplary embodiments.

FIG. **7***e* shows an exemplary embodiment of the profile of a non-planar surface including a convex front portion **130**, a convex central portion **132**, and a convex rear portion **134** according to an exemplary embodiment. In this embodiment, the front portion **130**, the central portion **132**, and the rear portion **134** each have the same convex curvature, but the curvature of one of more of the front portion **130**, the central portion **132**, and the rear portion **134** may differ according to other exemplary embodiments.

FIG. **7***f* shows an exemplary embodiment of the profile of a non-planar surface including a concave front portion **140**, a convex central portion **142**, and a convex rear portion **144** according to an exemplary embodiment. In this embodiment, the central portion **142** and the rear portion **144** having the same curvatures, but these curvatures may differ from each other according to other exemplary embodiments.

FIG. **7***g* shows an exemplary embodiment of the profile of a non-planar surface including a convex front portion **150**, a convex central portion **152**, and a concave rear portion **154** according to an exemplary embodiment. In this embodiment, the front portion **150** and the central portion **152** having the same curvatures, but these curvatures may differ from each other according to other exemplary embodiments.

FIG. **7***h* shows an exemplary embodiment of the profile of a non-planar surface including a concave front portion **160**, a convex central portion **162**, and a concave rear portion **164** according to an exemplary embodiment. In this embodiment, the front portion **160** and the rear portion **164** have different curvatures, but these curvatures may be the same according to other exemplary embodiments.

According to one exemplary embodiment, the non-planar running surface of the manual treadmill **10** is substantially curved, but that curve integrates one or more linear portions (e.g., that replace a "curved portion" or the curve or that are added/inserted into the curve). The linear portions may be substantially parallel to the longitudinal axis **18** or disposed at an angle relative thereto. FIG. **7***i* illustrates the profile of a non-planar surface wherein a substantially linear portion **170** has been integrated with a concave curve having a first concave portion **174** to one side of the linear portion **170** and a second concave portion **176** to the opposite side of the linear portion **170** according to an exemplary embodiment. In addition to the linear portion **170**, the first concave portion **174** and the second concave portion **176**, the profile further includes a fourth portion shown as a convex portion **178**. According to an another exemplary embodiment, a linear portion may replace all or a portion of the curve. Alternatively, multiple linear portions may be included in a profile of a non-planar surface.

FIG. **7***j* illustrates a linear portion **180** provided at the front of the running surface which transitions into a concave curve **182** which then transitions into a convex curve **184**.

According to an exemplary embodiment, the non-planar running surface of the manual treadmill **10** may include (or be so defined as to include) more or less than three portions. For example, FIG. **7***g* could be interpreted as defined two portions, the first portion including the front portion and the central portion, which comprise a convex curve having the same curvature throughout the front portion **150** and the central portion **152**, and the second portion including the rear portion **154** which generally comprises a concave curve. According to some exemplary embodiments, some non-planar running surfaces include at least three or more portions.

According to an exemplary embodiment, the profile defined by the non-planar running surface is substantially a portion of a curve defined by any suitable second-order polynomial, but, as clearly demonstrated in FIGS. **7***a-j*, the profile defined by the non-planar running surface can be a portion of a curve that is a third-order polynomial or a fourth-order polynomial. According to yet another exemplary embodiment, the running surface profile can be substantially defined by a first-order polynomial, in other words, the running surface is substantially planar. An exemplary embodiment of a manual treadmill including a planar running surface will be discussed in more detail below (see e.g., FIG. **35**).

According to an exemplary embodiment, the relative length of each portion of the running surface may vary. In the exemplary embodiment shown, the central portion is the longest. In other exemplary embodiments, the rear portion may be the longest, the front portion may be shorter than the intermediate portion, or the front portion may be longer than

the rear portion, etc. It should be noted that the relative length may be evaluated based on the distance the portion extends along the longitudinal axis or as measured along the surface of the running belt itself. One of the benefits of integrating one or more of the various curves or contours into the running surface is that the contour of the running surface can be used to enhance or encourage a particular running style. For example, a curve integrated into the front portion of the running surface can encourage the runner to run on the balls of her feet rather than a having the heel strike the running belt **16** first. Similarly, the contour of the running surface can be configured to improve a user's running biomechanics and to address common running induced injuries (e.g., plantar fasciitis, shin splints, knee pain, etc.). For example, integrating a curved contour on the front portion of the running surface can help to stretch the tendons and ligaments of the foot and avoid the onset of plantar fasciitis.

One of the difficulties associated with using a running surface that has a non-planar shape is inducing the running belt **16** to assume the non-planar shape and then maintaining the running belt **16** in that non-planar shape when the treadmill is being operated. In addition to discussing this difficultly in more detail below, a number of running belt retention systems providing ways to induce and maintain a belt in a desired non-planar shape to define the running surface are discussed below. Generally, these running belt retention systems are adapted to control the relative contour of the running belt so that the running belt substantially follows the contour of the running surface

One embodiment of a running belt retention system used to induce the running belt **16** to take-on the non-planar shape and then maintaining that shape, as shown in FIG. **5**, is discussed in reference to FIGS. **5-6** and **8-11** in which base **12** is shown further including a pair of opposed bearing rails **200** to support the running belt **16** along with a front synchronizing belt pulley **202**, a rear synchronizing belt pulley **204**, and a synchronizing belt **206** all of which are interconnected to the running belt **16**. The front rear synchronizing belt pulleys **202**, **204** may be formed of the same or different materials as the front and rear running belt pulleys **62**, **66**.

Referring to FIGS. **6** and **8-9**, in particular, the bearing rails **200** are shown including a plurality of bearings **208** and an upper or top profile **210**, shown shaped as a complex curve, according to an exemplary embodiment. The bearing rails **200** shown are supported by and preferably mounted to the frame **40** substantially between the front shaft assembly **44** and the rear shaft assembly **46**, the support members or elements about which the running belt **16** is disposed. One bearing rail **200** is coupled to one or more of the cross-members **56** proximate to the inner surface **58** of the left-hand side member **52** and the other bearing rail **200** is coupled to one of more of the cross-members **56** proximate to the inner surface **58** of the right-hand side member **54** thereby fixing the position of the bearing rails **200** relative to the frame **40**.

The bearing rails **200** are preferably configured to facilitate movement of the running belt **16**. In the exemplary embodiment seen in FIGS. **8-9**, the running belt **16** moves substantially along the top profile **210** of the bearing rails **200**. The running belt **16** contacts and is supported in part by the bearings **208** of the bearing rails and bearing **208** are configured to rotate, thereby decreasing the friction experienced by the running belt **16** as the belt moves along the top profile **210**. The bearing rails **200** are configured to help achieve the desired shape of the running surface. The shape of the top profile **210** of the bearing rails **200** at least partially corresponds to the desired shape for the running surface **70**. The at least somewhat flexible running belt **16** substantially assumes the shape of top profile **210** of the bearing rails **200** by being maintained substantially thereagainst, as will be discussed in more detail later. Accordingly, the running surface **70** has a shape that substantially corresponds to the shape of the top profile **210** of the bearing rails **200**. It should be noted that the front and/or rear running belt pulleys may also help define a portion of the shape of the running surface. Also, other suitable shape-providing components may be used in combination with the bearing rails.

FIG. **9** provides a side view of one of the bearing rails **200** to more clearly show the top profile **210** according to an exemplary embodiment. Similar to the running surface **70**, discussed above, the top profile **210** of the bearing rails **200** can be generally divided up into three general regions, the front portion **212** which is adjacent to the front shaft assembly **44** (see e.g., FIG. **5**), the rear portion **214** which is adjacent to the rear shaft assembly **46** (see e.g., FIG. **5**), and the central portion **216**, intermediate the front portion **212** and the rear portions **214**. The central portion **216** is shown as a concave curve **218** that has a radius of curvature R**1**. The front portion **212** is further shown as a continuation of the concave curve **218** of the central portion **216**, and, thus, also has a radius of curvature of R**1**. The rear portion **214** is shown as a convex curve **220** that has a radius of curvature R**2**. The front portion **212** is shown disposed substantially tangential to the central portion **216**, providing a smooth transition therebetween, and helping provide a smooth shape for the running surface **70**. The shape of the rear portion **214** also helps provide a smooth transition for the running belt **16** from the bearing rails **200** onto the rear running belt pulleys **66**, which helps ensure as much contact as possible between the running belt **16** and the rear running belt pulleys **66**. As the shape of the running surface substantially corresponds to the shape of top profile the bearing rails, the shape of the top profile of the bearing rails can necessarily be any of the shapes and/or have any of the variations (e.g., in length of portions, etc.) discussed above in FIGS. **7***a* through **7***j* with reference to possible shapes of the running surface.

According to an exemplary embodiment, each portion of the top profile is disposed substantially tangential to the portions adjacent thereto. According to other exemplary embodiments, less than all of the adjacent portions are disposed substantially tangential to the portions adjacent thereto, meaning the profile does not have an entirely smooth contour.

According to an exemplary embodiment shown in FIG. **9**, R**1** is approximately 7.26 feet. However, it is understood that a radius anywhere from 5 feet to 100-plus feet can be used. The size of the radius which can be used is typically a function of the length of the treadmill which can be accommodated. The range of possible radiuses for a convex bearing rail depends on the shaft-to-shaft distance of the treadmill (see e.g., measurement "x" in FIG. **5**, discussed in more detail below). Assuming that the radius of curvature of the curve is $R_C$, the radius of the front running belt pulley is $R_f$, and the radius of the rear running belt pulley is $R_r$, the range of possible radiuses is approximately: $\infty > R_C > (x - R_f - R_r)/2$. For most commercial-available treadmills, x is approximately between 14 inches and 10 feet but the treadmill can certainly be as great as 25 feet in length. According to the exemplary embodiment shown in FIG. **5**, x is approximately 57.8 inches in length. According to another exemplary embodiment, x is approximately 77.2 inches in length, with a radius R**1** of approximately 8.67 feet, wherein the greater length x and radius R**1** may facilitate use of the treadmill **10** by users with a longer running gait. The limiting factors in the length are the available space to accommodate the treadmill and the relative cost of constructing such a large treadmill.

When the treadmill **10** is being operated, the running belt **16** is driven rearwardly and the goal is to ensure that the running belt **16** follows the profile defined by a portion of the circumference of the front running pulleys **62**, the contoured profile defined by the bearings **208** supported on the bearing rails **200** and finally by a portion of the circumference of the rear running belt pulleys **66**. The particular contour which the running belt **16** assumes on the bottom of the base **12** between the rear running belt pulleys **66** and front running belt pulleys **62** is not terribly critical provided that the running belt continues to move with minimal friction and is not subject to excessive wear or obstruction.

Following the shape of the bearing rails **200** is not the natural tendency of the running belt for the particular contour seen in FIG. **5**. Rather, without more, the running belt **16** tends to be pulled upward, away from the curved bearing rails and across the central portion **76** of the treadmill **10**. Under the force of gravity, the weight of the running belt **16** coupled with the relative spacing between the front and rear running belt pulleys **62** and **66**, respectively, would likely result in the top surface of the running belt **16** assuming a position of the shortest distance between the two pulleys, namely, a substantially straight line between the two pulleys with any excess length of the running belt **16** collecting on the bottom of the treadmill and hanging below the front and rear running belt pulleys **62** and **66**, respectively. Therefore, a system of some sort needs to be integrated into a non-planar running surface treadmill to ensure that the running belt **16** follows the desired contour over the running surface.

Further referring to FIGS. **5-6** and **8-11**, one way to ensure that the running belt **16** follows the contour of the bearing rails **200** and the front and rear running belt pulleys **62**, **66** is to utilize the weight of the running belt **16** itself in addition to adjusting the relative size of the front and rear running belt pulleys **62**, **66**; and/or providing a synchronizing system **222** according to an exemplary embodiment.

As discussed above, the running belt **16** is disposed about the front and rear running belt pulleys **62**, **66** which in turn are disposed about front and rear shafts **64**, **68**, respectively. Measured along the longitudinal axis **18** between the centerlines of the front and rear shafts **64**, **68**, the front and rear shafts **64**, **68** are spaced a distance x from each other, as shown in FIG. **5**. Accordingly, when positioning the running belt **16** about the front and rear running belt pulleys **62**, **66**, the length of the running belt **16** provided therebetween must be at least x (e.g., the straight-line distance therebetween). It follows that, when the profile of the running surface **70** is non-planar, the length of the running belt provided between the front and rear shafts **64**, **68** will be greater than x.

In the exemplary embodiment shown in FIG. **5**, when positioning the running belt **16** about the front and rear running belt pulleys **62**, **66**, a length of the running belt **16** sufficient to permit the running belt **16** to correspond to (e.g., follow, be positioned against or above, etc.) the desired contours of the bearing rails **200** and the front and rear running belt pulleys **62**, **66** is generally disposed between the front and rear shafts **64**, **68**. At each location between the front and rear shafts **64**, **68**, the force of gravity pulls downward on the running belt **16**. Generally, this force will help pull the running belt **16** downward and against the desired components of base **12**. However, gravity can also cause slippage (e.g., over the front running belt pulley **62**, over the rear running belt pulley **66**, down along curves of the bearing rail **200**, etc.) in an amount that is undesirable and the magnitude of these slippage-problems tends to increase when the treadmill **10** is being operated. Accordingly, the solution typically relies on more than the weight of the running belt alone.

Further referring to FIGS. **5-6** and **8-11**, the preferred embodiment of the running belt **16** is shown including two reinforcing belts shown as endless belts **226** and a plurality of slats **228** according to an exemplary embodiment. The endless belts **226** are configured to provide support for the running belt **16** in order to support the weight of a user. The endless belts **226** are shown disposed on opposite sides of the running belt **16**, generally interior to the outer, lateral edge of the slats **228**. The endless belts **226** are themselves reinforced, and thus help stabilize the sides of the running belt and help prevent stretching of the running belt **16**. For example, the endless belts may be reinforced with metal wiring, which is surrounded by a molded plastic coating. According to some exemplary embodiments, more or less than two endless belts may be used. According to other exemplary embodiments, other suitable support elements may be used to provide support for the running belt. Further details regarding the structure of the running belt and endless belt structure are seen in U.S. Pat. No. 5,470,293, titled "Toothed-Belt, V-Belt, and Pulley Assembly, for Treadmills," which is incorporated by reference herein.

The endless belts **226** are further configured to interact with the front running belt pulleys **62** and the rear running belt pulleys **66**. The location of each endless belt **226** laterally, along the width of the running belt **16**, substantially corresponds to the location of a longitudinally aligned front running belt pulley **62** and rear running belt pulley **66**. Each endless belt **226** includes a first or inner portion **230** and a second or outer portion **232** at an interior surface **236** according to an exemplary embodiment. The inner portion **230** is in contact with an exterior surface **234** of the corresponding running belt pulleys **62**, **66**. According to some exemplary embodiments, the outer portion **232** is also in contact with the exterior surface **234** of the corresponding running belt pulleys **62**, **66**.

FIG. **12** illustrates a running belt and running belt pulley combination wherein the exterior surfaces **234** of the front running belt pulleys **62** are substantially smooth and are in contact with the interior surface **236** of the endless belts **226**, which is also substantially smooth according to an exemplary embodiment. The outer portion **232** is shown substantially not in contact with the exterior surfaces **234** of the front running belt pulleys **62**. The outer portion **232** is further shown including a plurality of teeth **238** (e.g., being toothed); however, according to other exemplary embodiments, the outer portion may be smooth or have any suitable texture and/or configuration. In this embodiment, both of the running belt pulleys come in contact with the inner, substantially smooth portion of the endless belts, and a toothed portion of the endless belts is disposed to the outside of the running belt pulleys on both sides.

FIG. **13** illustrates an alternative running belt and running belt pulley combination according to an exemplary embodiment. In this exemplary embodiment, the front running belt pulleys **62'** include a first or inner portion **230'** and a second or outer portion **232'**. The inner portion **230'** of the front running belt pulleys **62'** is substantially smooth, while the outer portion **232'** includes a plurality of teeth, to correspond to the inner and outer portions **230'**, **232'**, of the endless belts **226'**, respectively. In this embodiment, both of the running belt pulleys include an inner, smooth portion and an outer, toothed portion. These portions correspond to an inner, smooth portion of the endless belt and an outer, toothed portion of the endless belt. This endless belt/front running belt pulley configuration is discussed in more detail in U.S. Pat. No. 5,470,

293, titled "Toothed-Belt, V-Belt, and Pulley Assembly, for Treadmills," which is herein incorporated by reference in its entirety.

According to still another an exemplary embodiment, a combination of the endless belt/front running belt pulley configurations shown in FIGS. **12** and **13** is used. In this exemplary embodiment, the smooth belt and pulley configuration shown in FIG. **12** is used for the front running belt pulleys and the combination of smooth and toothed belt and pulley configuration shown in FIG. **13** is used for the rear running belt pulleys. In another exemplary embodiment, the configuration shown in FIG. **13** is used for the front running belt pulleys and the configuration shown in FIG. **12** is used for the rear running belt pulleys.

The slats **228** of the running belt **16** are configured to help support a user of the treadmill **10**. The slats **228** may be made of substantially any suitably sturdy material (e.g., wood, plastic, metal, etc.) and extend generally laterally between the endless belts **226**. Each slat **228** is coupled at its ends **252**, **254** to the second portions **232** of the endless belts **226** using fasteners. According to other exemplary embodiments, the slats may be otherwise coupled to the endless belts (e.g., adhered, welded, etc.) in the manner disclosed in U.S. Pat. No. 5,470,293, titled "Toothed-Belt, V-Belt, and Pulley Assembly, for Treadmills," which is incorporated herein by reference. Each slat is shown to include a portion **229** (e.g., stem, web, etc.) extending inwardly from an interior surface **256** of the slat **228**.

According to an exemplary embodiment, the running belt may be substantially any suitable, continuous loop element, including, but not limited to, a continuous urethane (e.g., polyurethane) loop, a continuous loop made of plastics other than polyurethane, a plastic belt reinforced with reinforcing elements (e.g., metal wire, a relatively harder plastic, wood, etc.), a continuous foam loop, a loop formed by a plurality of interconnected members (e.g., metallic members, wooden members, etc.) in a manner to provide at least some flexibility, etc.

Referring to FIGS. **6**, **10** and **11**, another aspect of the solution to ensuring the running belt **16** follows the desired contour involves the utilizing front running belt pulleys **62** that are slightly larger than the rear running belt pulleys **66**. That is, the radius of the front running belt pulleys, $R_f$, is greater than the radius of the rear running belt pulleys, $R_r$. Assuming the front running belt pulleys **62** are rotating with the same rotational velocity (e.g., angular speed) as the rear running belt pulleys **66**, the tangential velocity of the front running belt pulleys **62** is slightly greater than the tangential velocity of the rear running belt pulleys **66**. Thus, as the running belt **16** is driven, the portion of the running belt **16** disposed proximate the front end **20** of the treadmill **10** will be moved over the front running belt pulleys **62** and rearward with slightly greater speed than the rear running belt pulleys **66** move the portion of the running belt **16** proximate thereto. Thus, the front running belt pulleys **62** essentially "push" the running belt **16** rearward, creating a slight amount of excess running belt **16** in the area between the front running belt pulleys **62** and the rear running belt pulleys **66**, which helps to counter the force of gravity which would attempt to gather any excess length of running belt **16** on the bottom of the treadmill **10** thereby causing the top surface of the running belt **16** to assume a position of the shortest distance between the two pulleys, namely, a substantially straight line between the two pulleys. Obviously the system cannot tolerate too much excess length of running belt feeding off the front running belt pulley **62** so periodically, a portion of this excess running belt **16** will slip over the rear running belt pulley **66**. By specifically balancing the excess running belt **16** coming off the front running belt pulley **62** against the slippage allowed on the rear running belt pulley **66**, the running belt **16** will follow the desired concave, convex or linear (or combinations thereof) contours of the running surface.

If the difference between the radius of the front running belt pulleys **62** and the radius of the rear running belt pulleys **66** is too large, the running belt **16** will begin to bunch up atop the base **12** as too much excess is generated. Accordingly, there is a practical limit of differences between the radius of each of the front running belt pulleys **62** and the radius of each of the rear running belt pulleys **66**. Generally, this range may be dependent on the length of the running surface, as measured along the running belt, and/or the shape of the running surface. According to an exemplary embodiment, the size difference between the radii of the front and rear running belt pulleys, $R_f-R_r$, is within the range of approximately $0<R_f-R_r<0.100$ inches. Preferably, the size difference between the radii of the front and rear running belt pulleys, $R_f-R_r$, is within the range of approximately $0.005<R_f-R_r<0.035$ inches. In one embodiment, the radius of the front running belt pulleys is approximately 7.00"+/−0.010" and the radius of the rear running belt pulleys is approximately 6.985"+/−0.010. According to another exemplary embodiment, instead of using front and rear running belt pulleys having a radial size difference, the synchronizing belt pulleys may have a radial size difference. Similar to the differently sized front and rear running belt pulleys, the differently sized front and rear synchronizing pulleys would be used to essentially "push" the running belt rearward, creating a slight amount of excess running belt **16** in the area between the front running belt pulleys and the rear running belt pulleys.

Another means for ensuring that the running belt **16** follows the desired complex curve is to match the rotational velocity of the front running belt pulleys **62** to that of the rear running belt pulleys **66** utilizing a synchronizing system **222**. Further referring to FIGS. **5-6** and **8-11**, the synchronizing system **222** is shown generally to comprise the front synchronizing belt pulley **202**, the rear synchronizing belt pulley **204**, and the synchronizing belt **206** according to an exemplary embodiment.

The front synchronizing belt pulley **202** is rotatably mounted relative to the front shaft **64**, similar to the front running belt pulleys **62**. Preferably, the front synchronizing belt pulley **202** is securely mounted directly to the front shaft **64**. Similarly, the rear synchronizing belt pulley **204** is fixed relative to the rear shaft **68** and preferably securely mounted to the rear shaft **68**. Accordingly, the front synchronizing belt pulley **202** will move with substantially the same rotational speed as the front running belt pulleys **62**, and the rear synchronizing belt pulley **204** will move with the same rotational speed as the rear running belt pulleys **66**. When the front shaft assembly **44** and the rear shaft assembly **46** are coupled to the frame **40**, the front and rear synchronizing belt pulleys **202**, **204** are shown disposed exterior to the outer surface **60** of the left-hand side member **52**. According to another exemplary embodiment, the front and rear synchronizing belt pulleys may be placed exterior to the outer surface of the right-hand side member of the frame. According to other exemplary embodiments, the synchronizing system may be disposed substantially between the left-hand side member and the right-hand side member of the frame.

The synchronizing belt **206** is configured to provide a force that helps ensure that the front and rear shafts **64**, **68** are rotating (e.g., moving, spinning, etc.) at the same rotational velocity. The synchronizing belt **206** is shown as an endless belt that is adapted to be supported in tension about the front

synchronizing belt pulley **202** and the rear synchronizing belt pulley **204**, as shown in FIGS. **4-5**. As the running belt pulleys **62**, **66** and the synchronizing belt pulleys **202**, **204** are both substantially fixed relative to the front shaft **64** and the rear shaft **68**, the rotation of the front shaft **64** and the rear shaft **68** causes the front synchronizing belt pulley **202** and the rear synchronizing belt pulley **204** to similarly rotate. In response to the motion of the front synchronizing belt pulley **202** and the rear synchronizing belt pulley **204**, the synchronizing belt **206**, which connects the front shaft assembly **44** and the rear shaft assembly **46**, similarly rotates. Because of the tension in the synchronizing belt **206** and the fact that the synchronizing belt pulleys **202**, **204** are the same size, the synchronizing belt **206** provides a counter force in response to any deviation in rotational velocity between the front shaft assembly **44** and the rear shaft assembly **46**. For example, if the rear shaft assembly **46** was induced to start moving with greater rotational velocity than the front shaft assembly **44**, the tension in the upper portion of the synchronizing belt (i.e., that portion of the synchronizing belt that extends generally between the tops of the synchronizing pulleys) would resist any differential rotation between the front and rear synchronizing belt pulleys **202**, **204**. Continuing with the example, any discrepancy between the rotational velocity of the front and rear shafts **64**, **68** is similarly resisted by the engagement of the synchronizing belt **206**. Thus, by constraining the relative motion of the front shaft assembly **44** and the rear shaft assembly **46**, the synchronizing system **222** keeps their rotational velocity in sync, substantially preventing the front and rear running belt pulleys **62**, **66** from becoming unsynchronized and moving at different rotational velocities.

So, in practice, the running belt **16** is initially installed on the front and rear running belt pulleys **62**, **66** and the running belt **16** is manually positioned in the desired position so that a sufficient length of the running belt **16** is positioned along the top of the treadmill and the running belt **16** assumes the desired contour. While the running belt **16** is maintained in this position, the synchronizing belt **206** is mounted to the synchronizing belt pulleys **202**, **204** and once the synchronizing belt **206** is installed, it effectively resists differential rotation of the running belt pulleys **62**, **66** which could result in loss of the desired contour of the running belt **16**.

It should be noted that the tension in the synchronizing belt **206** also helps maintain the position of the synchronizing belt **206** relative to the synchronizing belt pulleys **202**, **204**. The tension helps enhance friction between an interior surface **244** of the synchronizing belt **206** and exterior surfaces **246** of the synchronizing belt pulleys **202**, **204**, making it less likely that the synchronizing belt **206** will slip relative to the synchronizing belt pulleys **202**, **204**.

One or more tensioning assemblies **248** may be provided to adjust the tension in the synchronizing belt **206** (see e.g., FIGS. **3** and **6** illustrating tensioning assemblies **248**). Tensioning assemblies **248** are configured to move portions of the synchronizing belt **206** relative to one another, stretching the synchronizing belt **206** and maintaining this stretch so that the synchronizing belt **206** can provide the necessary resistance to differential rotation of the front and rear running belt pulleys **62**, **66**. Alternatively, the tensioning assemblies **248** can be adjusted to release some of the tension in the synchronizing belt **206**. Releasing some of the tension may be desirable if the synchronizing belt **206** is too tight, causing excess friction between the synchronizing belt **206** that makes it too difficult to rotate the front and rear shaft assemblies **44**, **46** (e.g., greater than desired by the user, too great to function, etc.). The tensioning assemblies **248** are also used when the synchronizing belt **206** is being installed and removed. According to another exemplary embodiment, a single tensioning assembly is used in conjunction with one or more stationary idlers. According to still another exemplary embodiments, any devices or elements suitable for maintaining and/or adjusting the tension in the synchronizing belt may be used.

Referring to FIG. **14**, a synchronizing system **300** is shown according to another exemplary embodiment. The synchronizing system **300** would typically be used in lieu of the previously described synchronizing system **222**. In this next exemplary embodiment, the synchronizing system **300** is shown comprising a synchronizing shaft **302** mechanically connected at a first end **304** to a front gear **306** and at a second end **308** to a rear gear **310**. The front gear **306** is interconnected with, and preferably directly mounted and fixed relative to, the front shaft **64**, and the rear gear **310** is interconnected with, and preferably directly mounted and fixed relative to, the rear shaft **68**. Accordingly, the front gear **306** will move with substantially the same rotational speed as the front running belt pulleys **62**, and the rear gear **310** will move with the same rotational speed as the rear running belt pulleys **66**. When the front shaft assembly **44** and the rear shaft assembly **46** are coupled to the frame **40**, the front and rear gears **306**, **310** are shown disposed exterior to the outer surface **60** of the right-hand side member **54**. According to another exemplary embodiment, the front and rear gears **306**, **310** may be placed exterior to the outer surface of the left-hand side member of the frame. According to other exemplary embodiments, the synchronizing system may be disposed substantially between the left-hand side member and the right-hand side member of the frame.

The synchronizing shaft **302** is configured to provide a force that helps ensure that the front and rear shafts **64**, **68** are rotating (e.g., moving, spinning, etc.) at the same rotational velocity. The synchronizing shaft **302** is shown as an elongated, substantially cylindrical member that extends generally between the front shaft **64** and the rear shaft **68**. A first threaded portion **312** including a plurality of threads **314** is shown located at the first end **304** of the synchronizing shaft **302** and is configured to mesh with a plurality of teeth **316** of the front gear **306** that is fixed relative to the front shaft **64**. A second threaded portion **318** including a plurality of threads **320** is shown located at the second end **308** of the synchronizing shaft **302** and is configured to mesh with a plurality of teeth **322** of the rear gear **310** that is fixed relative to the rear shaft **68**.

The synchronizing shaft **302** rotates in response to the motion of the front gear **306** and the rear gear **310**. When the front shaft **64** and the rear shaft **68** rotate in response to the user driving the running belt **16**, the front gear **306** and the rear gear **310**, which are fixed relative to the front shaft **64** and the rear shaft **68**, respectively, similarly rotate. The front gear **306** meshes with and imparts rotational motion to the first threaded portion **312**, and, thereby, imparts rotational motion to the synchronizing shaft **302**. The rear gear **310** meshes with and imparts rotational motion to the second threaded portion **318**, and, thereby, imparts rotational motion to the synchronizing shaft **302**.

Because the synchronizing shaft **302** is rigid and the front and rear gears **306**, **310** are the same size, the synchronizing shaft **302** provides a counter force in response to any deviation in rotational velocity between the front shaft assembly **44** and the rear shaft assembly **46**. For example, if the rear shaft assembly **46** was induced to start moving with greater rotational velocity than the front shaft assembly **44**, the rear gear **310** would be prevented from moving with greater rotational velocity than the front gear **306** because of the synchronizing

shaft **302**. The second threaded portion **318** is meshed with the rear gear **310**. The second threaded portion **318** is fixed relative to the first threaded portion **312**. The first threaded portion **312** is meshed with the front gear **306**, which is moving with less rotational velocity than the rear gear **310**. The front gear **306**, being fixed relative to the front shaft assembly **44** which is also traveling at the same rotational velocity, seeks to continue at this rotational velocity. Thus, the force transmitted to the front gear **306** from the rear gear **310** by the synchronizing shaft **302** is met with a counter force. Specifically, the teeth **322** of the front gear **306** counter the force applied thereto by the threads **314** of the first threaded portion **312** at the first end **304**. This counter force substantially prevents the rotational velocity of the synchronizing shaft **302**, which includes the second threaded portion **318**, from increasing. Stated otherwise, the force applied is sufficient to prevent the second end **308** of the synchronizing shaft **302** from rotationally advancing ahead of the first end **304**. As the second threaded portion **318** is prevented from experiencing an increase in rotational velocity, the second threaded portion **318** provides a counter force to the rear gear **310**. Specifically, the threads **320** of the second threaded portion **318** counter the force applied thereto by the teeth **322** of the rear gear **310**. Thus, the synchronizing shaft **302** constrains the relative motion of the front gear **306** and rear gear **310**, and, thereby constrains the relative motion of the front shaft assembly **44** and the rear shaft assembly **46**.

Another embodiment of a running belt retention system used to induce and maintain the running belt in a desired non-planar shape to define the running surface is seen in FIG. **15**, specifically a braking system **400** configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface is shown according to an exemplary embodiment. Please note, the section lines **15-15** shown in FIG. **4** do not necessarily suggest that the braking system **400** seen in FIG. **15** is integrated into the manual treadmill depicted in FIG. **4**, rather, the section line **15-15** is included in FIG. **4** to show one potential location for the integration of a braking system into a manual treadmill according to the various innovations disclosed herein. The braking system **400** is shown in cooperation with the rear shaft assembly **402** and the synchronizing system **222**. The rear shaft assembly **402** differs from the above-discussed rear shaft assembly **46** in that the rear shaft assembly **402** includes a pair of rear running belt pulleys **404** that are substantially the same size as the front running belt pulleys (not shown).

The braking system **400** has substantially the same effect as the differently sized front and rear running belt pulleys discussed above. That is, the braking system **400** causes a slight amount of excess running belt **16** in the area between the front running belt pulleys and the rear running belt pulleys. More specifically, the braking system **400** causes the rotational velocity of the rear shaft assembly **402** to be slightly lower than the rotational velocity of the front shaft assembly by applying a frictional force to the rear synchronizing belt pulley **204**. Thus, the braking system **400** acts on the synchronizing system **222** to force (e.g., urge, push, move, etc.) the rear shaft assembly **402** out of synch with the front shaft assembly.

The braking system **400** includes a generally elongated member **406** in cooperation with the synchronizing system **222**. The elongated member **406** is coupled to the rear shaft assembly **402** by a bracket **408** having a first side **410** spaced a distance apart from an outer surface **250** of the rear synchronizing belt pulley **204**. The elongated member **406** is disposed through an aperture **412** of the bracket **408** and includes a first end **414** disposed to the inside of the first side **410** and a second end **416** disposed to the outside of the first side **410**. The first end **414** includes a surface **418** configured to contact the outer surface **250** of the rear synchronizing belt pulley **204**. The second end **416** includes a knob **420** configured to be gripped by a person (e.g., a user, a trainer, etc.) and to have a rotational force imparted thereto. An exterior surface of the elongated member **406** is at least partially threaded to correspond to threading at an interior surface defining the aperture **412**. Rotating the knob **420**, and, thereby, the elongated member **406**, in one direction, causes the surface **418** to be advanced toward the outer surface **250** of the rear synchronizing belt pulley **204**, and rotating the knob **420** in the opposite direction causes the surface **418** to retreat or be moved away from the outer surface **250** of the rear synchronizing belt pulley **204**.

During operation of the treadmill, the surface **418** of the elongated member **406** is substantially in contact with the outer surface **250** of the rear synchronizing belt pulley **204**, creating friction therebetween. As the rear synchronizing belt pulley **204** of the synchronizing system **222** is fixed relative to the rear shaft assembly **402**, some of the force directed to the rear shaft assembly **402** to impart rotation thereto must be used to overcome the frictional force between the surface **418** of the elongated member **406** and the outer surface of the rear synchronizing belt pulley **204**. As the force needed to overcome the frictional force between the surface **418** of the elongated member **406** and the outer surface **250** of the rear synchronizing belt pulley **204** is no longer being directed into rotation of the rear shaft assembly **402**, the rotational velocity of the rear shaft assembly **402** is less than the rotational velocity of the front shaft assembly. Thus, the front running belt pulleys of the front shaft assembly will "push" the running belt rearward, creating a slight amount of excess running belt **16** in the area between the front running belt pulleys and the rear running belt pulleys. This excess length of running belt **16** helps to counter the force of gravity, discussed in more detail above. It should be noted that, because the friction between the surface **418** of the elongated member **406** and the outer surface **250** of the rear synchronizing belt pulley **204** is substantially constant during operation, the rotational velocity will be substantially maintained at the lower rotational velocity.

The length of excess running belt "pushed" rearward by the front running belt pulleys can be varied by adjusting the position of the surface **418** relative to the outer surface **250** of the rear synchronizing belt pulley **204**. If one moves the surface **418** laterally closer to the outer surface **250**, the friction therebetween will increase, the differential between the rotational velocity of the rear shaft assembly and the front shaft assembly will increase, and the length of the excess will increase. If one moves the surface **418** away from the outer surface **250**, the friction therebetween will decrease (or be removed if they are brought out of contact), the differential between the rotational velocity of the rear shaft assembly and the front shaft assembly will decrease, and the length of the excess will decrease.

According to another exemplary embodiment, the braking system **400** may be used with front and rear running belt pulleys that have a size differential. In such an embodiment, the braking system **400** would be used to fine tune the length of excess running belt pushed rearward with each rotation of the front and rear running belt pulleys.

FIG. **16** illustrates another exemplary embodiment of a braking system, shown as braking system **500**, configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface. Please note, the section lines **16-16** shown in FIG. **4** do not necessarily suggest

that the braking system **500** seen in FIG. **16** is integrated into the manual treadmill depicted in FIG. **4**, rather, the section line **16-16** is included in FIG. **4** to show one potential location for the integration of a braking system into a manual treadmill according to the various innovations disclosed herein. The braking system **500** includes a pulley **502** mounted to a rear shaft assembly **504** generally opposite a front shaft assembly, both shaft assemblies having running belt pulleys that are substantially the same size. A belt **506** rotationally couples the pulley **502** to an idler pulley **508**. The idler pulley **508** is configured to be adjustable so that it may be moved towards or away from the pulley **502** along an axis generally parallel to the longitudinal axis **18**. Though, it should be noted that the idler pulley may be moved relative to the pulley **502** mounted to the rear shaft assembly along an axis other than one generally parallel to the longitudinal axis **18**.

By adjusting the position of the idler pulley **508** relative to the pulley **502**, one can adjust the friction between the belt **506** and the pulleys **502**, **508**. Moving the idler pulley **508** away from the pulley **502**, increases the tension in the belt **506**, and, accordingly, increases the friction between the belt **506** and the pulleys **502**, **508**. Moving the idler pulley **508** toward the pulley **502**, decreases the tension in the belt **506**, and, accordingly, decreases the friction between the belt **506** and the pulleys **502**, **508**.

Similar to the discussion of braking system **400**, increasing the friction between the belt **506** and the pulleys **502**, **508**, increases the differential between the rotation of the rear shaft assembly to which the braking system **500** is coupled and the front shaft assembly. As a corollary, decreasing the friction between the belt **506** and the pulleys **502**, **508**, decreases the differential between the rotational velocity of the rear shaft assembly **504** and the front shaft assembly. As discussed above, the greater the differential, the greater the length of the excess that the front running belt pulleys push rearward.

FIG. **17** illustrates another exemplary embodiment of a running belt retention system of the treadmill **10** used to help induce and maintain the running belt in a desired non-planar shape to define the running surface. The treadmill **10** is shown including a plurality of rollers **600** used to support the running belt **16** in place of bearing rails **200**, discussed above.

The each roller **600** is shown extending laterally generally between the left-hand side member **52** and the right-hand side member **54** of the frame **40**. Along the longitudinal axis **18**, the rollers **600** are disposed adjacent to one another generally between one or more front running belt pulleys **604** and one or more rear running belt pulleys **606**. Typically, the running belt used with this exemplary embodiment is a continuous polymer belt without slats; the use of a continuous polymer belt having greater flexibility in the lateral direction than running belt **16** improves the ease of movement of the running belt along the rollers **600**. However, other suitable continuous belts may be used according to other exemplary embodiment

In the exemplary embodiment shown, the one or more front running belt pulleys is shown as a single, front running belt pulley **604** that is substantially a large roller, disposed at the front end **48** of the frame **40**. Similarly, the one or more rear running belt pulleys is shown as a single, rear running belt pulley **606** that is a substantially a large roller, disposed at the rear portion of the frame **40**. According to other exemplary embodiments, any multiple of running pulleys may be used at one or both of the front end and the rear end, such as front running belt pulleys **62**.

Collectively, the rollers **600** define a top profile **608** similar to the top profile **210** defined by the bearing rails **200**, discussed above, and provide for a running belt to move therealong. Similar to the top profile of the bearing rails, the top profile **608** defined by the rollers may be varied (e.g., may include a convex portion and a concave portion, may be modeled by a third-order polynomial, may be modeled by a fourth-order polynomial, etc.).

The front and rear running belt pulleys **604**, **606** and the rollers **600** help define the running surface. In use, the running belt is disposed over the front running belt pulley **604**, along the top profile **602** defined by the rollers **600**, and over the rear running belt pulley **606**. The running belt is maintained in a position substantially along these elements primarily by the weight of the running belt; however, according to other exemplary embodiments, a synchronizing system may also be used to ensure that the running belt is maintained in the desired position.

Referring to FIGS. **18-21**, an embodiment of a running belt retention system including a track system **700** and configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface according to an exemplary embodiment.

A treadmill according to this exemplary embodiment does not include front and rear shaft assemblies or bearing rails, but, rather, includes a pair of opposed tracks **702** configured to provide for movement of a running belt **16** therealong. The tracks **702** are spaced apart, generally define the path that the running belt **16** will travel, and substantially replicate at least a portion of the running surface. Each track **702** includes a side support wall **708** and a guide portion **710** generally centrally-disposed along the side support wall **708**. The guide portion **710** extends from an inner side **712** of the side support wall **708** towards the interior of the treadmill frame, defined generally between the left-hand side member and the right-hand side member. The guide portion **710** generally defines the contour of the running surface that is defined by the running belt **16** when coupled to the tracks **702**. An outer side **714** each side support wall **708** is disposed substantially adjacent to an inner surface of one of the side members of the treadmill frame.

A plurality of roller or wheel assemblies **716** are connected with, preferably mounted directly to or integral with, each of a plurality of slats **228** of the running belt **16**. Each a laterally-oriented slat **228** includes a left-hand end **252** generally opposite a right-hand end **254**. One of a plurality of wheel assemblies **716** is coupled at each end **252**, **254** of each slat **228** at an interior surface **256**. The wheel assemblies **716** are configured to be mated with the tracks **702** and provide for motion of the running belt **16** along the tracks **702**.

Each wheel assembly **716** is shown including first roller or wheel **720** and a second roller or wheel **722** rotatably coupled to a support shown as an elongated connecting member **724**. The connecting member **724** connects each wheel assembly **716** to a slat **228** and maintains the relative position of the first wheel **720** and the second wheel **722**. When coupled to the track **702**, the first wheel **720** of a wheel assembly **716** is disposed to one side the guide portion **710** and rotatably movable therealong, and the second wheel **722** of the wheel assembly **716** is disposed generally opposite the first wheel **720** to the other side of the central guide portion **710**.

The wheels **720**, **722** and the tracks **702** are shaped such that when they are mated, the wheels **720**, **722** cannot be pulled inwardly off of or pushed outwardly off of the track **702**. In the exemplary embodiment shown, the guide portion **710** is shown having a substantially-circular cross section **724** and the wheels **720**, **722** are shown having circumferentially-disposed arcuate depressions **726** that receive and travel along an outer curved portion **728** and an inner curved portion **730** of the guide portion **710** of the track **702**. According to other exemplary embodiments, the wheels and the track guide

portion can have substantially any corresponding shapes that provide for the wheels and the track to mate and that provide for movement of the wheels therealong.

When the running belt **16** is being driven by a user, the interaction of the guide portion **710** and the first and second wheels **720**, **722** helps maintain the belt in the desired non-planar shape. As mentioned above, the tracks **702** generally defines the contour of the running surface defined by the running belt **16**. Being coupled to the guide portion **710** of the track **702**, each wheel assembly **716** rotates about the track **702**, following the contour defined thereby.

If the running belt **16** began to deviate from the desired path, the interaction between the wheels **720**, **722** and the guide portion **710** would substantially prevent undesirable shifting. While being rotatably coupled to the elongated connecting member **724**, the axes **732** and **734** of the first wheel **720** and second wheel **722**, respectively, are a fixed distance apart. Further, the arcuate depressions **726** of the wheels **720**, **722** are in contact with the outer curved portion **728** and inner curved portion **730**, respectively. Thus, as a result the interactions between the arcuate depressions **726** and the curved portions **728**, **730**, any movement of a wheel assembly **716** relative to the track **702** other than along the path defined by the track **702** is countered by a force from the guide portion **710**. It should also be noted that the interactions between the depressions **726** of adjacent wheel assemblies **716** and the curved portions **728**, **730** of the track **702** may also help keep a wheel assembly **716** in place.

Referring to FIGS. **22-24**, the treadmill **10** is shown including another exemplary embodiment of a track system configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface, shown as a track system **800**. Similar to track system **700**, a treadmill according to this exemplary embodiment does not include front and rear shaft assemblies or bearing rails, but, rather, includes a pair of tracks **802** configured to provide for movement of a running belt **16** therealong. In this exemplary embodiment, each track **802** is shown as an elongated member having a substantially C-shaped cross section that defines a channel **804** having an opening **806** that faces the interior of the frame **40**. An outer wall **808** each of the tracks **802** is disposed substantially adjacent to an inner surface of a left-hand or right-hand side member **52**, **54** (shown, e.g., in FIG. **2**) such that the openings **806** face each other. The outer wall **808** is substantially opposite an inner wall **810**

As discussed above, the running belt **16** includes a plurality of laterally-oriented slats **228** each having a left-hand end **252** generally opposite a right-hand end **254**. One of a plurality of roller or wheel assemblies **812** is coupled at each end **252**, **254** of each slat **228** to mate with the tracks **802** and to provide for motion of the running belt **16** along the tracks **802**.

Each wheel assembly **812** is shown including a support shown as a mounting block **814** and a wheel **816** rotatably coupled to the mounting block **814**. The mounting block **814** mounted to an interior surface **256** of a slat **228**. The wheel **816** is supported relative to the mounting block **814** by an axis **818** that extends substantially parallel to the slats **228** to facilitate positioning the wheel **816** in the channel **804**. The wheel **816** is received in the channel **804** and is rotatably movable therewithin to facilitate travel of the running belt **16** along the contour defined by the channel **804**. The shape of the channel **804** generally corresponds to the shape of the wheel **816**.

When the running belt **16** is being driven by a user, the walls of the track **802** defining the C-shaped channel **804** help forcibly retain the wheel **816** therein, preventing the wheel from moving in any direction other than along the contour defined by the channel **804**, and, thereby, maintaining the running belt **16** in the desired non-planar shape to define the running surface. The outer wall **808** and the inner wall **810** limit the side-to-side, lateral movement of the wheel **816** when it is disposed in the channel **804**. Limiting the motion of the wheel **816**, similarly limits the motion of the wheel assembly **812** and the slat **228** fixed relative thereto. Further, a first wall **820** substantially opposite a second wall **822** substantially limits the up-and-down motion of the wheel **816** relative to the channel **804**. In circumstances where side-to-side and/or up-and-down motion of the wheel **816** occurs, the walls **808**, **810**, **820**, **822** defining the channel **804**, providing counter forces to maintain the wheel **816** in the desired position and help direct the wheel **816** along the desired path.

Referring to FIGS. **25-28**, the treadmill **10** is shown including still another exemplary embodiment of a track system configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface, shown as a track system **900**. Similar to track system **800**, the treadmill according to this exemplary embodiment does not include bearing rails, but, rather, includes a pair of tracks **902** configured to provide for movement of a running belt **16** therealong. In this exemplary embodiment, each track **902** is shown as an elongated member having a substantially C-shaped cross section that defines a channel **904** having an opening **906** that faces the exterior of the track **902**. Stated otherwise, each channels **904** extend about an outer periphery **908** of a tracks **902**.

As discussed above, the running belt **16** includes a plurality of laterally-oriented slats **228** each having a left-hand end **252** generally opposite a right-hand end **254**. One of a plurality of roller or wheel assemblies **910** is coupled at each end **252**, **254** of each slat **228** to mate with the tracks **902** and to provide for motion of the running belt **16** along the tracks **902**.

Each wheel assembly **910** is shown including a support shown as a connecting bar **912** that is substantially T-shaped and connected to a first wheel **914** and a second wheel **916**. A first portion **918** of the connecting bar **912** is fixed relative to the interior surface **256** of a slat **228**. A second portion **920** extends substantially perpendicular to the first portion **918** and away from the interior surface **256** of the slat **228**. The first wheel **914** and the second wheel **916** are connected to the connecting bar **912** by an axis **922** that extends generally parallel to the first portion **918** and perpendicular to the second portion **920** of the connecting bar **912**. The first wheel **914** is disposed to one side of the second portion **920** of the connecting bar **912** and the second wheel **916** is disposed opposite the first wheel **914** to the other side of the second portion **920**.

When the wheel assemblies **910** are mated with the tracks **902**, the second portion of the connecting bar **912** extends partially into the channel **904**, the first wheel **914** is received within a first portion **924** of the channel **904** and the second wheel **916** is disposed within a second portion **926** of the channel **904**. The first portion **924** of each channel **904** is disposed proximate to an outer surface **928** of the track **902** relative to the second portion **926**.

When the running belt **16** is being driven by a user, the first wheel **914** and the second wheel **916** of a given wheel assembly rotate within the channel **904**, facilitating moment of the running belt **16** in the path defined by the track **902**. As the running belt **16** is rotated, the slats **228** are disposed generally exterior to the periphery **908** of the track **902**. The walls of the track **902** defining the channel **904** help forcibly retain the wheels **914**, **916**. An outer wall **930** and an inner wall **932** limit the side-to side movement of the wheels **914**, **916**, either by coming into contact with the wheels **914**, **916** themselves

or by coming into contact with another part of the wheel assembly **910** (e.g., the connecting bar **912**). Limiting the motion of the wheels **914**, **916** and the wheel assembly **910** similarly limits the motion of the slat fixed relative thereto, helping each slat, and, thereby, the running belt **16** to follow the desired path. Further, a first wall **934** substantially opposite a second wall **936** substantially limits the up-and-down motion of the wheels **914**, **916** relative to the channel **904**. In circumstances where side-to-side and/or up-and-down motion of the wheel **916** occurs, the walls **930**, **932**, **934**, **936** defining the channel **904**, providing counter forces to maintain the wheels **914**, **916** in the desired position and help direct the wheels **914**, **916** along the desired path.

Referring to FIGS. **29-30**, the treadmill **10** is shown including another exemplary embodiment of a track system configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface, shown as a track system **1000**.

Instead of using wheel assemblies, such as **716** and **910**, discussed above, the treadmill according to this exemplary embodiment utilizes a plurality of magnets **1002** to maintain the running belt **16** in the desired position. One or more magnets **1002** are fixed relative to the interior surface **256** of the slats **228** at locations substantially corresponding to the position of a track **1004**, which is typically along the left-hand end **252** and the right-hand end **254** of the slats **228**. The magnets **1002** may be coupled by any variety of fasteners or fastening mechanisms. Generally, it is preferable that, when the magnets **1002** are fixed relative to the slats, the fasteners do not directly contact the periphery **1006** of the tracks **1004** to avoid scratching and damage thereto. While it is generally desirable to mount a magnet **1002** to each slat, **228**, the number of magnets used will vary depending upon a variety of factors such as the relative weight of the belt and the relative magnetic strength of each magnet.

The magnets **1002** are configured to magnetically couple the running belt **16** to the track **1004**, which is made of metal (e.g., steel) or includes a peripheral metal portion. The magnets **1002** have strength suitable to maintain the running belt **16** in close proximity to a periphery **1006** of the tracks **1004**.

When the treadmill is driven by a user, the force imparted to the running belt **16** is sufficient to permit the magnets to move relative bearing rails, but not to lose the magnetic connection therebetween. According to one exemplary embodiment, as the running belt **16** moves relative to the track **1004**, the magnets **1002** are generally spaced a small distance from the periphery **1006** of the track **1004**, helping to further reduce the noise associated with operation of the treadmill. According to other exemplary embodiments, the magnets **1002** are in physical contact with the periphery **1006** of the track **1004** in addition to being magnetically coupled thereto.

According to an exemplary embodiment similar to track system **1000**, a plurality of magnets may be positioned on the frame, track, or other fixed component of the treadmill base to apply a downwardly-directed force to the metal slats of the running belt as it passes over the magnets. For example, the magnets may be positioned on the cross-members **56**. As the running belt rotates, the portion passing above the magnets will be drawn downward by the force of the magnets, helping maintain that portion of the running belt (i.e., defining the running surface) in the desired shape.

Referring to FIGS. **31-34**, the treadmill **10** is shown including another exemplary embodiment of a track system configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface, shown as a track system **1100**.

The track system **1100** is substantially similar to track system **700**, but configured to be operable with a running belt **1102** that is a conventional running belt rather than a slatted running belt **16**. The track system **1100** includes a pair of tracks **702** and a wheel assemblies **1104** having substantially the same configuration as wheel assembly **716** with the exception that a securing device shown as a clip **1106** is used to connect the wheel assembly **1104** to the running belt **1102**, rather than the elongated connecting member **724**. The clip **1106** is shown extending and having a first portion **1108** and a second portion **1110** that opening towards the interior of the treadmill **10** before being secured. When the running belt **1102** shown as a continuous polymer (e.g., urethane) belt is in position, a first edge **1112** of the running belt **1102** is received between a first portion **1108** and a second portion **1110** of the clip **1106** and fixed relative thereto (e.g., by a fastener, etc.). The polymer belt is a urethane belt according to an exemplary embodiment. The urethane belt is desirable heavy enough to help assume the shape of the rollers, but not so thick or heavy that it undesirably impedes movement. The clips extend along the first edge **1112** and the second edge **1114** of the running belt **1102**, substantially suspending the belt between the tracks **702**. According to an exemplary embodiment, the securing device may be any securing device suitable for securing an edge portion of the running belt **1102** relative thereto (e.g., a bolt, a clamp, etc.).

According to still another exemplary embodiment, a treadmill has a track system including a pair of tracks and wheel assemblies. The wheel assemblies include hangers (e.g., magnetic hangers) that are received in channels that are interior to the track, the hangers being slidably movable within the channels. According to one exemplary embodiment, the hangers are substantially I-shaped, having one transverse portion received in the channel and the other transverse portion fixed to an interior side of a slat. According to some exemplary embodiments, the system further includes bearing rails that facilitate motion of the running belt itself and the hangers within the track. The hangers and the channel of the track may have any configuration suitable for facilitating movement of the running belt and maintaining the running belt in the desired non-planar shape.

The above-described ways of inducing and maintaining the running belt in the desired non-planar shape can also be used with or adapted to a manual treadmill having a planar running surface, such as treadmill **1200** having planar running surface **1202** shown in FIG. **35**. The treadmill **1200** is shown substantially similar to treadmill **10**, but the running surface is substantially planar. Accordingly, the ability to manually drive the treadmill is substantially dependent on the incline of the running surface **1202** relative to the ground. Ways to adjust this incline for any treadmill disclosed herein will be discussed in more detail later.

In the exemplary embodiment shown, the running surface **1202** is defined by a running belt **1204** that is disposed about front and rear running belt pulleys of a front and rear shaft assembly, respectively. The running belt **1204** also travels along a pair of bearing rails having a substantially linear top profile that facilitate motion of the running belt **1204**.

As discussed above, the speed controls for the manual treadmill **10** and the various embodiments thereof are generally the user's cadence and relative position of her weight-bearing foot on the running surface. More generally, the running belt **16** of the treadmill **10** is responsive to the weight of the user mounting, dismounting, or running on the treadmill **10**. While it is generally desirable for the running belt **16** to be moved rearward, the running belt is capable of rotating forward. Forward rotation of the running belt can create safety

concerns. For example, if a user were to mount the treadmill by placing her weight bearing foot at a location (e.g., location D shown in FIG. **5**) along the rear portion **74** of the running surface **70**, the running belt **16** may move forward and cause them to loose their footing, resulting in an injury or simply an unpleasant user experience.

A number of safety devices may be used with the treadmill **10** to help prevent undesirable forward rotation of the running belt **16**. FIG. **36** illustrates a safety device shown as a one-way bearing assembly **1300** according to an exemplary embodiment. The one-way bearing assembly **1300** is a motion restricting element that is configured to permit rotation of at least one of the front and rear shaft assemblies **44**, **46** (and hence the running belt **16**) in only one direction, preferably clockwise as seen in FIGS. **1** and **5**.

In the exemplary embodiment shown, the one way bearing assembly **1300** is disposed about and cooperates with the rear shaft **68** as shown in FIG. **2**. The one-way bearing assembly **1300** comprises a housing **1302** which supports an inner ring **1304** that cooperates with the rear shaft **68** and supports an outer ring **1306** fixed relative to the housing **1302**. A plurality of sprags (not shown) are disposed between the inner ring **1304** and the outer ring **1306**. The sprags are asymmetric, and, thus, provide for motion in one direction and prevent rotation in the opposite direction. The housing **1302** is fixed to a bracket **1310** that is connected to, and preferably directly mounted to, the frame **40** to fix the location of the housing **1302** and prevent movement of the housing **1302** in response to the rotation of the rear shaft **68**. It should be noted that the location at which the bracket **1310** is mounted to the frame **40** can be adjusted depending on the location of the rear shaft **68**, which may change depending on the shape of the non-planar running surface or the desired tension in the running belt. According to another exemplary embodiment, the one-way bearing may be transitionally fit into the housing, rather than press fit. According to yet another exemplary embodiment, the one-way bearing may include rollers in addition to sprags.

The one-way bearing assembly **1300** further includes a key **1312** that is fixed relative to the inner ring **1304** and configured to cooperate with a keyway **1314** formed in the rear shaft **68**. Viewed from the perspective shown in FIGS. **1** and **5**, when the running belt **16** is moving rearward, rotating in the clockwise direction, the rear shaft **68** similarly rotates in the clockwise direction. The inner ring **1304** of the one-way bearing assembly **1300** rotates with rotational velocity corresponding to the rotational velocity of the rear shaft **68** because of the interaction between the key **1312** and the keyway **1314**. If a force is applied by the user to the running belt **16** that urges the rear shaft **68** to rotate counterclockwise, the one-way bearing assembly **1300** provides a counter force, preventing the counterclockwise rotation of the rear shaft **68** and the forward rotation of the running belt **16**. Specifically, as the rear shaft **68** begins to move counterclockwise, the interaction of the key **1312** and the keyway **1314** begins to drive the inner ring **1304** of the one-way bearing assembly **1300** rearward. The sprags become wedged between the inner ring **1304** and the outer ring **1306**, preventing the counterclockwise rotation of the inner ring and key **1312** disposed therein. The key **1312**, by virtue of its inability to rotate, provides a counterforce to the keyway **1314** as the keyway continues to attempt to rotate counterclockwise. By preventing the keyway **1314** from moving counterclockwise, the one-way bearing assembly **1300** thus prevents the rear shaft **68**, the rear running belt pulleys **66**, and running belt **16** from rotating counterclockwise as seen in FIGS. **1** and **5**.

FIG. **38** illustrates another safety device that may be used with the treadmill **10**, shown as a one-way bearing assembly **1500** according to an exemplary embodiment. The one-way bearing assembly **1500** is a motion restricting element that is configured to permit rotation of at least one of the front and rear shaft assemblies **44**, **46** (and hence the running belt **16**) in only one direction, preferably clockwise as seen in FIGS. **1** and **5**.

In the exemplary embodiment shown, the one-way bearing assembly **1500** is disposed about and cooperates with the rear shaft **68**. The one-way bearing assembly **1500** comprises a housing **1502** which supports an inner ring **1504** that cooperates with the rear shaft **68** and supports an outer ring **1506** fixed relative to the housing **1502**. A plurality of sprags (not shown) are disposed between the inner ring **1504** and the outer ring **1506**. The sprags are asymmetric, and, thus, provide for motion in one direction and prevent rotation in the opposite direction. The one-way bearing assembly **1500** is further shown to include a first snap ring **1532** and a second snap ring **1534**, which are configured to seat in a first circumferential groove **1536** and a second circumferential groove **1538** on the rear shaft **68**, respectively. When installed, the first snap ring **1532** is supported inboard of and adjacent to the inner ring **1504**, and the second snap ring **1534** is supported outboard of and adjacent to the inner ring **1504**, thereby further restricting axial motion of the one-way bearing assembly **1500** relative to the rear shaft **68**.

The housing **1502** is supported by a stud **1520** which is coupled to the frame **40**. The stud **1520** may be separated or spaced apart from the housing **1502** by a spacer **1522** and a sleeve **1523** which may be restrained on the stud **1520** by a nut **1524** and a washer **1526**. The sleeve **1523** of the embodiment shown is formed of rubber and is configured to reduce noise, wear, and shock load between the housing **1502** and the stud **1520** and/or the spacer **1522**. The housing **1502** includes a plurality of legs, shown as a first leg **1516** and a second leg **1518**, which extend on either side of the stud **1520**. Accordingly, the stud **1520** resists rotational motion of the housing **1502** in response to rotation of the rear shaft **68** and may provide sufficient reactive or counter force to the housing **1502** to enable the one-way bearing assembly **1500** to prevent counterclockwise rotation of the rear shaft **68**. Supporting the one-way bearing assembly **1500** in this manner negates the need for fixing the housing **1502** to the frame **40** or an intermediary bracket. Accordingly, the housing **1502** may move with the rear shaft **68** (e.g., the housing **1502** may pivot about the stud **1520**) as the rear shaft **68** flexes under load, thereby reducing side loading on the inner ring **1504**, which in turn reduces wear on, and extends the life of, the one-way bearing assembly **1500**.

It should be noted that the location at which the stud **1520** is mounted to the frame **40** can be adjusted depending on the location of the rear shaft **68**, which may change depending on the shape of the non-planar running surface or the desired tension in the running belt. Furthermore, the stud **1520** need not be positioned below or downward from the rear shaft **68**, as shown, but may be located in any direction relative to the rear shaft **68**. According to another exemplary embodiment, the one-way bearing may be transitionally fit into the housing, rather than press fit. According to yet another exemplary embodiment, the one-way bearing may include rollers in addition to sprags.

The one-way bearing assembly **1500** further includes a key **1512** that is fixed relative to the inner ring **1504** and configured to cooperate with a keyway **1514** formed in the rear shaft **68**. Viewed from the perspective shown in FIGS. **1** and **5**, when the running belt **16** is moving rearward, rotating in the clockwise direction, the rear shaft **68** similarly rotates in the clockwise direction. The inner ring **1504** of the one-way

bearing assembly **1500** rotates with rotational velocity corresponding to the rotational velocity of the rear shaft **68** because of the interaction between the key **1512** and the keyway **1514**. If a force is applied by the user to the running belt **16** that urges the rear shaft **68** to rotate counterclockwise as seen in FIGS. **1** and **5**, the one-way bearing assembly **1500** provides a counter force, preventing the counterclockwise rotation of the rear shaft **68** and the forward rotation of the running belt **16**. Specifically, as the rear shaft **68** begins to move counterclockwise, the interaction of the key **1512** and the keyway **1514** begins to drive the inner ring **1504** of the one-way bearing assembly **1500** rearward. The sprags become wedged between the inner ring **1504** and the outer ring **1506**, preventing the counterclockwise rotation of the inner ring and key **1512** disposed therein. The key **1512**, by virtue of its inability to rotate, provides a counterforce to the keyway **1514** as the keyway continues to attempt to rotate counterclockwise. By preventing the keyway **1514** from moving counterclockwise, the one-way bearing assembly **1500** thus prevents the rear shaft **68**, the rear running belt pulleys **66**, and running belt **16** from rotating counterclockwise as seen in FIGS. **1** and **5**.

Other safety devices to help prevent undesirable forward rotation of the running belt **16** may include cam locking systems, which may be particularly well-suited for use in conjunction with track systems **700**, **800**, and **900**. Also, taper locks, a user operated pin system, or a band brake system with a lever may be utilized.

Controlling the operation of the running belt **16** in ways in addition to preventing rearward rotation, can help improve the safety of the treadmill and/or help a user adjust the treadmill for a desirable level of performance. Including an incline or elevation adjustment system is one way to provide these benefits. As mentioned above, as the increasing or decreasing of the relative height or distance of the running surface relative to the ground is one way that the operation, most typically the speed, of the treadmill can be adjusted. Accordingly, adjusting the incline of the base of the treadmill results in an adjustment to the speeds a user can achieve and/or how easy or challenging it is for the user to achieve certain speeds.

Referring back to FIGS. **1-6**, a plurality of nuts **270** are fixed, and more preferably welded, to the bottom of the frame **40** allow the feet **28** to be adjusted. The feet **38** include a lower or base portion **272** and a threaded shaft **274** extending vertically upward from the base portion **272** according to an exemplary embodiment. Generally, by increasing the distance between the nuts **270** and the base portions **272** of the feet **28** at the front end **48** of the frame **40** relative to the rear end **50**, the incline of the base **12** will increase. Stated otherwise, the angle between the longitudinal axis **18** and the ground will increase. Similarly, the distance between the nuts **270** and the base portions **272** of the feet at the rear end **50** may be decreased relative to the feet **28** at the front end **48**, thereby increasing the incline. By increasing the incline, a user is typically able to achieve greater speeds on the treadmill **10**.

Treadmill **1200** shown in FIG. **35** preferably has at least some incline (i.e., the longitudinal axis of the treadmill to be other than parallel to the ground) when in operation as the shape of the running surface, substantially planar, does not provide for increases and decreases in height in and of itself. On the other hand, the longitudinal axes of the treadmills having non-planar running surfaces may be parallel to the ground or at an incline thereto during operation. It should be noted that, while it is generally desirable to have the front shaft at a height at or above the height of the rear shaft, with some running surface configurations, desirable orientations can be achieved by raising the rear shaft to a location above the front shaft relative to the ground.

In some cases, the user may want to decrease the incline of the treadmill (e.g., to decrease the speeds the treadmill can achieve, etc.). For example, the user may want to utilize a relatively long stride, but does not want to be running at such high speeds. This can be accomplished by lowering the incline of the treadmill from the higher incline position. Once in the lowered position, the same stride the user was using at the higher incline position will typically result in the user running at lower speeds in the lower incline position. This same principle can also be applied for the purposes of safety. That is, keeping the front of the treadmill at a lower incline position or lowering the treadmill to a lower incline position can help prevent a user from achieving speeds that are too great for them (e.g., that would cause them to be off-balance, lose control, be injured, etc.).

Because the treadmill is preferably manually operated, it does not have an external power source which can be utilized to operate a height adjusting motor as is found in conventional treadmills. Therefore, a manual height adjusting system is preferably integrated into the treadmill. Referring to FIG. **37**, an example of a manual incline or elevation adjustment system **1400** is shown according to an exemplary embodiment. A hand crank **1402** configured to be operated by a person, such as the user, is provided allow a user to operate the incline adjustment system **1400** to adjust the incline of the base **12** of the treadmill **10** relative to the ground. The front shaft **64** may be lowered relative to the rear shaft **68** and/or the front shaft **64** may be raised relative to the rear shaft **68** using the hand crank **1402**. In an alternative exemplary embodiment, the front shaft may be maintained at a position above the ground, and the rear shaft may be raised or lowered relative thereto adjust the incline.

Generally, the hand crank **1402** includes a handle portion **1404** disposed parallel to and spaced a distance from a shaft **1406** that is coupled to the frame **40** (e.g., with a bracket). When assembled, a drive belt or chain **1407** is disposed about a gear **1408** that is positioned about the shaft **1406** of the hand crank **1402**. Rotational motion can be imparted to the gear **1408** by rotating the handle portion **1404**. In response to rotation of the gear **1408**, the drive belt **1407** causes a sprocket **1410** is fixed relative to an internal connecting shaft **1412** of the internal connecting shaft assembly **1414** to rotate. The internal connecting shaft assembly **1414** further includes a pair of drive belts or chains **1416** that are operably coupled to gears **1418** of rack and pinion blocks **1420**. The rotation of the internal connecting shaft **1412** causes the drive belts or chains **1416** to rotate gears **1418**. As the gears **1418** rotate, a pinion (not shown) disposed within the rack and pinion blocks **1420** imparts linear motion to the racks **1422**, thereby operably raising or lowering the base **12** of the treadmill **10** depending on the direction of rotation of the handle portion **1404** of the hand crank **1402**.

According to another exemplary embodiment, an incline adjustment system that is a gas assisted un-weighting incline adjustment system may be utilized. According to other exemplary embodiments, any suitable linear actuator may serve as an incline adjustment system for the manual treadmill disclosed herein.

According to an exemplary embodiments, the incline of one or more portions of the running surface may be adjusted independent of adjusting the incline of the base. For example, one or more portions of a bearing rail may be configured to be movable relative to one or more other portion of the bearing rail. In one exemplary embodiment, a bearing rail is divided into a first portion and a second portion movable relative to

each of the about a pivot point disposed therebetween. A person (e.g., a user, trainer, technician, etc.) can adjust the operational characteristics of the treadmill (similar to the discussion of using running surfaces having different curved profiles above) by merely adjusting the relative position of the bearing rail portions. If the user wants to achieve greater speeds, they may increase the incline of the front portion, while leaving the center and rear portions unchanged. If the user would like to alter the configuration of the treadmill to more strongly encourage running on the balls of their feet, they might increase the incline of the front and rear portions from a higher radius of curvature so that they collectively define a lower radius of curvature. Adjustments to the position of the bearing rails may be imparted using a crank, or other suitable device.

It is further contemplated that, because the treadmill **10** does not require an electric motor for operation, it is well suited for operation in an aquatic environment. For example, the treadmill **10** may be at least partially submerged in a pool, thereby providing added resistance due to hydrodynamic drag on a user and/or reducing footfall impact due to the buoyancy of the user. Accordingly, a submerged embodiment of the treadmill **10** may be used for training and/or rehabilitation purposes. Modifications may be made to the treadmill **10** for use in an aquatic environment. For example, the treadmill **10** may include sealed bearings and components formed of corrosion-resistant materials (e.g., plastic, composite, stainless steel, brass, etc.) to extend its useful life. Further, the shape of the running surface **70** may also be modified to compensate for the buoyancy of the user in water and to compensate for the effects of salinity on buoyancy. For example, it is contemplated that the shape of the running surface **70** may be different for a treadmill **10** used in a freshwater environment and a highly saline environment.

A number of other devices, both mechanical and electrical, may be used in conjunction with or cooperate with a treadmill according to this disclosure. FIG. **1**, for example, shows a display **280** adapted to calculate and display performance data relating to operation of the treadmill according to an exemplary embodiment. The display **280** includes an independent power source (e.g., a battery) that provides for the display **280** to be electrically-operative. The feedback and data performance analysis from the display may include, but are not limited to, speed, time, distance, calories burned, heart rate, etc. For example, a the display may include a sensor that is responsive to the position of a magnet on one of the running belt pulleys. The sensor is configured to recognize every time the magnet rotates past (e.g., moves past, crosses, etc.) a certain location. With this data, the display may calculate the speed at which the user is running and then provide this data to them via a user interface. According to other exemplary embodiments, other displays, cup holders, cargo nets, heart rate grips, arm exercisers, TV mounting devices, user worktops, and/or other devices may be incorporated into the treadmill.

As utilized herein, the terms "approximately," "about," "substantially," and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numerical ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and are considered to be within the scope of the disclosure.

It should be noted that the term "exemplary" as used herein to describe various embodiments is intended to indicate that such embodiments are possible examples, representations, and/or illustrations of possible embodiments (and such term is not intended to connote that such embodiments are necessarily extraordinary or superlative examples).

For the purpose of this disclosure, the term "coupled" means the joining of two members directly or indirectly to one another. Such joining may be stationary or moveable in nature. Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another. Such joining may be permanent in nature or may be removable or releasable in nature.

It should be noted that the orientation of various elements may differ according to other exemplary embodiments, and that such variations are intended to be encompassed by the present disclosure.

It is important to note that the constructions and arrangements of the manual treadmill as shown in the various exemplary embodiments are illustrative only. Although only a few embodiments have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited in the claims. For example, elements shown as integrally formed may be constructed of multiple parts or elements, the position of elements may be reversed or otherwise varied, and the nature or number of discrete elements or positions may be altered or varied. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Other substitutions, modifications, changes and omissions may also be made in the design, operating conditions and arrangement of the various exemplary embodiments without departing from the scope of the present disclosure.

What is claimed is:

**1**. A manually operated treadmill comprising:

a treadmill frame having a front end and a rear end opposite the front end;

a front shaft rotatably coupled to the treadmill frame at the front end;

a rear shaft rotatably coupled to the treadmill frame at the rear end;

a running belt including a curved running surface upon which a user of the treadmill may run, wherein the running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running surface of the running belt to move from the front shaft toward the rear shaft;

a safety device coupled to at least one of the front shaft and the rear shaft, wherein the safety device prevents rotation of at least one of the front shaft and the rear shaft in one direction and permits rotation of at least one of the front shaft and the rear shaft in the opposite direction to restrict rotation of the running belt in a single direction; and

a synchronizing system interconnecting the front and rear shafts, wherein the synchronizing system is configured to provide a force that acts to resist differential rotation of the front and rear shafts;

wherein the treadmill is configured to allow the user to manually control the speed of the running belt and to facilitate maintenance of a contour of the curved running surface.

**2**. The manually operated treadmill of claim **1**, wherein the front shaft is configured such that the speed of the running belt at the front shaft is greater than the speed of the running belt at the rear shaft to facilitate the running belt maintaining the curved running surface.

**3**. The manually operated treadmill of claim **2**, further comprising:

a front pulley coupled to the front shaft; and

a rear pulley coupled to the rear shaft;

wherein the running belt is supported by and contacts the front pulley and the rear pulley, wherein the radius of the front pulley is greater than the radius of the rear pulley.

**4**. The manually operated treadmill of claim **3**, wherein the difference between the radius of the front pulley and the radius of the rear pulley is less than approximately 0.1 inches.

**5**. The manually operated treadmill of claim **4**, wherein the difference between the radius of the front pulley and the radius of the rear pulley is between approximately 0.005 and 0.035 inches.

**6**. The manually operated treadmill of claim **2**, further comprising a braking system configured to slow rotation of the rear shaft resulting in the greater speed of the running belt at the front shaft.

**7**. The manually operated treadmill of claim **1**, wherein the treadmill is configured to prevent movement of the running surface of the running belt in a direction from the rear shaft toward the front shaft.

**8**. The manually operated treadmill of claim **7**, wherein the curved running surface comprising at least a convex curved section and a concave curved section, wherein the concave curved section is located between the front shaft and the convex curved section and wherein the highest point of the convex section is above the lowest point of the concave section.

**9**. The manually operated treadmill of claim **1**, wherein the safety device comprises a one-way bearing.

**10**. The manually operated treadmill of claim **7**, wherein the safety device cooperates with the rear shaft to prevent movement of the running surface of the running belt in a direction from the rear shaft towards the front shaft.

**11**. A manually operated treadmill comprising:

a frame supported on a substantially horizontal surface;

a front shaft assembly supported by the frame and comprising:

a front shaft; and

at least one front running belt pulley supported by the front shaft;

a rear shaft assembly supported by the frame a spaced distance from the front shaft and comprising:

a rear shaft; and

at least one rear running belt pulley supported by the rear shaft;

a running belt supported at least in part by the front shaft assembly and the rear shaft assembly, the running belt including a front portion adjacent the front shaft assembly, a rear belt portion adjacent the rear shaft assembly, and a central belt portion intermediate the front belt portion and the rear belt portion, the front belt portion and the rear belt portion being positioned vertically higher than a lowest point found in the central belt portion to form a curved running surface upon which a user of the treadmill may walk or run, wherein gravitational force acting upon weight of the user's body on the running belt relative to the lowest point of the running belt causes rotation of the running belt, front shaft, and the rear shaft without the aid of a motor;

a safety device cooperating with the rear shaft to permit rotation of the rear shaft in only one direction; and

at least one bearing rail having a plurality of bearings rotatably coupled to the at least one bearing rail and forming a top profile, the top profile defined by a front profile portion adjacent the front shaft assembly, a rear profile portion adjacent the rear shaft assembly, and a central profile portion intermediate the front profile portion and the rear profile portion, the central profile portion having a concave curve, and the front profile portion and the profile rear portion being continuations of the concave curve;

wherein the running surface of the running belt is supported by the top profile of the at least one bearing rail such that the running surface substantially corresponds to the shape of the top profile of the at least one bearing rail.

**12**. The manually operated treadmill of claim **11**, the at least one bearing rail extending along the frame and longitudinally aligned with one of the at least one front running belt pulley and one of the at least one rear running belt pulley.

**13**. The manually operated treadmill of claim **12**, wherein the running belt comprises a plurality of laterally extending slats.

**14**. The manually operated treadmill of claim **13**, wherein:

the front shaft assembly comprises a second front running belt pulley supported by the front shaft and spaced laterally from the at least one front running belt pulley;

the rear shaft assembly comprises a second rear running belt pulley supported by the rear shaft and spaced laterally from the at least one rear running belt pulley;

the at least one bearing rail further comprises a second bearing rail having a plurality of bearings forming a top profile matching the top profile of the first of the at least one bearing rail, the second bearing rail being longitudinally aligned with the second front running belt pulley and the second rear running belt pulley;

the running belt comprises a first endless belt and a second endless belt, wherein the first endless belt is supported by the at least one front running belt pulley, the first of the at least one bearing rail, and the at least one rear running belt pulley, and wherein the second endless belt is supported by the second front running belt pulley, the second bearing rail, and the second rear running belt pulley; and

the plurality of laterally extending slats extend between the first endless belt and the second endless belt.

**15**. The manually operated treadmill of claim **14**, wherein the rear portion of the at least one bearing rail is positioned and shaped to provide a smooth transition for the running belt from the at least one bearing rail onto the at least one rear running belt pulley.

**16**. The manually operated treadmill of claim **11**, wherein the safety device comprises a one-way bearing.

* * * * *

**Exhibit A**

UNITED STATES PATENT AND TRADEMARK OFFICE

# CERTIFICATE OF CORRECTION



PATENT NO. : 8,986,169 B2
APPLICATION NO. : 14/243716
DATED : March 24, 2015
INVENTOR(S) : Douglas G. Bayerlein et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Claims

**Claim 11:**

In column 33, line 56, please replace the word "a" following the phrase "the frame" with the word "and".

In column 33, line 57, please insert the word --a-- before the word "distance".

In column 33, line 63, please replace the phrase "front portion" with the phrase "front belt portion".

In column 34, line 20, please replace the phrase "profile rear portion" with the phrase "rear profile portion".

**Claim 15:**

In column 34, line 58, please replace the phrase "rear portion" with the phrase "rear profile portion".

Signed and Sealed this
Twenty-ninth Day of March, 2016

Michelle K. Lee

Michelle K. Lee
*Director of the United States Patent and Trademark Office*

US009039580B1

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

(10) **Patent No.: US 9,039,580 B1**
(45) **Date of Patent: May 26, 2015**

(54) **MANUAL TREADMILL AND METHODS OF OPERATING THE SAME**

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( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/656,942**

(22) Filed: **Mar. 13, 2015**

**Related U.S. Application Data**

(63) Continuation of application No. 14/243,716, filed on Apr. 2, 2014, now Pat. No. 8,986,169, which is a continuation of application No. 13/235,065, filed on Sep. 16, 2011, which is a continuation-in-part of application No. PCT/US2010/002743, filed on Mar. 16, 2010.

(60) Provisional application No. 61/161,027, filed on Mar. 17, 2009.

(51) **Int. Cl.**
*A63B 22/02* (2006.01)

(52) **U.S. Cl.**
CPC ..... ***A63B 22/02*** (2013.01); ***A63B 22/0285*** (2013.01)

(58) **Field of Classification Search**
CPC ..... A63B 22/02; A63B 22/0285; A63B 2022/0207; A63B 22/0214; A63B 22/0221; A63B 22/0228; A63B 69/0028; A63B 69/0035
See application file for complete search history.

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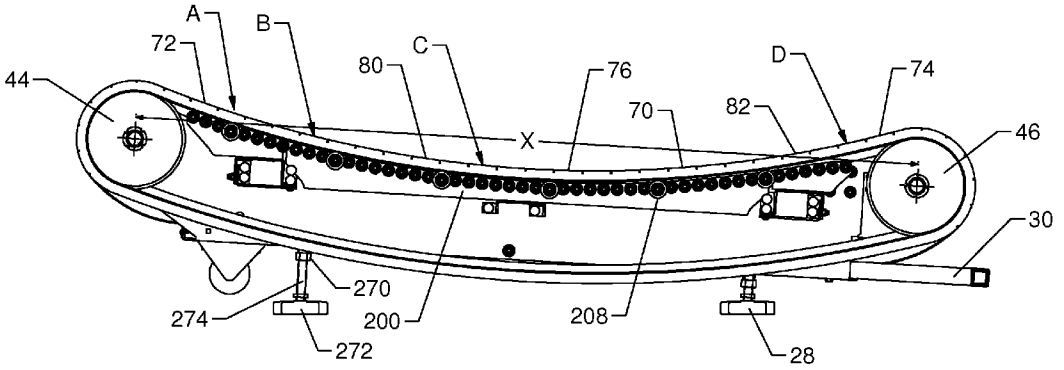
(57) **ABSTRACT**

A manually operated treadmill is provided. The treadmill includes a treadmill frame, a front shaft rotatably coupled to the treadmill frame, a rear shaft rotatably coupled to the treadmill frame, a running belt including a contoured running surface upon which a user of the treadmill may run, wherein the running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running belt to rotate about the front shaft and the rear shaft without the rotation of the running belt being generated by a motor, and a one-way bearing assembly configured to prevent rotation of the running surface of the running belt in one direction.

**25 Claims, 20 Drawing Sheets**



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| 2014/0011642 | A1 | 1/2014 | Astilean |

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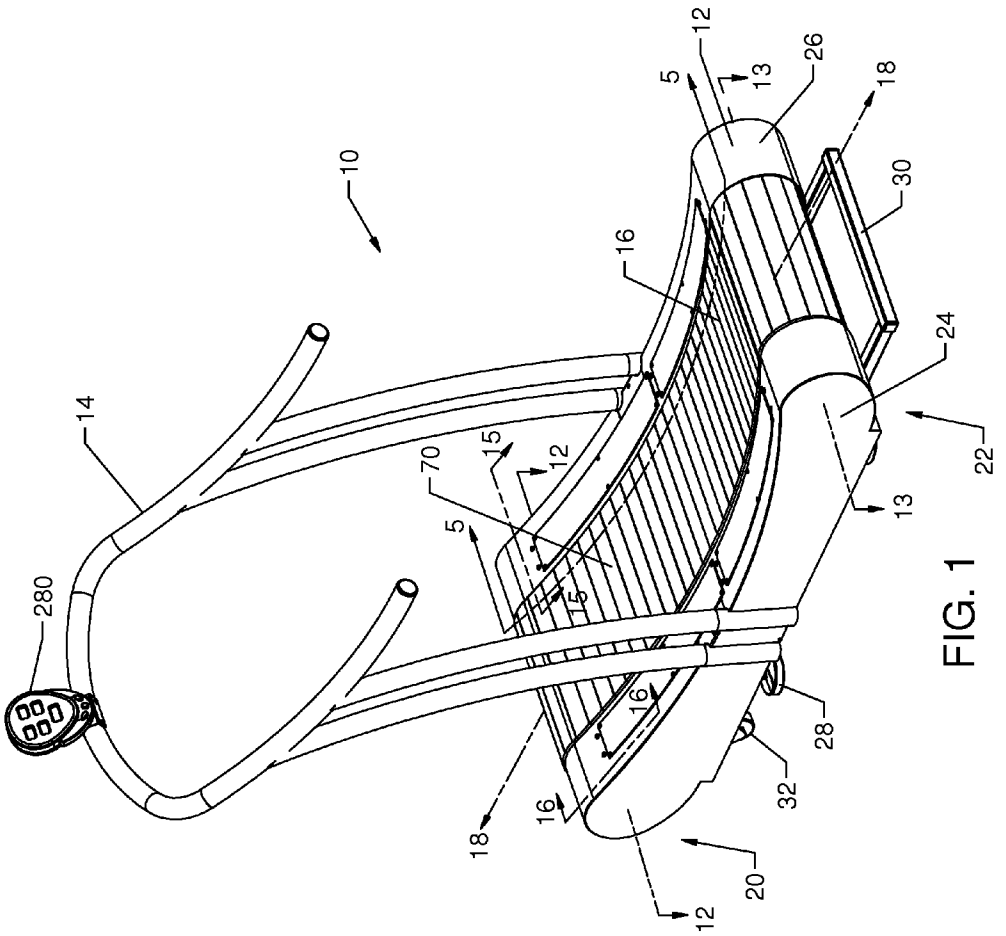


FIG. 1

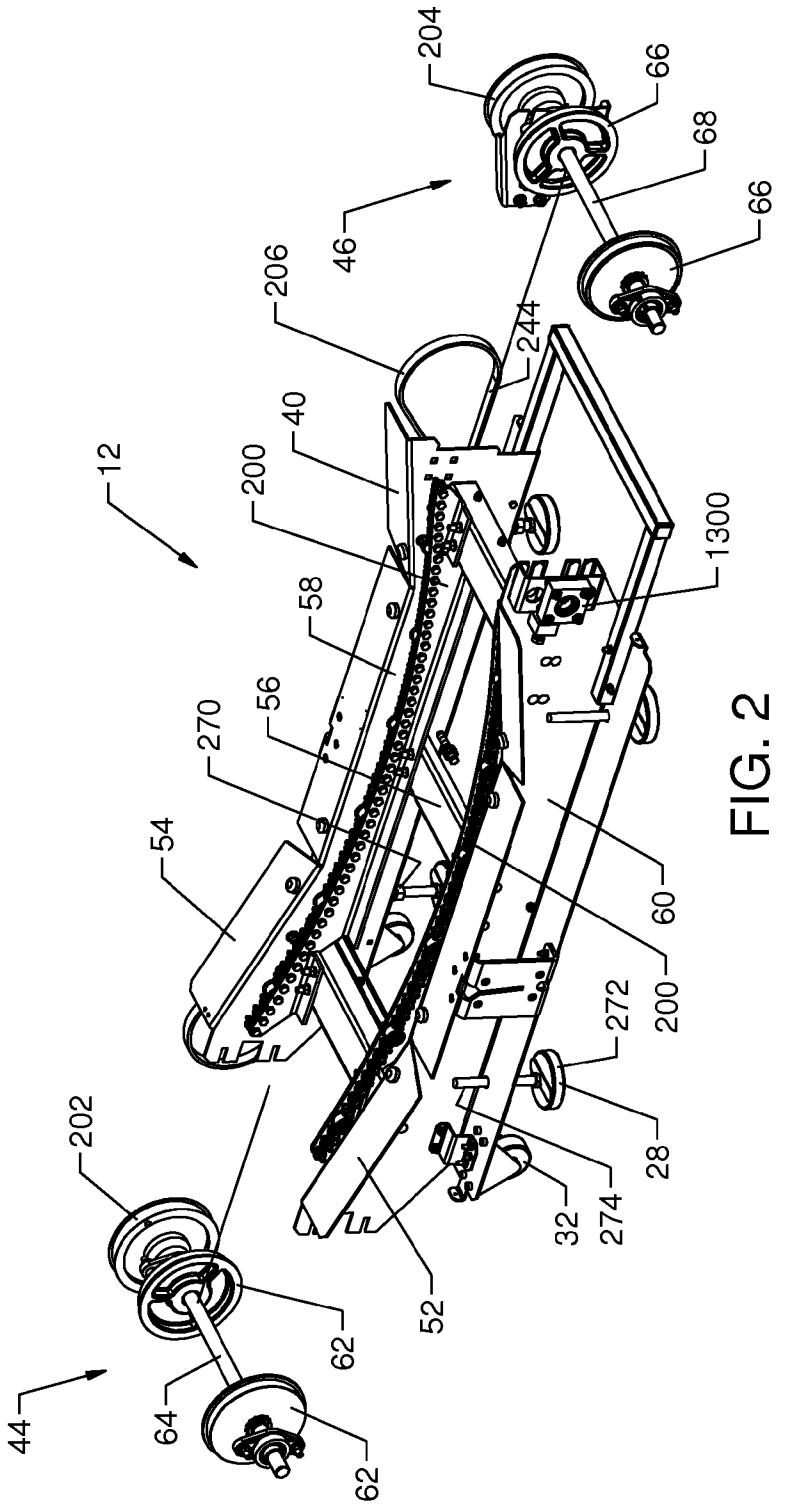
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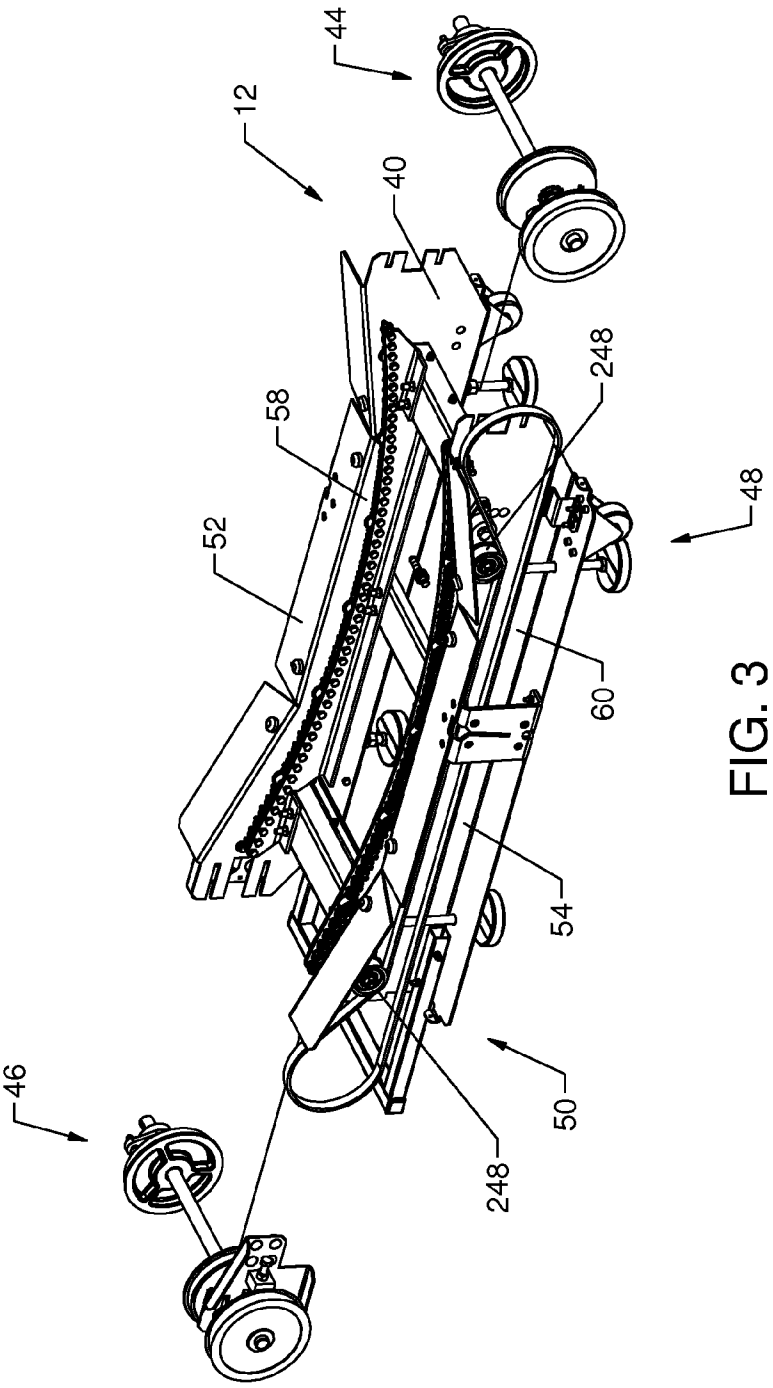
FIG. 2

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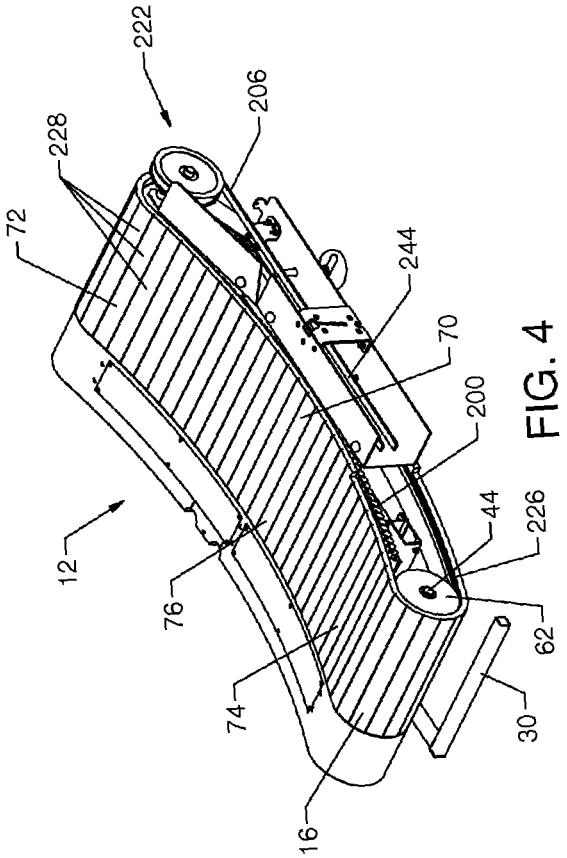
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FIG. 4

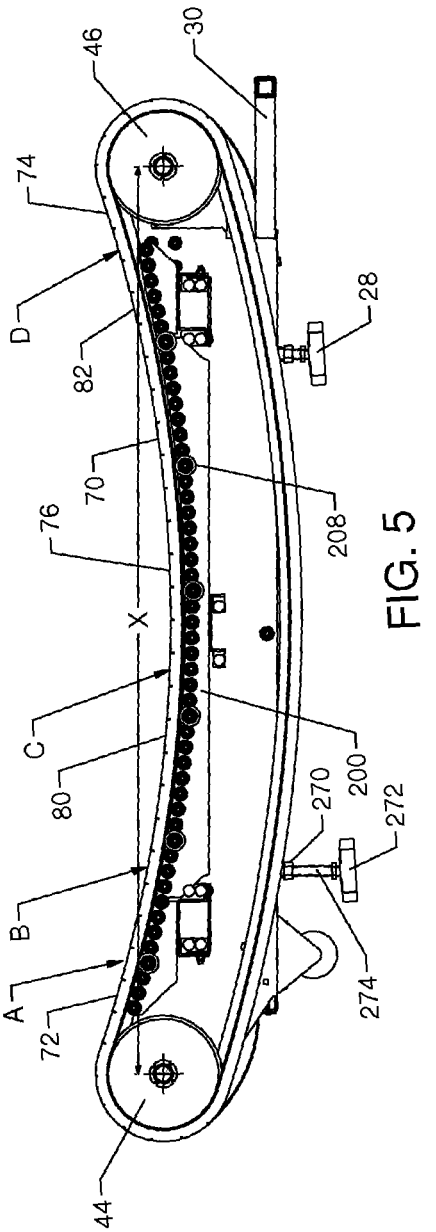
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FIG. 5

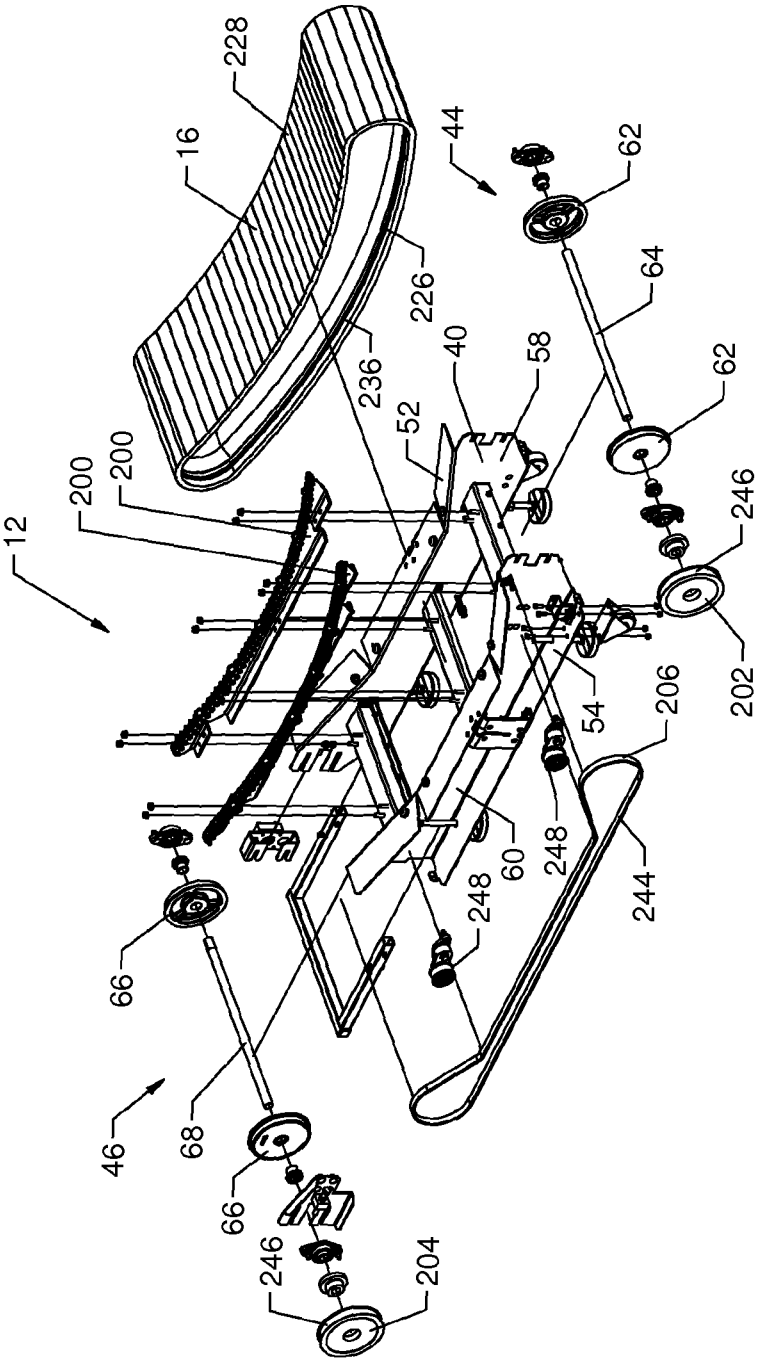
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FIG. 6

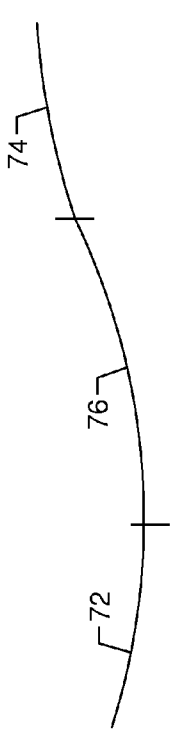


FIG. 7a

FIG. 7b

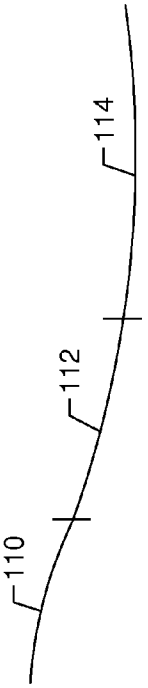


FIG. 7c

FIG. 7d

FIG. 7e

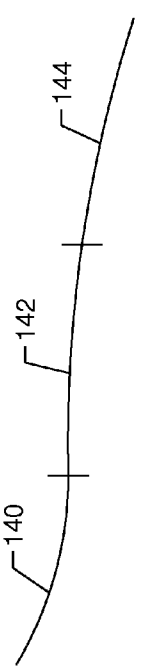


FIG. 7f

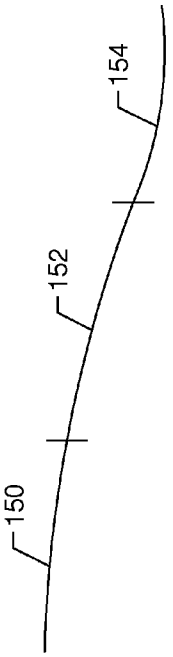


FIG. 7g

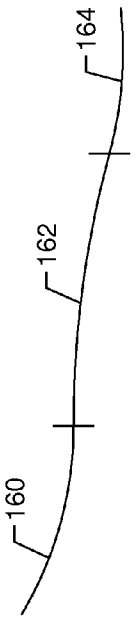


FIG. 7h

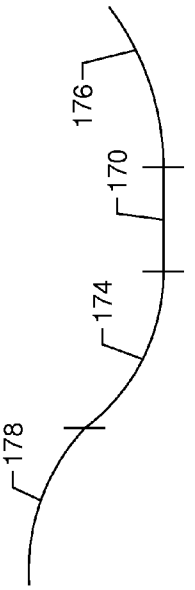


FIG. 7i

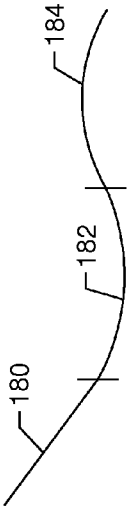


FIG. 7j

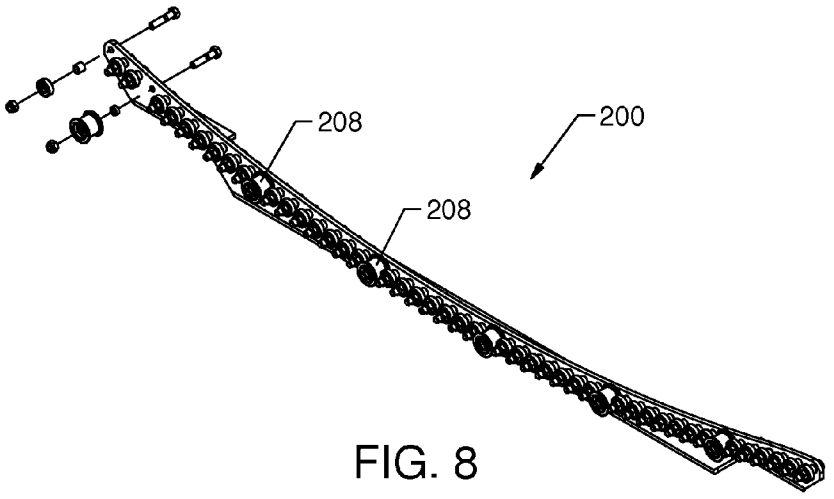


FIG. 8

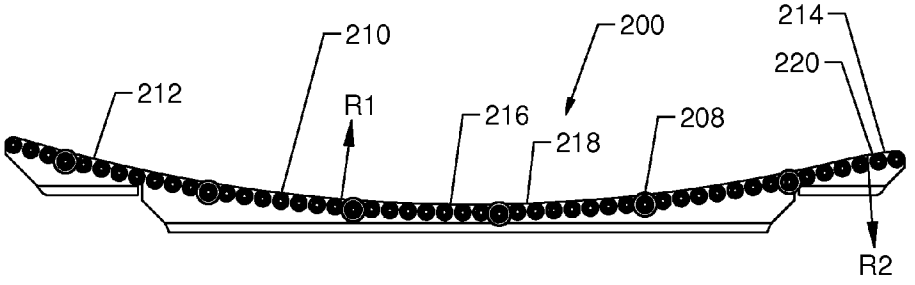


FIG. 9

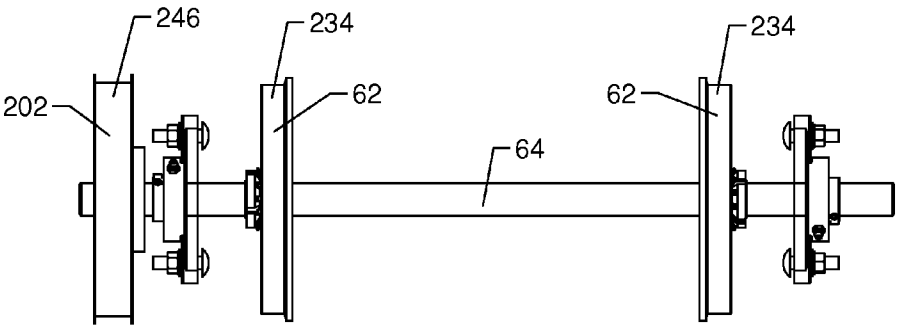


FIG. 10

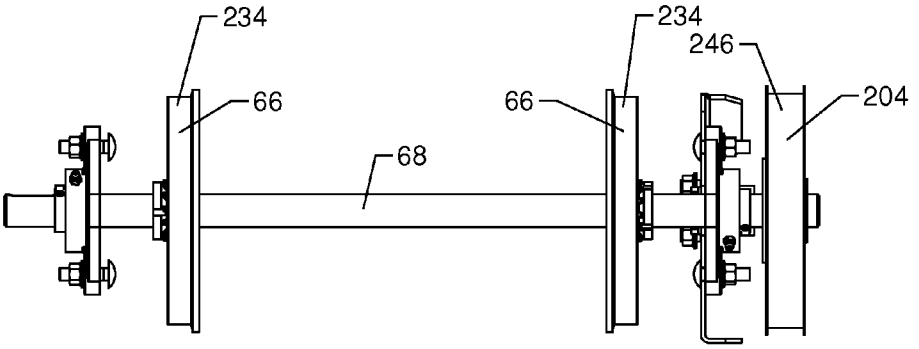


FIG. 11

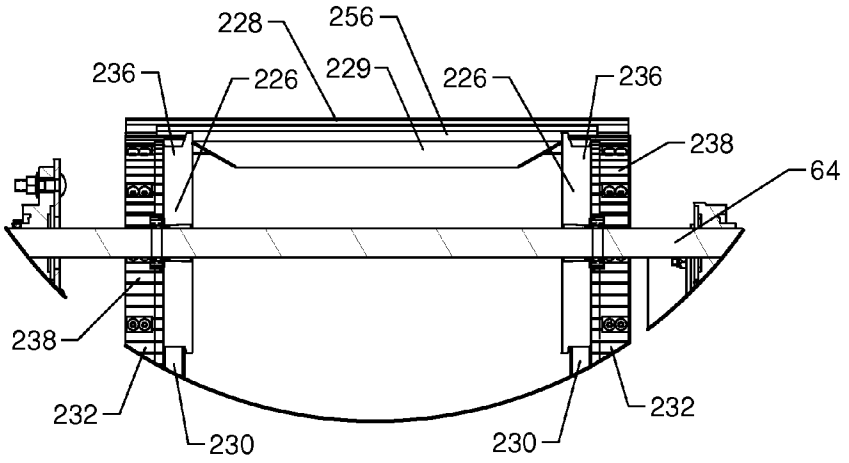
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FIG. 12

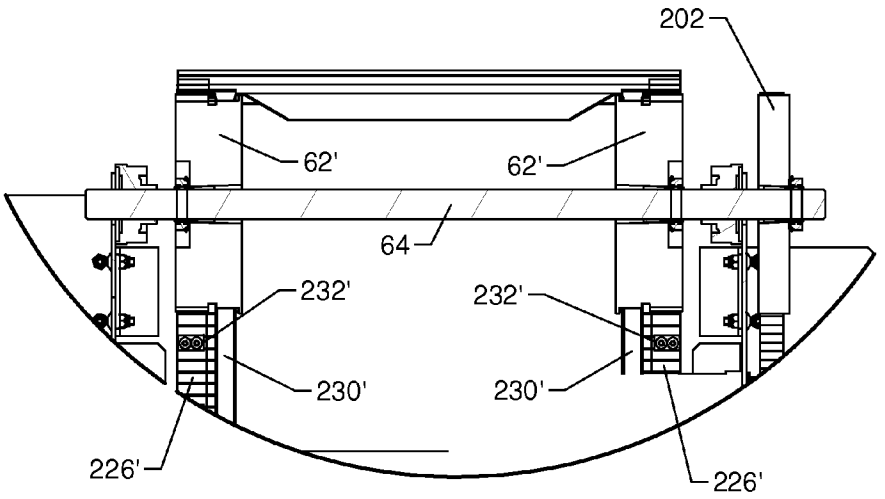
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FIG. 13

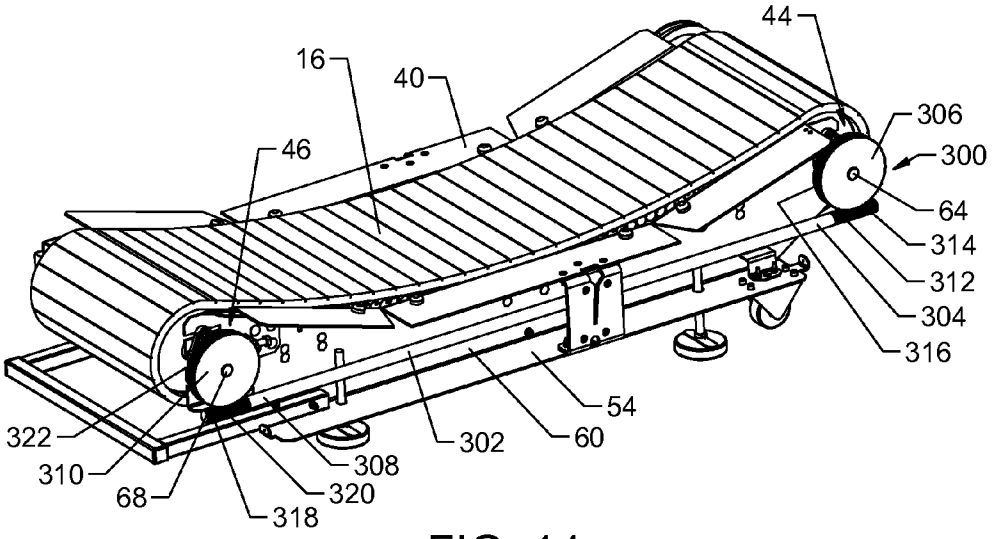
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FIG. 14

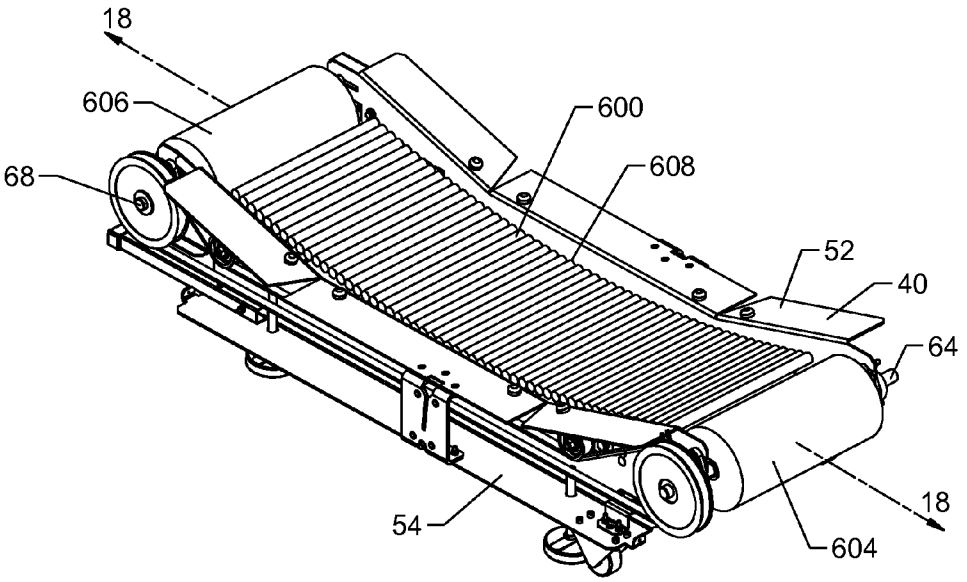
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FIG. 17

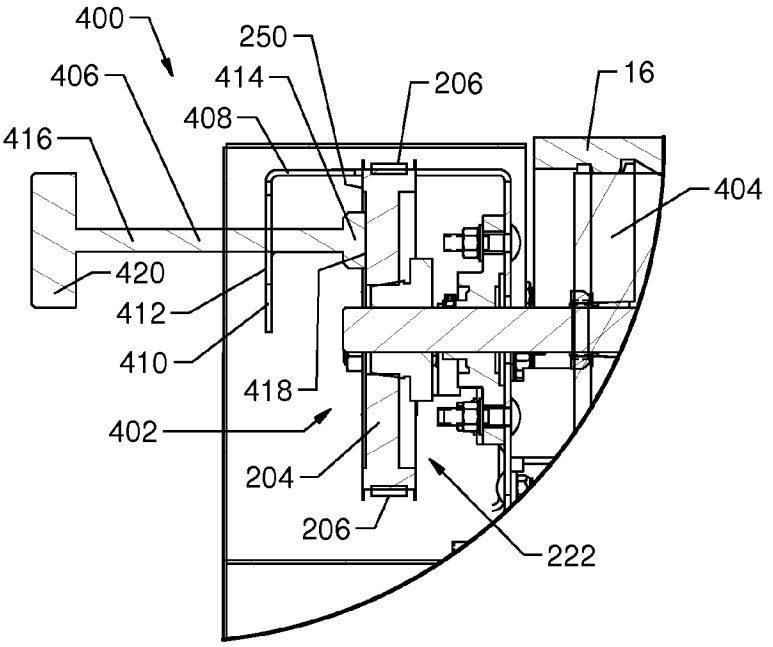
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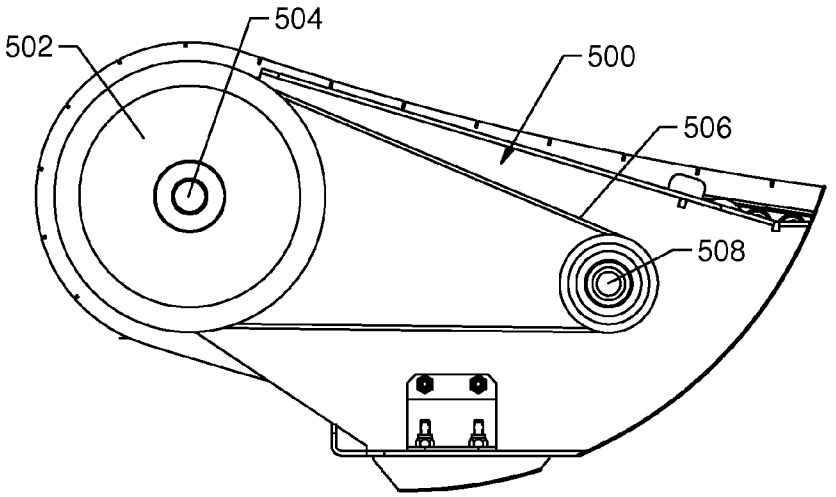
FIG. 15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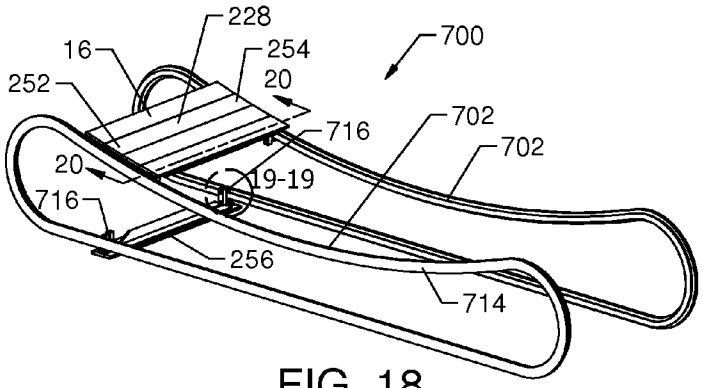



FIG. 18

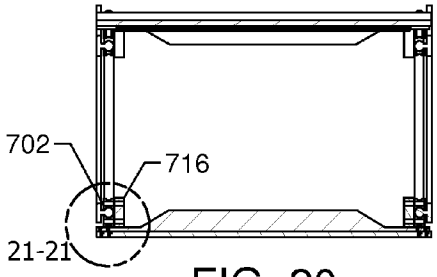
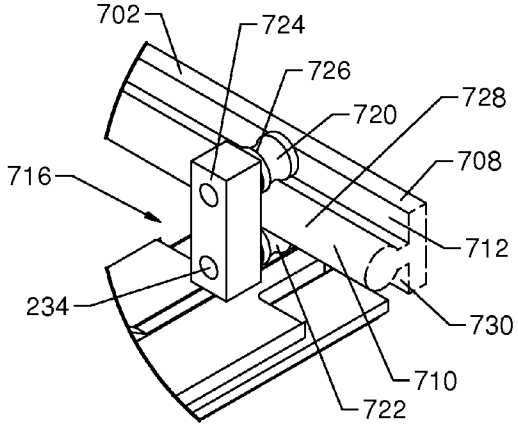



FIG. 20

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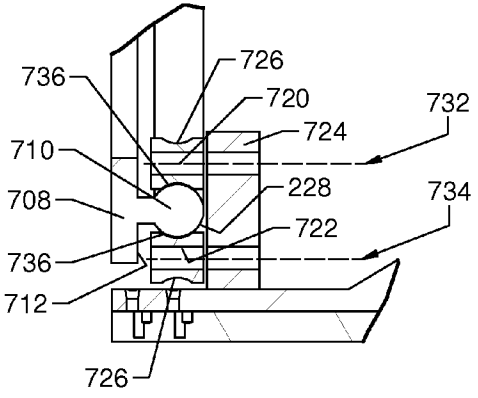



FIG. 21

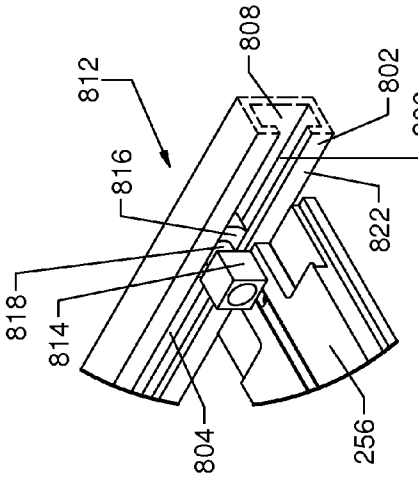



FIG. 23

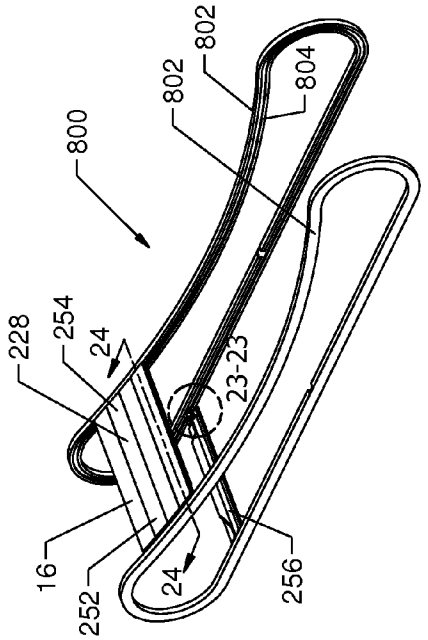



FIG. 22

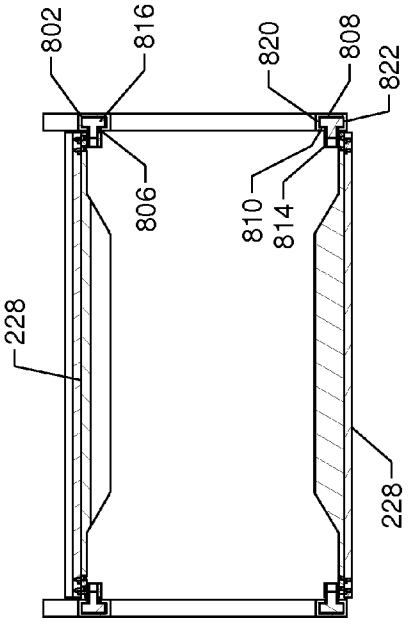
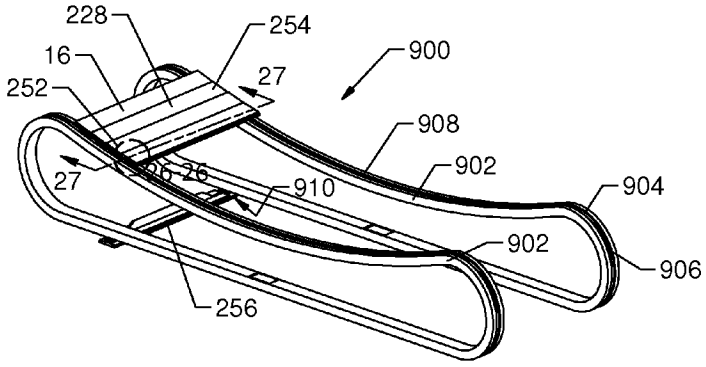



FIG. 24

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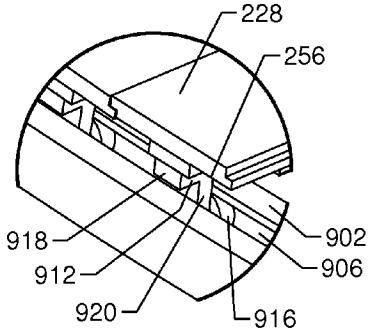



FIG. 26

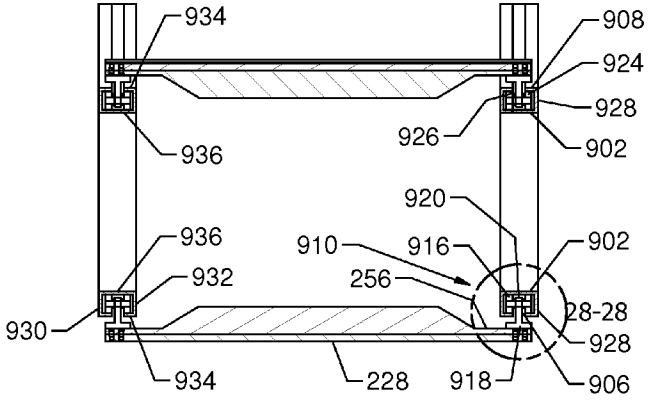
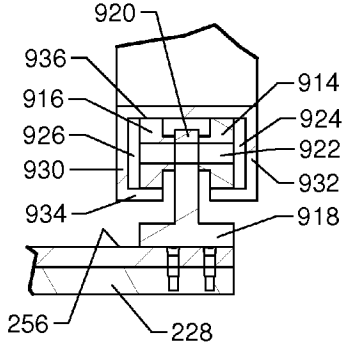



FIG. 27

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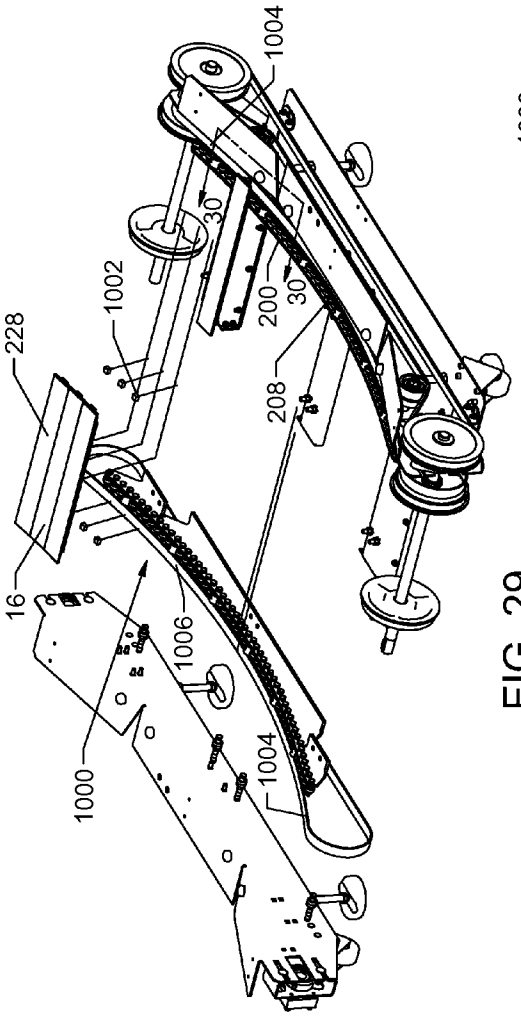
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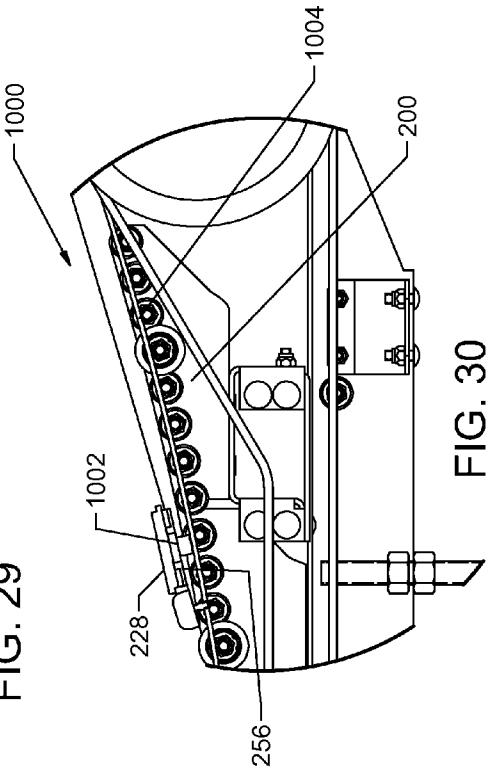
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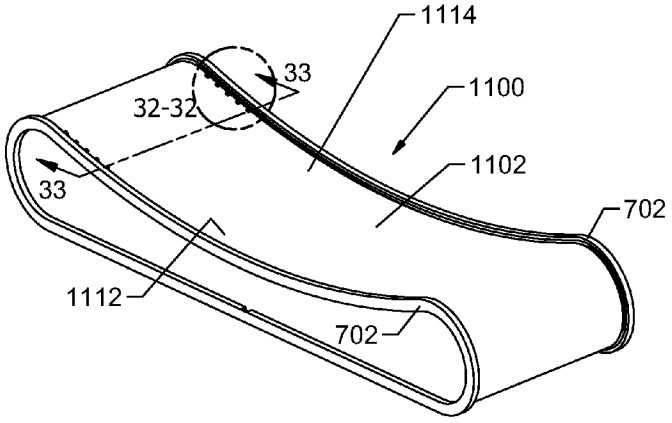
FIG. 30

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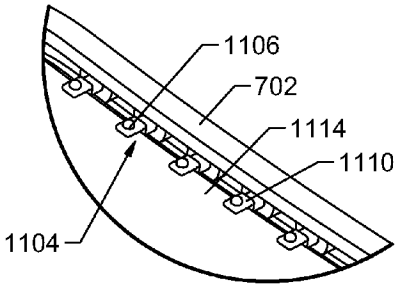


FIG. 32

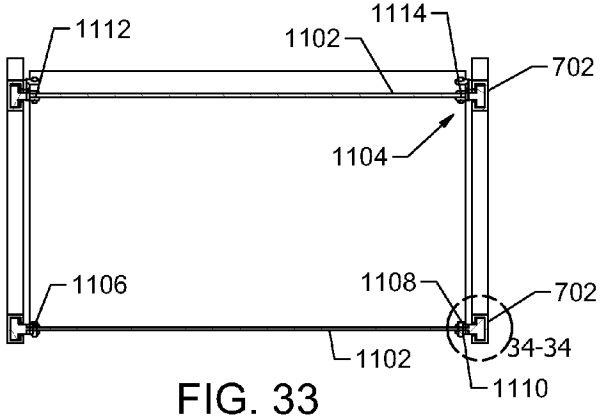


FIG. 33

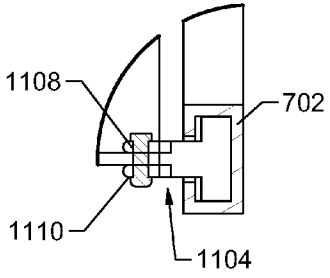


FIG. 34

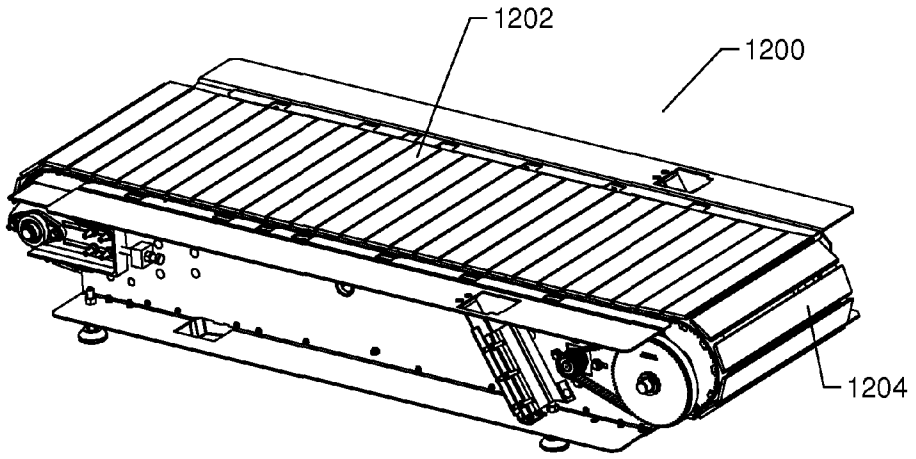


FIG. 35

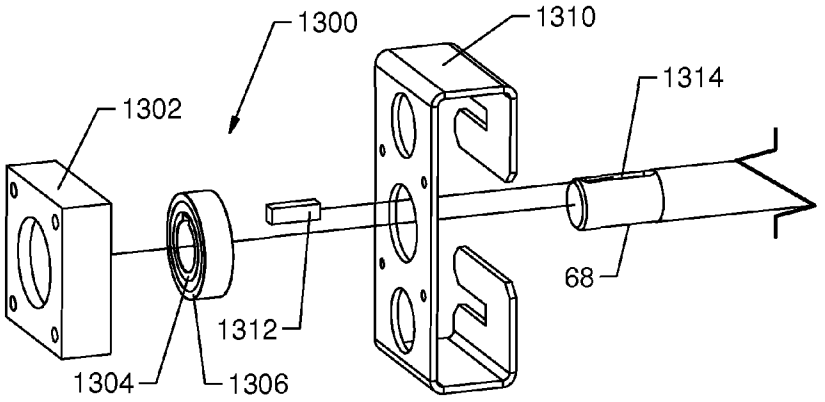


FIG. 36

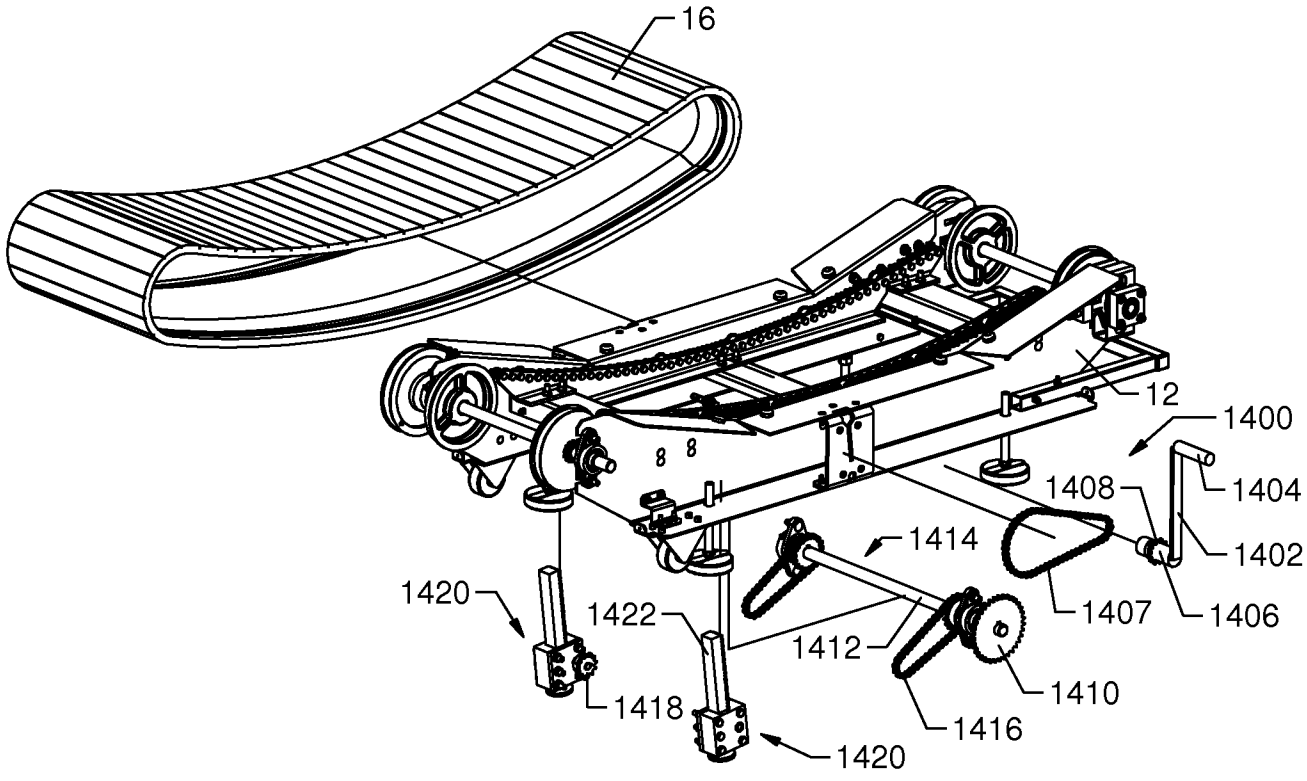
16
12
1400
1404
1408
1414
1402
1420
1422
1407
1406
1412
1410
1418
1416
1420

FIG. 37

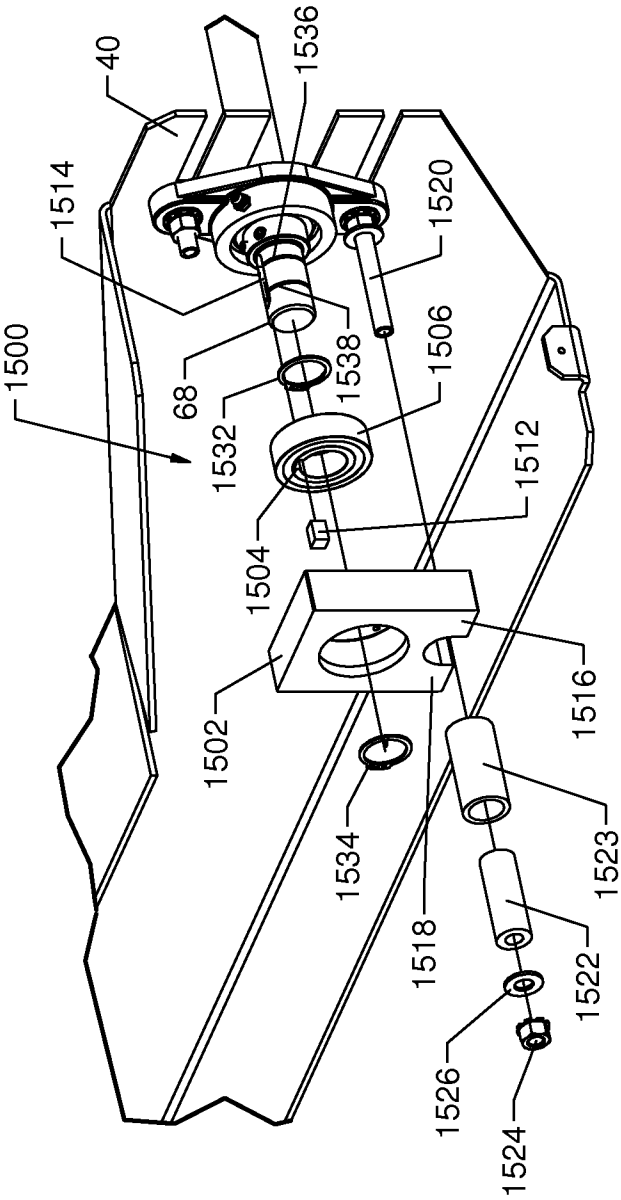
40
1536
1514
1520
1500
68
1538
1506
1532
1512
1504
1516
1502
1534
1523
1518
1522
1526
1524

FIG. 38

# MANUAL TREADMILL AND METHODS OF OPERATING THE SAME

## CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This application claims the benefit of priority as a continuation of U.S. patent application Ser. No. 14/243,716, filed Apr. 2, 2014, which is a continuation of U.S. patent application Ser. No. 13/235,065, filed Sep. 16, 2011, which is a continuation-in-part of prior international Application No. PCT/US10/27543, filed Mar. 16, 2010, which claims priority to U.S. Provisional Application Ser. No. 61/161,027, filed Mar. 17, 2009, all of which are incorporated herein by reference in their entireties.

## BACKGROUND

The present invention relates generally to the field of treadmills. More specifically, the present invention relates to manual treadmills. Treadmills enable a person to walk, jog, or run for a relatively long distance in a limited space. It should be noted that throughout this document, the term "run" and variations thereof (e.g., running, etc.) in any context is intended to include all substantially linear locomotion by a person. Examples of this linear locomotion include, but are not limited to, jogging, walking, skipping, scampering, sprinting, dashing, hopping, galloping, etc.

A person running generates force to propel themselves in a desired direction. To simplify this discussion, the desired direction will be designated as the forward direction. As the person's feet contact the ground (or other surface), their muscles contract and extend to apply a force to the ground that is directed generally rearward (i.e., has a vector direction substantially opposite the direction they desire to move). Keeping with Newton's third law of motion, the ground resists this rearwardly directed force from the person, resulting in the person moving forward relative to the ground at a speed related to the force they are creating.

To counteract the force created by the treadmill user so that the user stays in a relatively static fore and aft position on the treadmill, most treadmills utilize a belt that is driven by a motor. The motor operatively applies a rotational force to the belt, causing that portion of the belt on which the user is standing to move generally rearward. This force must be sufficient to overcome all sources of friction, such as the friction between the belt and other treadmill components in contact therewith and kinetic friction, to ultimately rotate the belt at a desired speed. The desired net effect is that, when the user is positioned on a running surface of the belt, the forwardly directed velocity achieved by the user is substantially negated or balanced by the rearwardly directed velocity of the belt. Stated differently, the belt moves at substantially the same speed as the user, but in the opposite direction. In this way, the user remains at substantially the same relative position along the treadmill while running. It should be noted that the belts of conventional, motor-driven treadmills must overcome multiple, significant sources of friction because of the presence of the motor and configurations of the treadmills themselves.

Similar to a treadmill powered by a motor, a manual treadmill must also incorporate some system or means to absorb or counteract the forward velocity generated by a user so that the user may generally maintain a substantially static position on the running surface of the treadmill. The counteracting force driving the belt of a manual treadmill is desirably sufficient to move the belt at substantially the same speed as the user so that the user stays in roughly the same static position on the running surface. Unlike motor-driven treadmills, however, this force is not generated by a motor.



## SUMMARY

One embodiment of the disclosure relates to a manually operated treadmill comprising a treadmill frame having a front end and a rear end opposite the front end, a front shaft rotatably coupled to the treadmill frame at the front end, a rear shaft rotatably coupled to the treadmill frame at the rear end, a running belt including a curved running surface upon which a user of the treadmill may run, and a one-way bearing assembly coupled to at least one of the front shaft and the rear shaft, wherein the one-way bearing assembly prevents rotation of at least one of the front shaft and the rear shaft in one direction and permits rotation of at least one of the front shaft and the rear shaft in the opposite direction to restrict rotation of the running belt in a single direction. The running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running surface of the running belt to move from the front shaft toward the rear shaft. The treadmill is configured to allow the user to manually control the speed of the running belt and to facilitate maintenance of a contour of the curved running surface.

Another embodiment of the disclosure relates to a manually operated treadmill comprising a treadmill frame, a front shaft rotatably coupled to the treadmill frame, a rear shaft rotatably coupled to the treadmill frame, a running belt including a contoured running surface upon which a user of the treadmill may run, wherein the running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running belt to rotate about the front shaft and the rear shaft without the rotation of the running belt being generated by a motor, and a one-way bearing assembly configured to prevent rotation of the running surface of the running belt in one direction.

Another embodiment of the disclosure relates to a manually operated treadmill comprising a frame supported on a substantially horizontal surface, a front shaft assembly supported by the frame and comprising a front shaft and at least one front running belt pulley supported by the front shaft, a rear shaft assembly supported by the frame a spaced distance from the front shaft and comprising a rear shaft and at least one rear running belt pulley supported by the rear shaft, a running belt supported at least in part by the front shaft assembly and the rear shaft assembly, and a one-way bearing assembly cooperating with one of the front shaft and the rear shaft to permit rotation of said one of the front shaft and the rear shaft in only one direction. The running belt includes a front portion adjacent the front shaft assembly, a rear portion adjacent the rear shaft assembly, and a central portion intermediate the front portion and the rear portion, the front portion and the rear portion being positioned vertically higher than a lowest point found in the central portion to form a non-planar running surface upon which a user of the treadmill may walk or run, wherein gravitational force acting upon weight of the user's body on the running belt relative to the lowest point of the running belt causes rotation of the running belt, front shaft, and the rear shaft without the aid of a motor.

Another embodiment of the disclosure relates to a manually operated treadmill comprising a treadmill frame having a front end and a rear end opposite the front end, a front shaft rotatably coupled to the treadmill frame at the front end, a rear shaft rotatably coupled to the treadmill frame at the rear end,

and a running belt including a curved running surface upon which a user of the treadmill may run. The running belt is disposed about the front and rear shafts such that force generated by the user causes rotation of the front shaft and the rear shaft and also causes the running surface of the running belt to move from the front shaft toward the rear shaft. The treadmill is configured to control the speed of the running belt to facilitate the maintenance of the contour of the curved running surface.

Another embodiment of the disclosure relates to a manually operated treadmill comprising a treadmill frame, a front support member rotatably coupled to the treadmill frame, a rear support member rotatably coupled to the treadmill frame, a running belt including a curved running surface upon which a user of the treadmill may run, wherein the running belt is supported by the front support member and the rear support member, and a synchronizing system configured to cause the front support member and the rear support member to rotate at substantially the same speeds. The force generated by the user causes rotation of the front support member and the rear support member and also causes the running belt to rotate relative to the treadmill frame.

Another embodiment of the disclosure relates to manually operated treadmill comprising a treadmill frame, a running belt including a running surface upon which a user of the treadmill may run, a front support member rotatably coupled to the treadmill frame, the front support member comprising the forwardmost support for the running belt, a rear support member rotatably coupled to the treadmill frame, the rear support member comprising the rearwardmost support for the running belt. The running surface comprises at least in part a complex curve located intermediate the front support member and the rear support member and incorporating a minimum of two geometric configurations.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an exemplary embodiment of a manual treadmill having a non-planar running surface.

FIG. **2** is a left-hand partially exploded perspective view of a portion of the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **3** is a right-hand partially exploded perspective view of a portion of the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **4** is a perspective view of the right-hand side of the manual treadmill of FIG. **1** with a portion of the rear of the treadmill cut-away to show a portion of the arrangement of elements.

FIG. **5** is a cross-sectional view of a portion of the manual treadmill taken along line 5-5 of FIG. **1**.

FIG. **6** is an exploded view of a portion of the manual treadmill of FIG. **1** having the side panels and handrail removed.

FIG. **7***a* is a side schematic view of the profile of the running surface of the manual treadmill according to an exemplary embodiment.

FIGS. **7***b*-**7***j* are sides schematic views of alternative profiles of the running surfaces of manual treadmills according to alternative exemplary embodiments.

FIG. **8** is a partially exploded, perspective view of a bearing rail for the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **9** is a side elevation view of the bearing rail of FIG. **6**.

FIG. **10** is a top elevation view of a front shaft assembly for the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **11** is a top elevation view of a rear shaft assembly for the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **12** is a partial, cross-sectional view of the manual treadmill taken along line 12-12 of FIG. **1**.

FIG. **13** is an alternative exemplary embodiment of the partial, cross-sectional view of the manual treadmill similar to FIG. **12**.

FIG. **14** is a perspective view of an alternative embodiment of a synchronizing system integrated into a manual treadmill.

FIG. **15** is a partial, cross-sectional view of a manual treadmill including an exemplary embodiment of a braking system taken along line 15-15 of FIG. **4**.

FIG. **16** is a partial, cross-sectional view of a manual treadmill including another exemplary embodiment of a braking system taken along line 16-16 of FIG. **4**.

FIG. **17** is a perspective side view of a portion of the manual treadmill according to the exemplary embodiment shown in FIG. **1** including a plurality of rollers used in place of bearing rails.

FIG. **18** is a side perspective view of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **19** is a detail view of the track system of FIG. **18** taken along line 19-19.

FIG. **20** is a partial cross-sectional view of the track system of FIG. **18** taken along line 20-20.

FIG. **21** is a detail view of the track system of FIG. **20** taken along line 21-21.

FIG. **22** is a side perspective view of another exemplary embodiment of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **23** is a detail view of the track system of FIG. **22** taken along line 23-23.

FIG. **24** is a partial cross-sectional view of the track system of FIG. **18** taken along line 24-24.

FIG. **25** is a side perspective view of another exemplary embodiment of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **26** is a detail view of the track system of FIG. **25** taken along a line 26-26.

FIG. **27** is a partial cross-sectional view of the track system of FIG. **25** taken along line 27-27.

FIG. **28** is a detail view of the track system of FIG. **27** taken along line 28-28.

FIG. **29** is a partially exploded, right-hand perspective view of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **30** is a detail view of the track system of FIG. **29** taken along line 30-30.

FIG. **31** is a side perspective view of another exemplary embodiment of a track system for use with the exemplary embodiment of a manual treadmill shown in FIG. **1** and configured to help induce and maintain a running belt in a desired non-planar shape to define a running surface.

FIG. **32** is a detail view of the track system of FIG. **31** taken along a line 32-32.

FIG. **33** is a partial cross-sectional view of the track system of FIG. **31** taken along a line 33-33.

FIG. **34** is a detail view of the track system of FIG. **32** taken along a line 34-34.

FIG. **35** is a perspective view of an exemplary embodiment of a manual treadmill according to another embodiment having a substantially planar running surface.

FIG. **36** is a perspective view of a one-way bearing for the manual treadmill according to the exemplary embodiment shown in FIG. **1**.

FIG. **37** is a left-hand partially exploded perspective view of a portion of the manual treadmill according to the exemplary embodiment shown in FIG. **1** including an incline adjustment system.

FIG. **38** is a perspective view of a one-way bearing for the manual treadmill shown in FIG. **1**, according to another embodiment.

## DETAILED DESCRIPTION

Referring to FIG. **1**, a manual treadmill **10** generally comprises a base **12** and a handrail **14** mounted to the base **12** as shown according to an exemplary embodiment. The base **12** includes a running belt **16** that extends substantially longitudinally along a longitudinal axis **18**. The longitudinal axis **18** extends generally between a front end **20** and a rear end **22** of the treadmill **10**; more specifically, the longitudinal axis **18** extends generally between the centerlines of a front shaft and a rear shaft, which will be discussed in more detail below.

A pair of side panels **24** and **26** (e.g., covers, shrouds, etc.) are preferably provided on the right and left sides of the base **12** to effectively shield the user from the components or moving parts of the treadmill **10**. The base **12** is supported by multiple support feet **28**, which will be described in greater detail below. A rearwardly extending handle **30** is provided on the rear end of the base **12** and a pair of wheels **32** are provided at the front of the base **12**, however, the wheels **32** are mounted so that they are generally not in contact with the ground when the treadmill is in an operating position. The user can easily move and relocate the treadmill **10** by lifting the rear of the treadmill base **12** a sufficient amount so that the multiple support feet **28** are no longer in contact with the ground, instead the wheels **32** contact the ground, thereby permitting the user to easily roll the entire treadmill **10**. It should be noted that the left and right-hand sides of the treadmill and various components thereof are defined from the perspective of a forward-facing user standing on the running surface of the treadmill **10**.

Referring to FIGS. **2-6**, the base **12** is shown further including a frame **40**, a front shaft assembly **44** positioned near a front end **48** of the frame **40**, and a rear shaft assembly **46** positioned near the rear end **50** of frame **40**, generally opposite the front end **48**. Specifically, the front shaft assembly **44** is coupled to the frame **40** at the front end **48**, and the rear shaft assembly **46** is coupled to the frame **40** at the rear end **50** so that the frame supports these two shaft assemblies.

The frame **40** comprises longitudinally-extending, opposing side members, shown as a left-hand side member **52** and a right-hand side member **54**, and one or more lateral or cross-members **56** extending between and structurally connecting the side members **52** and **54** according to an exemplary embodiment. Each side member **52**, **54** includes an inner surface **58** and an outer surface **60**. The inner surface **58** of the left-hand side member **52** is opposite to and faces the inner surface **58** of the right-hand side member **54**. According to other exemplary embodiments, the frame may have substantially any configuration suitable for providing structure and support for the manual treadmill.

Similar to most motor-driven treadmills, the front shaft assembly **44** includes a pair of front running belt pulleys **62** interconnected with, and preferably directly mounted to, a shaft **64**, and the rear shaft assembly **46** includes a pair of rear running belt pulleys **66** interconnected with, and preferably directly mounted to, a shaft **68**. The front and rear running belt pulleys **62**, **66** are configured to facilitate movement of the running belt **16**. The running belt **16** is disposed about the front and rear running belt pulleys **62**, **66**, which will be discussed in more detail below. As the front and rear running belt pulleys **62**, **66** are preferably fixed relative to shafts **64** and **68**, respectively, rotation of the front and rear running belt pulleys **62**, **66** causes the shafts **64**, **68** to rotate in the same direction. The front and rear running belt pulleys **62**, **66** are formed of a material sufficiently rigid and durable to maintain shape under load. Preferably, the material is of a relatively light weight so as to reduce the inertia of the pulleys **62**, **66**. The pulleys **62**, **66** may be formed of any material having one or more of these characteristics (e.g., metal, ceramic, composite, plastic, etc.). According to the exemplary embodiment shown, the front and rear running belt pulleys **62**, **66** are formed of cast aluminum. According to another embodiment, the front and rear running belt pulleys **62**, **66** are formed of a glass-filled nylon, for example, Grivory® GV-5H Black 9915 Nylon Copolymer available from EMS-GRIVORY of Sumter, S.C. 29151, which may save cost and reduce the weight of the pulleys **62**, **66** relative to metal pulleys. To prevent a static charge due to operation of the treadmill **10** from building on a pulley **62**, **66** formed of electrically insulative materials (e.g., plastic, composite, etc.), an antistatic additive, for example Antistat 10124 from Nexus Resin Group of Mystic, Conn. 06355, may be blended with the GV-5H material.

As noted above, the manual treadmill disclosed herein includes a force translation system that incorporates a variety of innovations to translate the forward force created by the user into rotation of the running belt and permit the user to maintain a substantially static fore and aft position on the running belt while running. One of the ways to translate this force is to configure the running belt **16** to be more responsive to the force generated by the user. For example, by minimizing the friction between the running belt **16** and the other relevant components of the treadmill **10**, more of the force the user applies to the running belt **16** to propel themselves forward can be utilized to rotate the running belt **16**.

Another way to counteract the user-generated force and convert or translate it into rotational motion of the running belt **16** is to integrate a non-planar running surface, such as non-planar running surface **70**. Depending on the configuration, non-planar running surfaces can provide a number of advantages. First, the shape of the non-planar running surface may be such that, when a user is on the running surface, the force of gravity acting upon the weight of the user's body helps rotate the running belt. Second, the shapes may be such that it creates a physical barrier to restrict or prevent the user from propelling themselves off the front end **20** of the treadmill **10** (e.g., acting essentially as a stop when the user positions their foot thereagainst, etc.). Third, the shapes of some of the non-planar running surfaces can be such that it facilitates the movement of the running belt **16** there along (e.g., because of the curvature, etc). Accordingly, the force the user applies to the running belt is more readily able to be translated into rotation of the running belt **16**.

As seen in FIGS. **1** and **4-5**, the running surface **70** is generally non-planar and shown shaped as a substantially complex curve according to an exemplary embodiment. The running surface can be generally divided up into three general

regions each having a particular geometric configuration, the front portion **72**, which is adjacent to the front shaft assembly **44**, the rear portion **74**, which is adjacent to the rear shaft assembly **46**, and the central portion **76**, which is intermediate the front portion **72** and the rear portion **74**. In the exemplary embodiment seen in FIGS. **1** and **4**, the running surface **70** includes a substantially concave curve **80** and a substantially convex curve **82**. At the front portion **72** of the running surface **70**, the relative height or distance of the running surface **70** relative to the ground is generally increasing moving forward along the longitudinal axis **18** from the central portion **76** toward the front shaft assembly **44**. This increasing height configuration provides one structure to translate the forward running force generated by the user into rotation of the running belt **16**. To initiate the rotation of the running belt **16**, the user places her first foot at some point along the upwardly-inclined front portion **72** of the running surface **70**. As the weight of the user is transferred to this first foot, gravity exerts a downward force on the user's foot and causes the running belt **16** to move (e.g., rotate, revolve, advance, etc.) in a generally clockwise direction as seen in FIG. **1** (or counter-clockwise as seen in FIG. **4**). As the running belt **16** rotates, the user's first foot will eventually reach the lowest point in the non-planar running surface **70** found in the central portion **76**, and, at that point, gravity is substantially no longer available as a counteracting source to the user's forward running force. Assuming a typical gait, at this point the user will place her second foot at some point along the upwardly-inclined front portion **72** of the running belt **16** and begin to transfer weight to this foot. Once again, as weight shifts to this second foot, gravity acts on the user's foot to continue the rotation of the running belt **16** in the clockwise direction as seen in FIG. **1**. This process merely repeats itself each and every time the user places her weight-bearing foot on the running belt **16** at any position vertically above the lowest point of central portion **76** of the running surface **70** of the of the running belt **16**. The upwardly-inclined front portion **72** of the running belt **16** also acts substantially as a physical stop, reducing the chance the user can inadvertently step off the front end **20** of the treadmill **10**.

A user can generally utilize the force translation system of the treadmill **10** to control the speed of the treadmill **10** by the relative placement of her weight-bearing foot along the running belt **16** of the base **12**. Generally, the rotational speed of the running belt **16** increases as greater force is applied thereto in the rearward direction. The generally upward-inclined shape of the front portion **72** thus provides an opportunity to increase the force applied to the running belt **16**, and, consequently, to increase the speed of the running belt **16**. For example, by increasing her stride and/or positioning her weight-bearing foot vertically higher on the front portion **72** relative to the lowest portion of the running belt **16**, gravity will exert a greater and greater amount of force on the running belt **16** to drive it rearwardly. In the configuration of the running belt **16** seen in FIG. **1**, this corresponds to the user positioning her foot closer to the front end **20** of the treadmill **10** along the longitudinal axis **18**. This results in the user applying more force to the running belt **16** because gravity is pulling her mass downward along a greater distance when her feet are in contact with the front portion **72** of the running surface **70**. As a result, the relative rotational speed of the running belt **16** and the relative running speed the user experiences is increased. Accordingly, the force translation system is adapted to convert a variable level of force generated by the user into a variable speed of rotation of the belt.

FIG. **5** illustrates a number of possible locations where a user may position her feet. A-C indicate locations along the front portion **72** of the running surface **70** where a user may place their weight bearing foot. When the user positions her weight bearing foot at location A, she will be running with greater speed than if her weight bearing foot was positioned at locations B or C based upon the fact that the force of gravity is able to have a greater effect as the user's weight bearing foot moves from location A towards the rear of the non-planar running surface **70** as the running belt **16** rotates. At location A, gravity is able to have the greatest impact on the user so that the greatest amount of force is translated into rotation of the running belt **16**. A user can decrease her relative running speed by positioning her weight bearing foot at locations B or C. As location B is relatively higher along the front portion **72** than C, gravity is able to exert a greater force on the user and the running belt **16** than if the user's weight bearing foot was positioned at location C.

Another factor which will increase the speed the user experiences on the treadmill **10** is the relative cadence the user assumes. As the user increases her cadence and places her weight-bearing foot more frequently on the upwardly extending front portion **72**, more gravitational force is available to counteract the user-generated force, which translates into greater running speed for the user on the running belt **16**. It is important to note that speed changes in this embodiment are substantially fluid, substantially instantaneous, and do not require a user to operate electromechanical speed controls. The speed controls in this embodiment are generally the user's cadence and relative position of her weight-bearing foot on the running surface. In addition, the user's speed is not limited by speed settings as with a driven treadmill.

In the embodiment shown in FIGS. **1-6**, gravity is also utilized as a means for slowing the rotational speed of the running belt. At a rear portion **74** of the running surface **70**, the distance of the running surface **70** relative to the ground generally increases moving rearward along the longitudinal axis **18** from the lowest point in the non-planar running surface **70**. As each of the user's feet move rearward during her stride, the rear portion **74** acts substantially as a physical stop to discourage the user from moving too close to the rear end of the running surface. To this point, the user's foot has been gathering rearward momentum while moving from the front portion **72**, into the central portion **76**, and toward the rear portion **74** of the running surface **70**. Accordingly, the user's foot is exerting a significant rearwardly-directed force on the running belt **16**. Under Newton's first law of motion, the user's foot would like to continue in the generally rearward direction. The upwardly-inclined rear portion **74**, interferes with this momentum and provides a force to counter the rearwardly-directed force of the user's foot by providing a physical barrier. As the user's non-leading foot moves up the incline (see position D in FIG. **5**), the running surface **70** provides a force that counters the force of the user's foot, absorbing some of the rearwardly-directed force from the user and preventing it from being translated into increasing speed of the running belt **16**. Also, gravity acts on the user's weight bearing foot as it moves upward, exerting a downwardly-directed force on the user's foot that the user must counter to lift their foot and bring it forward to continue running. In addition to acting as a stop, the rear portion **74** provides a convenient surface for the user to push off of when propelling themselves forward, the force applied by the user to the rear portion **74** being countered by the force the rear portion **74** applies to the user's foot.

One benefit of the manual treadmill according to the innovations described herein is positive environmental impact. A manual treadmill such as that disclosed herein does not utilize electrical power to operate the treadmill or generate the rota-

tional force on the running belt. Therefore, such a treadmill can be utilized in areas distant from an electrical power source, conserve electrical power for other uses or applications, or otherwise reduce the "carbon footprint" associated with the operation of the treadmill **10**.

A manual treadmill according to the innovations disclosed herein can incorporate one of a variety of shapes and complex contours in order to translate the user's forward force into rotation of the running belt or to provide some other beneficial feature or element. FIG. **7***a* generally depicts the curve defined by the running surface **70** of the exemplary embodiment shown in FIG. **1**, specifically, substantially a portion of a curve defined by a third-order polynomial. The front portion **72** and the central portion **76** define a concave curve and the rear portion **74** of the running surface **70** defines a convex curve. As the central portion **76** of the running surface **70** transitions to the rear portion **74**, the concave curve transitions to the convex curve. In the embodiment shown, the curvature of the front portion **72** and the central portion **76** is substantially the same; however, according to other exemplary embodiments, the curvature of the front portion **72** and the central portion **76** may differ. Please note, the description of the running surfaces as concave and convex provided herein is related to the relative curve which the user's foot would experience on the running surface **70**.

FIGS. **7***b*-**7***h* illustrate the side profiles of some exemplary non-planar, contoured running surfaces according to the innovations disclosed herein, each including a front portion, a central portion, and a rear portion. Each portion has a particular geometric configuration that is concave, convex, or linear; collectively, the portions define the non-planar running surface. For example, FIG. **7***b* shows an exemplary embodiment of the profile of a non-planar surface including a concave front portion **100**, a concave central portion **102**, and a concave rear portion **104** according to an exemplary embodiment. In this embodiment, the front portion **100**, central portion **102**, and rear portion **104** each have different curvatures. According to other exemplary embodiments, one or more of the front, central, and rear portions may have the same curvature.

FIG. **7***c* shows an exemplary embodiment of the profile of a non-planar surface including a convex front portion **110**, a concave central portion **112**, and a concave rear portion **114** according to an exemplary embodiment. Once again, this embodiment incorporates a smooth transition between the different curvatures of the front, central, and rear portions.

FIG. **7***d* shows an exemplary embodiment of the profile of a non-planar surface including a convex front portion **120**, a concave central portion **122**, and a convex rear portion **124** according to an exemplary embodiment. In this embodiment, the front portion **120** and the rear portion **122** have different curvatures, but these curvatures may be the same according to other exemplary embodiments.

FIG. **7***e* shows an exemplary embodiment of the profile of a non-planar surface including a convex front portion **130**, a convex central portion **132**, and a convex rear portion **134** according to an exemplary embodiment. In this embodiment, the front portion **130**, the central portion **132**, and the rear portion **134** each have the same convex curvature, but the curvature of one of more of the front portion **130**, the central portion **132**, and the rear portion **134** may differ according to other exemplary embodiments.

FIG. **7***f* shows an exemplary embodiment of the profile of a non-planar surface including a concave front portion **140**, a convex central portion **142**, and a convex rear portion **144** according to an exemplary embodiment. In this embodiment, the central portion **142** and the rear portion **144** having the same curvatures, but these curvatures may differ from each other according to other exemplary embodiments.

FIG. **7***g* shows an exemplary embodiment of the profile of a non-planar surface including a convex front portion **150**, a convex central portion **152**, and a concave rear portion **154** according to an exemplary embodiment. In this embodiment, the front portion **150** and the central portion **152** having the same curvatures, but these curvatures may differ from each other according to other exemplary embodiments.

FIG. **7***h* shows an exemplary embodiment of the profile of a non-planar surface including a concave front portion **160**, a convex central portion **162**, and a concave rear portion **164** according to an exemplary embodiment. In this embodiment, the front portion **160** and the rear portion **164** have different curvatures, but these curvatures may be the same according to other exemplary embodiments.

According to one exemplary embodiment, the non-planar running surface of the manual treadmill **10** is substantially curved, but that curve integrates one or more linear portions (e.g., that replace a "curved portion" or the curve or that are added/inserted into the curve). The linear portions may be substantially parallel to the longitudinal axis **18** or disposed at an angle relative thereto. FIG. **7***i* illustrates the profile of a non-planar surface wherein a substantially linear portion **170** has been integrated with a concave curve having a first concave portion **174** to one side of the linear portion **170** and a second concave portion **176** to the opposite side of the linear portion **170** according to an exemplary embodiment. In addition to the linear portion **170**, the first concave portion **174** and the second concave portion **176**, the profile further includes a fourth portion shown as a convex portion **178**. According to an another exemplary embodiment, a linear portion may replace all or a portion of the curve. Alternatively, multiple linear portions may be included in a profile of a non-planar surface.

FIG. **7***j* illustrates a linear portion **180** provided at the front of the running surface which transitions into a concave curve **182** which then transitions into a convex curve **184**.

According to an exemplary embodiment, the non-planar running surface of the manual treadmill **10** may include (or be so defined as to include) more or less than three portions. For example, FIG. **7***g* could be interpreted as defined two portions, the first portion including the front portion and the central portion, which comprise a convex curve having the same curvature throughout the front portion **150** and the central portion **152**, and the second portion including the rear portion **154** which generally comprises a concave curve. According to some exemplary embodiments, some non-planar running surfaces include at least three or more portions.

According to an exemplary embodiment, the profile defined by the non-planar running surface is substantially a portion of a curve defined by any suitable second-order polynomial, but, as clearly demonstrated in FIGS. **7***a-j*, the profile defined by the non-planar running surface can be a portion of a curve that is a third-order polynomial or a fourth-order polynomial. According to yet another exemplary embodiment, the running surface profile can be substantially defined by a first-order polynomial, in other words, the running surface is substantially planar. An exemplary embodiment of a manual treadmill including a planar running surface will be discussed in more detail below (see e.g., FIG. **35**).

According to an exemplary embodiment, the relative length of each portion of the running surface may vary. In the exemplary embodiment shown, the central portion is the longest. In other exemplary embodiments, the rear portion may be the longest, the front portion may be shorter than the intermediate portion, or the front portion may be longer than

the rear portion, etc. It should be noted that the relative length may be evaluated based on the distance the portion extends along the longitudinal axis or as measured along the surface of the running belt itself. One of the benefits of integrating one or more of the various curves or contours into the running surface is that the contour of the running surface can be used to enhance or encourage a particular running style. For example, a curve integrated into the front portion of the running surface can encourage the runner to run on the balls of her feet rather than a having the heel strike the running belt **16** first. Similarly, the contour of the running surface can be configured to improve a user's running biomechanics and to address common running induced injuries (e.g., plantar fasciitis, shin splints, knee pain, etc.). For example, integrating a curved contour on the front portion of the running surface can help to stretch the tendons and ligaments of the foot and avoid the onset of plantar fasciitis.

One of the difficulties associated with using a running surface that has a non-planar shape is inducing the running belt **16** to assume the non-planar shape and then maintaining the running belt **16** in that non-planar shape when the treadmill is being operated. In addition to discussing this difficulty in more detail below, a number of running belt retention systems providing ways to induce and maintain a belt in a desired non-planar shape to define the running surface are discussed below. Generally, these running belt retention systems are adapted to control the relative contour of the running belt so that the running belt substantially follows the contour of the running surface

One embodiment of a running belt retention system used to induce the running belt **16** to take-on the non-planar shape and then maintaining that shape, as shown in FIG. **5**, is discussed in reference to FIGS. **5-6** and **8-11** in which base **12** is shown further including a pair of opposed bearing rails **200** to support the running belt **16** along with a front synchronizing belt pulley **202**, a rear synchronizing belt pulley **204**, and a synchronizing belt **206** all of which are interconnected to the running belt **16**. The front rear synchronizing belt pulleys **202**, **204** may be formed of the same or different materials as the front and rear running belt pulleys **62**, **66**.

Referring to FIGS. **6** and **8-9**, in particular, the bearing rails **200** are shown including a plurality of bearings **208** and an upper or top profile **210**, shown shaped as a complex curve, according to an exemplary embodiment. The bearing rails **200** shown are supported by and preferably mounted to the frame **40** substantially between the front shaft assembly **44** and the rear shaft assembly **46**, the support members or elements about which the running belt **16** is disposed. One bearing rail **200** is coupled to one or more of the cross-members **56** proximate to the inner surface **58** of the left-hand side member **52** and the other bearing rail **200** is coupled to one of more of the cross-members **56** proximate to the inner surface **58** of the right-hand side member **54** thereby fixing the position of the bearing rails **200** relative to the frame **40**.

The bearing rails **200** are preferably configured to facilitate movement of the running belt **16**. In the exemplary embodiment seen in FIGS. **8-9**, the running belt **16** moves substantially along the top profile **210** of the bearing rails **200**. The running belt **16** contacts and is supported in part by the bearings **208** of the bearing rails and bearing **208** are configured to rotate, thereby decreasing the friction experienced by the running belt **16** as the belt moves along the top profile **210**. The bearing rails **200** are configured to help achieve the desired shape of the running surface. The shape of the top profile **210** of the bearing rails **200** at least partially corresponds to the desired shape for the running surface **70**. The at least somewhat flexible running belt **16** substantially assumes the shape of top profile **210** of the bearing rails **200** by being maintained substantially thereagainst, as will be discussed in more detail later. Accordingly, the running surface **70** has a shape that substantially corresponds to the shape of the top profile **210** of the bearing rails **200**. It should be noted that the front and/or rear running belt pulleys may also help define a portion of the shape of the running surface. Also, other suitable shape-providing components may be used in combination with the bearing rails.

FIG. **9** provides a side view of one of the bearing rails **200** to more clearly show the top profile **210** according to an exemplary embodiment. Similar to the running surface **70**, discussed above, the top profile **210** of the bearing rails **200** can be generally divided up into three general regions, the front portion **212** which is adjacent to the front shaft assembly **44** (see e.g., FIG. **5**), the rear portion **214** which is adjacent to the rear shaft assembly **46** (see e.g., FIG. **5**), and the central portion **216**, intermediate the front portion **212** and the rear portions **214**. The central portion **216** is shown as a concave curve **218** that has a radius of curvature R1. The front portion **212** is further shown as a continuation of the concave curve **218** of the central portion **216**, and, thus, also has a radius of curvature of R1. The rear portion **214** is shown as a convex curve **220** that has a radius of curvature R2. The front portion **212** is shown disposed substantially tangential to the central portion **216**, providing a smooth transition therebetween, and helping provide a smooth shape for the running surface **70**. The shape of the rear portion **214** also helps provide a smooth transition for the running belt **16** from the bearing rails **200** onto the rear running belt pulleys **66**, which helps ensure as much contact as possible between the running belt **16** and the rear running belt pulleys **66**. As the shape of the running surface substantially corresponds to the shape of top profile the bearing rails, the shape of the top profile of the bearing rails can necessarily be any of the shapes and/or have any of the variations (e.g., in length of portions, etc.) discussed above in FIGS. **7***a* through **7***j* with reference to possible shapes of the running surface.

According to an exemplary embodiment, each portion of the top profile is disposed substantially tangential to the portions adjacent thereto. According to other exemplary embodiments, less than all of the adjacent portions are disposed substantially tangential to the portions adjacent thereto, meaning the profile does not have an entirely smooth contour.

According to an exemplary embodiment shown in FIG. **9**, R1 is approximately 7.26 feet. However, it is understood that a radius anywhere from 5 feet to 100-plus feet can be used. The size of the radius which can be used is typically a function of the length of the treadmill which can be accommodated. The range of possible radiuses for a convex bearing rail depends on the shaft-to-shaft distance of the treadmill (see e.g., measurement "x" in FIG. **5**, discussed in more detail below). Assuming that the radius of curvature of the curve is $R_C$, the radius of the front running belt pulley is $R_f$, and the radius of the rear running belt pulley is $R_r$, the range of possible radiuses is approximately: $\infty > R_C > (x - R_f - R_r)/2$. For most commercial-available treadmills, x is approximately between 14 inches and 10 feet but the treadmill can certainly be as great as 25 feet in length. According to the exemplary embodiment shown in FIG. **5**, x is approximately 57.8 inches in length. According to another exemplary embodiment, x is approximately 77.2 inches in length, with a radius R1 of approximately 8.67 feet, wherein the greater length x and radius R1 may facilitate use of the treadmill **10** by users with a longer running gait. The limiting factors in the length are the available space to accommodate the treadmill and the relative cost of constructing such a large treadmill.

When the treadmill **10** is being operated, the running belt **16** is driven rearwardly and the goal is to ensure that the running belt **16** follows the profile defined by a portion of the circumference of the front running pulleys **62**, the contoured profile defined by the bearings **208** supported on the bearing rails **200** and finally by a portion of the circumference of the rear running belt pulleys **66**. The particular contour which the running belt **16** assumes on the bottom of the base **12** between the rear running belt pulleys **66** and front running belt pulleys **62** is not terribly critical provided that the running belt continues to move with minimal friction and is not subject to excessive wear or obstruction.

Following the shape of the bearing rails **200** is not the natural tendency of the running belt for the particular contour seen in FIG. **5**. Rather, without more, the running belt **16** tends to be pulled upward, away from the curved bearing rails and across the central portion **76** of the treadmill **10**. Under the force of gravity, the weight of the running belt **16** coupled with the relative spacing between the front and rear running belt pulleys **62** and **66**, respectively, would likely result in the top surface of the running belt **16** assuming a position of the shortest distance between the two pulleys, namely, a substantially straight line between the two pulleys with any excess length of the running belt **16** collecting on the bottom of the treadmill and hanging below the front and rear running belt pulleys **62** and **66**, respectively. Therefore, a system of some sort needs to be integrated into a non-planar running surface treadmill to ensure that the running belt **16** follows the desired contour over the running surface.

Further referring to FIGS. **5-6** and **8-11**, one way to ensure that the running belt **16** follows the contour of the bearing rails **200** and the front and rear running belt pulleys **62**, **66** is to utilize the weight of the running belt **16** itself in addition to adjusting the relative size of the front and rear running belt pulleys **62**, **66**; and/or providing a synchronizing system **222** according to an exemplary embodiment.

As discussed above, the running belt **16** is disposed about the front and rear running belt pulleys **62**, **66** which in turn are disposed about front and rear shafts **64**, **68**, respectively. Measured along the longitudinal axis **18** between the centerlines of the front and rear shafts **64**, **68**, the front and rear shafts **64**, **68** are spaced a distance x from each other, as shown in FIG. **5**. Accordingly, when positioning the running belt **16** about the front and rear running belt pulleys **62**, **66**, the length of the running belt **16** provided therebetween must be at least x (e.g., the straight-line distance therebetween). It follows that, when the profile of the running surface **70** is non-planar, the length of the running belt provided between the front and rear shafts **64**, **68** will be greater than x.

In the exemplary embodiment shown in FIG. **5**, when positioning the running belt **16** about the front and rear running belt pulleys **62**, **66**, a length of the running belt **16** sufficient to permit the running belt **16** to correspond to (e.g., follow, be positioned against or above, etc.) the desired contours of the bearing rails **200** and the front and rear running belt pulleys **62**, **66** is generally disposed between the front and rear shafts **64**, **68**. At each location between the front and rear shafts **64**, **68**, the force of gravity pulls downward on the running belt **16**. Generally, this force will help pull the running belt **16** downward and against the desired components of base **12**. However, gravity can also cause slippage (e.g., over the front running belt pulley **62**, over the rear running belt pulley **66**, down along curves of the bearing rail **200**, etc.) in an amount that is undesirable and the magnitude of these slippage-problems tends to increase when the treadmill **10** is being operated. Accordingly, the solution typically relies on more than the weight of the running belt alone.

Further referring to FIGS. **5-6** and **8-11**, the preferred embodiment of the running belt **16** is shown including two reinforcing belts shown as endless belts **226** and a plurality of slats **228** according to an exemplary embodiment. The endless belts **226** are configured to provide support for the running belt **16** in order to support the weight of a user. The endless belts **226** are shown disposed on opposite sides of the running belt **16**, generally interior to the outer, lateral edge of the slats **228**. The endless belts **226** are themselves reinforced, and thus help stabilize the sides of the running belt and help prevent stretching of the running belt **16**. For example, the endless belts may be reinforced with metal wiring, which is surrounded by a molded plastic coating. According to some exemplary embodiments, more or less than two endless belts may be used. According to other exemplary embodiments, other suitable support elements may be used to provide support for the running belt. Further details regarding the structure of the running belt and endless belt structure are seen in U.S. Pat. No. 5,470,293, titled "Toothed-Belt, V-Belt, and Pulley Assembly, for Treadmills," which is incorporated by reference herein.

The endless belts **226** are further configured to interact with the front running belt pulleys **62** and the rear running belt pulleys **66**. The location of each endless belt **226** laterally, along the width of the running belt **16**, substantially corresponds to the location of a longitudinally aligned front running belt pulley **62** and rear running belt pulley **66**. Each endless belt **226** includes a first or inner portion **230** and a second or outer portion **232** at an interior surface **236** according to an exemplary embodiment. The inner portion **230** is in contact with an exterior surface **234** of the corresponding running belt pulleys **62**, **66**. According to some exemplary embodiments, the outer portion **232** is also in contact with the exterior surface **234** of the corresponding running belt pulleys **62**, **66**.

FIG. **12** illustrates a running belt and running belt pulley combination wherein the exterior surfaces **234** of the front running belt pulleys **62** are substantially smooth and are in contact with the interior surface **236** of the endless belts **226**, which is also substantially smooth according to an exemplary embodiment. The outer portion **232** is shown substantially not in contact with the exterior surfaces **234** of the front running belt pulleys **62**. The outer portion **232** is further shown including a plurality of teeth **238** (e.g., being toothed); however, according to other exemplary embodiments, the outer portion may be smooth or have any suitable texture and/or configuration. In this embodiment, both of the running belt pulleys come in contact with the inner, substantially smooth portion of the endless belts, and a toothed portion of the endless belts is disposed to the outside of the running belt pulleys on both sides.

FIG. **13** illustrates an alternative running belt and running belt pulley combination according to an exemplary embodiment. In this exemplary embodiment, the front running belt pulleys **62'** include a first or inner portion **230'** and a second or outer portion **232'**. The inner portion **230'** of the front running belt pulleys **62'** is substantially smooth, while the outer portion **232'** includes a plurality of teeth, to correspond to the inner and outer portions **230'**, **232'**, of the endless belts **226'**, respectively. In this embodiment, both of the running belt pulleys include an inner, smooth portion and an outer, toothed portion. These portions correspond to an inner, smooth portion of the endless belt and an outer, toothed portion of the endless belt. This endless belt/front running belt pulley configuration is discussed in more detail in U.S. Pat. No. 5,470,

293, titled "Toothed-Belt, V-Belt, and Pulley Assembly, for Treadmills," which is herein incorporated by reference in its entirety.

According to still another an exemplary embodiment, a combination of the endless belt/front running belt pulley configurations shown in FIGS. **12** and **13** is used. In this exemplary embodiment, the smooth belt and pulley configuration shown in FIG. **12** is used for the front running belt pulleys and the combination of smooth and toothed belt and pulley configuration shown in FIG. **13** is used for the rear running belt pulleys. In another exemplary embodiment, the configuration shown in FIG. **13** is used for the front running belt pulleys and the configuration shown in FIG. **12** is used for the rear running belt pulleys.

The slats **228** of the running belt **16** are configured to help support a user of the treadmill **10**. The slats **228** may be made of substantially any suitably sturdy material (e.g., wood, plastic, metal, etc.) and extend generally laterally between the endless belts **226**. Each slat **228** is coupled at its ends **252**, **254** to the second portions **232** of the endless belts **226** using fasteners. According to other exemplary embodiments, the slats may be otherwise coupled to the endless belts (e.g., adhered, welded, etc.) in the manner disclosed in U.S. Pat. No. 5,470,293, titled "Toothed-Belt, V-Belt, and Pulley Assembly, for Treadmills," which is incorporated herein by reference. Each slat is shown to include a portion **229** (e.g., stem, web, etc.) extending inwardly from an interior surface **256** of the slat **228**.

According to an exemplary embodiment, the running belt may be substantially any suitable, continuous loop element, including, but not limited to, a continuous urethane (e.g., polyurethane) loop, a continuous loop made of plastics other than polyurethane, a plastic belt reinforced with reinforcing elements (e.g., metal wire, a relatively harder plastic, wood, etc.), a continuous foam loop, a loop formed by a plurality of interconnected members (e.g., metallic members, wooden members, etc.) in a manner to provide at least some flexibility, etc.

Referring to FIGS. **6**, **10** and **11**, another aspect of the solution to ensuring the running belt **16** follows the desired contour involves the utilizing front running belt pulleys **62** that are slightly larger than the rear running belt pulleys **66**. That is, the radius of the front running belt pulleys, $R_f$, is greater than the radius of the rear running belt pulleys, $R_r$. Assuming the front running belt pulleys **62** are rotating with the same rotational velocity (e.g., angular speed) as the rear running belt pulleys **66**, the tangential velocity of the front running belt pulleys **62** is slightly greater than the tangential velocity of the rear running belt pulleys **66**. Thus, as the running belt **16** is driven, the portion of the running belt **16** disposed proximate the front end **20** of the treadmill **10** will be moved over the front running belt pulleys **62** and rearward with slightly greater speed than the rear running belt pulleys **66** move the portion of the running belt **16** proximate thereto. Thus, the front running belt pulleys **62** essentially "push" the running belt **16** rearward, creating a slight amount of excess running belt **16** in the area between the front running belt pulleys **62** and the rear running belt pulleys **66**, which helps to counter the force of gravity which would attempt to gather any excess length of running belt **16** on the bottom of the treadmill **10** thereby causing the top surface of the running belt **16** to assume a position of the shortest distance between the two pulleys, namely, a substantially straight line between the two pulleys. Obviously the system cannot tolerate too much excess length of running belt feeding off the front running belt pulley **62** so periodically, a portion of this excess running belt **16** will slip over the rear running belt pulley **66**. By specifically balancing the excess running belt **16** coming off the front running belt pulley **62** against the slippage allowed on the rear running belt pulley **66**, the running belt **16** will follow the desired concave, convex or linear (or combinations thereof) contours of the running surface.

If the difference between the radius of the front running belt pulleys **62** and the radius of the rear running belt pulleys **66** is too large, the running belt **16** will begin to bunch up atop the base **12** as too much excess is generated. Accordingly, there is a practical limit of differences between the radius of each of the front running belt pulleys **62** and the radius of each of the rear running belt pulleys **66**. Generally, this range may be dependent on the length of the running surface, as measured along the running belt, and/or the shape of the running surface. According to an exemplary embodiment, the size difference between the radii of the front and rear running belt pulleys, $R_f-R_r$, is within the range of approximately $0<R_f-R_r<0.100$ inches. Preferably, the size difference between the radii of the front and rear running belt pulleys, $R_f-R_r$, is within the range of approximately $0.005<R_f-R_r<0.035$ inches. In one embodiment, the radius of the front running belt pulleys is approximately 7.00"+/−0.010" and the radius of the rear running belt pulleys is approximately 6.985"+/−0.010. According to another exemplary embodiment, instead of using front and rear running belt pulleys having a radial size difference, the synchronizing belt pulleys may have a radial size difference. Similar to the differently sized front and rear running belt pulleys, the differently sized front and rear synchronizing pulleys would be used to essentially "push" the running belt rearward, creating a slight amount of excess running belt **16** in the area between the front running belt pulleys and the rear running belt pulleys.

Another means for ensuring that the running belt **16** follows the desired complex curve is to match the rotational velocity of the front running belt pulleys **62** to that of the rear running belt pulleys **66** utilizing a synchronizing system **222**. Further referring to FIGS. **5-6** and **8-11**, the synchronizing system **222** is shown generally to comprise the front synchronizing belt pulley **202**, the rear synchronizing belt pulley **204**, and the synchronizing belt **206** according to an exemplary embodiment.

The front synchronizing belt pulley **202** is rotatably mounted relative to the front shaft **64**, similar to the front running belt pulleys **62**. Preferably, the front synchronizing belt pulley **202** is securely mounted directly to the front shaft **64**. Similarly, the rear synchronizing belt pulley **204** is fixed relative to the rear shaft **68** and preferably securely mounted to the rear shaft **68**. Accordingly, the front synchronizing belt pulley **202** will move with substantially the same rotational speed as the front running belt pulleys **62**, and the rear synchronizing belt pulley **204** will move with the same rotational speed as the rear running belt pulleys **66**. When the front shaft assembly **44** and the rear shaft assembly **46** are coupled to the frame **40**, the front and rear synchronizing belt pulleys **202**, **204** are shown disposed exterior to the outer surface **60** of the left-hand side member **52**. According to another exemplary embodiment, the front and rear synchronizing belt pulleys may be placed exterior to the outer surface of the right-hand side member of the frame. According to other exemplary embodiments, the synchronizing system may be disposed substantially between the left-hand side member and the right-hand side member of the frame.

The synchronizing belt **206** is configured to provide a force that helps ensure that the front and rear shafts **64**, **68** are rotating (e.g., moving, spinning, etc.) at the same rotational velocity. The synchronizing belt **206** is shown as an endless belt that is adapted to be supported in tension about the front

synchronizing belt pulley **202** and the rear synchronizing belt pulley **204**, as shown in FIGS. **4-5**. As the running belt pulleys **62**, **66** and the synchronizing belt pulleys **202**, **204** are both substantially fixed relative to the front shaft **64** and the rear shaft **68**, the rotation of the front shaft **64** and the rear shaft **68** causes the front synchronizing belt pulley **202** and the rear synchronizing belt pulley **204** to similarly rotate. In response to the motion of the front synchronizing belt pulley **202** and the rear synchronizing belt pulley **204**, the synchronizing belt **206**, which connects the front shaft assembly **44** and the rear shaft assembly **46**, similarly rotates. Because of the tension in the synchronizing belt **206** and the fact that the synchronizing belt pulleys **202**, **204** are the same size, the synchronizing belt **206** provides a counter force in response to any deviation in rotational velocity between the front shaft assembly **44** and the rear shaft assembly **46**. For example, if the rear shaft assembly **46** was induced to start moving with greater rotational velocity than the front shaft assembly **44**, the tension in the upper portion of the synchronizing belt (i.e., that portion of the synchronizing belt that extends generally between the tops of the synchronizing pulleys) would resist any differential rotation between the front and rear synchronizing belt pulleys **202**, **204**. Continuing with the example, any discrepancy between the rotational velocity of the front and rear shafts **64**, **68** is similarly resisted by the engagement of the synchronizing belt **206**. Thus, by constraining the relative motion of the front shaft assembly **44** and the rear shaft assembly **46**, the synchronizing system **222** keeps their rotational velocity in sync, substantially preventing the front and rear running belt pulleys **62**, **66** from becoming unsynchronized and moving at different rotational velocities.

So, in practice, the running belt **16** is initially installed on the front and rear running belt pulleys **62**, **66** and the running belt **16** is manually positioned in the desired position so that a sufficient length of the running belt **16** is positioned along the top of the treadmill and the running belt **16** assumes the desired contour. While the running belt **16** is maintained in this position, the synchronizing belt **206** is mounted to the synchronizing belt pulleys **202**, **204** and once the synchronizing belt **206** is installed, it effectively resists differential rotation of the running belt pulleys **62**, **66** which could result in loss of the desired contour of the running belt **16**.

It should be noted that the tension in the synchronizing belt **206** also helps maintain the position of the synchronizing belt **206** relative to the synchronizing belt pulleys **202**, **204**. The tension helps enhance friction between an interior surface **244** of the synchronizing belt **206** and exterior surfaces **246** of the synchronizing belt pulleys **202**, **204**, making it less likely that the synchronizing belt **206** will slip relative to the synchronizing belt pulleys **202**, **204**.

One or more tensioning assemblies **248** may be provided to adjust the tension in the synchronizing belt **206** (see e.g., FIGS. **3** and **6** illustrating tensioning assemblies **248**). Tensioning assemblies **248** are configured to move portions of the synchronizing belt **206** relative to one another, stretching the synchronizing belt **206** and maintaining this stretch so that the synchronizing belt **206** can provide the necessary resistance to differential rotation of the front and rear running belt pulleys **62**, **66**. Alternatively, the tensioning assemblies **248** can be adjusted to release some of the tension in the synchronizing belt **206**. Releasing some of the tension may be desirable if the synchronizing belt **206** is too tight, causing excess friction between the synchronizing belt **206** that makes it too difficult to rotate the front and rear shaft assemblies **44**, **46** (e.g., greater than desired by the user, too great to function, etc.). The tensioning assemblies **248** are also used when the synchronizing belt **206** is being installed and removed. According to another exemplary embodiment, a single tensioning assembly is used in conjunction with one or more stationary idlers. According to still another exemplary embodiments, any devices or elements suitable for maintaining and/or adjusting the tension in the synchronizing belt may be used.

Referring to FIG. **14**, a synchronizing system **300** is shown according to another exemplary embodiment. The synchronizing system **300** would typically be used in lieu of the previously described synchronizing system **222**. In this next exemplary embodiment, the synchronizing system **300** is shown comprising a synchronizing shaft **302** mechanically connected at a first end **304** to a front gear **306** and at a second end **308** to a rear gear **310**. The front gear **306** is interconnected with, and preferably directly mounted and fixed relative to, the front shaft **64**, and the rear gear **310** is interconnected with, and preferably directly mounted and fixed relative to, the rear shaft **68**. Accordingly, the front gear **306** will move with substantially the same rotational speed as the front running belt pulleys **62**, and the rear gear **310** will move with the same rotational speed as the rear running belt pulleys **66**. When the front shaft assembly **44** and the rear shaft assembly **46** are coupled to the frame **40**, the front and rear gears **306**, **310** are shown disposed exterior to the outer surface **60** of the right-hand side member **54**. According to another exemplary embodiment, the front and rear gears **306**, **310** may be placed exterior to the outer surface of the left-hand side member of the frame. According to other exemplary embodiments, the synchronizing system may be disposed substantially between the left-hand side member and the right-hand side member of the frame.

The synchronizing shaft **302** is configured to provide a force that helps ensure that the front and rear shafts **64**, **68** are rotating (e.g., moving, spinning, etc.) at the same rotational velocity. The synchronizing shaft **302** is shown as an elongated, substantially cylindrical member that extends generally between the front shaft **64** and the rear shaft **68**. A first threaded portion **312** including a plurality of threads **314** is shown located at the first end **304** of the synchronizing shaft **302** and is configured to mesh with a plurality of teeth **316** of the front gear **306** that is fixed relative to the front shaft **64**. A second threaded portion **318** including a plurality of threads **320** is shown located at the second end **308** of the synchronizing shaft **302** and is configured to mesh with a plurality of teeth **322** of the rear gear **310** that is fixed relative to the rear shaft **68**.

The synchronizing shaft **302** rotates in response to the motion of the front gear **306** and the rear gear **310**. When the front shaft **64** and the rear shaft **68** rotate in response to the user driving the running belt **16**, the front gear **306** and the rear gear **310**, which are fixed relative to the front shaft **64** and the rear shaft **68**, respectively, similarly rotate. The front gear **306** meshes with and imparts rotational motion to the first threaded portion **312**, and, thereby, imparts rotational motion to the synchronizing shaft **302**. The rear gear **310** meshes with and imparts rotational motion to the second threaded portion **318**, and, thereby, imparts rotational motion to the synchronizing shaft **302**.

Because the synchronizing shaft **302** is rigid and the front and rear gears **306**, **310** are the same size, the synchronizing shaft **302** provides a counter force in response to any deviation in rotational velocity between the front shaft assembly **44** and the rear shaft assembly **46**. For example, if the rear shaft assembly **46** was induced to start moving with greater rotational velocity than the front shaft assembly **44**, the rear gear **310** would be prevented from moving with greater rotational velocity than the front gear **306** because of the synchronizing

shaft **302**. The second threaded portion **318** is meshed with the rear gear **310**. The second threaded portion **318** is fixed relative to the first threaded portion **312**. The first threaded portion **312** is meshed with the front gear **306**, which is moving with less rotational velocity than the rear gear **310**. The front gear **306**, being fixed relative to the front shaft assembly **44** which is also traveling at the same rotational velocity, seeks to continue at this rotational velocity. Thus, the force transmitted to the front gear **306** from the rear gear **310** by the synchronizing shaft **302** is met with a counter force. Specifically, the teeth **322** of the front gear **306** counter the force applied thereto by the threads **314** of the first threaded portion **312** at the first end **304**. This counter force substantially prevents the rotational velocity of the synchronizing shaft **302**, which includes the second threaded portion **318**, from increasing. Stated otherwise, the force applied is sufficient to prevent the second end **308** of the synchronizing shaft **302** from rotationally advancing ahead of the first end **304**. As the second threaded portion **318** is prevented from experiencing an increase in rotational velocity, the second threaded portion **318** provides a counter force to the rear gear **310**. Specifically, the threads **320** of the second threaded portion **318** counter the force applied thereto by the teeth **322** of the rear gear **310**. Thus, the synchronizing shaft **302** constrains the relative motion of the front gear **306** and rear gear **310**, and, thereby constrains the relative motion of the front shaft assembly **44** and the rear shaft assembly **46**.

Another embodiment of a running belt retention system used to induce and maintain the running belt in a desired non-planar shape to define the running surface is seen in FIG. **15**, specifically a braking system **400** configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface is shown according to an exemplary embodiment. Please note, the section lines 15-15 shown in FIG. **4** do not necessarily suggest that the braking system **400** seen in FIG. **15** is integrated into the manual treadmill depicted in FIG. **4**, rather, the section line 15-15 is included in FIG. **4** to show one potential location for the integration of a braking system into a manual treadmill according to the various innovations disclosed herein. The braking system **400** is shown in cooperation with the rear shaft assembly **402** and the synchronizing system **222**. The rear shaft assembly **402** differs from the above-discussed rear shaft assembly **46** in that the rear shaft assembly **402** includes a pair of rear running belt pulleys **404** that are substantially the same size as the front running belt pulleys (not shown).

The braking system **400** has substantially the same effect as the differently sized front and rear running belt pulleys discussed above. That is, the braking system **400** causes a slight amount of excess running belt **16** in the area between the front running belt pulleys and the rear running belt pulleys. More specifically, the braking system **400** causes the rotational velocity of the rear shaft assembly **402** to be slightly lower than the rotational velocity of the front shaft assembly by applying a frictional force to the rear synchronizing belt pulley **204**. Thus, the braking system **400** acts on the synchronizing system **222** to force (e.g., urge, push, move, etc.) the rear shaft assembly **402** out of synch with the front shaft assembly.

The braking system **400** includes a generally elongated member **406** in cooperation with the synchronizing system **222**. The elongated member **406** is coupled to the rear shaft assembly **402** by a bracket **408** having a first side **410** spaced a distance apart from an outer surface **250** of the rear synchronizing belt pulley **204**. The elongated member **406** is disposed through an aperture **412** of the bracket **408** and includes a first end **414** disposed to the inside of the first side **410** and a second end **416** disposed to the outside of the first side **410**. The first end **414** includes a surface **418** configured to contact the outer surface **250** of the rear synchronizing belt pulley **204**. The second end **416** includes a knob **420** configured to be gripped by a person (e.g., a user, a trainer, etc.) and to have a rotational force imparted thereto. An exterior surface of the elongated member **406** is at least partially threaded to correspond to threading at an interior surface defining the aperture **412**. Rotating the knob **420**, and, thereby, the elongated member **406**, in one direction, causes the surface **418** to be advanced toward the outer surface **250** of the rear synchronizing belt pulley **204**, and rotating the knob **420** in the opposite direction causes the surface **418** to retreat or be moved away from the outer surface **250** of the rear synchronizing belt pulley **204**.

During operation of the treadmill, the surface **418** of the elongated member **406** is substantially in contact with the outer surface **250** of the rear synchronizing belt pulley **204**, creating friction therebetween. As the rear synchronizing belt pulley **204** of the synchronizing system **222** is fixed relative to the rear shaft assembly **402**, some of the force directed to the rear shaft assembly **402** to impart rotation thereto must be used to overcome the frictional force between the surface **418** of the elongated member **406** and the outer surface of the rear synchronizing belt pulley **204**. As the force needed to overcome the frictional force between the surface **418** of the elongated member **406** and the outer surface **250** of the rear synchronizing belt pulley **204** is no longer being directed into rotation of the rear shaft assembly **402**, the rotational velocity of the rear shaft assembly **402** is less than the rotational velocity of the front shaft assembly. Thus, the front running belt pulleys of the front shaft assembly will "push" the running belt rearward, creating a slight amount of excess running belt **16** in the area between the front running belt pulleys and the rear running belt pulleys. This excess length of running belt **16** helps to counter the force of gravity, discussed in more detail above. It should be noted that, because the friction between the surface **418** of the elongated member **406** and the outer surface **250** of the rear synchronizing belt pulley **204** is substantially constant during operation, the rotational velocity will be substantially maintained at the lower rotational velocity.

The length of excess running belt "pushed" rearward by the front running belt pulleys can be varied by adjusting the position of the surface **418** relative to the outer surface **250** of the rear synchronizing belt pulley **204**. If one moves the surface **418** laterally closer to the outer surface **250**, the friction therebetween will increase, the differential between the rotational velocity of the rear shaft assembly and the front shaft assembly will increase, and the length of the excess will increase. If one moves the surface **418** away from the outer surface **250**, the friction therebetween will decrease (or be removed if they are brought out of contact), the differential between the rotational velocity of the rear shaft assembly and the front shaft assembly will decrease, and the length of the excess will decrease.

According to another exemplary embodiment, the braking system **400** may be used with front and rear running belt pulleys that have a size differential. In such an embodiment, the braking system **400** would be used to fine tune the length of excess running belt pushed rearward with each rotation of the front and rear running belt pulleys.

FIG. **16** illustrates another exemplary embodiment of a braking system, shown as braking system **500**, configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface. Please note, the section lines 16-16 shown in FIG. **4** do not necessarily suggest

that the braking system **500** seen in FIG. **16** is integrated into the manual treadmill depicted in FIG. **4**, rather, the section line 16-16 is included in FIG. **4** to show one potential location for the integration of a braking system into a manual treadmill according to the various innovations disclosed herein. The braking system **500** includes a pulley **502** mounted to a rear shaft assembly **504** generally opposite a front shaft assembly, both shaft assemblies having running belt pulleys that are substantially the same size. A belt **506** rotationally couples the pulley **502** to an idler pulley **508**. The idler pulley **508** is configured to be adjustable so that it may be moved towards or away from the pulley **502** along an axis generally parallel to the longitudinal axis **18**. Though, it should be noted that the idler pulley may be moved relative to the pulley **502** mounted to the rear shaft assembly along an axis other than one generally parallel to the longitudinal axis **18**.

By adjusting the position of the idler pulley **508** relative to the pulley **502**, one can adjust the friction between the belt **506** and the pulleys **502**, **508**. Moving the idler pulley **508** away from the pulley **502**, increases the tension in the belt **506**, and, accordingly, increases the friction between the belt **506** and the pulleys **502**, **508**. Moving the idler pulley **508** toward the pulley **502**, decreases the tension in the belt **506**, and, accordingly, decreases the friction between the belt **506** and the pulleys **502**, **508**.

Similar to the discussion of braking system **400**, increasing the friction between the belt **506** and the pulleys **502**, **508**, increases the differential between the rotation of the rear shaft assembly to which the braking system **500** is coupled and the front shaft assembly. As a corollary, decreasing the friction between the belt **506** and the pulleys **502**, **508**, decreases the differential between the rotational velocity of the rear shaft assembly **504** and the front shaft assembly. As discussed above, the greater the differential, the greater the length of the excess that the front running belt pulleys push rearward.

FIG. **17** illustrates another exemplary embodiment of a running belt retention system of the treadmill **10** used to help induce and maintain the running belt in a desired non-planar shape to define the running surface. The treadmill **10** is shown including a plurality of rollers **600** used to support the running belt **16** in place of bearing rails **200**, discussed above.

The each roller **600** is shown extending laterally generally between the left-hand side member **52** and the right-hand side member **54** of the frame **40**. Along the longitudinal axis **18**, the rollers **600** are disposed adjacent to one another generally between one or more front running belt pulleys **604** and one or more rear running belt pulleys **606**. Typically, the running belt used with this exemplary embodiment is a continuous polymer belt without slats; the use of a continuous polymer belt having greater flexibility in the lateral direction than running belt **16** improves the ease of movement of the running belt along the rollers **600**. However, other suitable continuous belts may be used according to other exemplary embodiment

In the exemplary embodiment shown, the one or more front running belt pulleys is shown as a single, front running belt pulley **604** that is substantially a large roller, disposed at the front end **48** of the frame **40**. Similarly, the one or more rear running belt pulleys is shown as a single, rear running belt pulley **606** that is a substantially a large roller, disposed at the rear portion of the frame **40**. According to other exemplary embodiments, any multiple of running pulleys may be used at one or both of the front end and the rear end, such as front running belt pulleys **62**.

Collectively, the rollers **600** define a top profile **608** similar to the top profile **210** defined by the bearing rails **200**, discussed above, and provide for a running belt to move therealong. Similar to the top profile of the bearing rails, the top profile **608** defined by the rollers may be varied (e.g., may include a convex portion and a concave portion, may be modeled by a third-order polynomial, may be modeled by a fourth-order polynomial, etc.).

The front and rear running belt pulleys **604**, **606** and the rollers **600** help define the running surface. In use, the running belt is disposed over the front running belt pulley **604**, along the top profile **602** defined by the rollers **600**, and over the rear running belt pulley **606**. The running belt is maintained in a position substantially along these elements primarily by the weight of the running belt; however, according to other exemplary embodiments, a synchronizing system may also be used to ensure that the running belt is maintained in the desired position.

Referring to FIGS. **18-21**, an embodiment of a running belt retention system including a track system **700** and configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface according to an exemplary embodiment.

A treadmill according to this exemplary embodiment does not include front and rear shaft assemblies or bearing rails, but, rather, includes a pair of opposed tracks **702** configured to provide for movement of a running belt **16** therealong. The tracks **702** are spaced apart, generally define the path that the running belt **16** will travel, and substantially replicate at least a portion of the running surface. Each track **702** includes a side support wall **708** and a guide portion **710** generally centrally-disposed along the side support wall **708**. The guide portion **710** extends from an inner side **712** of the side support wall **708** towards the interior of the treadmill frame, defined generally between the left-hand side member and the right-hand side member. The guide portion **710** generally defines the contour of the running surface that is defined by the running belt **16** when coupled to the tracks **702**. An outer side **714** each side support wall **708** is disposed substantially adjacent to an inner surface of one of the side members of the treadmill frame.

A plurality of roller or wheel assemblies **716** are connected with, preferably mounted directly to or integral with, each of a plurality of slats **228** of the running belt **16**. Each a laterally-oriented slat **228** includes a left-hand end **252** generally opposite a right-hand end **254**. One of a plurality of wheel assemblies **716** is coupled at each end **252**, **254** of each slat **228** at an interior surface **256**. The wheel assemblies **716** are configured to be mated with the tracks **702** and provide for motion of the running belt **16** along the tracks **702**.

Each wheel assembly **716** is shown including first roller or wheel **720** and a second roller or wheel **722** rotatably coupled to a support shown as an elongated connecting member **724**. The connecting member **724** connects each wheel assembly **716** to a slat **228** and maintains the relative position of the first wheel **720** and the second wheel **722**. When coupled to the track **702**, the first wheel **720** of a wheel assembly **716** is disposed to one side the guide portion **710** and rotatably movable therealong, and the second wheel **722** of the wheel assembly **716** is disposed generally opposite the first wheel **720** to the other side of the central guide portion **710**.

The wheels **720**, **722** and the tracks **702** are shaped such that when they are mated, the wheels **720**, **722** cannot be pulled inwardly off of or pushed outwardly off of the track **702**. In the exemplary embodiment shown, the guide portion **710** is shown having a substantially-circular cross section **724** and the wheels **720**, **722** are shown having circumferentially-disposed arcuate depressions **726** that receive and travel along an outer curved portion **728** and an inner curved portion **730** of the guide portion **710** of the track **702**. According to other exemplary embodiments, the wheels and the track guide

portion can have substantially any corresponding shapes that provide for the wheels and the track to mate and that provide for movement of the wheels therealong.

When the running belt **16** is being driven by a user, the interaction of the guide portion **710** and the first and second wheels **720**, **722** helps maintain the belt in the desired non-planar shape. As mentioned above, the tracks **702** generally defines the contour of the running surface defined by the running belt **16**. Being coupled to the guide portion **710** of the track **702**, each wheel assembly **716** rotates about the track **702**, following the contour defined thereby.

If the running belt **16** began to deviate from the desired path, the interaction between the wheels **720**, **722** and the guide portion **710** would substantially prevent undesirable shifting. While being rotatably coupled to the elongated connecting member **724**, the axes **732** and **734** of the first wheel **720** and second wheel **722**, respectively, are a fixed distance apart. Further, the arcuate depressions **726** of the wheels **720**, **722** are in contact with the outer curved portion **728** and inner curved portion **730**, respectively. Thus, as a result the interactions between the arcuate depressions **726** and the curved portions **728**, **730**, any movement of a wheel assembly **716** relative to the track **702** other than along the path defined by the track **702** is countered by a force from the guide portion **710**. It should also be noted that the interactions between the depressions **726** of adjacent wheel assemblies **716** and the curved portions **728**, **730** of the track **702** may also help keep a wheel assembly **716** in place.

Referring to FIGS. **22-24**, the treadmill **10** is shown including another exemplary embodiment of a track system configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface, shown as a track system **800**. Similar to track system **700**, a treadmill according to this exemplary embodiment does not include front and rear shaft assemblies or bearing rails, but, rather, includes a pair of tracks **802** configured to provide for movement of a running belt **16** therealong. In this exemplary embodiment, each track **802** is shown as an elongated member having a substantially C-shaped cross section that defines a channel **804** having an opening **806** that faces the interior of the frame **40**. An outer wall **808** each of the tracks **802** is disposed substantially adjacent to an inner surface of a left-hand or right-hand side member **52**, **54** (shown, e.g., in FIG. **2**) such that the openings **806** face each other. The outer wall **808** is substantially opposite an inner wall **810**

As discussed above, the running belt **16** includes a plurality of laterally-oriented slats **228** each having a left-hand end **252** generally opposite a right-hand end **254**. One of a plurality of roller or wheel assemblies **812** is coupled at each end **252**, **254** of each slat **228** to mate with the tracks **802** and to provide for motion of the running belt **16** along the tracks **802**.

Each wheel assembly **812** is shown including a support shown as a mounting block **814** and a wheel **816** rotatably coupled to the mounting block **814**. The mounting block **814** mounted to an interior surface **256** of a slat **228**. The wheel **816** is supported relative to the mounting block **814** by an axis **818** that extends substantially parallel to the slats **228** to facilitate positioning the wheel **816** in the channel **804**. The wheel **816** is received in the channel **804** and is rotatably movable therewithin to facilitate travel of the running belt **16** along the contour defined by the channel **804**. The shape of the channel **804** generally corresponds to the shape of the wheel **816**.

When the running belt **16** is being driven by a user, the walls of the track **802** defining the C-shaped channel **804** help forcibly retain the wheel **816** therein, preventing the wheel from moving in any direction other than along the contour defined by the channel **804**, and, thereby, maintaining the running belt **16** in the desired non-planar shape to define the running surface. The outer wall **808** and the inner wall **810** limit the side-to-side, lateral movement of the wheel **816** when it is disposed in the channel **804**. Limiting the motion of the wheel **816**, similarly limits the motion of the wheel assembly **812** and the slat **228** fixed relative thereto. Further, a first wall **820** substantially opposite a second wall **822** substantially limits the up-and-down motion of the wheel **816** relative to the channel **804**. In circumstances where side-to-side and/or up-and-down motion of the wheel **816** occurs, the walls **808**, **810**, **820**, **822** defining the channel **804**, providing counter forces to maintain the wheel **816** in the desired position and help direct the wheel **816** along the desired path.

Referring to FIGS. **25-28**, the treadmill **10** is shown including still another exemplary embodiment of a track system configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface, shown as a track system **900**. Similar to track system **800**, the treadmill according to this exemplary embodiment does not include bearing rails, but, rather, includes a pair of tracks **902** configured to provide for movement of a running belt **16** therealong. In this exemplary embodiment, each track **902** is shown as an elongated member having a substantially C-shaped cross section that defines a channel **904** having an opening **906** that faces the exterior of the track **902**. Stated otherwise, each channels **904** extend about an outer periphery **908** of a tracks **902**.

As discussed above, the running belt **16** includes a plurality of laterally-oriented slats **228** each having a left-hand end **252** generally opposite a right-hand end **254**. One of a plurality of roller or wheel assemblies **910** is coupled at each end **252**, **254** of each slat **228** to mate with the tracks **902** and to provide for motion of the running belt **16** along the tracks **902**.

Each wheel assembly **910** is shown including a support shown as a connecting bar **912** that is substantially T-shaped and connected to a first wheel **914** and a second wheel **916**. A first portion **918** of the connecting bar **912** is fixed relative to the interior surface **256** of a slat **228**. A second portion **920** extends substantially perpendicular to the first portion **918** and away from the interior surface **256** of the slat **228**. The first wheel **914** and the second wheel **916** are connected to the connecting bar **912** by an axis **922** that extends generally parallel to the first portion **918** and perpendicular to the second portion **920** of the connecting bar **912**. The first wheel **914** is disposed to one side of the second portion **920** of the connecting bar **912** and the second wheel **916** is disposed opposite the first wheel **914** to the other side of the second portion **920**.

When the wheel assemblies **910** are mated with the tracks **902**, the second portion of the connecting bar **912** extends partially into the channel **904**, the first wheel **914** is received within a first portion **924** of the channel **904** and the second wheel **916** is disposed within a second portion **926** of the channel **904**. The first portion **924** of each channel **904** is disposed proximate to an outer surface **928** of the track **902** relative to the second portion **926**.

When the running belt **16** is being driven by a user, the first wheel **914** and the second wheel **916** of a given wheel assembly rotate within the channel **904**, facilitating moment of the running belt **16** in the path defined by the track **902**. As the running belt **16** is rotated, the slats **228** are disposed generally exterior to the periphery **908** of the track **902**. The walls of the track **902** defining the channel **904** help forcibly retain the wheels **914**, **916**. An outer wall **930** and an inner wall **932** limit the side-to side movement of the wheels **914**, **916**, either by coming into contact with the wheels **914**, **916** themselves

or by coming into contact with another part of the wheel assembly **910** (e.g., the connecting bar **912**). Limiting the motion of the wheels **914**, **916** and the wheel assembly **910** similarly limits the motion of the slat fixed relative thereto, helping each slat, and, thereby, the running belt **16** to follow the desired path. Further, a first wall **934** substantially opposite a second wall **936** substantially limits the up-and-down motion of the wheels **914**, **916** relative to the channel **904**. In circumstances where side-to-side and/or up-and-down motion of the wheel **916** occurs, the walls **930**, **932**, **934**, **936** defining the channel **904**, providing counter forces to maintain the wheels **914**, **916** in the desired position and help direct the wheels **914**, **916** along the desired path.

Referring to FIGS. **29-30**, the treadmill **10** is shown including another exemplary embodiment of a track system configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface, shown as a track system **1000**.

Instead of using wheel assemblies, such as **716** and **910**, discussed above, the treadmill according to this exemplary embodiment utilizes a plurality of magnets **1002** to maintain the running belt **16** in the desired position. One or more magnets **1002** are fixed relative to the interior surface **256** of the slats **228** at locations substantially corresponding to the position of a track **1004**, which is typically along the left-hand end **252** and the right-hand end **254** of the slats **228**. The magnets **1002** may be coupled by any variety of fasteners or fastening mechanisms. Generally, it is preferable that, when the magnets **1002** are fixed relative to the slats, the fasteners do not directly contact the periphery **1006** of the tracks **1004** to avoid scratching and damage thereto. While it is generally desirable to mount a magnet **1002** to each slat, **228**, the number of magnets used will vary depending upon a variety of factors such as the relative weight of the belt and the relative magnetic strength of each magnet.

The magnets **1002** are configured to magnetically couple the running belt **16** to the track **1004**, which is made of metal (e.g., steel) or includes a peripheral metal portion. The magnets **1002** have strength suitable to maintain the running belt **16** in close proximity to a periphery **1006** of the tracks **1004**.

When the treadmill is driven by a user, the force imparted to the running belt **16** is sufficient to permit the magnets to move relative bearing rails, but not to lose the magnetic connection therebetween. According to one exemplary embodiment, as the running belt **16** moves relative to the track **1004**, the magnets **1002** are generally spaced a small distance from the periphery **1006** of the track **1004**, helping to further reduce the noise associated with operation of the treadmill. According to other exemplary embodiments, the magnets **1002** are in physical contact with the periphery **1006** of the track **1004** in addition to being magnetically coupled thereto.

According to an exemplary embodiment similar to track system **1000**, a plurality of magnets may be positioned on the frame, track, or other fixed component of the treadmill base to apply a downwardly-directed force to the metal slats of the running belt as it passes over the magnets. For example, the magnets may be positioned on the cross-members **56**. As the running belt rotates, the portion passing above the magnets will be drawn downward by the force of the magnets, helping maintain that portion of the running belt (i.e., defining the running surface) in the desired shape.

Referring to FIGS. **31-34**, the treadmill **10** is shown including another exemplary embodiment of a track system configured to help induce and maintain the running belt in a desired non-planar shape to define the running surface, shown as a track system **1100**.

The track system **1100** is substantially similar to track system **700**, but configured to be operable with a running belt **1102** that is a conventional running belt rather than a slatted running belt **16**. The track system **1100** includes a pair of tracks **702** and a wheel assemblies **1104** having substantially the same configuration as wheel assembly **716** with the exception that a securing device shown as a clip **1106** is used to connect the wheel assembly **1104** to the running belt **1102**, rather than the elongated connecting member **724**. The clip **1106** is shown extending and having a first portion **1108** and a second portion **1110** that opening towards the interior of the treadmill **10** before being secured. When the running belt **1102** shown as a continuous polymer (e.g., urethane) belt is in position, a first edge **1112** of the running belt **1102** is received between a first portion **1108** and a second portion **1110** of the clip **1106** and fixed relative thereto (e.g., by a fastener, etc.). The polymer belt is a urethane belt according to an exemplary embodiment. The urethane belt is desirable heavy enough to help assume the shape of the rollers, but not so thick or heavy that it undesirably impedes movement. The clips extend along the first edge **1112** and the second edge **1114** of the running belt **1102**, substantially suspending the belt between the tracks **702**. According to an exemplary embodiment, the securing device may be any securing device suitable for securing an edge portion of the running belt **1102** relative thereto (e.g., a bolt, a clamp, etc.).

According to still another exemplary embodiment, a treadmill has a track system including a pair of tracks and wheel assemblies. The wheel assemblies include hangers (e.g., magnetic hangers) that are received in channels that are interior to the track, the hangers being slidably movable within the channels. According to one exemplary embodiment, the hangers are substantially I-shaped, having one transverse portion received in the channel and the other transverse portion fixed to an interior side of a slat. According to some exemplary embodiments, the system further includes bearing rails that facilitate motion of the running belt itself and the hangers within the track. The hangers and the channel of the track may have any configuration suitable for facilitating movement of the running belt and maintaining the running belt in the desired non-planar shape.

The above-described ways of inducing and maintaining the running belt in the desired non-planar shape can also be used with or adapted to a manual treadmill having a planar running surface, such as treadmill **1200** having planar running surface **1202** shown in FIG. **35**. The treadmill **1200** is shown substantially similar to treadmill **10**, but the running surface is substantially planar. Accordingly, the ability to manually drive the treadmill is substantially dependent on the incline of the running surface **1202** relative to the ground. Ways to adjust this incline for any treadmill disclosed herein will be discussed in more detail later.

In the exemplary embodiment shown, the running surface **1202** is defined by a running belt **1204** that is disposed about front and rear running belt pulleys of a front and rear shaft assembly, respectively. The running belt **1204** also travels along a pair of bearing rails having a substantially linear top profile that facilitate motion of the running belt **1204**.

As discussed above, the speed controls for the manual treadmill **10** and the various embodiments thereof are generally the user's cadence and relative position of her weight-bearing foot on the running surface. More generally, the running belt **16** of the treadmill **10** is responsive to the weight of the user mounting, dismounting, or running on the treadmill **10**. While it is generally desirable for the running belt **16** to be moved rearward, the running belt is capable of rotating forward. Forward rotation of the running belt can create safety

concerns. For example, if a user were to mount the treadmill by placing her weight bearing foot at a location (e.g., location D shown in FIG. **5**) along the rear portion **74** of the running surface **70**, the running belt **16** may move forward and cause them to loose their footing, resulting in an injury or simply an unpleasant user experience.

A number of safety devices may be used with the treadmill **10** to help prevent undesirable forward rotation of the running belt **16**. FIG. **36** illustrates a safety device shown as a one-way bearing assembly **1300** according to an exemplary embodiment. The one-way bearing assembly **1300** is a motion restricting element that is configured to permit rotation of at least one of the front and rear shaft assemblies **44**, **46** (and hence the running belt **16**) in only one direction, preferably clockwise as seen in FIGS. **1** and **5**.

In the exemplary embodiment shown, the one way bearing assembly **1300** is disposed about and cooperates with the rear shaft **68** as shown in FIG. **2**. The one-way bearing assembly **1300** comprises a housing **1302** which supports an inner ring **1304** that cooperates with the rear shaft **68** and supports an outer ring **1306** fixed relative to the housing **1302**. A plurality of sprags (not shown) are disposed between the inner ring **1304** and the outer ring **1306**. The sprags are asymmetric, and, thus, provide for motion in one direction and prevent rotation in the opposite direction. The housing **1302** is fixed to a bracket **1310** that is connected to, and preferably directly mounted to, the frame **40** to fix the location of the housing **1302** and prevent movement of the housing **1302** in response to the rotation of the rear shaft **68**. It should be noted that the location at which the bracket **1310** is mounted to the frame **40** can be adjusted depending on the location of the rear shaft **68**, which may change depending on the shape of the non-planar running surface or the desired tension in the running belt. According to another exemplary embodiment, the one-way bearing may be transitionally fit into the housing, rather than press fit. According to yet another exemplary embodiment, the one-way bearing may include rollers in addition to sprags.

The one-way bearing assembly **1300** further includes a key **1312** that is fixed relative to the inner ring **1304** and configured to cooperate with a keyway **1314** formed in the rear shaft **68**. Viewed from the perspective shown in FIGS. **1** and **5**, when the running belt **16** is moving rearward, rotating in the clockwise direction, the rear shaft **68** similarly rotates in the clockwise direction. The inner ring **1304** of the one-way bearing assembly **1300** rotates with rotational velocity corresponding to the rotational velocity of the rear shaft **68** because of the interaction between the key **1312** and the keyway **1314**. If a force is applied by the user to the running belt **16** that urges the rear shaft **68** to rotate counterclockwise, the one-way bearing assembly **1300** provides a counter force, preventing the counterclockwise rotation of the rear shaft **68** and the forward rotation of the running belt **16**. Specifically, as the rear shaft **68** begins to move counterclockwise, the interaction of the key **1312** and the keyway **1314** begins to drive the inner ring **1304** of the one-way bearing assembly **1300** rearward. The sprags become wedged between the inner ring **1304** and the outer ring **1306**, preventing the counterclockwise rotation of the inner ring and key **1312** disposed therein. The key **1312**, by virtue of its inability to rotate, provides a counterforce to the keyway **1314** as the keyway continues to attempt to rotate counterclockwise. By preventing the keyway **1314** from moving counterclockwise, the one-way bearing assembly **1300** thus prevents the rear shaft **68**, the rear running belt pulleys **66**, and running belt **16** from rotating counterclockwise as seen in FIGS. **1** and **5**.

FIG. **38** illustrates another safety device that may be used with the treadmill **10**, shown as a one-way bearing assembly **1500** according to an exemplary embodiment. The one-way bearing assembly **1500** is a motion restricting element that is configured to permit rotation of at least one of the front and rear shaft assemblies **44**, **46** (and hence the running belt **16**) in only one direction, preferably clockwise as seen in FIGS. **1** and **5**.

In the exemplary embodiment shown, the one-way bearing assembly **1500** is disposed about and cooperates with the rear shaft **68**. The one-way bearing assembly **1500** comprises a housing **1502** which supports an inner ring **1504** that cooperates with the rear shaft **68** and supports an outer ring **1506** fixed relative to the housing **1502**. A plurality of sprags (not shown) are disposed between the inner ring **1504** and the outer ring **1506**. The sprags are asymmetric, and, thus, provide for motion in one direction and prevent rotation in the opposite direction. The one-way bearing assembly **1500** is further shown to include a first snap ring **1532** and a second snap ring **1534**, which are configured to seat in a first circumferential groove **1536** and a second circumferential groove **1538** on the rear shaft **68**, respectively. When installed, the first snap ring **1532** is supported inboard of and adjacent to the inner ring **1504**, and the second snap ring **1534** is supported outboard of and adjacent to the inner ring **1504**, thereby further restricting axial motion of the one-way bearing assembly **1500** relative to the rear shaft **68**.

The housing **1502** is supported by a stud **1520** which is coupled to the frame **40**. The stud **1520** may be separated or spaced apart from the housing **1502** by a spacer **1522** and a sleeve **1523** which may be restrained on the stud **1520** by a nut **1524** and a washer **1526**. The sleeve **1523** of the embodiment shown is formed of rubber and is configured to reduce noise, wear, and shock load between the housing **1502** and the stud **1520** and/or the spacer **1522**. The housing **1502** includes a plurality of legs, shown as a first leg **1516** and a second leg **1518**, which extend on either side of the stud **1520**. Accordingly, the stud **1520** resists rotational motion of the housing **1502** in response to rotation of the rear shaft **68** and may provide sufficient reactive or counter force to the housing **1502** to enable the one-way bearing assembly **1500** to prevent counterclockwise rotation of the rear shaft **68**. Supporting the one-way bearing assembly **1500** in this manner negates the need for fixing the housing **1502** to the frame **40** or an intermediary bracket. Accordingly, the housing **1502** may move with the rear shaft **68** (e.g., the housing **1502** may pivot about the stud **1520**) as the rear shaft **68** flexes under load, thereby reducing side loading on the inner ring **1504**, which in turn reduces wear on, and extends the life of, the one-way bearing assembly **1500**.

It should be noted that the location at which the stud **1520** is mounted to the frame **40** can be adjusted depending on the location of the rear shaft **68**, which may change depending on the shape of the non-planar running surface or the desired tension in the running belt. Furthermore, the stud **1520** need not be positioned below or downward from the rear shaft **68**, as shown, but may be located in any direction relative to the rear shaft **68**. According to another exemplary embodiment, the one-way bearing may be transitionally fit into the housing, rather than press fit. According to yet another exemplary embodiment, the one-way bearing may include rollers in addition to sprags.

The one-way bearing assembly **1500** further includes a key **1512** that is fixed relative to the inner ring **1504** and configured to cooperate with a keyway **1514** formed in the rear shaft **68**. Viewed from the perspective shown in FIGS. **1** and **5**, when the running belt **16** is moving rearward, rotating in the clockwise direction, the rear shaft **68** similarly rotates in the clockwise direction. The inner ring **1504** of the one-way

bearing assembly **1500** rotates with rotational velocity corresponding to the rotational velocity of the rear shaft **68** because of the interaction between the key **1512** and the keyway **1514**. If a force is applied by the user to the running belt **16** that urges the rear shaft **68** to rotate counterclockwise as seen in FIGS. **1** and **5**, the one-way bearing assembly **1500** provides a counter force, preventing the counterclockwise rotation of the rear shaft **68** and the forward rotation of the running belt **16**. Specifically, as the rear shaft **68** begins to move counterclockwise, the interaction of the key **1512** and the keyway **1514** begins to drive the inner ring **1504** of the one-way bearing assembly **1500** rearward. The sprags become wedged between the inner ring **1504** and the outer ring **1506**, preventing the counterclockwise rotation of the inner ring and key **1512** disposed therein. The key **1512**, by virtue of its inability to rotate, provides a counterforce to the keyway **1514** as the keyway continues to attempt to rotate counterclockwise. By preventing the keyway **1514** from moving counterclockwise, the one-way bearing assembly **1500** thus prevents the rear shaft **68**, the rear running belt pulleys **66**, and running belt **16** from rotating counterclockwise as seen in FIGS. **1** and **5**.

Other safety devices to help prevent undesirable forward rotation of the running belt **16** may include cam locking systems, which may be particularly well-suited for use in conjunction with track systems **700**, **800**, and **900**. Also, taper locks, a user operated pin system, or a band brake system with a lever may be utilized.

Controlling the operation of the running belt **16** in ways in addition to preventing rearward rotation, can help improve the safety of the treadmill and/or help a user adjust the treadmill for a desirable level of performance. Including an incline or elevation adjustment system is one way to provide these benefits. As mentioned above, as the increasing or decreasing of the relative height or distance of the running surface relative to the ground is one way that the operation, most typically the speed, of the treadmill can be adjusted. Accordingly, adjusting the incline of the base of the treadmill results in an adjustment to the speeds a user can achieve and/or how easy or challenging it is for the user to achieve certain speeds.

Referring back to FIGS. **1-6**, a plurality of nuts **270** are fixed, and more preferably welded, to the bottom of the frame **40** allow the feet **28** to be adjusted. The feet **38** include a lower or base portion **272** and a threaded shaft **274** extending vertically upward from the base portion **272** according to an exemplary embodiment. Generally, by increasing the distance between the nuts **270** and the base portions **272** of the feet **28** at the front end **48** of the frame **40** relative to the rear end **50**, the incline of the base **12** will increase. Stated otherwise, the angle between the longitudinal axis **18** and the ground will increase. Similarly, the distance between the nuts **270** and the base portions **272** of the feet at the rear end **50** may be decreased relative to the feet **28** at the front end **48**, thereby increasing the incline. By increasing the incline, a user is typically able to achieve greater speeds on the treadmill **10**.

Treadmill **1200** shown in FIG. **35** preferably has at least some incline (i.e., the longitudinal axis of the treadmill to be other than parallel to the ground) when in operation as the shape of the running surface, substantially planar, does not provide for increases and decreases in height in and of itself. On the other hand, the longitudinal axes of the treadmills having non-planar running surfaces may be parallel to the ground or at an incline thereto during operation. It should be noted that, while it is generally desirable to have the front shaft at a height at or above the height of the rear shaft, with some running surface configurations, desirable orientations can be achieved by raising the rear shaft to a location above the front shaft relative to the ground.

In some cases, the user may want to decrease the incline of the treadmill (e.g., to decrease the speeds the treadmill can achieve, etc.). For example, the user may want to utilize a relatively long stride, but does not want to be running at such high speeds. This can be accomplished by lowering the incline of the treadmill from the higher incline position. Once in the lowered position, the same stride the user was using at the higher incline position will typically result in the user running at lower speeds in the lower incline position. This same principle can also be applied for the purposes of safety. That is, keeping the front of the treadmill at a lower incline position or lowering the treadmill to a lower incline position can help prevent a user from achieving speeds that are too great for them (e.g., that would cause them to be off-balance, lose control, be injured, etc.).

Because the treadmill is preferably manually operated, it does not have an external power source which can be utilized to operate a height adjusting motor as is found in conventional treadmills. Therefore, a manual height adjusting system is preferably integrated into the treadmill. Referring to FIG. **37**, an example of a manual incline or elevation adjustment system **1400** is shown according to an exemplary embodiment. A hand crank **1402** configured to be operated by a person, such as the user, is provided allow a user to operate the incline adjustment system **1400** to adjust the incline of the base **12** of the treadmill **10** relative to the ground. The front shaft **64** may be lowered relative to the rear shaft **68** and/or the front shaft **64** may be raised relative to the rear shaft **68** using the hand crank **1402**. In an alternative exemplary embodiment, the front shaft may be maintained at a position above the ground, and the rear shaft may be raised or lowered relative thereto adjust the incline.

Generally, the hand crank **1402** includes a handle portion **1404** disposed parallel to and spaced a distance from a shaft **1406** that is coupled to the frame **40** (e.g., with a bracket). When assembled, a drive belt or chain **1407** is disposed about a gear **1408** that is positioned about the shaft **1406** of the hand crank **1402**. Rotational motion can be imparted to the gear **1408** by rotating the handle portion **1404**. In response to rotation of the gear **1408**, the drive belt **1407** causes a sprocket **1410** is fixed relative to an internal connecting shaft **1412** of the internal connecting shaft assembly **1414** to rotate. The internal connecting shaft assembly **1414** further includes a pair of drive belts or chains **1416** that are operably coupled to gears **1418** of rack and pinion blocks **1420**. The rotation of the internal connecting shaft **1412** causes the drive belts or chains **1416** to rotate gears **1418**. As the gears **1418** rotate, a pinion (not shown) disposed within the rack and pinion blocks **1420** imparts linear motion to the racks **1422**, thereby operably raising or lowering the base **12** of the treadmill **10** depending on the direction of rotation of the handle portion **1404** of the hand crank **1402**.

According to another exemplary embodiment, an incline adjustment system that is a gas assisted un-weighting incline adjustment system may be utilized. According to other exemplary embodiments, any suitable linear actuator may serve as an incline adjustment system for the manual treadmill disclosed herein.

According to an exemplary embodiments, the incline of one or more portions of the running surface may be adjusted independent of adjusting the incline of the base. For example, one or more portions of a bearing rail may be configured to be movable relative to one or more other portion of the bearing rail. In one exemplary embodiment, a bearing rail is divided into a first portion and a second portion movable relative to

each of the about a pivot point disposed therebetween. A person (e.g., a user, trainer, technician, etc.) can adjust the operational characteristics of the treadmill (similar to the discussion of using running surfaces having different curved profiles above) by merely adjusting the relative position of the bearing rail portions. If the user wants to achieve greater speeds, they may increase the incline of the front portion, while leaving the center and rear portions unchanged. If the user would like to alter the configuration of the treadmill to more strongly encourage running on the balls of their feet, they might increase the incline of the front and rear portions from a higher radius of curvature so that they collectively define a lower radius of curvature. Adjustments to the position of the bearing rails may be imparted using a crank, or other suitable device.

It is further contemplated that, because the treadmill **10** does not require an electric motor for operation, it is well suited for operation in an aquatic environment. For example, the treadmill **10** may be at least partially submerged in a pool, thereby providing added resistance due to hydrodynamic drag on a user and/or reducing footfall impact due to the buoyancy of the user. Accordingly, a submerged embodiment of the treadmill **10** may be used for training and/or rehabilitation purposes. Modifications may be made to the treadmill **10** for use in an aquatic environment. For example, the treadmill **10** may include sealed bearings and components formed of corrosion-resistant materials (e.g., plastic, composite, stainless steel, brass, etc.) to extend its useful life. Further, the shape of the running surface **70** may also be modified to compensate for the buoyancy of the user in water and to compensate for the effects of salinity on buoyancy. For example, it is contemplated that the shape of the running surface **70** may be different for a treadmill **10** used in a freshwater environment and a highly saline environment.

A number of other devices, both mechanical and electrical, may be used in conjunction with or cooperate with a treadmill according to this disclosure. FIG. **1**, for example, shows a display **280** adapted to calculate and display performance data relating to operation of the treadmill according to an exemplary embodiment. The display **280** includes an independent power source (e.g., a battery) that provides for the display **280** to be electrically-operative. The feedback and data performance analysis from the display may include, but are not limited to, speed, time, distance, calories burned, heart rate, etc. For example, a the display may include a sensor that is responsive to the position of a magnet on one of the running belt pulleys. The sensor is configured to recognize every time the magnet rotates past (e.g., moves past, crosses, etc.) a certain location. With this data, the display may calculate the speed at which the user is running and then provide this data to them via a user interface. According to other exemplary embodiments, other displays, cup holders, cargo nets, heart rate grips, arm exercisers, TV mounting devices, user worktops, and/or other devices may be incorporated into the treadmill.

As utilized herein, the terms "approximately," "about," "substantially," and similar terms are intended to have a broad meaning in harmony with the common and accepted usage by those of ordinary skill in the art to which the subject matter of this disclosure pertains. It should be understood by those of skill in the art who review this disclosure that these terms are intended to allow a description of certain features described and claimed without restricting the scope of these features to the precise numerical ranges provided. Accordingly, these terms should be interpreted as indicating that insubstantial or inconsequential modifications or alterations of the subject matter described and are considered to be within the scope of the disclosure.

It should be noted that the term "exemplary" as used herein to describe various embodiments is intended to indicate that such embodiments are possible examples, representations, and/or illustrations of possible embodiments (and such term is not intended to connote that such embodiments are necessarily extraordinary or superlative examples).

For the purpose of this disclosure, the term "coupled" means the joining of two members directly or indirectly to one another. Such joining may be stationary or moveable in nature. Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate members being attached to one another. Such joining may be permanent in nature or may be removable or releasable in nature.

It should be noted that the orientation of various elements may differ according to other exemplary embodiments, and that such variations are intended to be encompassed by the present disclosure.

It is important to note that the constructions and arrangements of the manual treadmill as shown in the various exemplary embodiments are illustrative only. Although only a few embodiments have been described in detail in this disclosure, those skilled in the art who review this disclosure will readily appreciate that many modifications are possible (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters, mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited in the claims. For example, elements shown as integrally formed may be constructed of multiple parts or elements, the position of elements may be reversed or otherwise varied, and the nature or number of discrete elements or positions may be altered or varied. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. Other substitutions, modifications, changes and omissions may also be made in the design, operating conditions and arrangement of the various exemplary embodiments without departing from the scope of the present disclosure.

What is claimed is:

**1**. A manually powered treadmill comprising:

a frame having a front end and a rear end positioned opposite the front end;

a front shaft rotatably coupled to the frame at the front end;

a rear shaft rotatably coupled to the frame at the rear end;

a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;

a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;

a running belt supported by the first bearing rail and the second bearing rail and disposed about the front shaft and the rear shaft, wherein the running belt follows a curved running surface; and

a safety device coupled to at least one of the front shaft and the rear shaft, wherein the safety device is structured to substantially prevent rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of the at least one of the front shaft and the rear shaft in a second rotational direction opposite the first rotational direction.

2. The manually powered treadmill of claim 1,
wherein the frame includes at least one cross-member, a left side member, and a right side member; and
wherein the at least one cross-member extends between the left side member and the right side member.

3. The manually powered treadmill of claim 2, wherein each one of the first and second bearing rails are coupled to at least one of the at least one cross-member.

4. The manually powered treadmill of claim 1, wherein each one of the first and second bearing rails are attached longitudinally to the frame between the front shaft and the rear shaft.

5. The manually powered treadmill of claim 1, wherein each one of the first bearing rail and the second bearing rail define in part a top profile corresponding to the curved running surface.

6. The manually powered treadmill of claim 1, wherein the safety device includes a one-way bearing.

7. The manually powered treadmill of claim 6, wherein the one-way bearing includes an inner ring, an outer ring, and a plurality of sprags disposed between the inner ring and outer ring, wherein the plurality of sprags are asymmetric shaped to substantially prevent rotation of the inner ring in the first rotational direction while permitting rotation of the inner ring in the second rotational direction.

8. The manually powered treadmill of claim 7, further comprising a key that is fixed relative to the inner ring and a keyway formed in the rear shaft, wherein the key is configured to cooperate with the keyway to prevent rotation of the rear shaft in the first rotational direction while permitting rotation of the rear shaft in the second rotational direction.

9. The manually powered treadmill of claim 7, further comprising a key that is fixed relative to the inner ring and a keyway formed in the front shaft, wherein the key is configured to cooperate with the keyway to prevent rotation of the front shaft in the first rotational direction while permitting rotation of the front shaft in the second rotational direction.

10. The manually powered treadmill of claim 1, further comprising a handrail attached to the frame and structured to provide a support structure for the user of the manually powered treadmill.

11. A manually powered treadmill, comprising:
a frame having a front end and a rear end positioned opposite the front end;
a front shaft attached to the frame adjacent the front end;
a rear shaft attached to the frame adjacent the rear end;
a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;
a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;
a running belt at least partially disposed about the front shaft and the rear shaft and at least partially supported by the first bearing rail and the second bearing rail, wherein the running belt includes a front belt portion proximate the front end, a rear belt portion proximate the rear end, and a central belt portion intermediate the front and rear belt portions, wherein the central belt portion is positioned vertically closer to a ground surface supporting the frame than the front and rear belt portions such that the running belt follows a curved running surface; and
a safety device for substantially preventing rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of the at least one of the front shaft and the rear shaft in a second rotational direction opposite the first rotational direction.

12. The manually powered treadmill of claim 11, wherein the safety device includes a one-way bearing.

13. The manually powered treadmill of claim 11, further comprising a pair of wheels mounted to the frame, wherein the pair of wheels are mounted so that the pair of wheels are not in contact with the ground surface when the manually powered treadmill is in an operating position.

14. The manually powered treadmill of claim 11, further comprising support feet coupled to the frame, wherein the support feet are vertically adjustable to adjust an incline of the manually powered treadmill relative to the ground surface.

15. The manually powered treadmill of claim 11, further comprising at least one front pulley coupled to the front shaft and at least one rear pulley coupled to the rear shaft, wherein a radius of the at least one front pulley is greater than a radius of the at least one rear pulley.

16. The manually powered treadmill of claim 11, further comprising a braking system configured to induce and maintain the curved running surface.

17. The manually powered treadmill of claim 16, wherein the braking system includes a pulley mounted to the rear shaft, an idler pulley, and a belt disposed about the pulley and the idler pulley, wherein the idler pulley is movably adjustable closer to and further from the pulley, wherein adjustment of the idler pulley adjusts an amount of friction provided by the braking system to the rear shaft to either reduce or increase an ease of rotation of the rear shaft.

18. The manually powered treadmill of claim 11, wherein each of the first and second bearing rails are attached longitudinally to the frame between the front shaft and the rear shaft.

19. A manually powered treadmill, comprising:
a frame having a front end and a rear end;
a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame;
a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame;
a handrail attached to the frame and structured to provide a support structure for a user of the manually powered treadmill;
a pair of wheels mounted to the frame, wherein the pair of wheels are mounted so that the pair of wheels are not in contact with a ground surface when the manually powered treadmill is in an operating position;
at least two support feet coupled to the frame, wherein the support feet are vertically adjustable to adjust an incline of the manually powered treadmill relative to the ground surface;
a running belt supported by the first and second bearing rails, wherein the running belt follows a curved running surface; and
a safety device coupled to the frame and operatively coupled to the running belt, wherein the safety device is structured to substantially prevent movement of the running belt in a first direction and permit movement of the running belt in a second direction opposite the first direction.

20. The manually powered treadmill of claim 19, further comprising a sensor configured to acquire data indicative of a speed of the running belt.

21. The manually powered treadmill of claim 19,
wherein the frame includes at least one cross-member, a left side member, and a right side member; and
wherein the at least one cross-member extends between the left side member and the right side member.

22. The manually powered treadmill of claim 21, wherein each one of the first and second bearing rails are coupled to at least one of the at least one cross-member.

23. The manually powered treadmill of claim 19, wherein the safety device includes a one-way bearing, wherein the one-way bearing includes an inner ring, an outer ring, and a plurality of sprags disposed between the inner ring and outer ring, wherein the plurality of sprags are asymmetric shaped to substantially prevent rotation of the inner ring in the first direction while permitting rotation of the inner ring in the second direction.

24. The manually powered treadmill of claim 23, further comprising a key that is fixed relative to the inner ring and a keyway formed in at least one of the front shaft and the rear shaft, wherein the key is adapted to cooperate with the keyway to prevent rotation of the at least one front shaft and rear shaft in the first direction while permitting rotation of the at least one front shaft and rear shaft in the second direction.

25. A method, comprising:

providing a manually powered treadmill, the manually powered treadmill having a frame with a front end and rear end;

providing a first bearing rail and a second bearing rail, the first and second bearing rails each comprising a plurality of bearings and extending longitudinally on the frame, wherein the first and second bearing rails define a curved top profile;

disposing a running belt on the plurality of bearings of the first bearing rail and the second bearing rail such that the running belt follows a top curved running surface corresponding to the curved top profile of the first and second bearing rails;

permitting movement of the running belt in a first direction; and

substantially preventing movement of the running belt in a second direction opposite the first direction.

* * * * *

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## PROFILE

Extensive experience in the development of innovative solutions to challenging technical problems in academic, start-up, small-medium enterprise, and large corporate cultures. Proven skills in strategic planning, innovation management, business development, consulting firm operations, project management, product development, team building, and engineering design and analysis. Over ten years experience developing and delivering innovative, hands-on educational programs in engineering, product development process, and innovation process.

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*A Sports Technology Innovation & Engineering consultancy*

**Founder** **2017 – Present**

Provide business and strategic planning, technology scouting, open innovation, technology development and assessment, and development of strategic alliances to the sports industry. Serve as advisory board member for emerging companies developing innovative sports products using advanced technology. Provide expert witness services in patent infringement cases.

**COOPER PERKINS, INC.** **Lexington, MA and San Francisco, CA**

*A technology development and product engineering consultancy*

**Vice President Business Development & Manager Sports Engineering Practice** **2010 – 2017**

Cooper Perkins is a product engineering and technology development consulting firm specializing in the design of highly integrated electro-mechanical systems. Member of five-person senior management team. Led business development and client facing operations resulting in a period of significant company growth. Managed client relationships in a number of industry sectors. Managed and supported projects in sports engineering including research and development, new product innovation, product development, development of product testing capabilities, technology assessment, and patent litigation support.

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY** **Cambridge, MA**

*Department of Aeronautics and Astronautics and Department of Mechanical Engineering*

**External Advisor, Sports Technology and Education @ MIT** **2012 – Present (Pro-Bono)**

Sports Technology and Education @ MIT (STE@M) is the re-birth of the Sports Innovation Program, now based in the department of mechanical engineering, but reaching across the MIT campus. Work with MIT faculty to define the mission of the new entity and develop educational and outreach programs to support that mission. Focused on growing corporate involvement and managing the MIT - Loughborough University student exchange program.

**Founding Director, Sports Innovation @ MIT** **1999 – 2003, 2003 – 2012 (Pro-Bono)**

Founded a unique sports product development research and educational center. Lead multiple one to six member product development teams in numerous projects focused on sports products, sports product design tools, and sports performance monitoring systems. Develop business and operational plans using market research results. Negotiated intellectual property policies and contractual agreements for program sponsors. Over 100 students have been involved in the program, resulting in over 30 BS theses, two MS theses, and two MEng theses.

**Lecturer, MIT Department of Aeronautics and Astronautics** **1999 – 2003**

*Lead Instructor*, Experimental Projects I/II. Led a team of three faculty, four technical instructors, and 40 project teams consisting of a faculty advisor and two students through a two-semester senior thesis course requiring conception through implementation of an experimental project. Course content included project management, experiment design, and technical communications. *Lecturer*, Structural Dynamics (graduate course). *Co-developer and co-instructor*, Advanced Dynamics (undergraduate course).

**LOUGHBOROUGH UNIVERSITY** **Leicestershire, UK**

*Wolfson School of Mechanical, Electrical and Manufacturing Engineering*

**Visiting Professor** **2008 – Present**

Advise on research and teaching initiatives. Developing student exchange program between MIT STE@M and the Loughborough Sports Technology Institute. Serve as an external examiner for Loughborough Ph.D. student theses.

**SPORTS INNOVATION GROUP LLC** **Arlington, MA**

*A consultancy bringing strategy, innovation and technology expertise to the sports industry.*

**Founder/President** **2000 – 2009**

Provided business and strategic planning, technology scouting, open innovation, technology development and assessment, and development of strategic alliances to the sports industry. Serve as advisory board member for emerging companies developing innovative sports products using advanced technology. Provide expert witness services in patent infringement cases.

**MOLDYN, INC.** **Cambridge, MA**

*Launched as a division of Photon Research Associates to develop biomechanics, molecular modeling, and bioinformatics software products. Purchased by Structural Bioinformatics, Inc. in 2000.*

**Senior Staff Scientist** **1992 – 1999**

Senior Management: Member of 3-person management team responsible for all company operations. Individually responsible for IT infrastructure and support team.

Principal Investigator**:** Directed four NASA-sponsored projects with total revenue of $1.4 million in two product development areas. (1) Coupling of multi-body dynamics analysis techniques modeling human motion with general systems performance theory. (2) Development of a software infrastructure coupling structures, dynamics and controls analyses for complex satellite systems.

Task Leader**:** Key contributions in the development of MBO(N)D a molecular dynamics analysis tool.

**NASA, JOHNSON SPACE CENTER** **Houston, TX**

**Aerospace Engineer** (Summer Intern/Graduate Co-op – 15 months total) **1987 – 1990**

Investigated dynamic interaction between payloads and their attachment points in the Space Shuttle. Adapted lunar-landing simulation software for Mars Lander program. Studied Space Shuttle nose-gear landing loads to define the conditions limiting shuttle landings at Kennedy Space Flight Center.

**PURDUE UNIVERSITY** **West Lafayette, IN**

**Graduate Student** Schools of Mechanical Engineering and Aeronautics and Astronautics **1985 – 1992**

**Doctoral Research:** Thesis topic: Nonlinear Dynamic Response of Shallow Arches to Harmonic Forcing.

**Master's Research:** Developed analytical model to estimate error in measurement of crack length in fatigue test specimens. Performed fatigue testing on advanced aluminum alloys.

**Teaching Assistant:** Developed the lab section of a junior-level mechanical design course and supervised other lab instructors. Guest lectured in graduate fatigue course. Managed logistics of graduate distance learning courses. Assisted in undergraduate and graduate courses in structures and dynamics.

**ALPO PETFOODS, INC.** **Crete, NE**

**Associate Project Engineer** **1983 – 1985**

Directed high-speed, pet food manufacturing line upgrades from conception through start up. Directly responsible for $500K, and assisted with $400K, of capital projects.

## EDUCATION

**PURDUE UNIVERSITY** West Lafayette, IN
**Ph.D.,** Aeronautics and Astronautics 1992
**M.S.,** Mechanical Engineering 1987

**UNIVERSITY OF NEBRASKA** Lincoln, NE
**B.S.,** Mechanical Engineering 1983
**B.A.,** Psychology 1981

## PUBLICATIONS, PRESENTATIONS, MEDIA

**Lead Author:** 5 journal articles, 12 conference proceedings, 1 book chapter.

**Contributing Author:** 2 journal articles, 5 conference proceedings.

**Invited Presentations:** Smithsonian Institute Lemelson Foundation, IDEAS Boston 2004, University of London, Loughborough University, École Polytechnique Fédérale de Lausanne, University of Nebraska, Boston University, The International Congress on Technological and Social Innovation in Sport (Spain), the Sporting Goods Manufacturers Association International Business Intelligence Series, MIT Center for Innovation and Product Development, The 2005 Growth and Innovation Conference, New York.

**Media:** Featured in regional, national, and international print, radio, or television programs.

## PROFESSIONAL ACTIVITIES

**Societies, Journals and Conferences:** Secretary, President and Past President - International Sports Engineering Association, Member - American Society of Mechanical Engineers, Editorial Board - Journal of Sports Engineering and Technology, Reviewer - Journal of Sports Engineering, Scientific Committee Member - Engineering of Sport Conferences 5-11, and Asia Pacific Congress on Sports Technology 4.

**Educational Outreach:** Boston Museum of Science, ISEA Summer School in Prato, Italy, Sport Science, Engineering and Technology Summer Camp for Young Women in Cambridge, MA.

## AWARDS

University of Nebraska Alumni Achievement Award, 2005.

Eagle Scout, Overland Trails Council, Grand Island, Nebraska, 1973.

## OTHER INTERESTS

**MIT Triathlon Club:** Faculty advisor. Guided club officers from conception through recognition as an MIT Club Sport. Delivered talks and guidance on getting involved in the sport and training programs.

**Team Psycho Ltd.** (a New England elite triathlon team)**:** Former President, Board of Directors. Led team through 50% membership growth and incorporation as a nonprofit enterprise. Triathlete: Competitions include Regional and US Championships, Ironman Austria, and Ironman World Championships.

## PROFESSIONAL AFFILIATIONS

ISEA, International Sports Engineering Association, Past President 2014 – 2016, President 2010 – 2014, Secretary 2008 – 2010.

Journal of Sports Engineering and Technology, Editorial Board, 2007 – 2010.

Reviewer, Journal of Applied Biomechanics, 2009.

National Science Foundation Design Science Workshop Series, 2008 – 2009.

Golf Digest Technical Advisory Group Member, Technical Review of 2006 Golf Product Offerings, Naples, FL. October 2005.

Golf Digest Technical Advisory Group Member, Technical Review of 2005 Golf Product Offerings, Las Vegas, NV. October 2004 and the PGA Show, Orlando, 2005.

IMCRC International Expert Review Committee Member, Loughborough University, UK, 2004 – 2008.

## JOURNAL ARTICLES AND BOOK CHAPTERS

Crouch, T. N., Burton, D., LaBry, Z. A., and Blair, K. B., "Riding Against the Wind – A Review of Competition Cycling Aerodynamics," Invited Paper, Journal of Sports Engineering, In Press.

Caine, M. P., Blair, K. B., and Vasquez, M., "Materials and Technology in Sport", Invited Commentary, *Nature Materials*, Vol. 11, August 2012.

Blair, K. B., Chew, G-L, and Cote, M., 2007, "The Effect of Static Leg Position and Cadence on the Drag of a Cyclist," *Human Power eJournal,* Article 14, Issue 4.

Blair, K. B., 2007, "Materials and design for sports apparel," *Materials in Sports Equipment (Volume 2),* Woodhead Publishing Limited, Cambridge, UK, pp 60-86.

Blair, K. B., Custer, D., Graham, J., Okal, M., 2005, "Analysis of Fatigue Failure in D-Shaped Carabiners," *Sports Engineering*, Vol. 8, No. 2, pp 107-113.

Chun, H. M., Padilla, C. E., Alper, H. E., Chin, D. N., Watanabe, M. Karlov, V. I., Soosaar, K., Blair, K. B., Becker, O., Caves, L, Nagle, R., and Farmer, B. L., 2000, "MBO(N)D: A Multi-body Method For Long-Time Molecular Dynamics Simulations," Journal of Computational Chemistry, Vol. 21, No. 3, pp. 159-184.

Blair, K. B., Krousgrill, C. M., and Farris, T. N., 1997, "Harmonic Balance and Continuation Techniques in Nonlinear Dynamics with an Application to Duffing's Equation," Journal of Sound and Vibration, Vol. 202, No. 5, pp. 717–731.

Blair, K. B., Krousgrill, C. M., and Farris, T. N., 1996, "Nonlinear Dynamic Response of Shallow Arches to Harmonic Forcing," Journal of Sound and Vibration, Vol. 194, No. 3, pp. 353–367.

## CONFERENCE PAPERS

Berry, M., Las Fargeas, J., and Blair, K. B., 2010, "Wind Tunnel Testing of a Novel Wingsuit Design," *The Engineering of Sport 8*, Proceedings of the 8th Conference of the International Sports Engineering Association, Vienna, Austria, Procedia Engineering, Vol. 2, No. 2, pp 2735-2740.

Blair, K. B., Turner, J. M., and Vasquez, M., "High Speed Sensor and Testing System for Baseball Chest Protectors," *The Impact of Technology on Sport III*, Proceedings of the 4th Asia Pacific Congress on Sports Technology, Honolulu, HI, USA, eds F. Alam, L. V. Smith, A. Subic, F. K. Fuss and S. Ujihashi, Publishing Solutions Pty Ltd, pp 435-439, 2009.

## CONFERENCE PAPERS (Continued)

Holschuh, B. T., Gray, T. L., Blair, K. B., 2009, "Golf Driver/Ball Impact Acoustic Measurement System," *The Impact of Technology on Sport III*, Proceedings of the 4th Asia Pacific Congress on Sports Technology, Honolulu, HI, USA, eds F. Alam, L. V. Smith, A. Subic, F. K. Fuss and S. Ujihashi, Publishing Solutions Pty Ltd, pp 287-291.

Blair, K. B., Vasquez, M., and Groudas, P., 2008, "Testing Procedures for Baseball Chest Protection Equipment," *The Engineering of Sport 7*, Proceedings of the 7th International Conference on the Engineering of Sport, Biarritz, France, Springer-Verlag, Vol. 2, pp. 215-222.

Blair, K. B., and Sidelko, S., 2008, "Aerodynamic Performance of Cycling Time Trial Helmets," *The Engineering of Sport 7*, Proceedings of the 7th International Conference on the Engineering of Sport, Biarritz, France, Springer-Verlag, Paris, France, Vol. 1, pp 371-377.

Blair, K. B., Williams, G., and Vasquez G., 2007, "The Effect of Wood Properties on the Performance of Baseball Bats," in: Fuss F.K., Subic A. and Ujihashi S. (Eds.) *The Impact of Technology on Sport II*. Proceedings of the Asia-Pacific Congress on Sports Technology, Singapore, Taylor & Francis Group, London, pp 345-349.

Blair, K. B., 2006, "Synopsis of Current Developments: Modeling Equipment," *The Engineering of Sport 6*, Proceedings of the 6th International Conference on the Engineering of Sport, TUM - Munich University of Technology, Germany, Vol. 2, pp 107-108.

Blair, K. B., Culligan, K. F., and Walfisch, D., 2006, "Analysis of Fulcrum Skate Performance," *The Engineering of Sport 6*, Proceedings of the 6th International Conference on the Engineering of Sport, TUM - Munich University of Technology, Germany, Vol. 3, pp 301-306.

Blair, K. B., Custer, D., Alziati, S., and Bennett, W., 2004, "The Effect of Load Rate, Placement Angle, and Ice Type on Ice Screw Failure," *The Engineering of Sport 5*, Proceedings of the 5th International Conference on the Engineering of Sport, University of California, Davis, Vol. 2, pp 283-289.

Hastings, A. Z. Blair, K. B., Culligan, K. F., and Pober, D. M., 2004, "Measuring the effect of transmitted road vibration on cycling performance," *The Engineering of Sport 5*, Proceedings of the 5th International Conference on the Engineering of Sport, University of California, Davis, Vol. 2, pp 619-625.

Young, L. R., Bush, D. J., Blair, K. B., 2003, "Rear-Releasable Ski Boots for ACL Protection: An Engineering Evaluation," International Society for Skiing Safety, 15th Congress, St. Moritz, Switzerland.

Brodeur, D. R., Young, P. W., and Blair, K. B., 2002, "Problem-Based Learning in Aerospace Engineering Education," Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Montreal, Canada.

Blair, K. B., Custer, D., Graham, J., Okal, M., 2002, "Analysis of Fatigue Failure in D-Shaped Carabiners," 2nd International Conference on Science and Technology in Climbing and Mountaineering, Leeds, United Kingdom.

Chun, H. M., Padilla, C. E., Blair, K. B., Li, J. H., Haney, D. N., and Alper, H. E., 1994, "A Reduced Variable Approach for Long–Time Dynamics of Large Macromolecular Systems," Air Force Materials Directorate Workshop on Large Scale Simulations in Chemistry/Materials Science.

Blair, K. B., Krousgrill, C. M., and Farris, T. N., 1994, "Dynamic Response of a Shallow Arch to Antisymmetric, Harmonic Loading," Proceedings of the 5th International Conference on Recent Advances in Structural Dynamics, Southampton, England, Vol. I, pp. 326–339.

Blair, K. B., Krousgrill, C. M., and Farris, T. N., 1992, "Nonlinear Dynamic Response of Shallow Arches," Proceedings of the 33rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference, Dallas, TX, pp. 2376–2384.

Blair, K. B., Krousgrill, C. M., and Farris, T. N., 1992, "Harmonic Balance and Continuation Techniques in Nonlinear Dynamics with an Application to Duffing's Equation," ASME Applied Mechanics, Materials and Aerospace Summer Meeting, Scottsdale, AZ, 1992.

## CONFERENCE COMMITTEES

Session Chair, 11th International Conference on Engineering of Sport, Delft University of Technology, Delft, NL, July 2016.

Session Chair, 10th International Conference on Engineering of Sport, Sheffield Hallam University, Sheffield, UK, July 2014.

Scientific Committee Member, 10th International Conference on Engineering of Sport, Sheffield Hallam University, Sheffield, UK, July 2014.

Session Chair, 9th International Conference on Engineering of Sport, University of Massachusetts - Lowell, Lowell, MA, July 2012.

Scientific Committee Member, 9th International Conference on Engineering of Sport, University of Massachusetts - Lowell, Lowell, MA, July 2012.

Session Chair, 8th International Conference on Engineering of Sport, Fachhochschule Technikum Wein, Vienna, Austria, July 2010.

Scientific Committee Member, 8th International Conference on Engineering of Sport, Fachhochschule Technikum Wein, Vienna Austria, July 2010.

Scientific Committee Member, 4th Asia Pacific Congress on Sports Technology, Honolulu, HI, September 2009.

Session Chair, 7th International Conference on Engineering of Sport, Ecole Supérieure des Technologies Industrielles Avancées, Biarritz, France, June 2008.

Scientific Committee Member, 7th International Conference on Engineering of Sport, Ecole Supérieure des Technologies Industrielles Avancées, Biarritz, France, July 2008.

Member, Board of Advisors, Sporting Goods Manufacturers Association Sport + Technology Summit, San Diego, CA, October 2007.

Conference Chair, Better Golf Through Technology Conference, Massachusetts Institute of Technology, March 2007.

Session Chair, 6th International Conference on Engineering of Sport, Technischen Universität München, Munich, Germany, July 2006.

Scientific Committee Member, 6th International Conference on Engineering of Sport, Technischen Universität München, Munich, Germany, July 2006.

Conference Chair, Better Golf Through Technology Conference, Massachusetts Institute of Technology, February 2006.

Session Chair, “What Industry Wants – A Panel Discussion,” 5th International Conference on Engineering of Sport, University of California – Davis, September 2005.

Scientific Committee Member, 5th International Conference on Engineering of Sport, University of California – Davis, September 2005.

## INVITED PRESENTATIONS

“Smart Devices in Sports Products”, Guest lecture for EM 153 – Management of Innovation, Gordon Institute, Tufts University, February 2017.

“Smart Devices in Sports Products”, Guest lecture for ME 597 – Sports Technology and Entrepreneurship, School of Materials Engineering, Purdue University, February 2017.

## INVITED PRESENTATIONS (Continued)

"Hardware Development for Smart Products in Sports", Invited seminar, Sports Technology Institute, Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, November 2016.

"Hardware Development for Smart Products in Sports", Invited entrepreneurship seminar, Loughborough University London, November 2016.

"Pressure Sensitive Adhesives - An Application Engineer's Point of View", Keynote presentation, 3M 2015 PSA Symposium, 3M Headquarters, St. Paul, MN, May 2015.

"Hardware Innovation and Product Development Process", 3M Automotive Applications Group Lunch and Learn, 3M Headquarters, St. Paul, MN, May 2015.

Panelist – "Innovations Fueling the Sports and Entertainment Industries", Licensing Executives Silicon Valley Chapter Fifteenth Annual Conference, Palo Alto, CA, April 2015.

"Wearable Technology – The Hardware Challenge", Evolve – The CSE Innovation Summit, Atlanta, GA, January 2015.

"Multi-Disciplinary Engineering for the Development of Advanced Applications in Sport Textiles", The AISTS & CSEM Conference on Smart Textile Opportunities for Sport, Rolex Centre, École Polytechnique Fédérale de Lausanne, Switzerland, November 2013.

"The Disciplines of Technology Development and Product Design", Sports Tech and Innovation Summit, The Emirates Stadium, London, UK, November 2013.

"The Disciplines of Technology Development and Product Design", Executive MBA at the School of Management in Fribourg Workshop, Swissnex, Cambridge, MA, October 2013.

"The Disciplines of Technology Development and Product Design", Sports Analytics Innovation Meet Up, Boston, MA, July 2013.

"The Disciplines of Technology Development and Product Design", Centre for Sport and Exercise Sciences, Sheffield Hallam University, Sheffield, UK, September 2012.

Panelist – "How Can Sport Drive Engineering Innovation?", Royal Academy of Engineering, London, UK, September, 2012.

"The Disciplines of Technology Development and Product Design", Swissnex Venture Leaders Conference, Cambridge, MA, October 2011.

"The Disciplines of Technology Development and Product Design", Department of Mechanical and Aerospace Engineering, Rutgers University, Piscataway, NJ, October 2011.

"The Disciplines of Technology Development and Product Design", Department of Industrial and Systems Engineering at Rensselaer Polytechnic Institute, Rochester, NY, October 2011.

"The Disciplines of Technology Development and Product Design", Department of Mechanical & Materials Engineering Pierson Lecture Series, University of Nebraska, Lincoln, NE, September 2011.

"The Disciplines of Technology Development and Product Design", Nebraska Society of Professional Engineers, Eagle, NE, September 2011.

Panelist – "Golf Analytics", MIT Sloan Sports Analytics Conference, Cambridge, MA, March 2011.

"The Disciplines of Technology Development and Product Design", Applied Ocean Physics & Engineering Seminar Series, Woods Hole Oceanographic Institute, Woods Hole, MA, February 2011.

"Innovation Workshop," University of Jyväskylä, Jyväskylä, Finland, November 2010.

Panelist – "Performance Enhancement: Will Future Athletes be Formula One or NASCAR?", MIT Sloan Sports Analytics Conference, Cambridge, MA, March 2010.

## INVITED PRESENTATIONS (Continued)

"Aerodynamics of Sports Balls," adidas International, Pre-Release of 2010 World Cup Soccer Ball, Scheinfeld, Germany, November 2009.

"Innovation in Sports Technology – Developing Marketable Products," University of Bridgeport, November, 2009.

"Applications of High Speed Imaging in Sports Product Design," Massachusetts Institute of Technology Professional Education Short Program in High-Speed Imaging for Motion Analysis: Systems and Techniques, June 2009.

"Engineering Sporting Excellence," Sports Engineering and Technology, Institute of Mechanical Engineers, London, March 2009.

"Innovation in Sports Technology – Developing Marketable Products," Purdue University Mechanical Engineering Design Seminar, April, 2009.

Panel Moderator – Sport 2.0: The Evolution of Technology and Sports, MIT Sloan Sports Analytics Conference, Cambridge, MA, March 2009.

"Innovation in Sports Technology – Developing Marketable Products," New England American College of Sports Medicine Conference, November, 2008.

"Location Switzerland – Sports Business Tour," Switzerland, April 2008.

Panel Moderator – Technology, MIT Sloan Sports Analytics Conference, Cambridge, MA, February 2008.

"Innovative Technologies in Sport," Netherlands Office for Science & Technology, Netherlands Ministry of Economic Affairs, The Hague, The Netherlands, November 2007.

"Building Collaborative Relationships Between Industry, Government and Academia – An International Discussion Panel," SGMA's Sports and Technology Convergence, La Jolla, CA, October 2007.

"Creating Sports Performance Innovations," Jyväskylä Regional Development Company, Jyväskylä, Finland, July 2007.

"Creating Sports Performance Innovations," Oulu Wellness Institute, Oulu, Finland, July 2007.

Panel Moderator – "Sponsorship", MIT Sloan Sports Analytics Conference, Cambridge, MA, February 2007.

"Implementing Sports Performance Innovations in Mass Sports Products," SGMA's Sports and Technology Convergence, La Jolla, CA, October 2006.

"Sports Apparel Aerodynamics," Department of Materials and Textiles," University of Massachusetts Dartmouth, May 2006.

"Cycling Aerodynamics," Exercise and Health Science Department, University of Massachusetts Boston, April 2006.

"Teaching and Research at the MIT Center for Sports Innovation," Sports and Rehabilitation Engineering Center, École Polytechnique Fédérale de Lausanne, Switzerland, November 2005.

"Teaching and Research at the MIT Center for Sports Innovation," NeuroMuscular Research Center Seminar Series, Boston University, October 2005.

"Innovation and Product Development in Sports," Mechanical Engineering Colloquium Series, University of Nebraska, October 2005.

"Predicting the Success of Innovation," The 2005 Growth and Innovation Conference, New York, NY, May 2005.

"New Technology and Sports Equipment," International Business Intelligence Series, Orlando, FL, January 2005.

## INVITED PRESENTATIONS (Continued)

"New Technologies to Monitor and Enhance Athletic Performance," CIMIT – Center for the Integration of Medicine and Innovative Technology Forum, Boston, MA, January 2005.

"Technology and Sports," International Congress on Technological and Social Innovation in Sport, San Sebastian, Spain, December 2004.

"Applications of Smart Textiles in the Sports Industry," ESPRC Network: Smart Textiles for Intelligent Consumer Products, London, United Kingdom, June 2004.

"Driving Innovation in Product Development," IDEAS 2004, Boston, MA, June 2004.

"Hands-on Experience in Teaching Innovation and Product Development", Center for Innovation and Product Development Seminar Series, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA, April 2004.

"Sports Product Innovation," Lemelson Center's Symposium, Inventing Ourselves, Lemelson Center for the Study of Invention and Innovation, Smithsonian National Museum of American History, Washington, DC, November 2003.

"Sports Product Development in Engineering Education," Queen Mary University of London, United Kingdom, November 2003.

"Sports Product Development in Engineering Education," Loughborough University, United Kingdom, November 2003.

"Advanced Development of Sports Equipment – Prototype Production," United States Olympic Committee Coach's Conference, Colorado Springs, CO, April 2003.

"Teaching Product Development in a Laboratory Context," The 2002 MIT Engineering/Manufacturing Conference: Innovations in Product Development, Cambridge, MA, October 2002.

## EDUCATIONAL OUTREACH

WGBH "Fetch" Scientific Advisory Board, 2007 – 2009.

Lecturer, MIT Science of Baseball Program, Cambridge, MA, July 2008.

Sports Product Development Segment, Teacher's Domain, Multimedia Resources for the Classroom and Professional Development, http://www.teachersdomain.org, Produced by WGBH, July 2006.

Course Faculty, International Sports Engineering Association Summer School, Lectures in aerodynamics, materials, and a seminar in product development process, Prato, Italy, June 2005.

Associate Director Get SSET!: Sport Science, Engineering and Technology Summer Camp for Young Women, MIT, Cambridge, MA, August 2005.

Course Faculty, Get SSET!: Sport Science, Engineering and Technology Summer Camp for Young Women, MIT, "Wind Tunnel Testing of Sports Equipment", and "Understanding User Needs in Sports Equipment Design," Cambridge, MA, August 2005.

Boston Museum of Science Lowell Institute Lecture Series, "Material Science in Sports: High Performance Equipment Design," Boston, MA, December 2004.

Course faculty, Get SSET!: Sport Science, Engineering and Technology Summer Camp for Young Women, MIT, "Wind Tunnel Testing of Sports Equipment", and "Understanding User Needs in Sports Equipment Design," Cambridge, MA, August 2004.

## EDUCATIONAL OUTREACH (Continued)

Boston Museum of Science Lowell First Friday Lecture Series, "Aerodynamics and Sports," Boston, MA, February 2004.

Get SSET!: Sport Science, Engineering and Technology Summer Camp for Young Women, "Wind Tunnel Testing of Sports Equipment," MIT, Cambridge, MA, August 2003.

Aerodynamics and wind tunnel testing advisor, POVme, an educational science of sports television program aimed at preteens and teens, primarily targeting young women, minorities, and the disabled who have a strong interest in sports, May 2003.

Member, Board of Advisors, Harvard-Smithsonian SportSmarts, a national education campaign of the designed to increase the understanding and appreciation of science through sports, 2000 – 2004.

## AWARDS FOR SUPERVISED ACADEMIC PROJECTS

Aeronautics and Astronautics Department, MIT: Leaders for Manufacturing Award for directly dealing with issues that are related to the interface of engineering and manufacturing, Santiago, N., and Williams, G., "Performance Benefits of Handle Flex in Baseball Bats," June 2006.

ispo - Technical University of Munich: Academic Challenge Award, Munich, Germany. 1st Place Popular and Leisure Sports Category, Okal, M., "Carabiner Damage Detection Device," February 2004.

ispo - Technical University of Munich: Academic Challenge Award, Munich, Germany. 2nd Place Popular and Leisure Sports Category, Wang, C-A, "Triathlon Shoe Design", February 2004.

Aeronautics and Astronautics Department, MIT: United Technologies Corporation Award for outstanding achievement in the design, construction, execution, and reporting of an undergraduate experimental project, Alziati, S. A., and Bennett, W. L. M., "Simulating and Testing Ice Screw Performance in the Laboratory," May 2003.

2nd International Conference on Science and Technology in Climbing and Mountaineering, Leeds, United Kingdom: Best Student Presentation in Technological Fields, Okal, M., "Analysis of Fatigue Failure in D-Shaped Carabiners", April 2002.

Aeronautics and Astronautics Department, MIT: Admiral Luis de Florez Award for original thinking or ingenuity, Okal, M., and Graham, J., "Fatigue Failure of Climbing Carabiners," May 2002.

## SUPERVISED THESES

Li, Harriet and Obropta, "Bicycle Fork Aerodynamics," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2012.

Hyatt, D., "Proposed Testing Method for Foam Padding," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2011.

Ryne, B, and Kays, C., "Laptop Computer Shock and Vibration Characterization in Commuter Bike Packs," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, December 2010.

Racz, R., "Development of an Improved Wind Tunnel Test Platform for Bicycles," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2010.

Berry, M., Fargeas, J. L., "Lift to Drag Increase of Wingsuits," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2010.

## SUPERVISED THESES (Continued)

Vasquez, M., "Economic and Technological Advantages of Using High Speed Sintering as a Rapid Manufacturing Alternative in Footwear Applications," M Eng, Materials Science and Engineering, Massachusetts Institute of Technology, June 2009.

Pier, T., "Development of a Camber Measurement System for Skis and Snowboards," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2008.

Desrochers, C., "Product Development of a Resistive Athletic Suit," SB Mechanical Engineering, Massachusetts Institute of Technology, January 2008.

Cote, M., "Product Design and Development of an Aerodynamic Hydration Systems for Bicycling and Triathlon," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2007.

LaCrosse, B. A., "Measurement of Baseball Glove and Hand Dynamics," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2007.

Renjifo, J. F., "Developing the Next "Wow" Fitness Product," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2007.

Sidelko, S., "Aerodynamic Performance of Time Trial Helmets," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2007.

Liburd, S., and Naranjo, J. L., "Thermal Performance of Under Armour Sports Apparel," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2007.

Gray, T., and Holschuh, B., "Golf Driver-Ball Impact Acoustic Measurement System," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2006.

Santiago, N., and Williams, G., "Performance Benefits of Handle Flex in Baseball Bats," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2006.

Culligan, K., and Walfisch, D., "Analysis of a New Speed Skating Hinge Mechanism," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2005.

Kendall, B., and Newell, D., "Friction Testing of Luge Runners," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2005.

Yandell, A., "Design of Wind Tunnel Test Device for Spinning Sports Balls," SB Ocean Engineering, Massachusetts Institute of Technology, June 2005.

Raghunathan, S., "Potential Impact of Advanced Sensing and Communication Technologies in Sports Products", SB Mechanical Engineering, Massachusetts Institute of Technology, June 2005.

Hildago, M., "Integration of Computer Based Design Tools in the Athletic Shoe Design Process," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2004.

LaValley, Z, "Teaching Motion to a Group Using Integrated Motion Sensing Systems," MEng Electrical Engineering and Computer Science, Massachusetts Institute of Technology, June 2004.

Hoying, B., "Wind Tunnel Interface for Testing Bicycle Aerodynamics," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2003.

Yang, C., "Materials Selection in Shoe Sole Design," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2003.

Alziati, S. A., and Bennett, W. L. M., "Simulating and Testing Ice Screw Performance in the Laboratory," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2003.

## SUPERVISED THESES (Continued)

Talon, L., "Development of a Biofeedback System for Optimizing Cycling Performance Assessment During Wind Tunnel Testing," SM Aeronautics and Astronautics, Massachusetts Institute of Technology, August 2002.

Blundo, J. "Design of an Ultra-Marathon Shoe," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2002.

Bush, D. "Evaluation of the Lange V-9 Ski Boot Release Mechanism," SB Mechanical Engineering, Massachusetts Institute of Technology, June 2002.

Mauger, A., "Optimizing the Incorporation of Technology into the Custom Golf Club Market," SM Systems Design and Management, Massachusetts Institute of Technology, January 2002.

Graham, J., and Okal, M., "Fatigue Failure of Climbing Carabiners," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, December 2001.

Bonnell, J., Pendexter, M., "Characterization of In-Line Skating Motion," SB Aeronautics and Astronautics, Massachusetts Institute of Technology, June 2001.

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"A Study of the Relationship Between Surface Features and the In-Flight Performance of Footballs," David Mark Rogers, Ph.D., Loughborough University, United Kingdom, Advisor: Dr. Andy Harland, June 2011.

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"Customisation of Sport Grips Using Rapid Manufacturing Methodologies," David Barrass, Ph.D. Loughborough University, United Kingdom, Advisor: Professor Roy Jones, November 2006.

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"Space Age Sports: Science is Being Utilized to Improve Modern Sports Equipment and Athlete Performance", *The NewsHour*, PBS Television Network, July 2005.

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"IDEAS Boston, 2004" *Boston Globe*, June 13, 2004.

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"Better Playing Through Science," *Riverdeep*, www.riverdeep.net, March 12, 2001.

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"Research Center Focuses on Oar, Wheel, Rod and Bat," *MIT Tech Talk*, Vol. 44, No. 18, January 26, 2000.

"The Future of Sports," *7 News*, WHDH Television Network, December 24, 1999.

"Ride With the Wind," *MIT Tech Talk*, Vol. 44, No. 13, November 17, 1999.

## LITIGATION SUPPORT

I have been qualified as an expert in District courts. I have been deposed five times and provided inside consulting for litigation matters. My duties have included discovery assistance, literature searches, document review, patent analysis, and writing expert and rebuttal reports. I have provided technical assistance for litigation matters including reverse engineering and analysis as well as designed, developed, and utilized equipment for performance testing of patent claims.

**Foley & Lardner, LLP representing Woodway USA, Inc.** **2015 – Present**

United States District Court Eastern District of New York, 2013 Civ. 01276, Speedfit LLC and Aurel Astilean v. Woodway USA Inc. and Douglas G. Bayerlein.

Patent Infringement case related to treadmills. Prepared and submitted expert report and rebuttal reports on invalidity. Deposed.

**Maschoff Brennan, representing Icon Health & Fitness, Inc.** **2012 – 2013**

JAMS, Inc. Reference No. 1200047858. Icon Health & Fitness, Inc., Claimant, v. Dayco International, Inc. and Spirit Manufacturing, Inc. d/b/a Spirit Fitness Products, Respondents.

Patent infringement case related to fitness equipment. Prepared and submitted expert report on infringement and rebuttal reports on claim construction and engineering analyses. Present during JAMS hearing.

United States District Court for the District of Utah (Northern Division). Civil Action No. 1:10-cv-00195-RJS-DBP, Icon Health & Fitness, Inc., Plaintiff and Counterclaim Defendant, v. Park City Entertainment, Inc., Defendant and Counterclaim Plaintiff.

Patent infringement case related to fitness equipment. Prepared and submitted expert report on claim construction. Deposed.

**Workman | Nydegger, representing Icon Health & Fitness, Inc.** **2012**

United States District Court for the District of Utah (Northern Division). Civil Action No. 2:10-cv-01264-PMW, Icon Health & Fitness, Inc., Plaintiff, v. Fitness Equipment Services LLC, d/b/a/ Sole Fitness, Spirit Manufacturing, Inc, d/b/a Spirit Fitness Products, Defendants.

United States District Court for the District of Utah (Northern Division). Civil Action No. 1:10-cv-00195-DAK, Icon Health & Fitness, Inc., Plaintiff, v. Park City Entertainment, Inc., Defendant.

Patent infringement cases related to fitness equipment. Discovery assistance including document review, patent analysis, engineering analysis and technical support.

Cases transferred to Maschoff Gilmore & Israelsen (which became Maschoff Brennan) October 2012.

**Miller Canfield, representing Dickinson Wright, P.L.L.C.** **2012**

United States District Court, Eastern District of Michigan (Southern Division). Case No. 09-12102 Warrior Sports, Inc., Plaintiff-Appellee, v. Dickinson Wright, P.L.L.C., Defendant, Appellant.

Malpractice case related to an underlying patent infringement case regarding lacrosse equipment. Discovery assistance including document review, patent analysis, engineering analysis and technical support. Prepared and submitted expert report on infringement. Deposed.

**Williams Mullen, representing Fitness Anywhere** **2011**

United States District Court, Eastern District of Virginia (Norfolk Division). C.A. 2:11CV156 HCM/DEM. Fitness Anywhere, LLC, Plaintiff, v. Lifeline International, Inc., Defendant.

Patent infringement case related to fitness equipment. Discovery assistance including document review, patent analysis, literature searches, engineering analysis and technical support. Prepared and submitted expert report on infringement and rebuttal report on invalidity. Deposed.

## LITIGATION SUPPORT (Continued)

**Sunstein, Kann, Murphy & Timbers LLP, representing MacNeill Engineering Company 2009 - 2010**

United States District Court, District of Delaware. C.A. No. 08-469-GMS.
Softspikes, LLC and Pride Manufacturing Company, LLC, Plantiffs, v. MacNeill Engineering Company, Inc., Defendant.

Patent infringement case related to golf cleats. Discovery assistance including document review, patent analysis, technical support, engineering analysis, designed, built and used test mechanism to test performance of accused products against patent claims.

**Sterne, Kessler, Goldstein & Fox PLLC, representing adidas International 2009**

United States Patent and Trademark Office. Control No.: 95/001,198.

Re-examination of a patent related to portable training devices. Discovery assistance including document review, patent analysis, engineering analysis and technical support. Prepared and submitted declaration including obviousness analysis.

**Fish & Richardson PC, representing Callaway Golf Company 2008**

United States District Court, District of Delaware. C.A. No. 07-367-SLR.
Callaway Golf Company, Plaintiff, v. Acushnet Company, Defendant.

Patent infringement case related to golf clubs. Discovery assistance including document review, patent analysis, and providing technical support and engineering analysis.

**Paul, Hastings, Janofsky & Walker LLP, representing Bridgestone Golf 2005 – 2007**

(Case transferred from Sughrue Mion, PLLC, March 2006)
United States District Court, District of Delaware. C.A. No. 05-132-JJF.
Bridgestone Sports Co., LTD., and Bridgestone Golf, Inc., Plaintiffs, v. Acushnet Company, Defendant.

Patent infringement case related to golf balls. Discovery assistance including document review, patent analysis, literature searches, engineering analysis and technical support. Prepared and submitted expert report. Deposed.

**Kegler, Brown, Hill & Ritter Co., LPA, representing High Cedar Enterprises 2005 – 2006**

United States District Court, Central District of California, Southern Division. SACV 05-535-AHS.
High Cedar Enterprises, Co., and Karakal Far East, Ltd., a/k/a Karakal Golf Grips, Plaintiffs, v. Winn Inc., Defendant.

Patent infringement case related to golf grips. Discovery assistance including document review, patent analysis, engineering analysis and technical support. Supervised third party testing of products involved in the case. Prepared and submitted expert report on invalidity and rebuttal report on infringenment. Deposed.

**Sughrue Mion, PLLC, representing Eaton Corporation 2003**

United States District Court, Central District of California, Southern Division. CV 03-1568-SJO.
Winn Inc., and Ben Huang, an individual, Plaintiff, v. Eaton Corporation, Defendant.

Patent infringement case related to golf grips. Discovery assistance including document review, patent analysis, engineering analysis and technical support. Prepared and submitted expert report on invalidity and rebuttal report on infringement. Deposed.

## EXHIBIT D

## MATERIALS CONSIDERED

In connection with my study of this matter, I have reviewed the following materials:

1. U.S. Patent No. 8,986,169, including its file history
2. U.S. Patent No. 9,039,580, including its file history
3. U.S. Design Patent No. D736,866, including file history
4. U.S. Design Patent No. D753,776, including file history
5. Complaint and Exhibits (Dkt. 1), November 16, 2015
6. Woodway's Answer, Affirmative Defense, and Counterclaims and Exhibits (Dkt. 54), July 25, 2016
7. Woodway's Preliminary Infringement Contentions, April 18, 2016
8. Plaintiffs' Preliminary Non-Infringement Contentions, May 27, 2016
9. Plaintiffs' Preliminary Invalidity Contentions, May 27, 2016
10. Woodway's Supplemental Preliminary Infringement Contentions, July 18, 2016
11. Stipulated Protective Order (Dkt. 52-1), July 21, 2016
12. Plaintiffs' Supplemental Non-Infringement Contentions and Exhibits, August 8, 2016
13. Plaintiffs' Supplemental Invalidity Contentions and Exhibits, August 8, 2016
14. Plaintiffs' Opening and Responsive Claim Construction Brief and Exhibits (Dkt. 59 – 63)
15. Woodway's Opening and Responsive Claim Construction Briefs and Exhibits (Dkt. 55, 64)
16. Supplemental Declaration of Kadie M. Jelenchick and Exhibits (Dkt. 65 – 65-8), September 6, 2016
17. Plaintiffs' Reply Claim Construction Brief (Dkt. 66)
18. Declaration of Christine K. Bush and Exhibits 27 and 28 (Dkt. 67 – 67-2), September 20, 2016
19. Plaintiffs' Markman Presentation, November 28, 2016

20. Woodway USA, Inc.'s Tutorial and Claim Construction Presentation, November 28, 2016

21. Markman Hearing Transcript, November 28, 2016

22. Claim Construction Ruling (Dkt. 76), December 8, 2016

23. Deposition transcript of Jeremiah Rabe, October 18, 2016

24. Deposition transcript of Gerardo Aristi, October 19, 2016

25. Deposition transcript of Chapco 30(b)(6), October 20, 2016

26. Deposition transcript of Samsara 30(b)(6), November 1, 2016

27. Deposition transcript of Robert Weinstein, November 30, 2016

28. Deposition transcript of Bruce Bickford, December 12, 2016

29. Deposition of Douglas Bayerlein, December 14, 2016

30. Deposition Exhibits 1-379

31. U.S. Patent No. 219,439

32. U.S. Patent No. 1,211,765

33. U.S. Patent No. 3,489,408

34. U.S. Patent No. 3,637,206

35. U.S. Patent No. 3,642,279

36. U.S. Patent No. 3,669,238

37. U.S. Patent No. 3,968,543

38. U.S. Patent No. 4,334,676

39. U.S. Patent No. 4,548,405

40. U.S. Patent No. 4,614,337

41. U.S. Patent No. 4,635,928

42. U.S. Patent No. 4,726,581

43. U.S. Patent No. 5,162,988

44. U.S. Patent No. 5,411,279

45. U.S. Patent No. 5,411,455

46. U.S. Patent No. 5,470,293

47. U.S. Patent No. 5,538,489

48. U.S. Patent No. 5,577,598

49. U.S. Patent No. 5,709,632

50. U.S. Patent No. 5,887,579

51. U.S. Patent No. 6,042,514

52. U.S. Patent No. 6,053,848

53. U.S. Patent No. 6,146,315

54. U.S. Patent No. 6,348,025

55. Photographs and CAD of Woodway treadmills and their assemblies and components

56. Photographs of an Original TrueForm Runner Treadmill and its assemblies and components

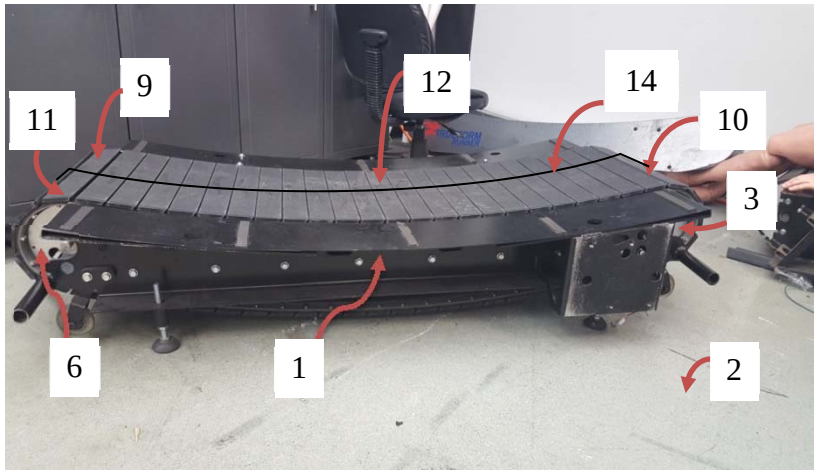
57. Photographs of a Redesigned TrueForm Runner Treadmill and its assemblies and components

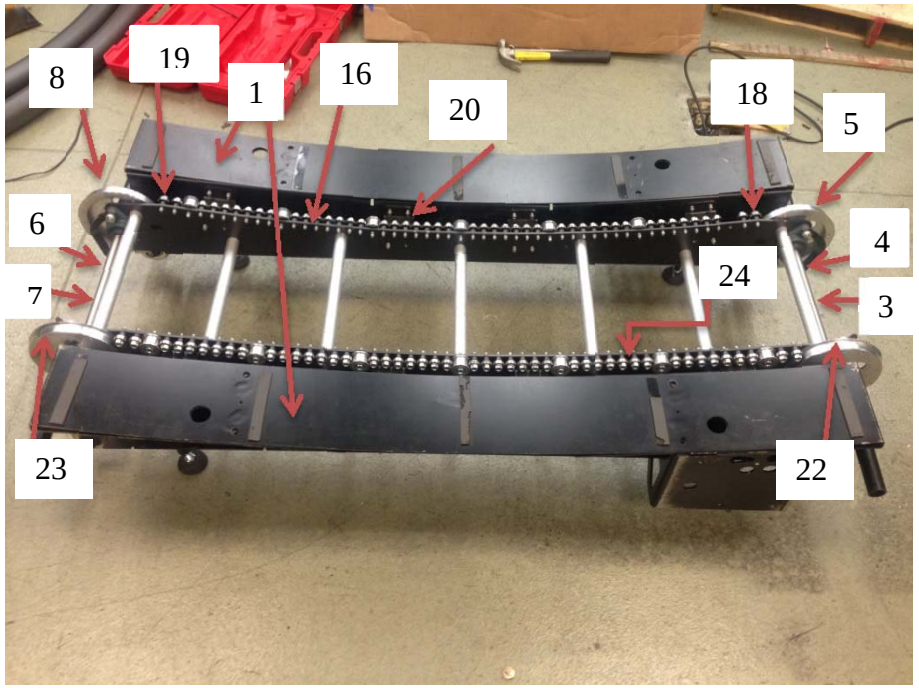
58. Photographs of SkillMill and its assemblies and components

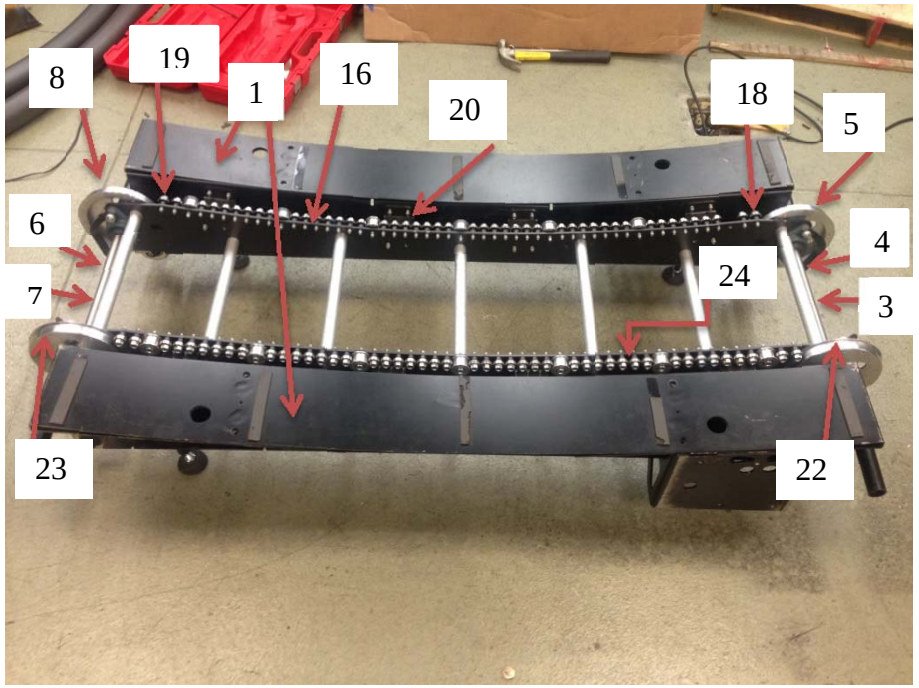
59. Koyo Catalog, http://www.jtekt-na.com/assets/ce/Documents/(B2018E-1)%20Needle%20Roller%20Bearing%20Catalog.pdf

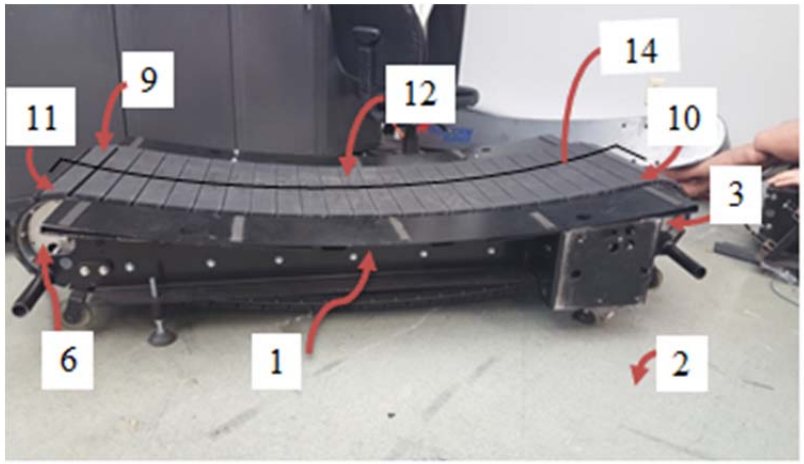
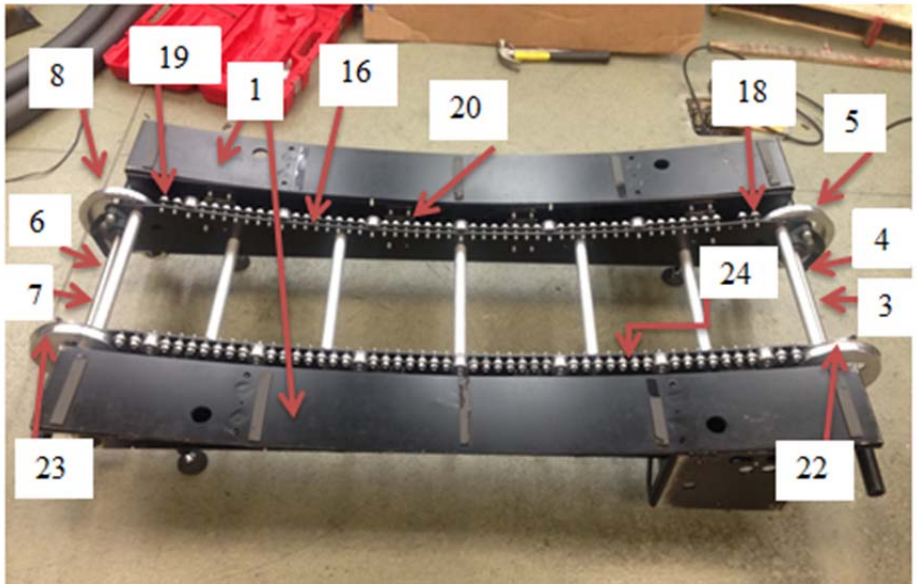
60. The Federal Circuit Bar Association Model Patent Jury Instructions, last edited July 2016

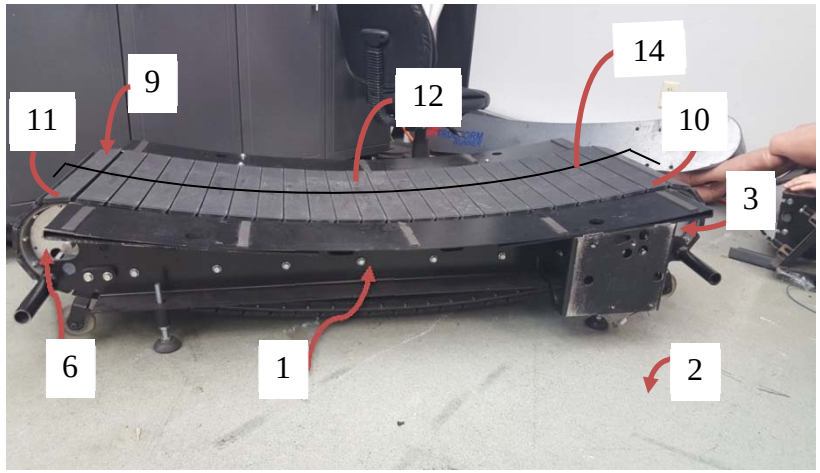
61. Littelfuse, Inc., *55505 Hall Effect Flange Mount Geartooth Speed Sensor* (October 16, 2015), http://www.littelfuse.com/~/media/electronics/datasheets/hall_effect_sensors/littelfuse_hall_effect_sensors_55505_datasheet.pdf.pdf

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| 11. A manually operated treadmill comprising: | A “manually operated treadmill” is literally each Original TrueForm Runner Treadmill.<br><br>As described in the product literature attached as Exhibit G and as Chapco and Samsara have admitted, the Original TrueForm Runner Treadmill is human powered and non-motorized. | |
| a frame supported on a substantially horizontal surface; | A “frame supported on a substantially horizontal surface” is present literally in each Original TrueForm Runner.<br><br>As shown, a frame [1], which designates the entire frame assembly not a single piece of metal is supported on a substantially horizontal surface [2], *e.g.*, the ground.<br><br>Chapco’s and Samsara’s argument that the Original TrueForm Runner Treadmill does not meet this claim limitation because it has two frames and not one frame is inconsistent with the ’169 patent’s disclosure. The specification of the ’169 patent states that “the frame may have substantially any configuration suitable for providing structure and support for the manual treadmill.” Col. 5, ll. 65-67. Nothing about the plain and ordinary meaning of “frame” requires a single unitary structure. |  |

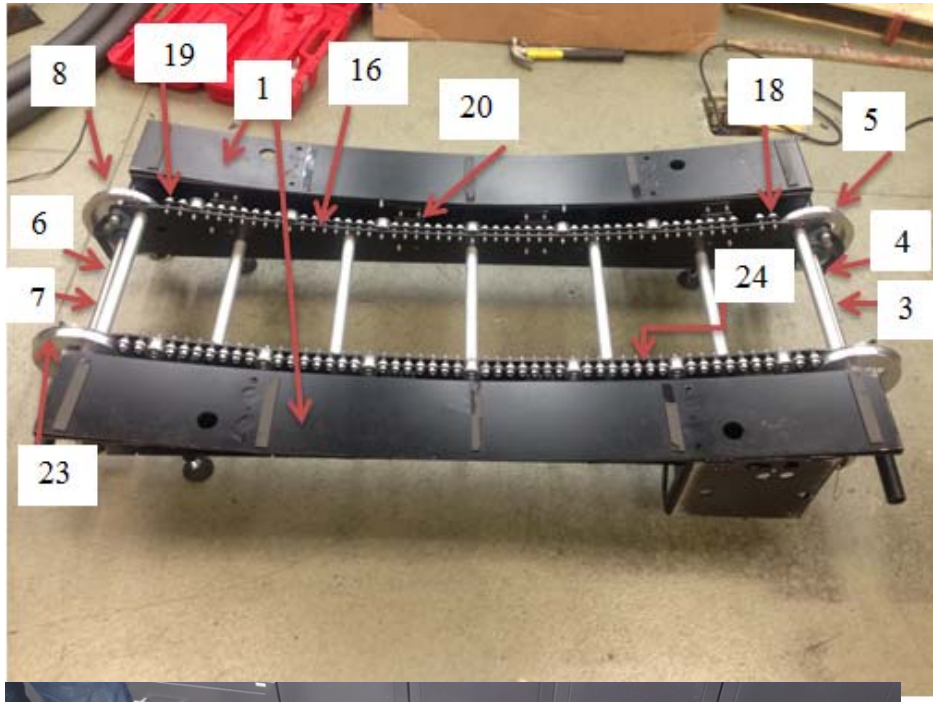
| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| a front shaft assembly supported by the frame and comprising:<br><br>a front shaft; and<br><br>at least one front running belt pulley supported by the front shaft; | A “front shaft assembly” having a “front shaft” and “at least one front running belt pulley supported by the front shaft” are literally present in each Original TrueForm Runner.<br><br>As shown, the frame [1] supports a shaft assembly [3] (i.e., the “front shaft assembly”), which includes a shaft [4] (i.e., the “front shaft”) and a pulley [5] (i.e., the “at least one front running belt pulley”). The plain and ordinary meaning of “support” does not require that components must be directly or physically connected or touching. “Support” may be provided directly, may be provided indirectly via an intermediary component or series of components, may bear some of the weight of another component or a series of components, and/or may bear all of the weight of another component or series of components. Here, the frame supports the front shaft assembly indirectly via the bearing rail.<br><br>More particularly and as shown, a bearing rail is coupled to the front shaft assembly [3] whereby the bearing rail is coupled to the frame [1]. In this regard, “the term ‘coupled’ means the joining of two members directly or indirectly to one another. … Such joining may be achieved with the two members or the two members and any additional intermediate members.” Col. 32, ll. 10-14.<br><br>Thus, via the bearing rail, the front shaft assembly [3] is supported by the frame [1]. |  |

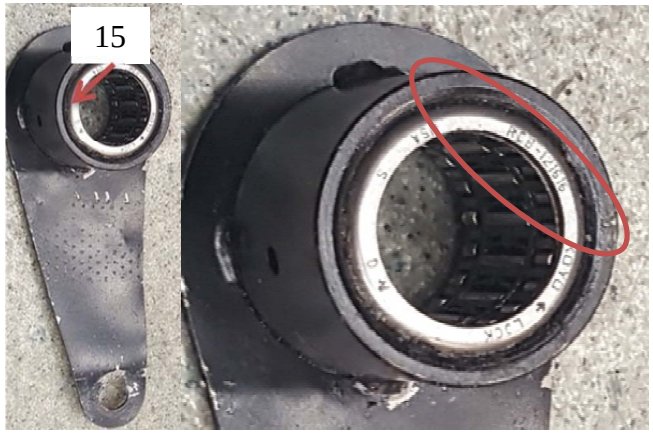
| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| a rear shaft assembly supported by the frame and spaced a distance from the front shaft and comprising:<br><br>a rear shaft; and<br><br>at least one rear running belt pulley supported by the rear shaft; | A “rear shaft assembly” having a “rear shaft supported by the frame” spaced from “the front shaft,” and an “at least one rear running belt pulley” are literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the frame [1] supports another shaft assembly [6] (i.e., the “rear shaft assembly”), which is spaced from the front shaft assembly [3] and includes a shaft [7] (i.e., the “rear shaft”) and a pulley [8] (i.e., the “at least one rear running belt pulley”). The plain and ordinary meaning of “support” does not require that components must be directly or physically connected or touching. “Support” may be provided directly, may be provided indirectly via an intermediary component or series of components, may bear some of the weight of another component or a series of components, and/or may bear all of the weight of another component or series of components. Here, the frame supports the rear shaft assembly indirectly via the bearing rail.<br><br>More particularly and as shown, a bearing rail is coupled to the rear shaft assembly [6] whereby the bearing rail is coupled to the frame [1]. In this regard, “the term ‘coupled’ means the joining of two members directly or indirectly to one another. … Such joining may be achieved with the two members or the two members and any additional intermediate members.” *See* the ’169 patent at col. 32, ll. 10-14.<br><br>Thus, via the bearing rail, the rear shaft assembly [6] is supported by the frame [1]. |  <br>3 |

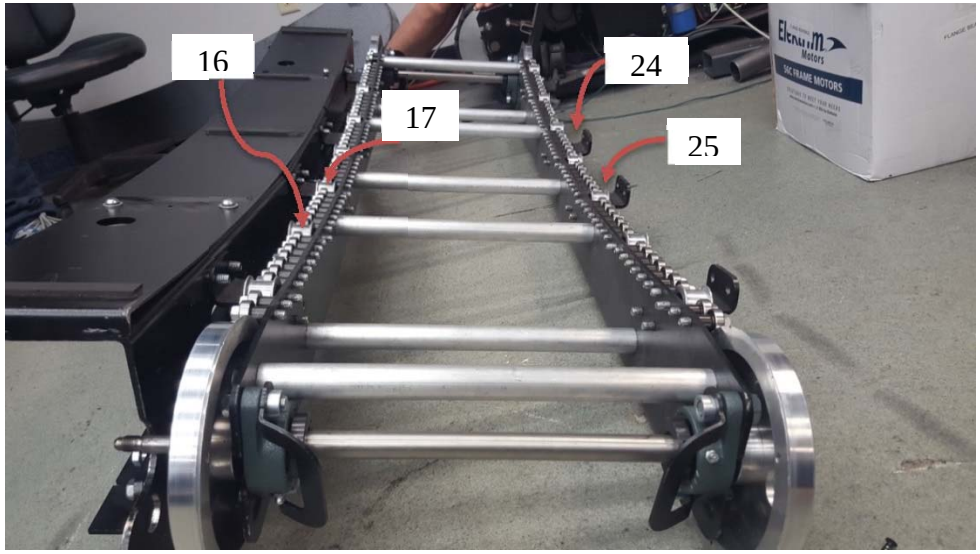
| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| a running belt supported at least in part by the front shaft assembly and the rear shaft assembly, | A “running belt” that is “supported at least in part by the front shaft assembly and the rear shaft assembly” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the running belt [9] is supported, at least in part, by the front and rear shaft assemblies [3] and [6], respectively. More particularly, the front shaft assembly [3] includes at least one front running belt pulley [5] while the rear shaft assembly [6] includes at least one rear running belt pulley [8], each of which support, at least in part, the running belt [9]. Because the at least one front running belt pulley [5] is included with the front shaft assembly [3] and the at least one rear running belt pulley [8] is included with the rear shaft assembly [6], the front and rear shaft assemblies [3] and [6] in turn support, at least in part, the running belt [9]. |  <br>  |

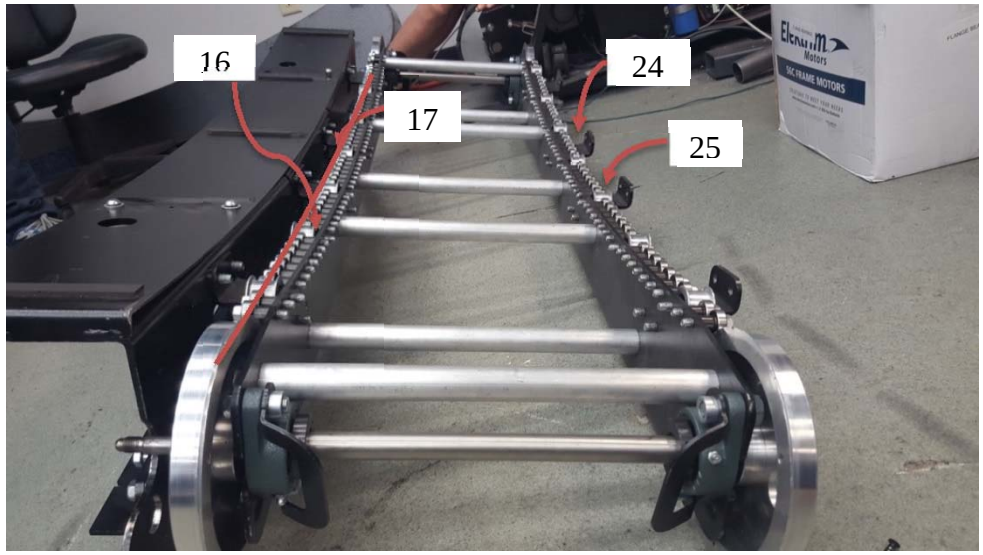
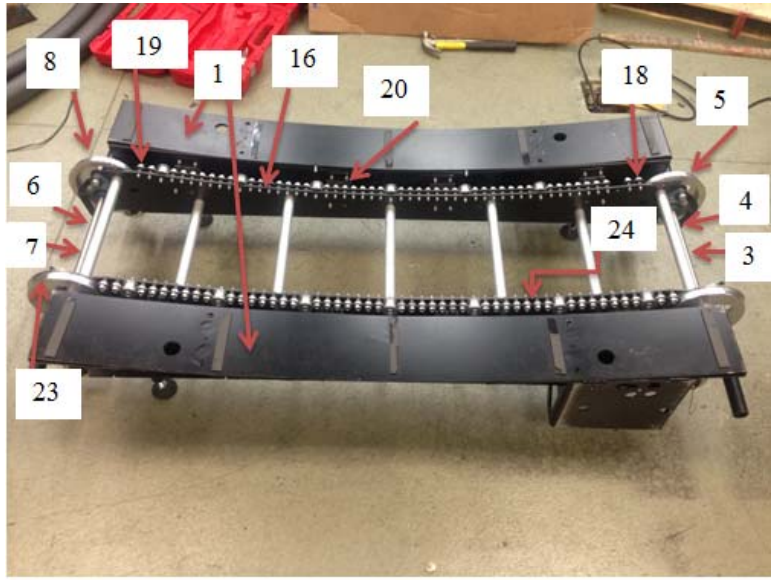
| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| the running belt including a front belt portion adjacent the front shaft assembly,<br><br>a rear belt portion adjacent the rear shaft assembly, and<br><br>a central belt portion intermediate the front belt portion and the rear belt portion, | The “running belt” having a “front portion,” “rear belt portion,” and “central belt portion intermediate the front belt portion and the rear belt portion” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the plain and ordinary meaning of the “running belt” [9] includes a front portion [10] adjacent the front shaft assembly [3], a rear belt portion [11] adjacent the rear shaft assembly [6], and a central belt portion [12] that is intermediate the front portion [10] and the rear belt portion [11]. |  |

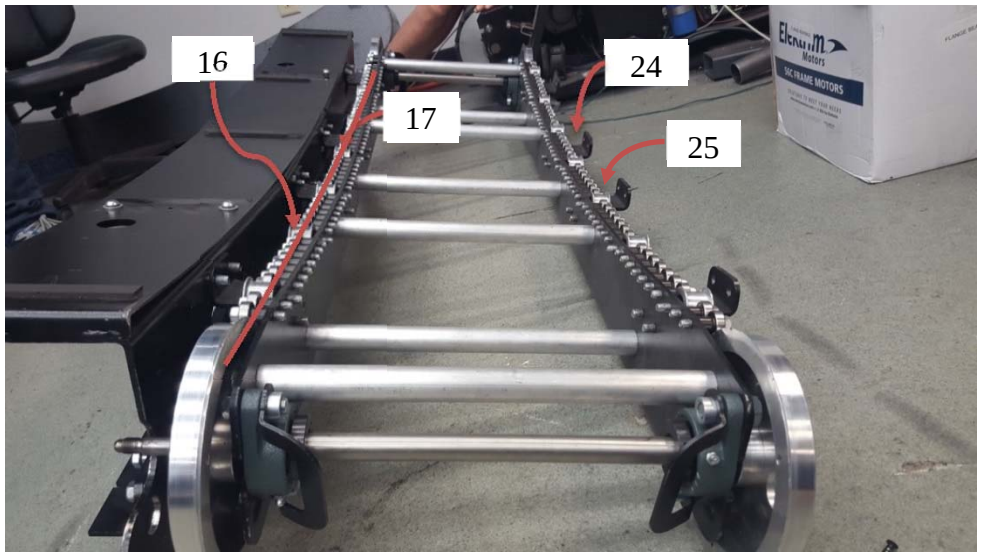
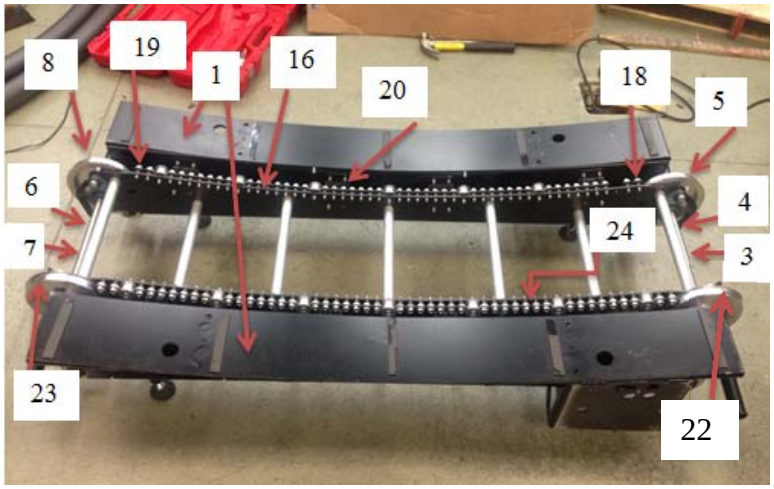
| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| the front belt portion and the rear belt portion being positioned vertically higher than a lowest point found in the central belt portion to form a curved running surface upon which a user of the treadmill may walk or run, | The “front belt portion” and “rear belt portion being positioned vertically higher than a lowest point found in the central belt portion to form a curved running surface upon which a user of the treadmill may walk or run” are literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, a horizontal plane line [13] has been inserted on the picture of the representative TrueForm Low Rider Treadmill. While the horizontal plane line [13] is shown as angled, this is due to the orientation of the product in the photograph. In this regard, the horizontal plane line [13] represents a horizontal planar support surface for the treadmill (i.e., a ground surface).<br><br>Insertion of vertically perpendicular lines from the horizontal line [13] to each of the highest points on the front portion [10] and rear belt portion [11] as well as the lowest point on the central belt portion [12] indicates that the front belt portion [10] and rear belt portion [11] are vertically higher than the central belt portion [12].<br><br>Due to the front belt portion [10] and rear belt portion [11] being vertically higher than the central belt portion [12], a curved running surface [14] is formed, which Chapco and Samsara admit is present in the Original TrueForm Runner Treadmill. | |

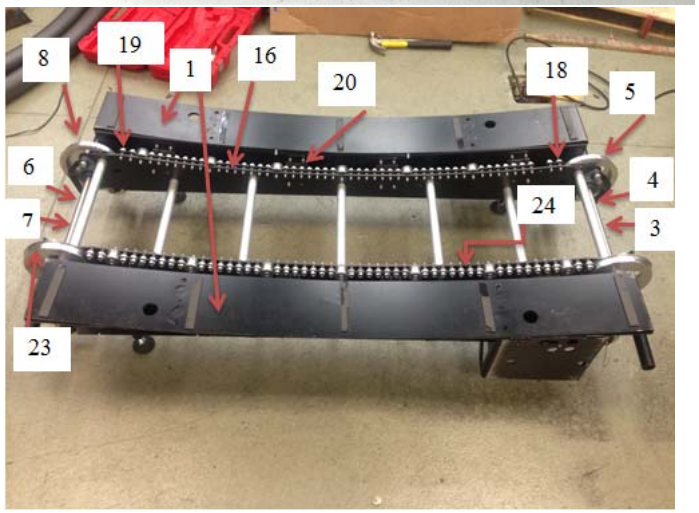
| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| wherein gravitational force acting upon weight of the user’s body on the running belt relative to the lowest point of the running belt causes rotation of the running belt, front shaft, and the rear shaft without the aid of a motor; | “Gravitational force acting upon weight of the user's body on the running belt relative to the lowest point of the running belt” that “causes rotation of the running belt, front shaft, and the rear shaft without the aid of a motor” is literally present in each Original TrueForm Runner Treadmill.<br><br>According to the product literature at Exhibit G, the treadmill is “non-motorized, powered by you. … The TrueForm requires ***the runner to turn the belt*** with their own power, which means better results” (emphasis added). Further, the force of gravity acts on all objects in the Earth’s gravitational field. Thus, treadmill users are acted on by the force of gravity. That force is transmitted to the treadmill through the contact points of the user on the treadmill.<br><br>Thus, the running belt [9] rotates from the runner with “their own power” and the “gravitational force acting upon weight of the user’s body.” Because the running belt [9] is disposed on the front and rear pulleys [5] and [8], rotation of the running belt [9] causes rotation of the front and rear pulleys [5] and [8]. In turn, rotation of the front and rear pulleys [5] and [8] causes rotation of the front and rear shafts [4] and [7]. |  <br> <br>7 |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| a safety device cooperating with the rear shaft to permit rotation of the rear shaft in only one direction; and | A “safety device cooperating with the rear shaft to permit rotation of the rear shaft in only one direction” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the safety device [15] is adjoined to the rear shaft [7].<br><br>As also shown, the safety device [15] is a Koyo brand with a model number of RCB-121616. This model number corresponds with a “regular clutch and bearing assembly” that “transmits torque between [the] shaft and housing in one direction and allows free overrun in the opposite direction” as described in the Koyo catalog.<br><br>Thus, because the safety device [15] is adjoined to the rear shaft [7] and because the safety device [15] “allows free overrun” in one rotational direction, the safety device [15] “cooperate[s] with the rear shaft to permit rotation the rear shaft in only one direction.” | <br>  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| at least one bearing rail having a plurality of bearings rotatably coupled to the at least one bearing rail and forming a top profile, | “At least one bearing rail having a plurality of bearings rotatably coupled to the at least one bearing rail and forming a top profile” is literally present in each Original TrueForm Runner Treadmill.<br><br>Chapco personnel in internal documents and in deposition refer to the structure depicted at the right as a “bearing rail.” Deposition of Jeremiah Rabe, October 18, 2016, pp. 88-99, 113-117, Exs. 12, 16. Mr. Rabe agrees that “inner frame” is synonymous with “bearing rail” and that the three models of the TrueForm Runner have the same “rail bearing curved” as depicted in Exhibit 16. Indeed, a person of ordinary skill in the art would understand that the photograph to the right shows two rails with bearings whose top profile corresponds to the shape of the running surface, as required by the Court’s claim construction.<br><br>As shown, a person of ordinary skill in the art would understand that at least one bearing rail with a plurality of bearings [16] is rotatably coupled and therefore forms a top profile [17]. |  |

| the '169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| the top profile defined by a front profile portion adjacent the front shaft assembly,<br><br>a rear profile portion adjacent the rear shaft assembly, and<br><br>a central profile portion intermediate the front profile portion and the rear profile portion, | A "top profile defined by a front profile portion adjacent the front shaft assembly, a rear profile portion adjacent the rear shaft assembly, and a central profile portion intermediate the front profile portion and the rear profile portion" is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the top profile [17] has a front profile portion [18] adjacent the front shaft assembly [3], a rear profile portion [19] adjacent the rear shaft assembly [6], and a central profile portion [20] intermediate the front profile portion [18] and rear profile portion [19]. |  <br>  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| the central profile portion having a concave curve, and<br><br>the front profile portion and the rear profile portion being continuations of the concave curve; | “The central profile portion having a concave curve” where “the front profile portion and the profile rear portion [are] continuations of the concave curve” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the central profile portion [20] has a concave curve. As also shown, the front profile portion [18] and the rear profile portion [19] do not include any breaks or interruptions; rather, the front profile portion [18] and the rear profile portion [19] are continuations of the concave curve of the central profile portion [20]. |  <br>  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| wherein the running surface of the running belt is supported by the top profile of the at least one bearing rail such that the running surface substantially corresponds to the shape of the top profile of the at least one bearing rail. | “The running surface” being “supported by the top profile of the at least one bearing rail” to cause “the running surface [to] substantially correspond[] to the shape of the top profile of the at least one bearing rail” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the running belt [9] is supported by the plurality of bearings [16] mounted to the at least one bearing rail along the top profile [17] of at least one bearing rail. Because the running belt is supported in this manner, the running surface substantially corresponds to the top profile [17] of the at least one bearing rail. | <br>  |

| the ’169 patent | Claim Chart Directed To Original Design | |
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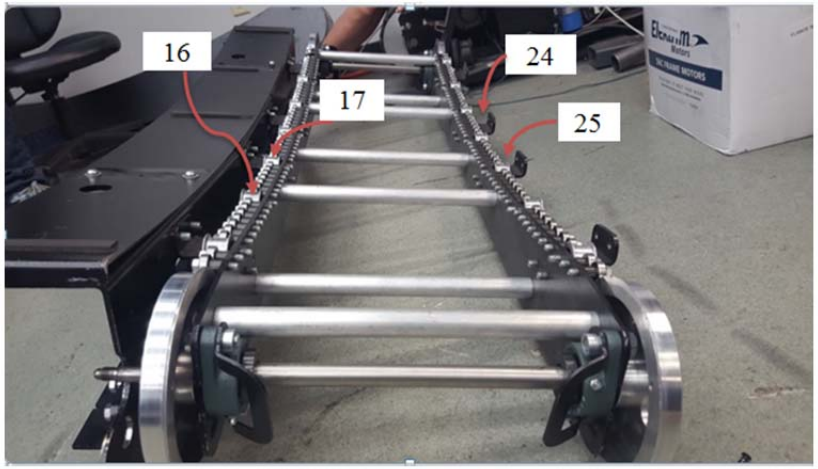
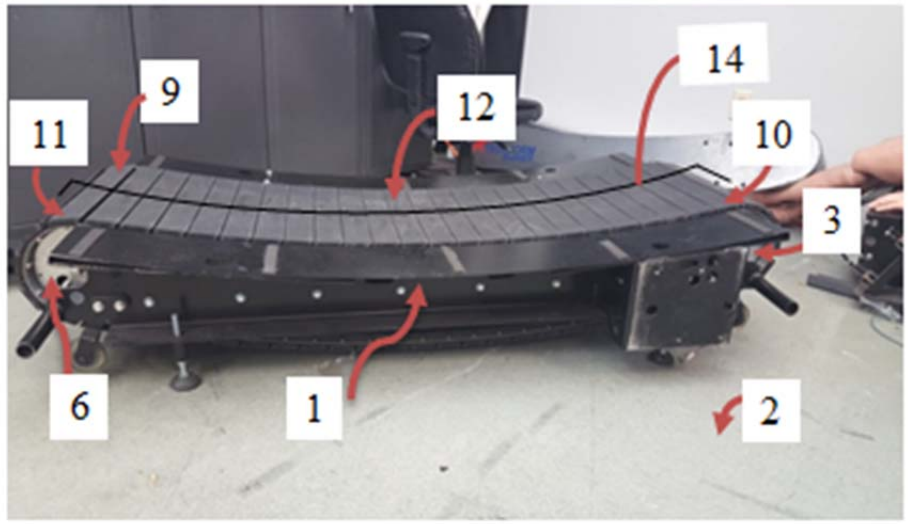
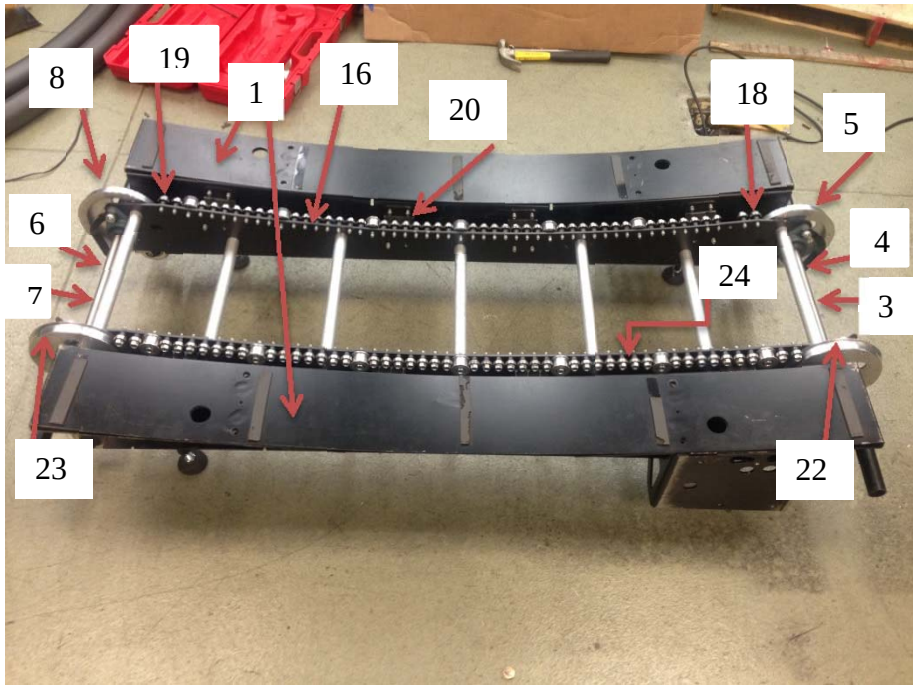
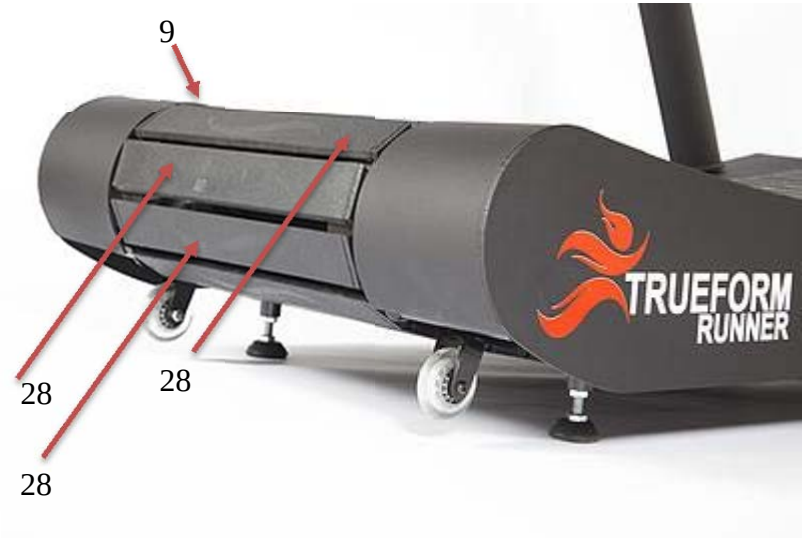
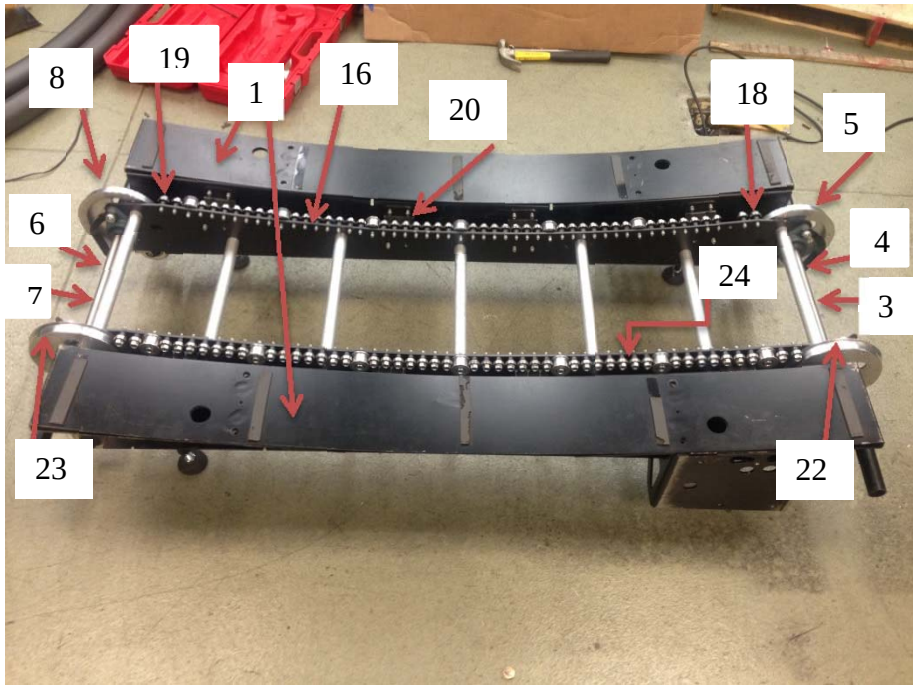
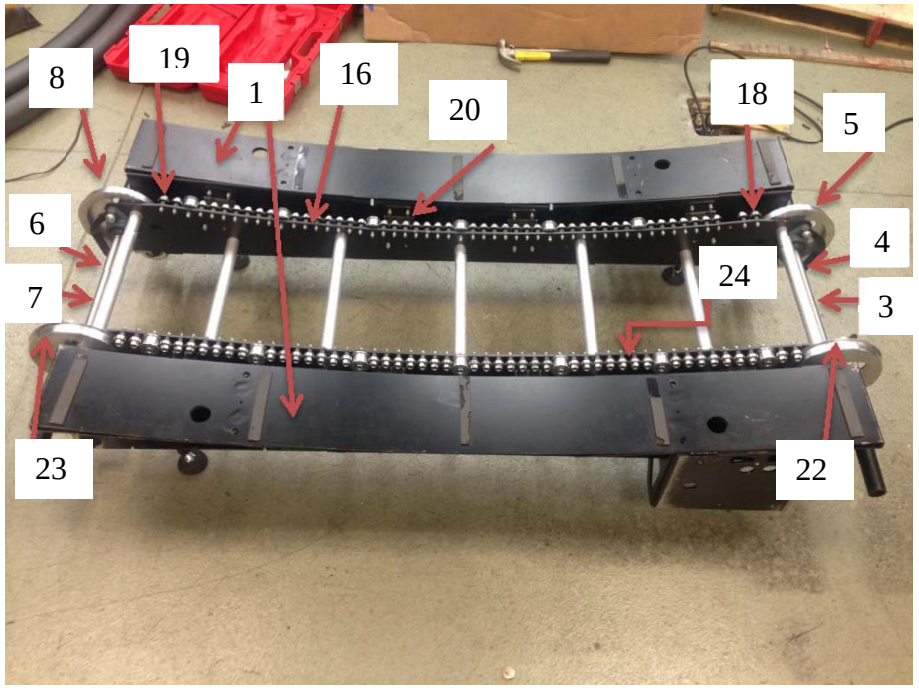
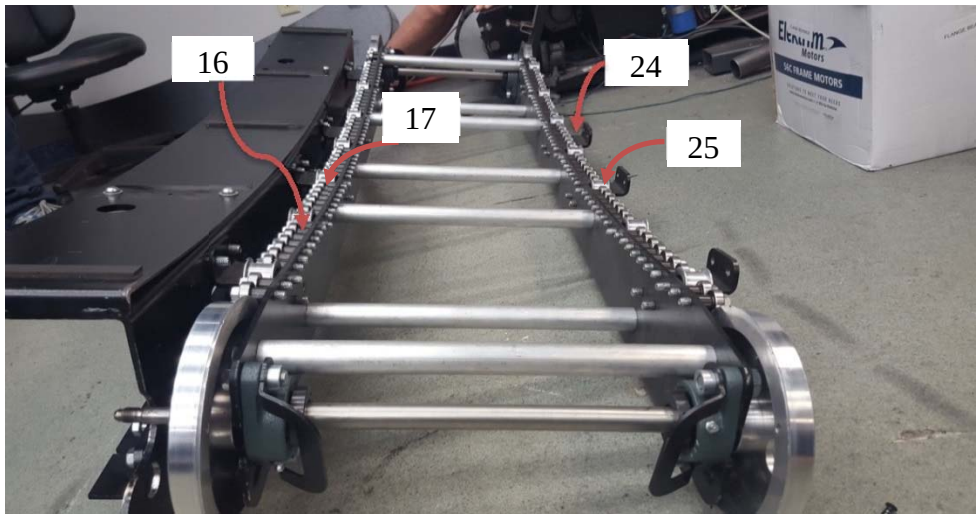
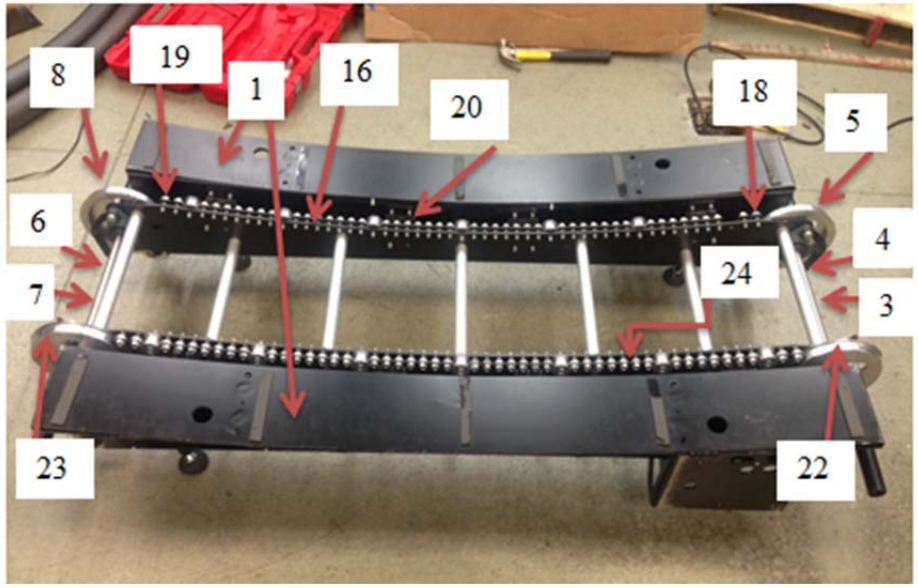
| | |  <br>  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| 12. The manually operated treadmill of claim 11,<br><br>the at least one bearing rail extending along the frame and longitudinally aligned with one of the at least one front running belt pulley and one of the at least one rear running belt pulley. | The “at least one bearing extending along the frame and longitudinally aligned with one of the at least one front running belt pulley and one of the at least one rear running belt pulley” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the at least one bearing rail [16], as that phrase is construed by the Court, extends along the frame [1] and is longitudinally aligned with each of the front running belt pulley [5] and rear running belt pulley [8]. |  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| 13. The manually operated treadmill of claim 12,<br><br>wherein the running belt comprises a plurality of laterally extending slats. | “A plurality of laterally extending slats” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the running belt [9] includes a plurality of laterally extending slats [28]. Chapco and Samsara agree. |  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| 14. The manually operated treadmill of claim 13, wherein:<br><br>the front shaft assembly comprises a second front running belt pulley supported by the front shaft and spaced laterally from the at least one front running belt pulley; | “The front shaft assembly” having “a second front running belt pulley supported by the front shaft and spaced laterally from the at least one front running belt pulley” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the front shaft assembly [3] includes a front shaft [4] that supports the at least one front running belt pulley [5] and a second front running belt pulley [22].<br><br>As discussed above, the plain and ordinary meaning of “support” does not require that components must be directly or physically connected or touching. “Support” may be provided directly, may be provided indirectly via an intermediary component or series of components, may bear some of the weight of another component or a series of components, and/or may bear all of the weight of another component or series of components. |  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| the rear shaft assembly comprises a second rear running belt pulley supported by the rear shaft and spaced laterally from the at least one rear running belt pulley; | “The rear shaft assembly” having “a second rear running belt pulley supported by the rear shaft and spaced laterally from the at least one rear running belt pulley” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the rear shaft assembly [6] includes a rear shaft [7] that supports the at least one rear running belt pulley [8] and a second rear running belt pulley [23].<br><br>As discussed above, the plain and ordinary meaning of “support” does not require that components must be directly or physically connected or touching. “Support” may be provided directly, may be provided indirectly via an intermediary component or series of components, may bear some of the weight of another component or a series of components, and/or may bear all of the weight of another component or series of components. |  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| the at least one bearing rail further comprises a second bearing rail having a plurality of bearings forming a top profile matching the top profile of the first of the at least one bearing rail,<br><br>the second bearing rail being longitudinally aligned with the second front running belt pulley and the second rear running belt pulley; | “A second bearing rail having a plurality of bearings forming a top profile matching the top profile of the first of the at least one bearing rail” and being “longitudinally aligned with the second front running belt pulley and the second rear running belt pulley” is literally in each Original TrueForm Runner Treadmill.<br><br>As shown, a second bearing rail, as that phrase has been defined by the Court, has a plurality of bearings [24] and forms a top profile [25]. The top profile [25] of the bearings [25] matches the top profile [17] of the first bearing rail. As also shown, the second bearing rail [24] is longitudinally aligned with the second front running belt pulley [22] and the second rear running belt pulley [23]. |  <br>  |

| the ’169 patent | Claim Chart Directed To Original Design | |
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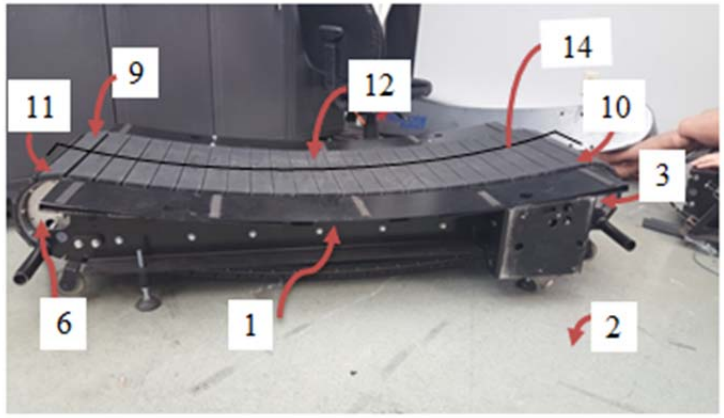
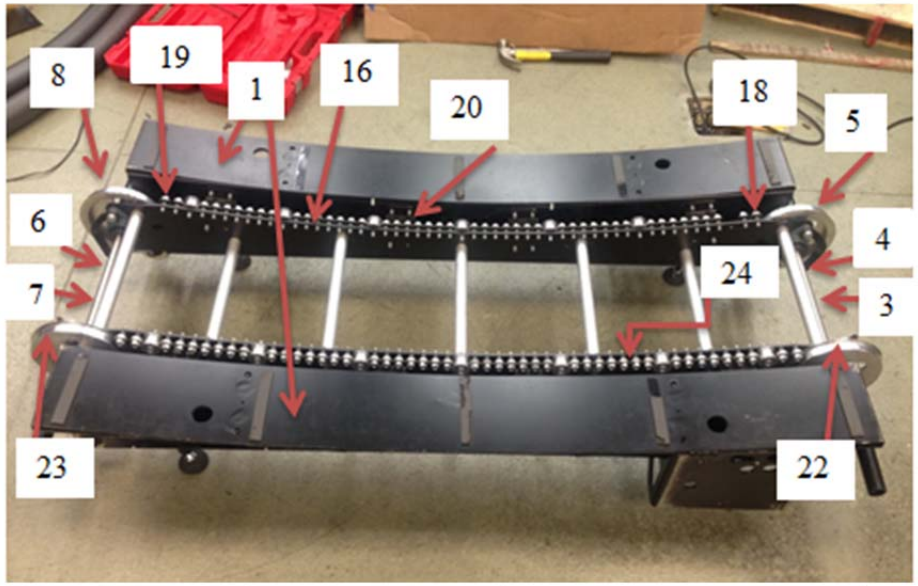
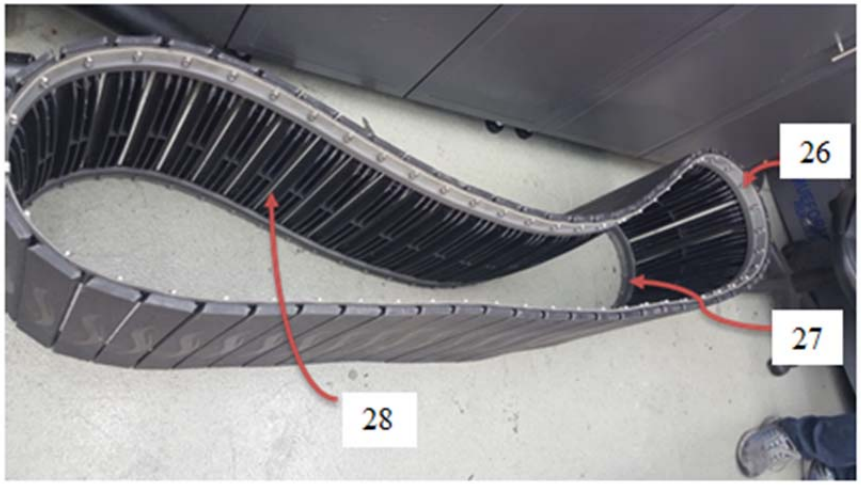
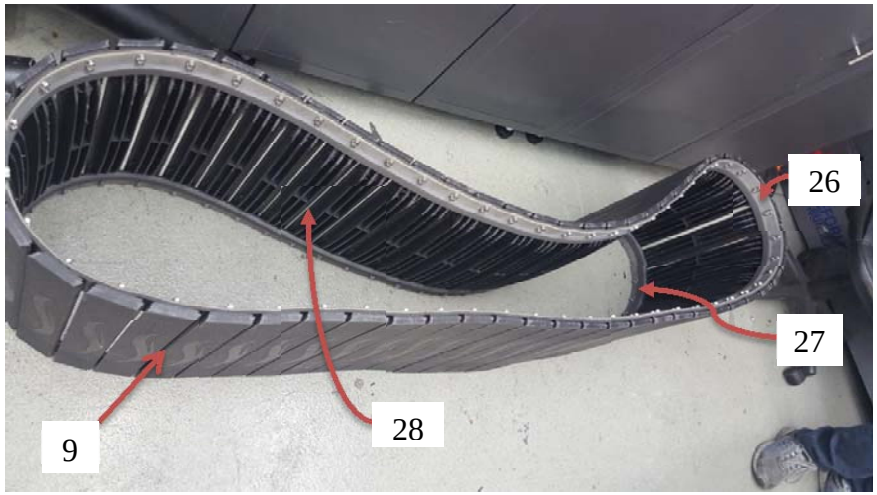
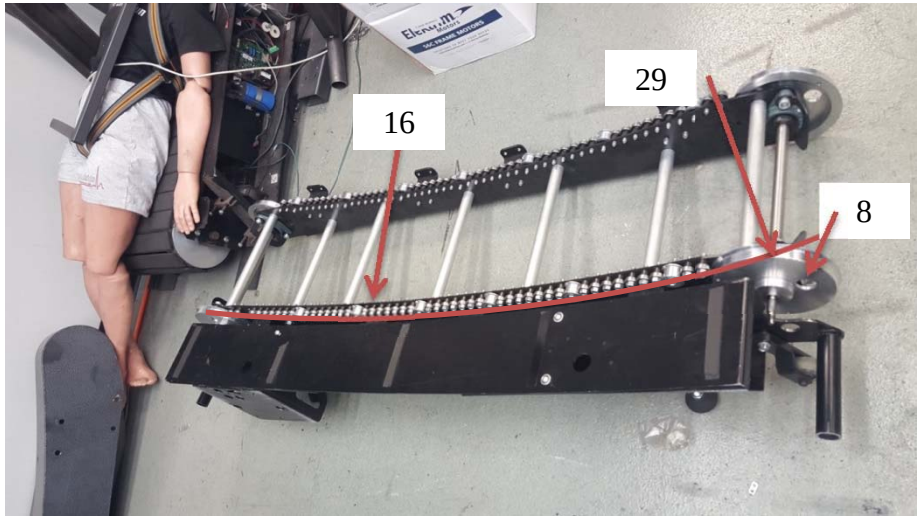
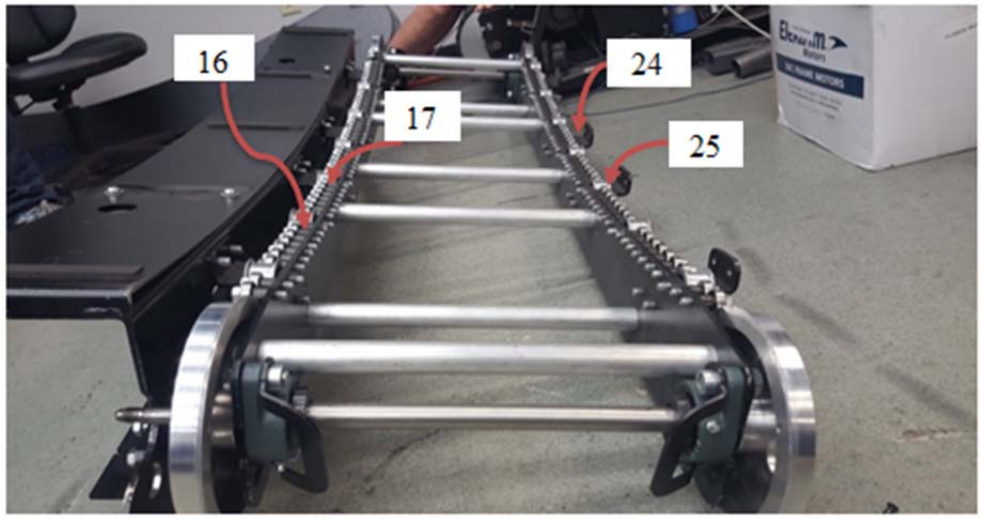
| | |  |
| the running belt comprises a first endless belt and a second endless belt, wherein the first endless belt is supported by the at least one front running belt pulley, the first of the at least one bearing rail, and the at least one rear running belt pulley, and wherein the second endless belt is supported by the second front running belt pulley, the second bearing rail, and the second | The “running belt” having “a first endless belt and a second endless belt, wherein the first endless belt is supported by the at least one front running belt pulley, the first of the at least one bearing rail, and the at least one rear running belt pulley, and wherein the second endless belt is supported by the second front running belt pulley, the second bearing rail, and the second rear running belt pulley” is literally present in each Original TrueForm Runner Treadmill.<br><br>The running belt [9] includes a first endless belt [27] and a second endless belt [26], where the first endless belt [27] is supported by the first running belt pulley [5], the at least one first bearing rail, and the first rear running belt pulley [8] while the second endless belt [27] is supported by the second front running belt pulley [22], the second of the at least one bearing rail, and the second rear running belt | |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| rear running belt pulley; | pulley [23]. |  <br>  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| and the plurality of laterally extending slats extend between the first endless belt and the second endless belt. | The “plurality of laterally extending slats” that “extend between the first endless belt and the second endless belt” are literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the slats [28] extend laterally across the running belt [9] between the first endless belt [27] and the second endless belt [26]. Chapco and Samsara agree. |  |
| 15. The manually operated treadmill of claim 14,<br><br>wherein the rear profile portion of the at least one bearing rail is positioned and shaped to provide a smooth transition for the running belt from the at least one bearing rail onto the at least one rear running belt pulley. | The “the rear portion of the at least one bearing rail is positioned and shaped to provide a smooth transition for the running belt from the at least one bearing rail onto the at least one rear running belt pulley” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, a continuous curve [29] of the bearing rail, which corresponds with the top profile [17], is inserted to show the smooth transition from the at least one bearing rail onto the at least one rear running belt pulley [8]. |  |

| the ’169 patent | Claim Chart Directed To Original Design | |
|---|---|---|
| | |  |
| 16. The manually operated treadmill of claim 11,<br><br>wherein the safety device comprises a one-way bearing. | The “safety device” comprising “a one-way bearing” is literally present in each Original TrueForm Runner Treadmill.<br><br>As shown, the safety device [15] is a Koyo brand with a model number of RCB-121616. This model number corresponds with a “regular clutch and ***bearing*** assembly” that “transmits torque between [the] shaft and housing in one direction and allows free overrun in the opposite direction” as described in the Koyo catalog. | |

| the ’169 patent | Claim Chart Directed To Original Design | |
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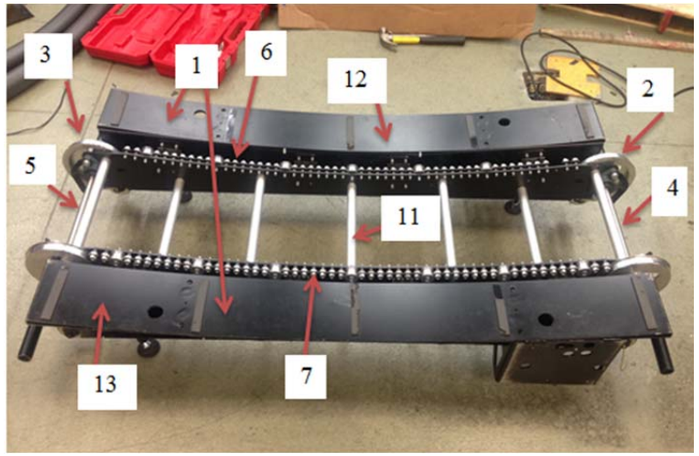
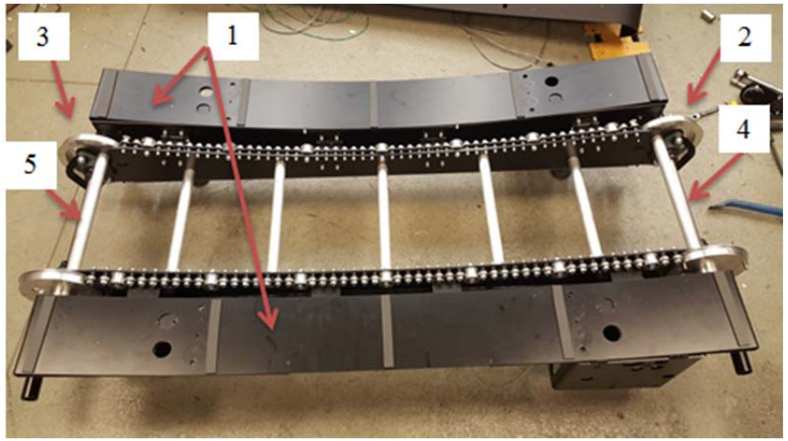
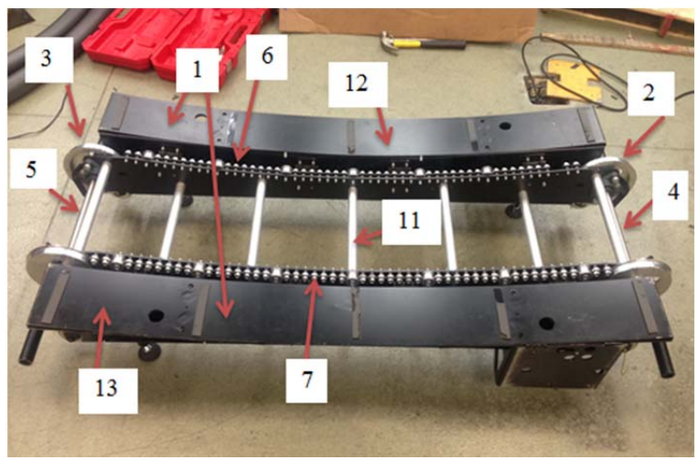
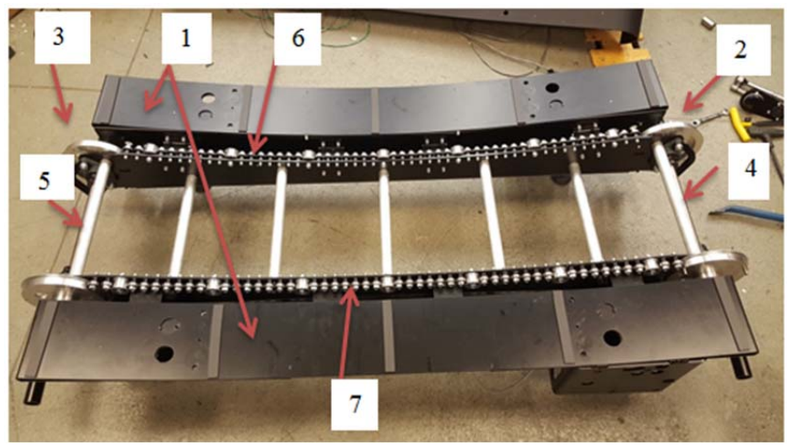
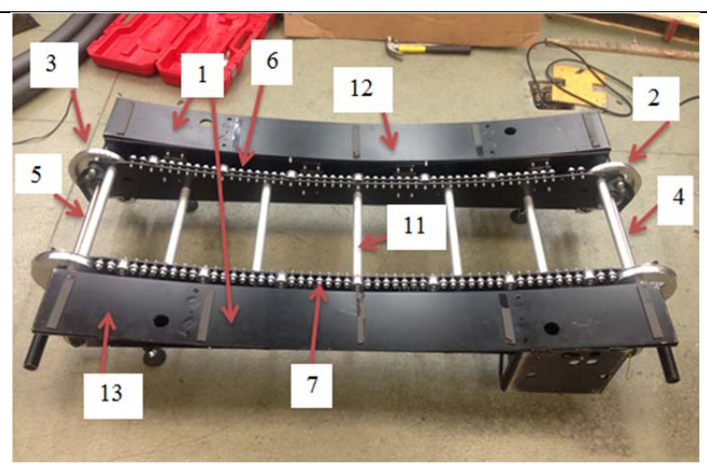
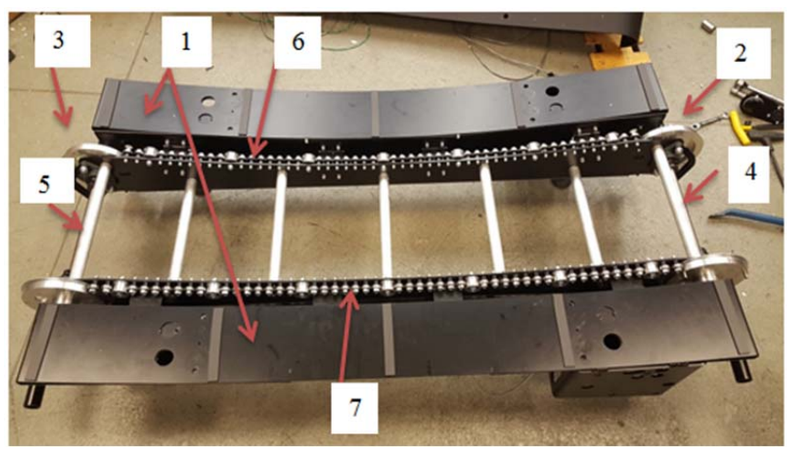
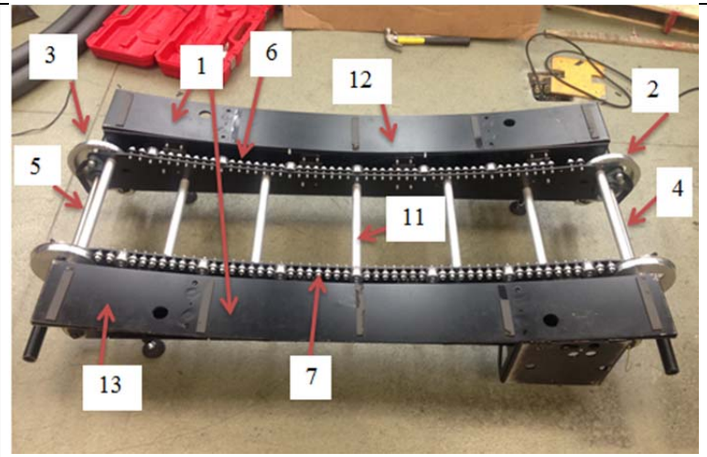
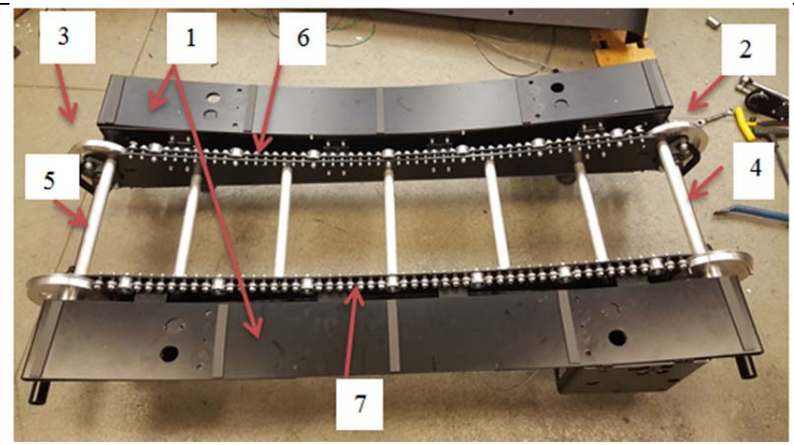
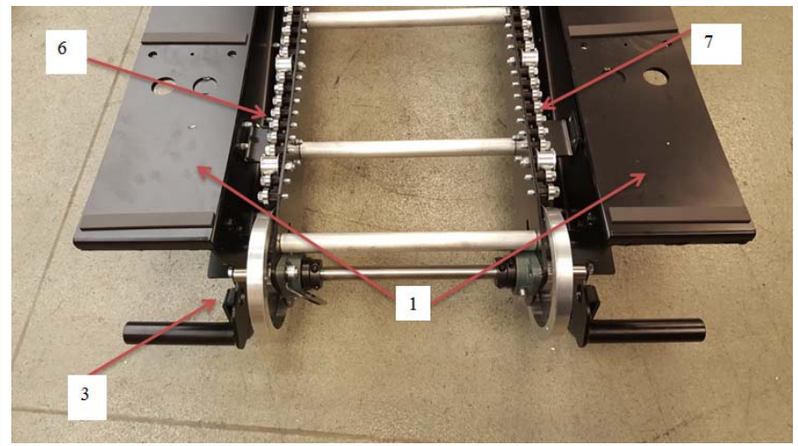
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| 1. A manually powered treadmill comprising: | A “manually powered treadmill” is literally each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As described in the product literature attached as Exhibit G and as Chapco and Samsara have admitted, the Original and Redesigned TrueForm Runner Treadmills are human powered and non-motorized. | | |

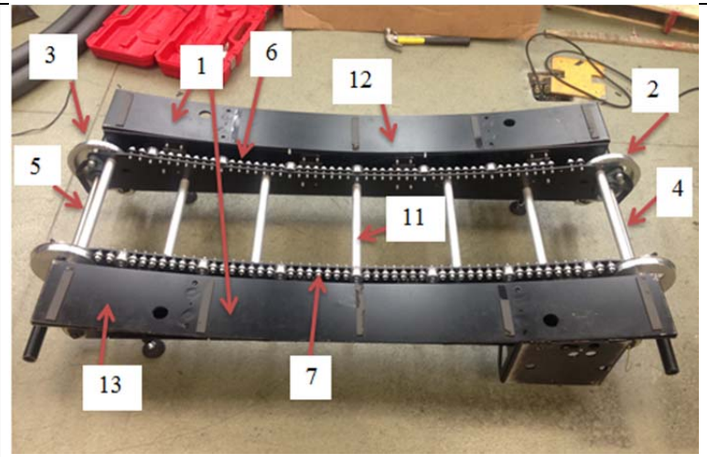
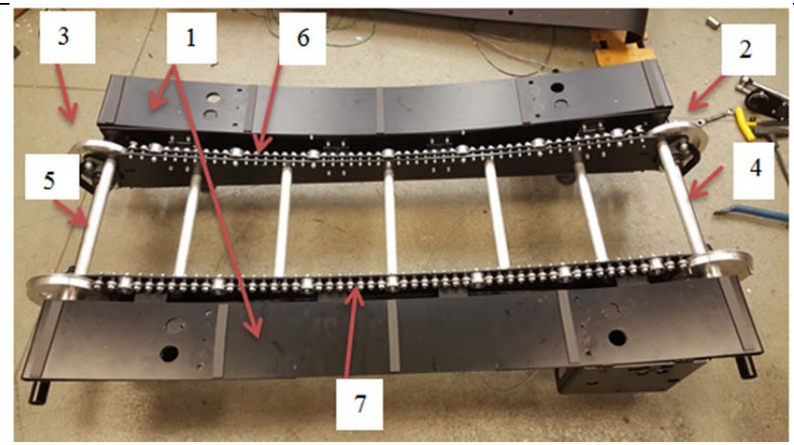
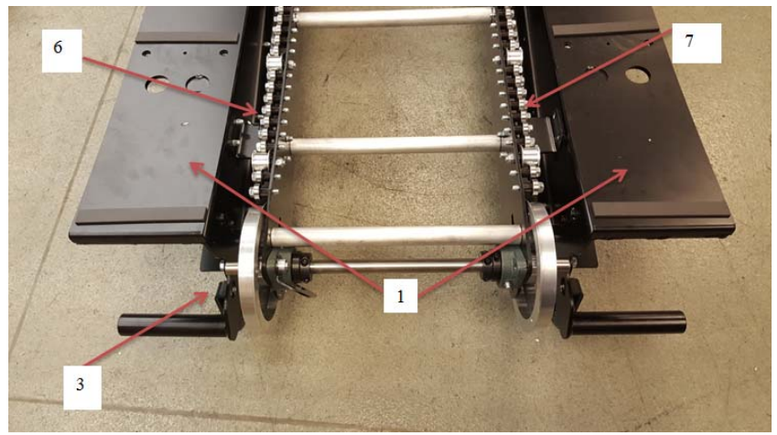
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a frame having a front end and a rear end positioned opposite the front end; | A “frame having a front end and a rear end positioned opposite the front end” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, the frame [1], which designates the entire frame assembly not a single piece of metal, has a front end [2] and a rear end [3], where the front end [2] is positioned opposite the rear end [3].<br><br>Chapco’s and Samsara’s argument that the Original TrueForm Runner Treadmill does not meet this claim limitation because it has two frames and not one frame is inconsistent with the ’580 patent’s disclosure. The specification of the ’580 patent states that “the frame may have substantially any configuration suitable for providing structure and support for the manual |  |  |

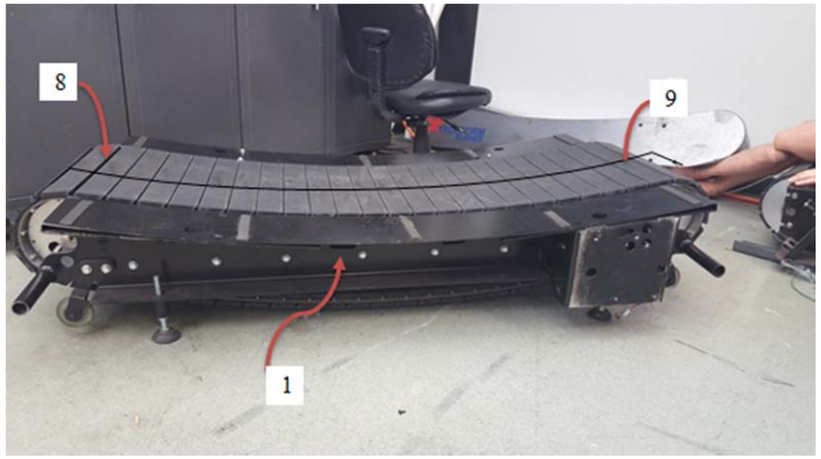
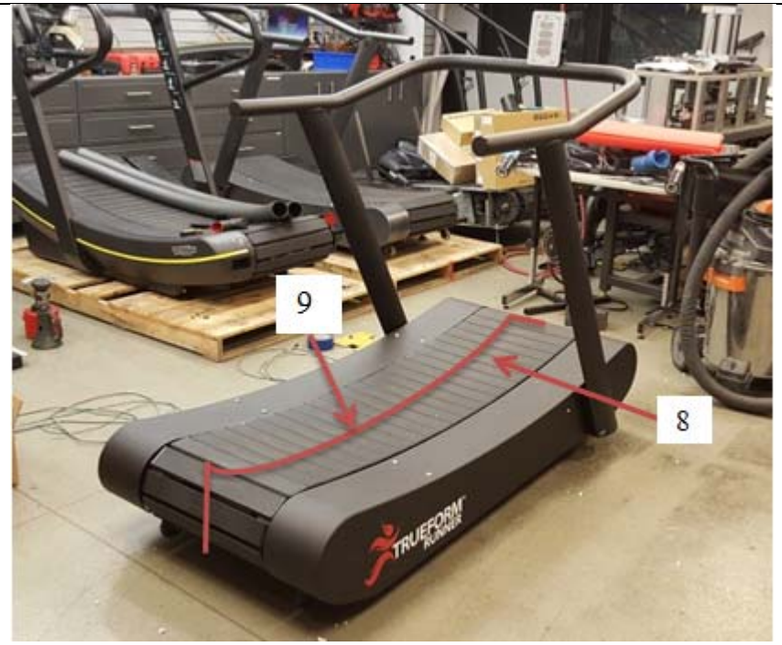
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | treadmill.” Col. 5, ll. 65-67. Nothing about the plain and ordinary meaning of “frame” requires a single unitary structure. | | |
| a front shaft rotatably coupled to the frame at the front end; | A “front shaft rotatably coupled to the frame at the front end” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, to a person of ordinary skill in the art, a front shaft [4] is rotatably coupled to the frame [1] at the front end [2]. In this regard, “the term ‘coupled’ means the joining of two members directly or indirectly to one another. … Such joining may be achieved |  |  |

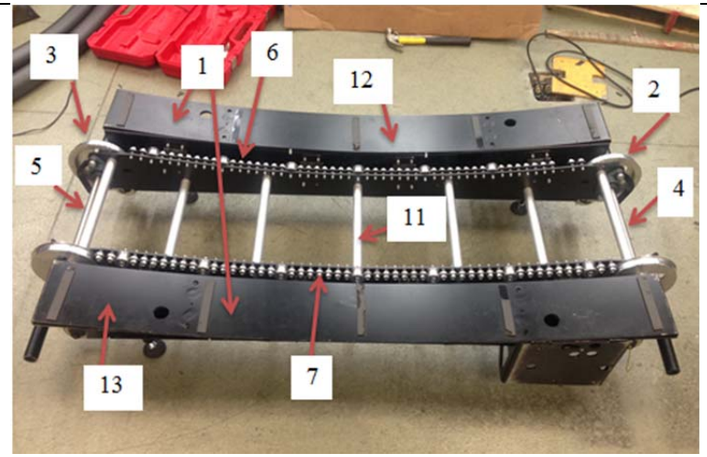
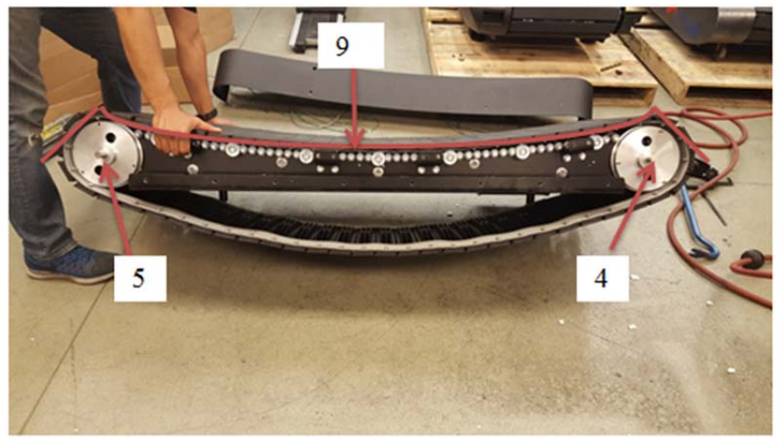
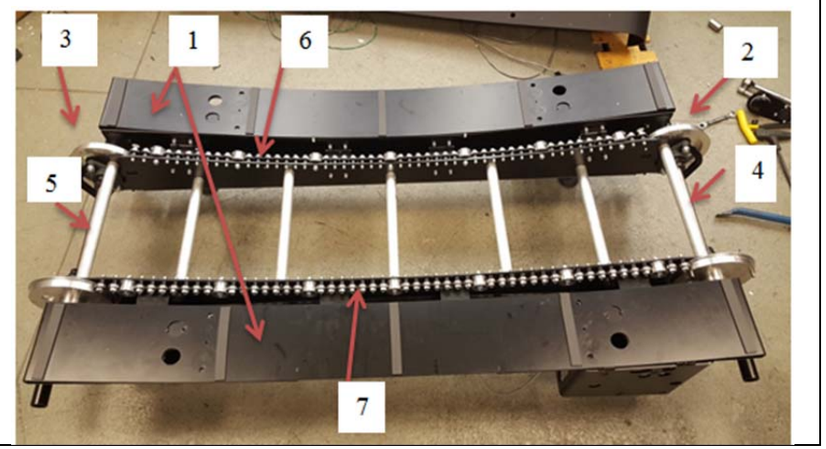
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | with the two members or the two members and any additional intermediate members.”<br><br>Thus, coupling of the front shaft [4] to the frame [1] may be directly or indirectly, such as through an intermediary component or series of components (e.g., via bearing rail [6] or [7]).<br><br>It is not required that each part be connected in such a way to permit rotation of one entire element relative to the other element. | | |
| a rear shaft rotatably coupled to the frame at the rear end; | A “rear shaft rotatably coupled to the frame at the rear end” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, to a person of ordinary skill in the art, a rear shaft [5] is rotatably coupled to the frame [1] at the rear end [3]. In this regard, “the term ‘coupled’ means the |  |  |

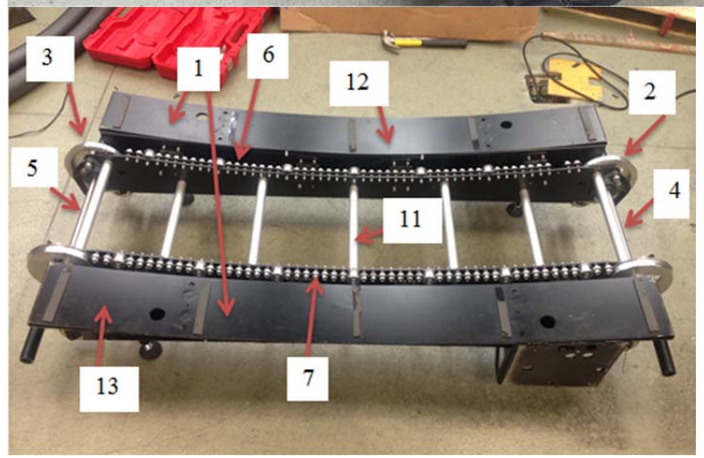
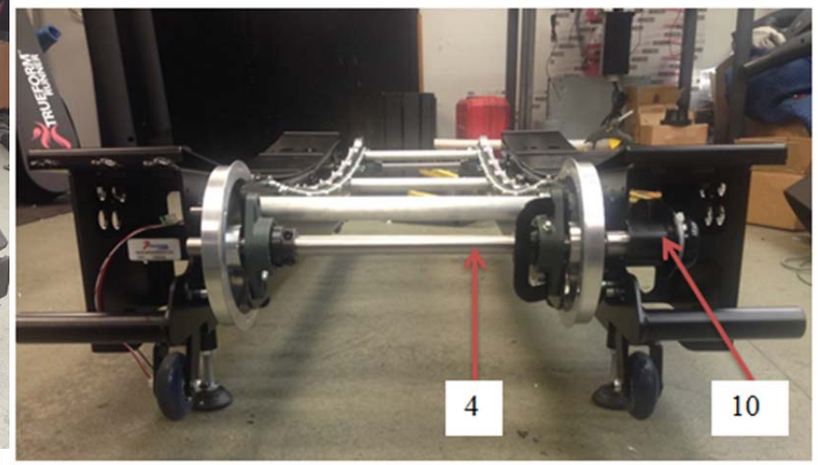
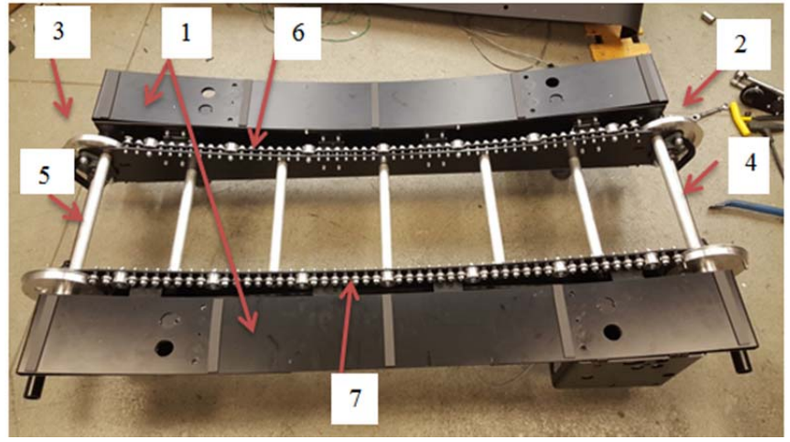
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | joining of two members directly or indirectly to one another. … Such joining may be achieved with the two members or the two members and any additional intermediate members.”<br><br>Thus, coupling of the rear shaft [5] to the frame [1] may be directly or indirectly, such as through an intermediary component or series of components (e.g., via bearing rail [6] or [7]).<br><br>It is not required that each part be connected in such a way to permit rotation of one entire element relative to the other element. | | |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame; | A “first bearing rail having a plurality of bearings” and “attached to a left side of the frame” are literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a plurality of bearings [6] are supported by a bearing rail, which is the first rail with bearings whose top profile corresponds to the shape of the running surface, and the bearing rail is attached to the left side of the frame [1]. |  |  <br>  |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame; | A “second bearing rail having a plurality of bearings” and “attached to a right side of the frame” are literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a plurality of bearings [7] are supported by a bearing rail, which is the second rail with bearings whose top profile corresponds to the shape of the running surface, and the bearing rail is attached to the right side of the frame [1]. |  |  <br>  |

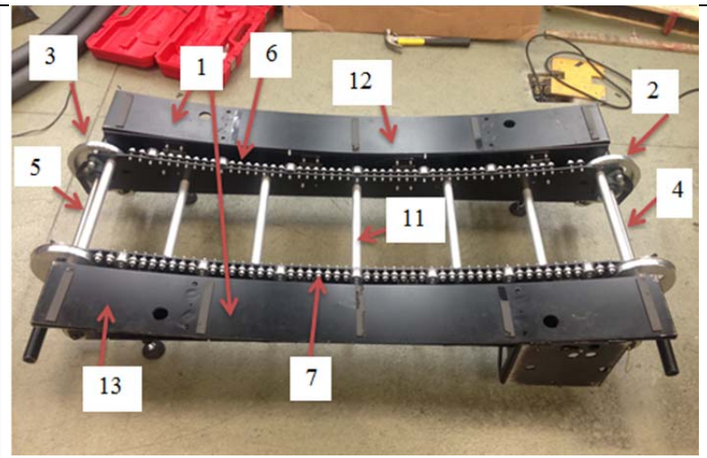
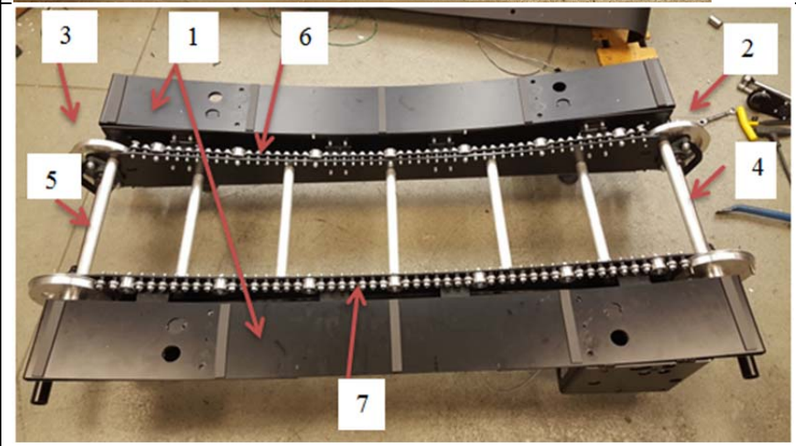
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a running belt supported by the first bearing rail and the second bearing rail and disposed about the front shaft and the rear shaft,<br><br>wherein the running belt follows a curved running surface; and | A “running belt” supported by the “first bearing rail” and the “second bearing rail” and following a “curved running surface” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, to a person of ordinary skill in the art, a running belt [8] follows a curved running surface [9]. The running belt [8] is supported by the plurality of bearings [6] and [7] which are in turn supported by the first bearing rail and the second bearing rail. The running belt [8] is supported by the first and second bearing rails. The running belt is also disposed about the front shaft [4] and the rear shaft [5].<br><br>The plain and ordinary meaning of “support” does not require that components must be |  <br> |  |

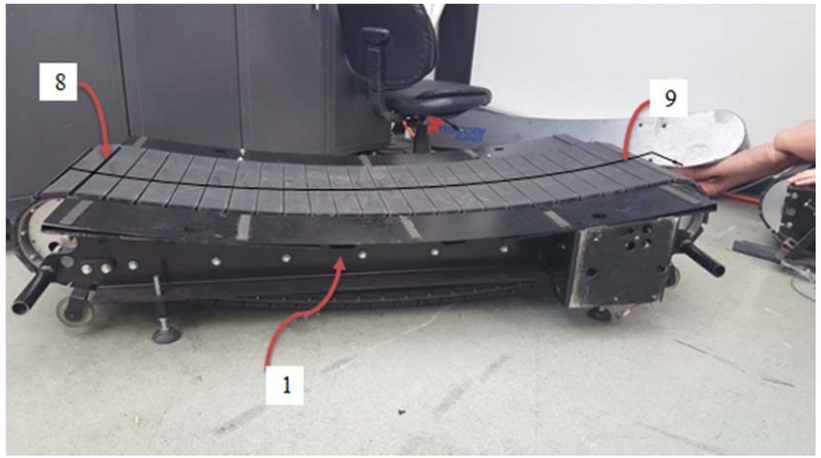
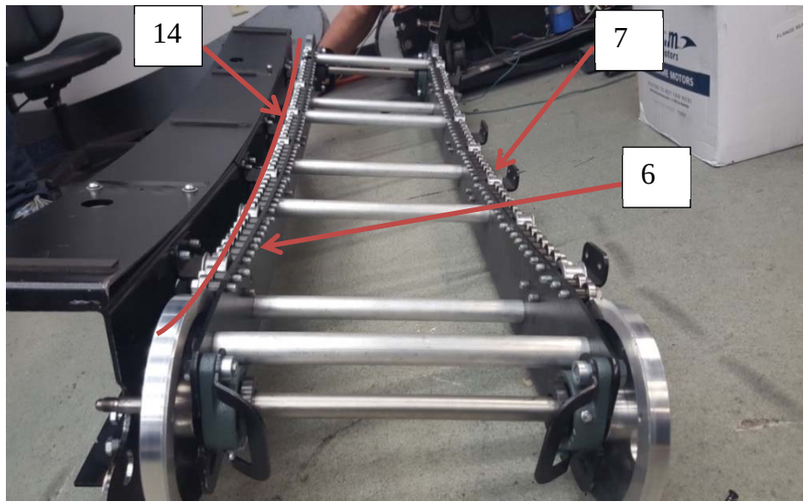
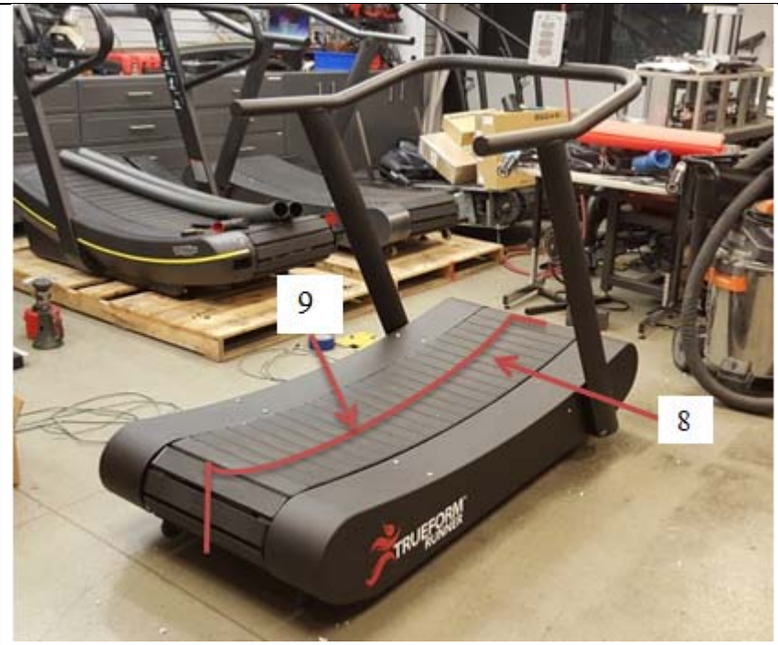
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | directly or physically connected or touching. “Support” may be provided directly, may be provided indirectly via an intermediary component or series of components, may bear some of the weight of another component or a series of components, and/or may bear all of the weight of another component or series of components. |  |  <br>  |

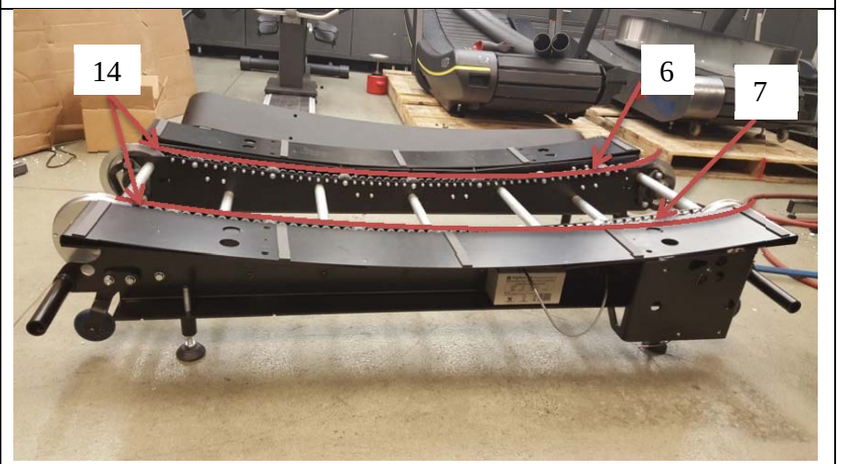
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a safety device coupled to at least one of the front shaft and the rear shaft,<br><br>wherein the safety device is structured to substantially prevent rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of the at least one of the front shaft and the rear shaft in a second rotational direction opposite the first rotational direction. | A “safety device coupled to at least one of the front shaft and the rear shaft” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown in the Original Design, the safety device [10] is coupled to the rear shaft [5], to which Chapco and Samsara agree. As shown in the Redesign, the safety device [10] is coupled to the front shaft [4], to which Chapco and Samsara also agree.<br><br>As also shown, the safety device [10] of the Original Design is a Koyo brand with a model number of RCB-121616 while the safety device [10] of the Redesign is a Koyo brand with a model number of RCB-162117.<br><br>Each of these model numbers corresponds with a “regular clutch and bearing assembly” that “transmits torque between | <br>  |  <br>  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | [the] shaft and housing in one direction and allows free overrun in the opposite direction” as described in the Koyo catalog.<br><br>In regard to the Original Design, because the safety device [10] is coupled to the rear shaft [5] and because the safety device [10] “allows free overrun,” in one rotational direction, the safety device [10] is “structured to substantially prevent rotation of … the rear shaft in a first rotational direction while permitting rotation of the … rear shaft in a second rotational direction opposite the first rotational direction.”<br><br>In regard to the Redesign, because the safety device [10] is coupled to the front shaft [4] and because the safety device [10] “allows free overrun,” in one rotational direction, the safety device [10] is “structured to substantially | | |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | prevent rotation of … the front shaft … in a first rotational direction while permitting rotation of … the front shaft … in a second rotational direction opposite the first rotational direction.” | | |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| | | | |
| 4. The manually powered treadmill of claim 1,<br><br>wherein each one of the first and second bearing rails are attached longitudinally to the frame between the front shaft and the rear shaft. | “Each one of the first and second bearing rails” being “attached longitudinally to the frame between the front shaft and rear shaft” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, the bearing rails are longitudinally attached to the frame [1] between the front shaft [4] and the rear shaft [5]. |  |  |

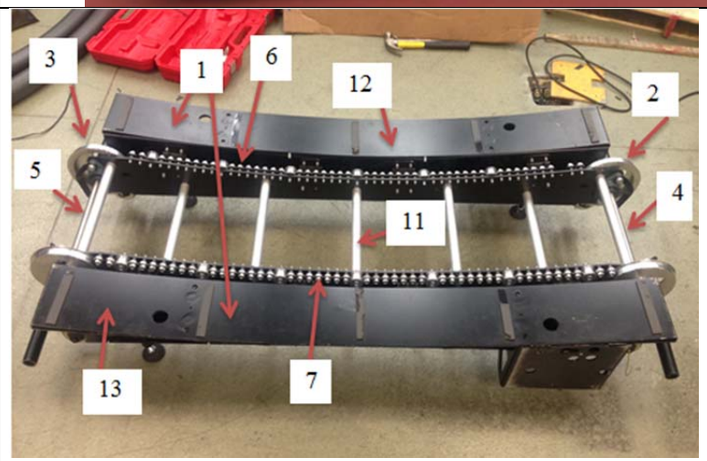
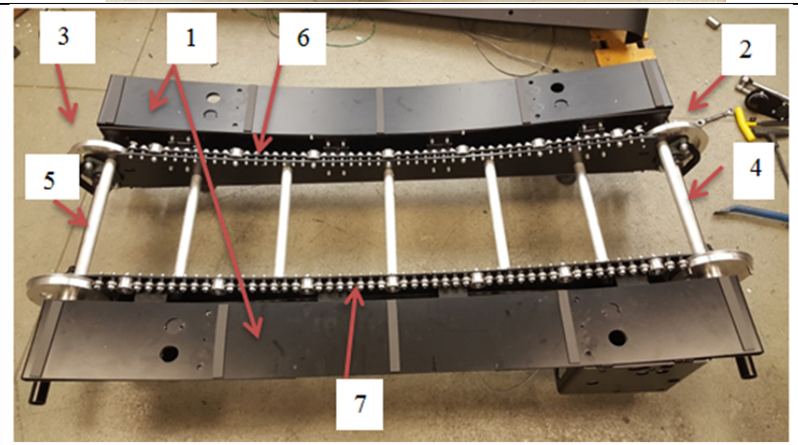
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| 5. The manually powered treadmill of claim 1,<br><br>wherein each one of the first bearing rail and the second bearing rail define in part a top profile corresponding to the curved running surface. | “Each one of the first bearing rail and the second bearing rail” that “define in part a top profile corresponding to the curved running surface” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>The top profile edge of the bearing rails is curved. The plurality of bearings [6] and [7], which in part support the running belt [8], are mounted to the bearing rails to follow this top profile to create the curved running surface. As seen in the photographs, the top surface of the bearing rails corresponds to the curved running surface. |  <br>  |  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | | |  |

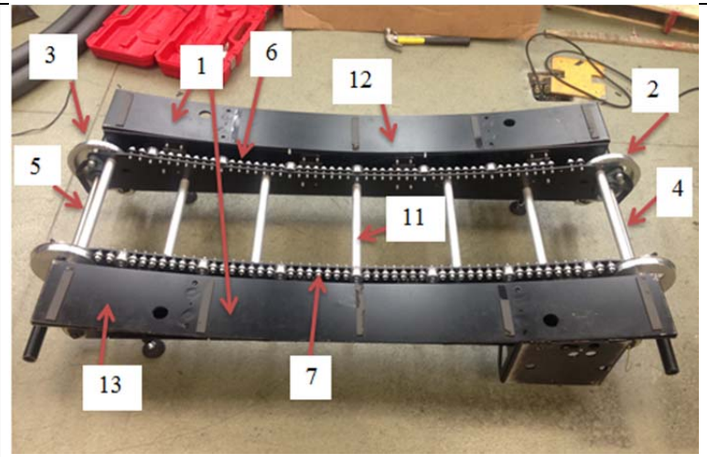
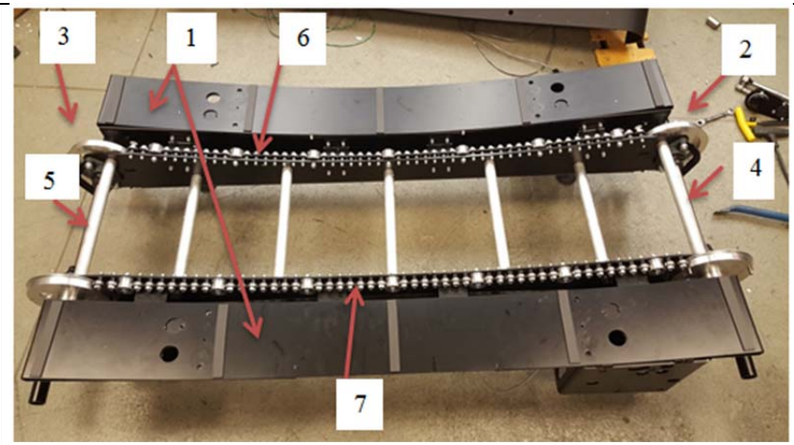
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| 6. The manually powered treadmill of claim 1,<br><br>wherein the safety device includes a one-way bearing. | The “safety device” includes “a one-way bearing” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samara agree.<br><br>As shown, the safety device [10] of the Original Design is a Koyo brand with a model number of RCB-121616 while the safety device of the Redesign is Koyo brand with a model number of RCB-162117. Each model number corresponds with a “regular clutch and ***bearing*** assembly” that “transmits torque between [the] shaft and housing in one direction and allows free overrun in the opposite direction,” as described in the Koyo catalog. | | |

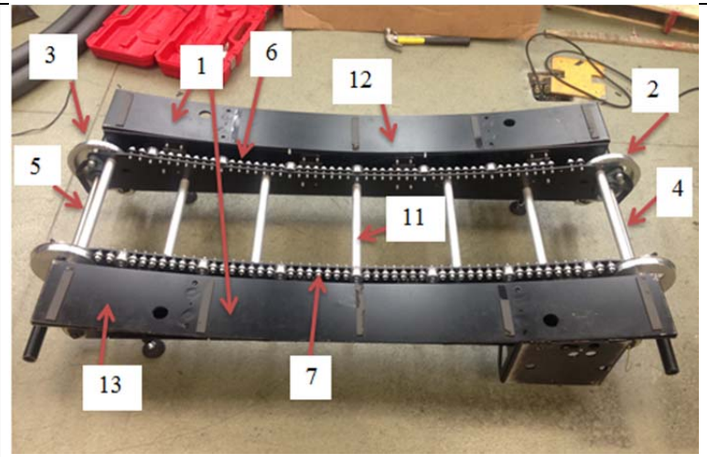
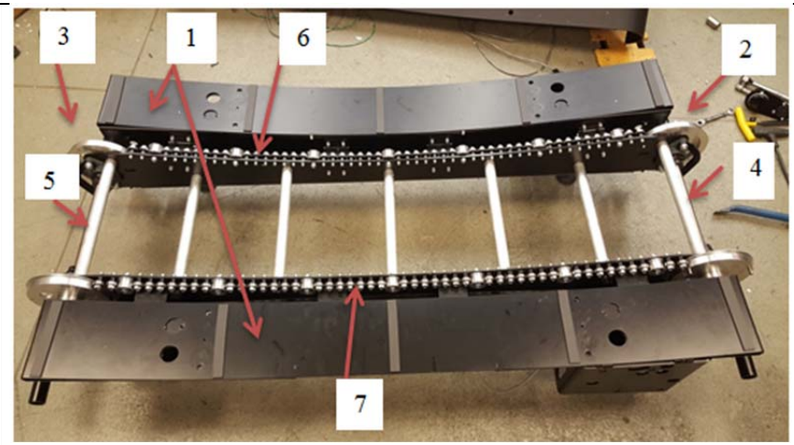
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | | | |

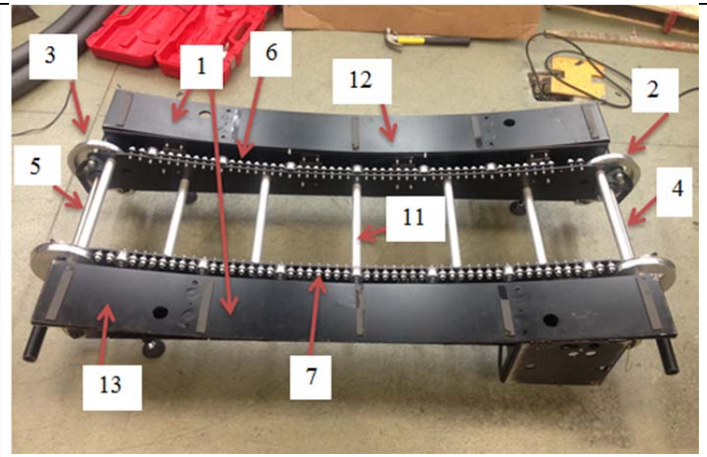
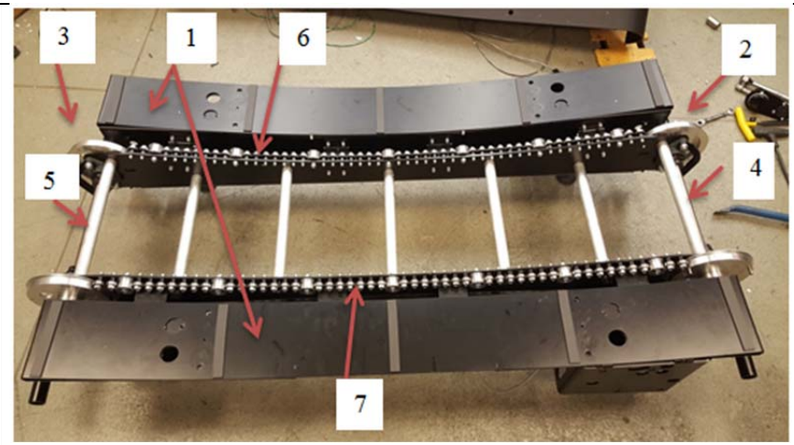
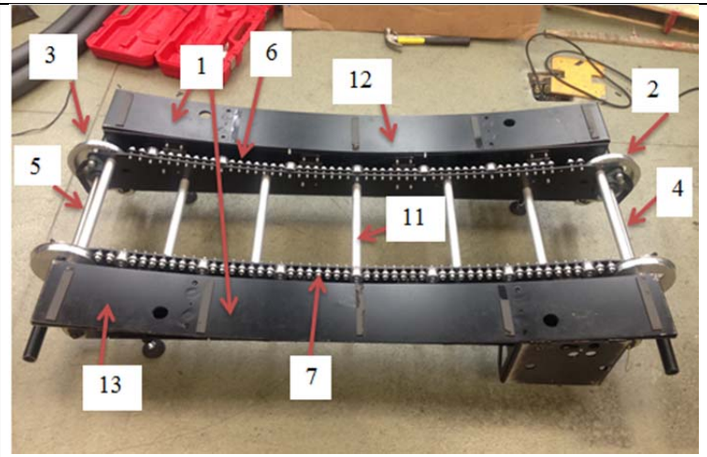
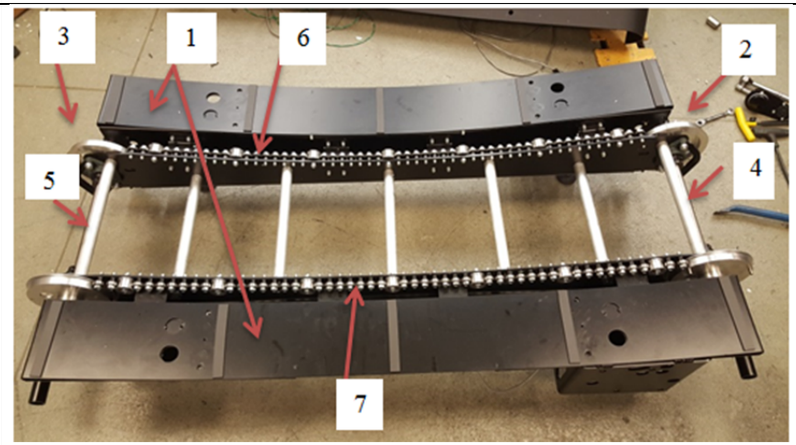
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| | | | |
| 10. The manually powered treadmill of claim 1,<br><br>further comprising a handrail attached to the frame and structured to provide a support structure for the user of the manually powered treadmill. | A “handrail attached to the frame” which is “structured to provide a support structure for the user of the manually powered treadmill” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, the manually powered treadmill includes a handrail [15] that is structured to provide a support structure to a user of the manually powered treadmill. | | |

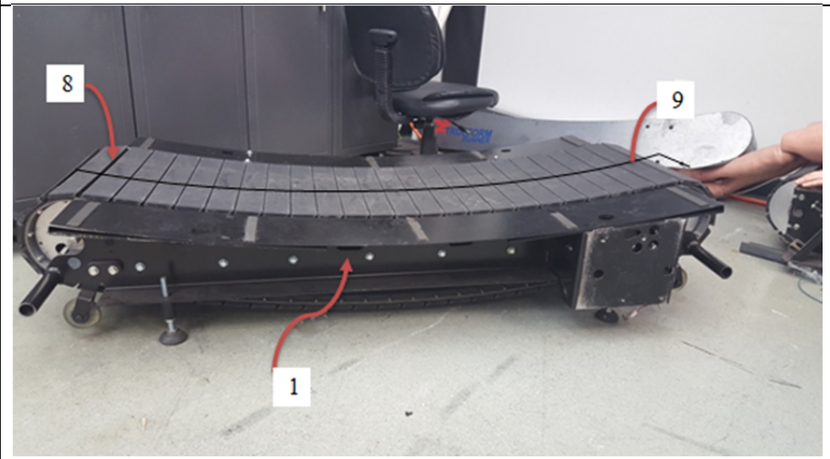
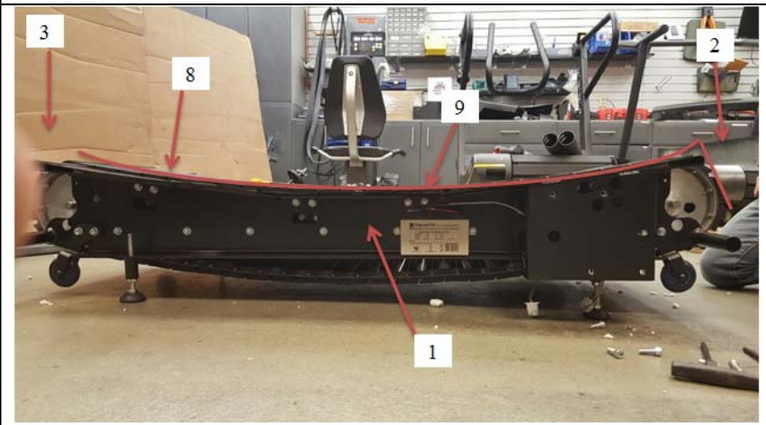
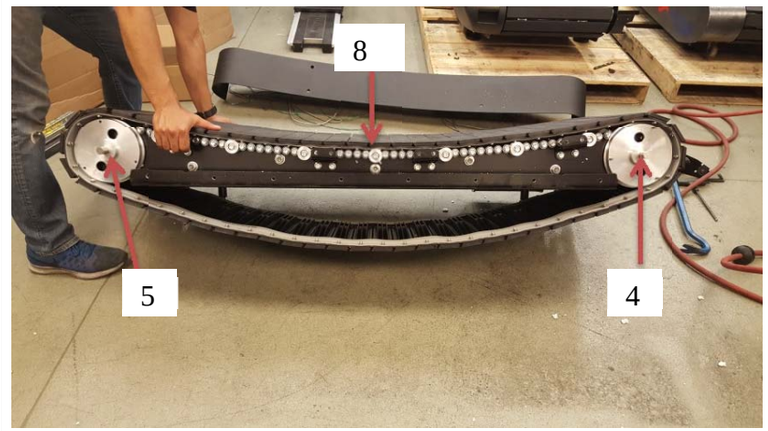
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| 11. A manually powered treadmill, comprising: | A “manually powered treadmill” is literally each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As described in the product literature attached as Exhibit G and as Chapco and Samsara have admitted, the Original and Redesigned TrueForm Runner Treadmills are human powered and non-motorized. | | |
| a frame having a front end and a rear end positioned opposite the front end; | A “frame having a front end and a rear end positioned opposite the front end” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, the frame [1], which designates the entire frame assembly not a single piece of metal, has a front end [2] and a rear end [3], where the front end [2] is positioned |  |  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | opposite the rear end [3].<br><br>Chapco’s and Samsara’s argument that the Original TrueForm Runner Treadmill does not meet this claim limitation because it has two frames and not one frame is inconsistent with the ’580 patent’s disclosure. The specification of the ’580 patent states that “the frame may have substantially any configuration suitable for providing structure and support for the manual treadmill.” Col. 5, ll. 65-67. Nothing about the plain and ordinary meaning of “frame” requires a single unitary structure. | | |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a front shaft attached to the frame adjacent the front end; | A “front shaft attached to the frame adjacent the front end” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a front shaft [4] is attached to the frame [1] at the front end [2]. In this regard, “the term ‘coupled’ means the joining of two members directly or indirectly to one another. … Such joining may be achieved with the two members or the two members and any additional intermediate members.” *See* the ’580 patent at col. 32, ll. 10-14. The term “coupling” is analogous to the term “attached.”<br><br>Therefore, attachment of the front shaft [4] to the frame [1] may be directly or indirectly, such as through an intermediary member (e.g., via bearing rail). |  |  |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a rear shaft attached to the frame adjacent the rear end; | A “rear shaft attached to the frame adjacent the rear end” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a rear shaft [5] is attached to the frame [1] adjacent the rear end [3]. In this regard, “the term ‘coupled’ means the joining of two members directly or indirectly to one another. … Such joining may be achieved with the two members or the two members and any additional intermediate members.” *See* the ’580 patent at col. 32, ll. 10-14. The term “coupling” is analogous to the term “attached.”<br><br>Therefore, attachment of the front shaft [5] to the frame [1] may be directly or indirectly, such as through an intermediary member (e.g., via bearing rail). |  |  |
| a first bearing rail | A “first bearing rail having | | |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| having a plurality of bearings, the first bearing rail attached to a left side of the frame; | a plurality of bearings” and “attached to a left side of the frame” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a plurality of bearings [6] are supported by a bearing rail, which is the first rail with bearings whose top profile corresponds to the shape of the running surface, and the bearing rail is attached to the left side of the frame [1]. |  |  |
| a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame; | A “second bearing rail having a plurality of bearings” and “attached to a right side of the frame” are literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a plurality of bearings [7] are supported by a bearing rail, which is the second rail with bearings whose top profile corresponds to the shape |  |  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | of the running surface, and the bearing rail is attached to the right side of the frame [1]. | | |
| a running belt at least partially disposed about the front shaft and the rear shaft and at least partially supported by the first bearing rail and the second bearing rail, | A “running belt” that is “at least partially disposed about the front shaft and the rear shaft and at least partially supported by the first bearing and the second bearing rail” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a running belt [8] is supported by the first bearing rail and the second bearing rail and disposed about the front shaft [4] and the rear shaft [5]. |  |  <br>  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
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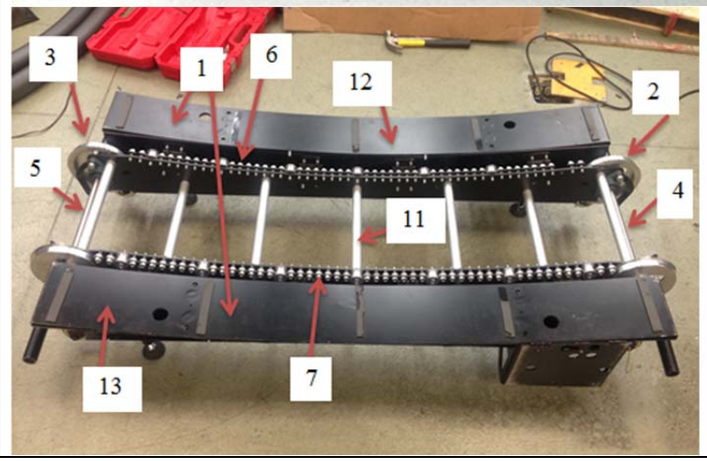
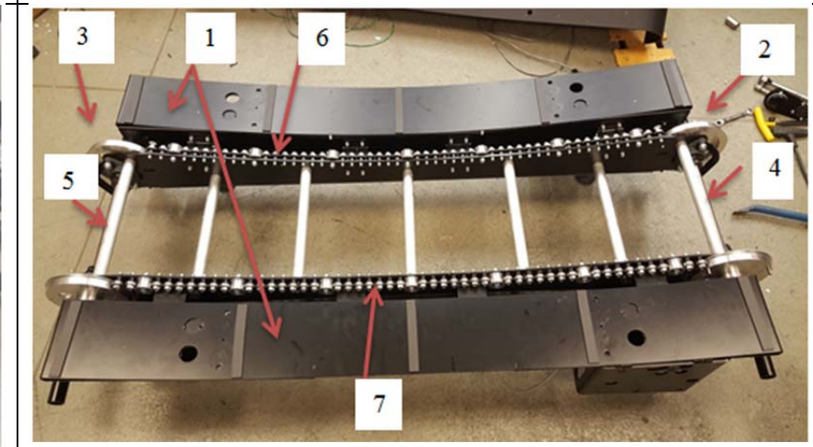
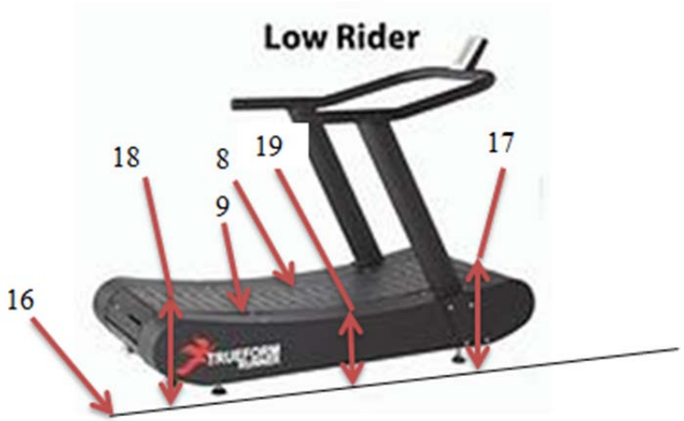
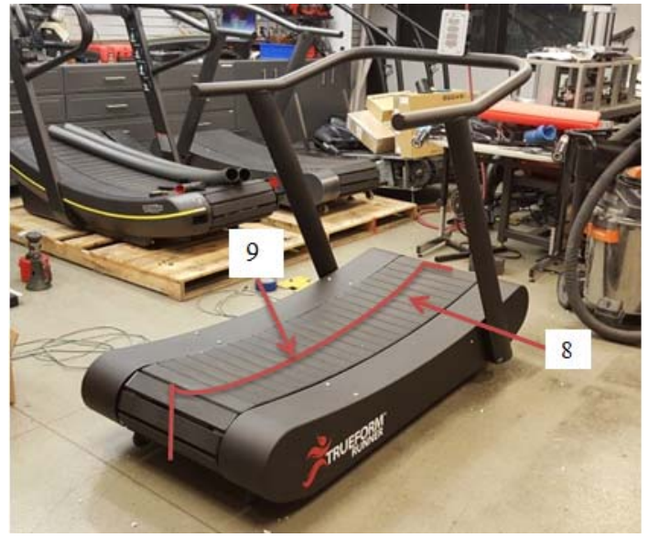
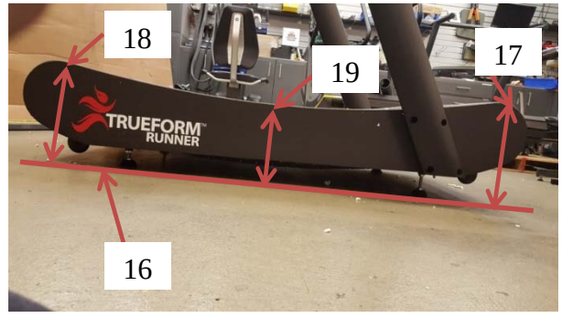
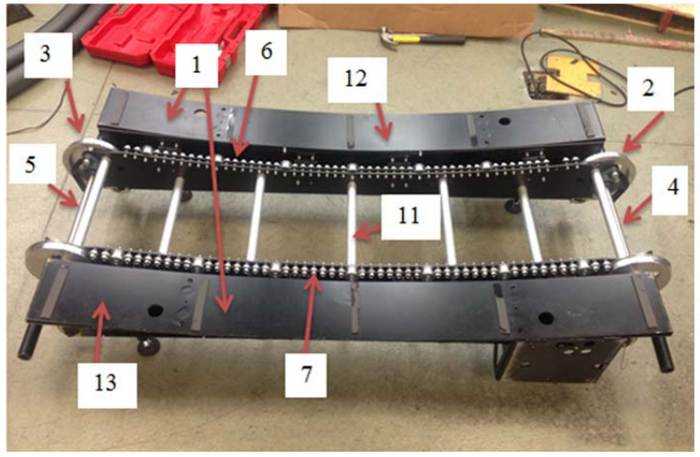
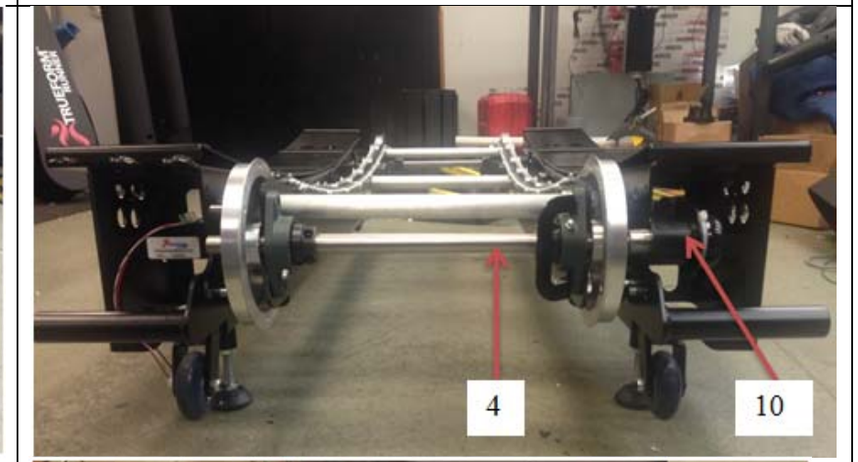
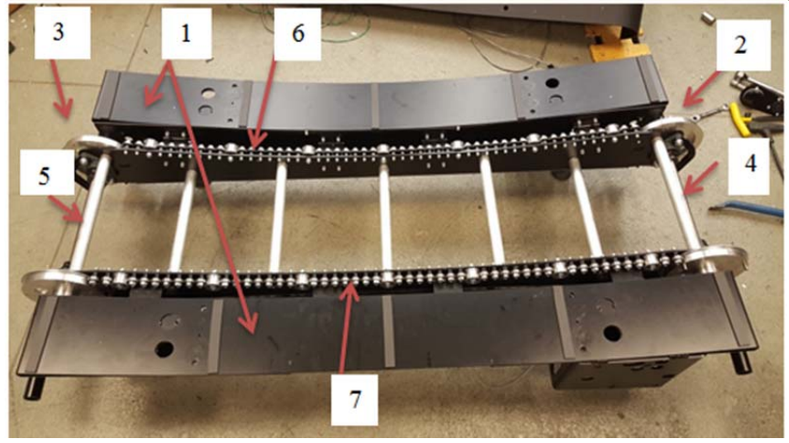
| | | <br>  |  |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| wherein the running belt includes a front belt portion proximate the front end,<br><br>a rear belt portion proximate the rear end, and<br><br>a central belt portion intermediate the front and rear belt portions,<br><br>wherein the central belt portion is positioned vertically closer to a ground surface supporting the frame than the front and rear belt portions such that the running belt follows a curved running surface; | The “running belt” having “front belt portion,” a “rear belt portion,” and “a central belt portion” that is “positioned vertically closer to a ground surface … than the front and rear belt portions such that the running belt follows a curved running surface” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, the running belt [8] includes a front belt portion [17] proximate the front end, a rear belt portion [18] proximate the rear end, and a central belt portion [19] intermediate the front belt portion [17] and the rear belt portion [18].<br><br>As also shown, a horizontal plane line [16] has been inserted on the picture of each of the Original and Redesigned TrueForm Runner Treadmills. While the horizontal plane line [16] |  |  <br>  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | is shown as angled, this is due to the orientation of the treadmills. In this regard, the horizontal plane line [16] represents a ground surface that supports the treadmill.<br><br>Relative to the horizontal plane line [16], the central portion [19] is vertically lower (i.e., closer to the horizontal plane line [16]) than each of the front belt portion [17] and the rear belt portion [18].<br>Due to the front belt portion [17] and rear belt portion [18] being vertically higher than the central belt portion [19], a curved running surface [9] is formed. | | |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| and a safety device for substantially preventing rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of the at least one of the front shaft and the rear shaft in a second rotational direction opposite the first rotational direction. | A “safety device for substantially preventing rotation of at least one of the front shaft and the rear shaft in a first rotational direction while permitting rotation of at least one of the front shaft and the rear shaft in a second rotational direction” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown in the Original Design, the safety device [10] is coupled to the rear shaft [5]; Chapco and Samsara agree. As shown in the Redesign, the safety device [10] is coupled to the front shaft [4]; Chapco and Samara agree.<br><br>As also shown, the safety device [10] of the Original Design is a Koyo brand with a model number of RCB-121616 while the safety device [10] of the Redesign is a Koyo brand with a model number of RCB-162117. | <br>  |  <br>  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | Each of these model numbers corresponds with a “regular clutch and bearing assembly” that “transmits torque between [the] shaft and housing in one direction and allows free overrun in the opposite direction,” as described in the Koyo catalog.<br><br>In regard to the Original Design, because the safety device [10] is coupled to the rear shaft [5] and because the safety device [10] “allows free overrun,” in one rotational direction, the safety device [10] “substantially prevent[s] rotation of … the rear shaft in a first rotational direction while permitting rotation of … the rear shaft in a second rotational direction opposite the first rotational direction.”<br><br>In regard to the Redesign, because the safety device [10] is coupled to the front shaft [4] and because the | | |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | safety device [10] “allows free overrun,” in one rotational direction, the safety device [10] “substantially prevent[s] rotation of … the front shaft in a first rotational direction while permitting rotation of … the front shaft in a second rotational direction opposite the first rotational direction.” | | |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
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| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| 12. The manually powered treadmill of claim 11,<br><br>wherein the safety device includes a one-way bearing. | The “safety device” including “a one-way bearing” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, the safety device [10] of the Original Design is a Koyo brand with a model number of RCB-121616 while the safety device of the Redesign is Koyo brand with a model number of RCB-162117. Each model number corresponds with a “regular clutch and ***bearing*** assembly” that “transmits torque between [the] shaft and housing in one direction and allows free overrun in the opposite direction,” as described in the Koyo catalog. | | |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
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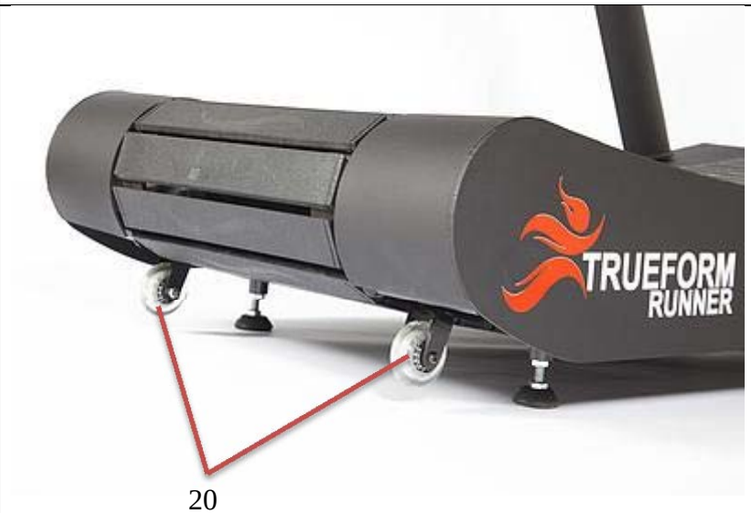
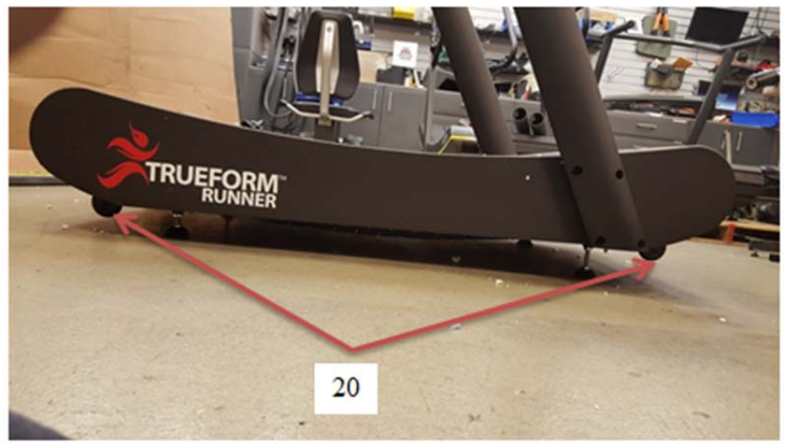
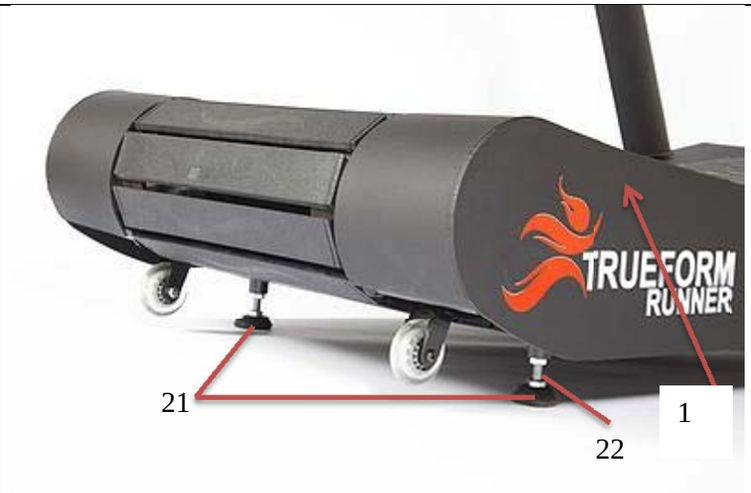
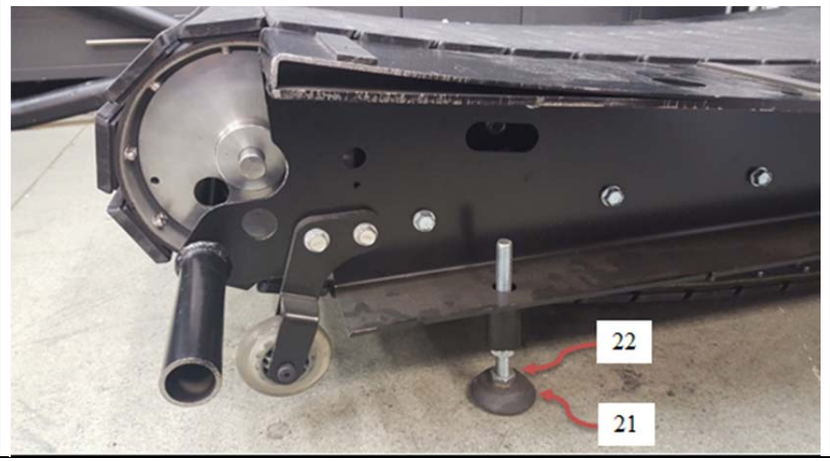
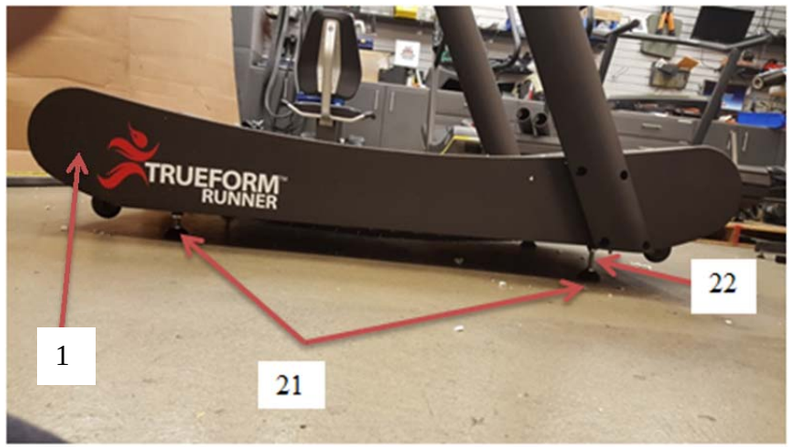
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| | | | |
| 13. The manually powered treadmill of claim 11,<br><br>further comprising a pair of wheels mounted to the frame,<br><br>wherein the pair of wheels are mounted so that the pair of wheels are not in contact with the ground surface when the manually powered treadmill is in an operating | A “pair of wheels mounted to the frame” that “are not in contact with the ground surface when the manually powered treadmill is in an operating position” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, a pair of wheels [20] are not in contact with a ground surface when each of the Original Design and Redesign is in an operating position whereby a user may walk or run on the treadmill (i.e., the operating |  |  |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| position. | position). | | |
| 14. The manually powered treadmill of claim 11,<br><br>further comprising support feet coupled to the frame,<br><br>wherein the support feet are vertically adjustable to adjust an incline of the manually powered treadmill relative to the ground surface. | “Support feet coupled to the frame” that are “vertically adjustable relative to the ground surface” are literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, support feet [21] are coupled to the frame [1] using a threaded rod [22]. The threaded nature of the rod [22] allows the rod [22] to be rotatably movable towards the frame [1] and away from the frame [1] to adjust the incline of the treadmill to a ground surface. |  <br>  |  |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
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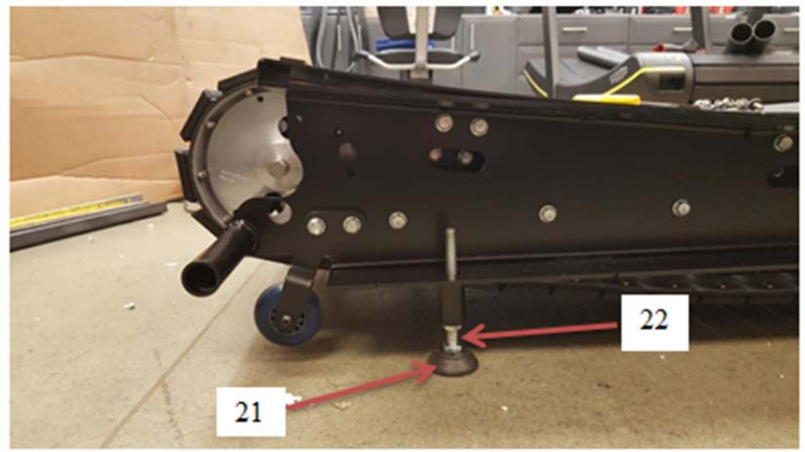
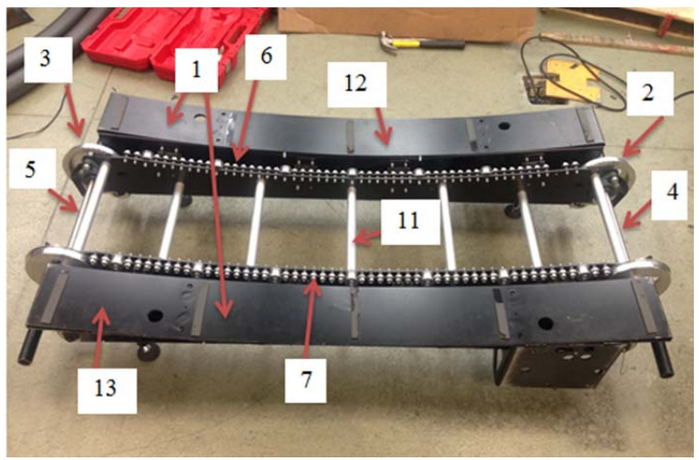
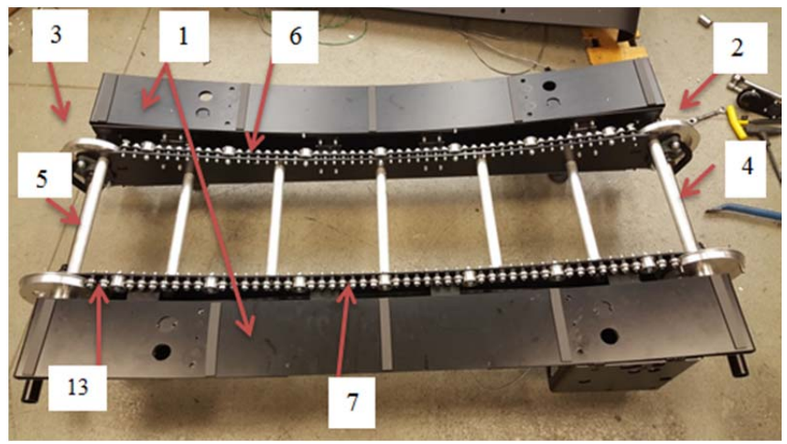
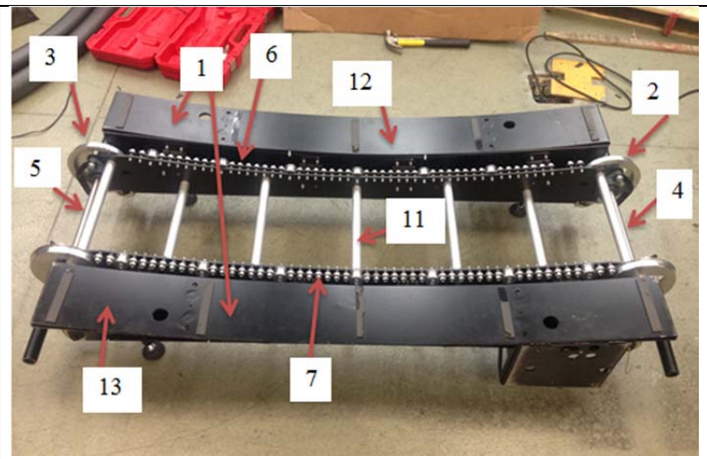
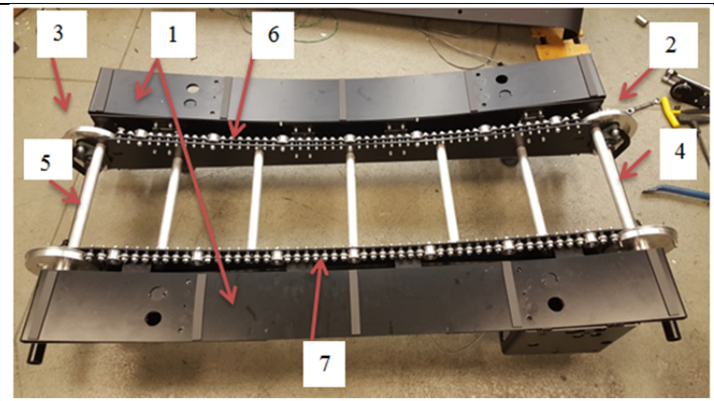
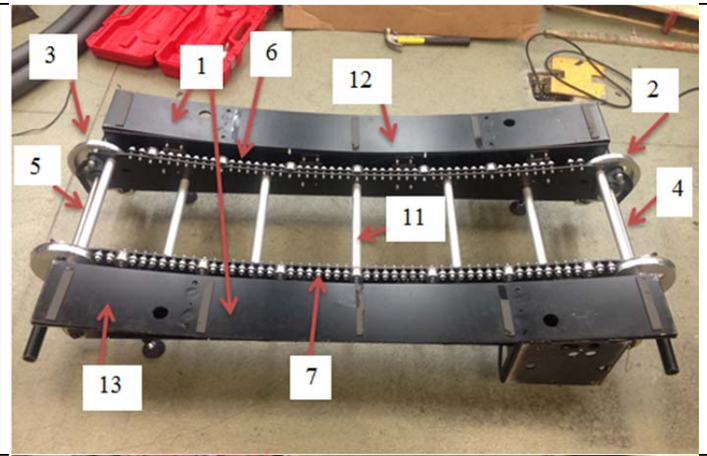
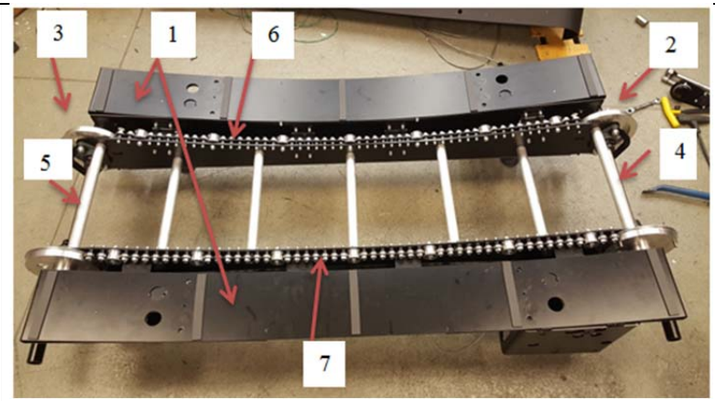
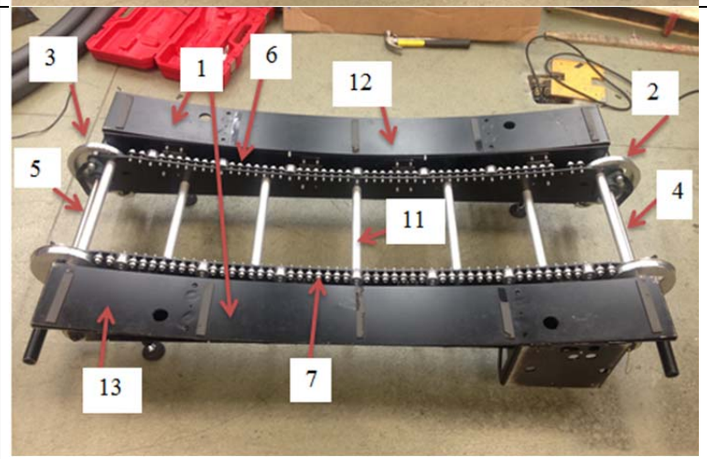
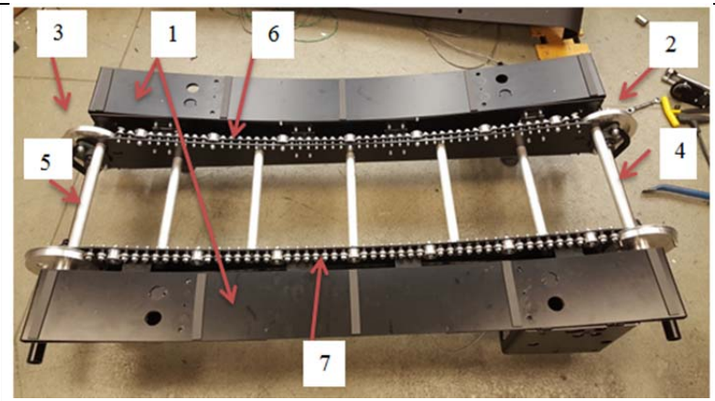
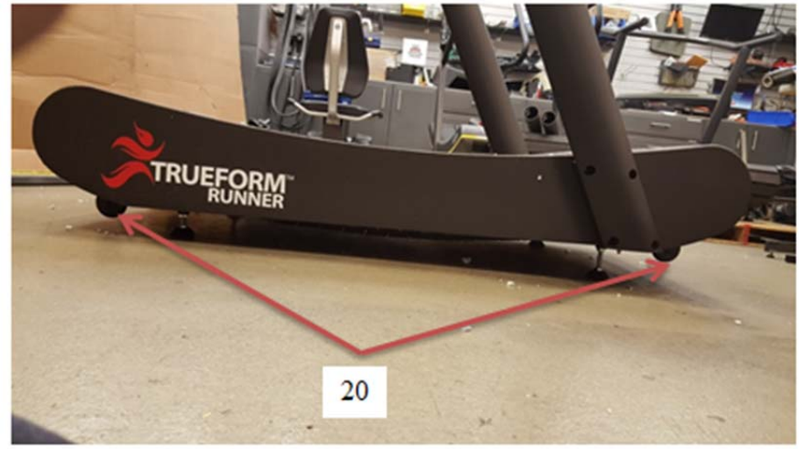
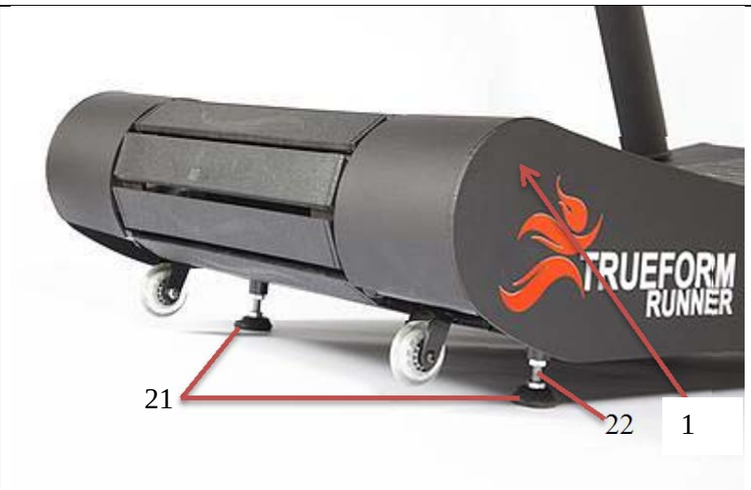
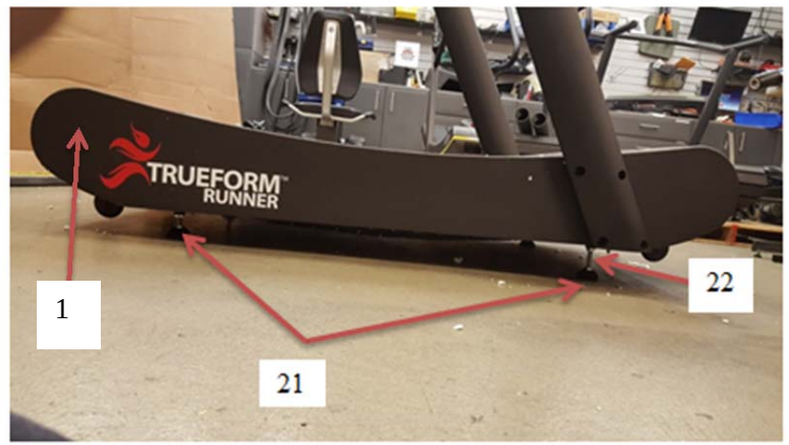
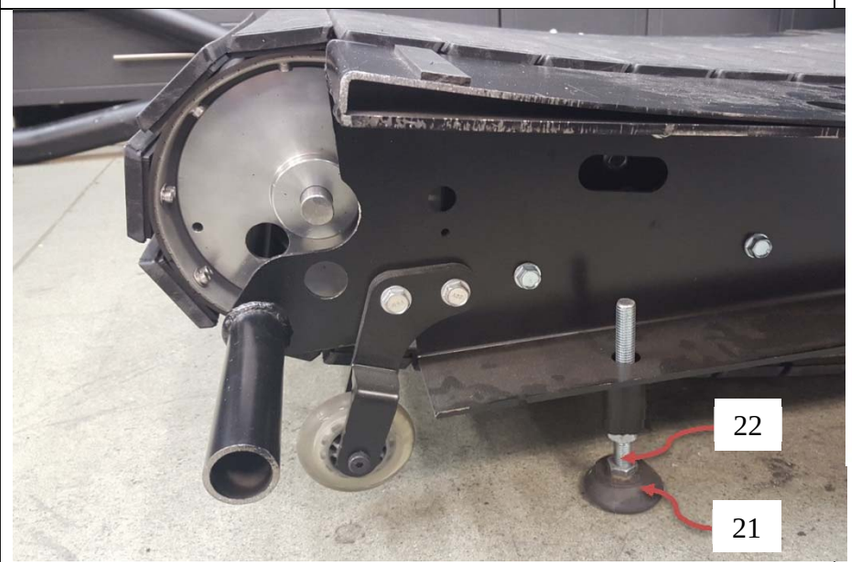
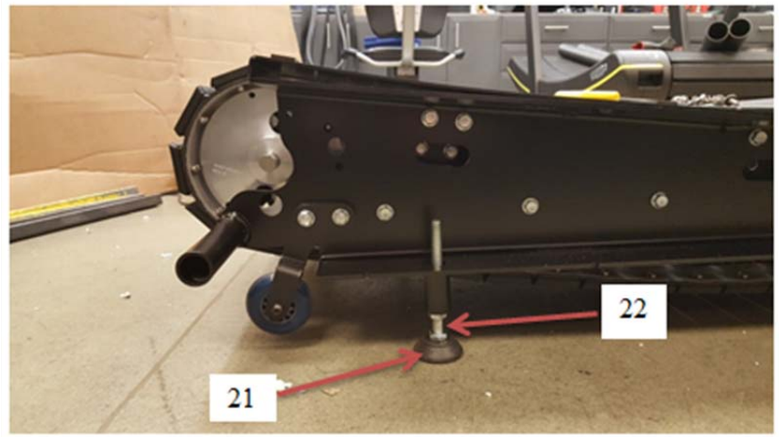
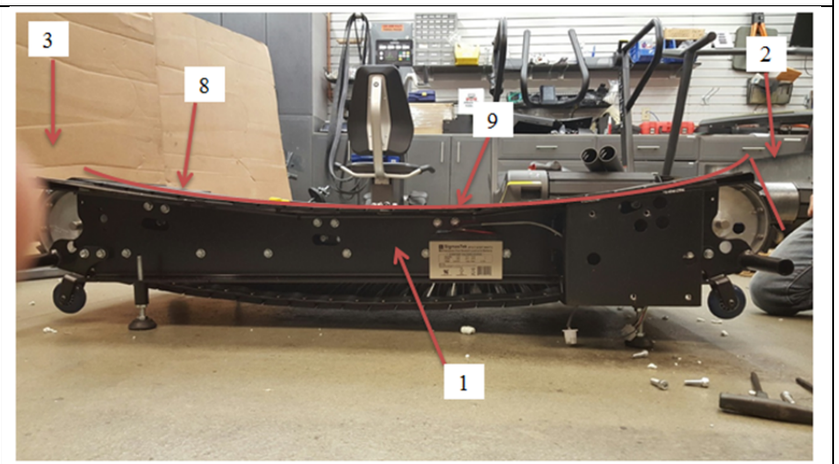
| | | |  |
| 18. The manually powered treadmill of claim 11,<br><br>wherein each of the first and second bearing rails are attached longitudinally to the frame between the front shaft and the rear shaft. | “Each one of the first and second bearing rails” being “attached longitudinally to the frame between the front shaft and rear shaft” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, the first bearing rail and the second bearing rail are longitudinally attached to the frame [1] between the front shaft [4] and the rear shaft [5]. |  |  |
| 19. A manually | A “manually powered | | |

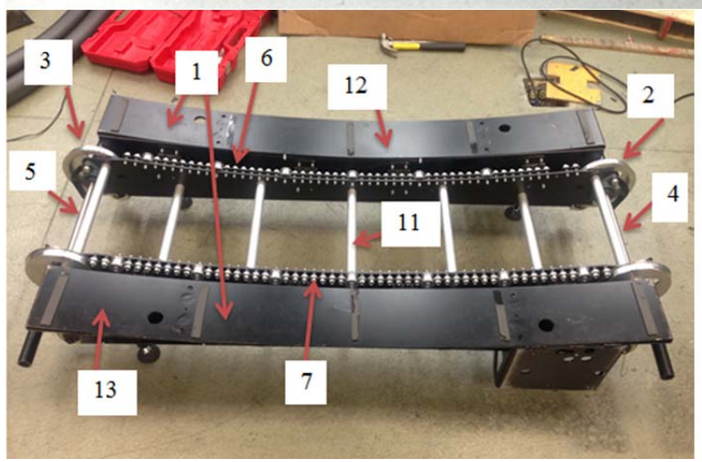
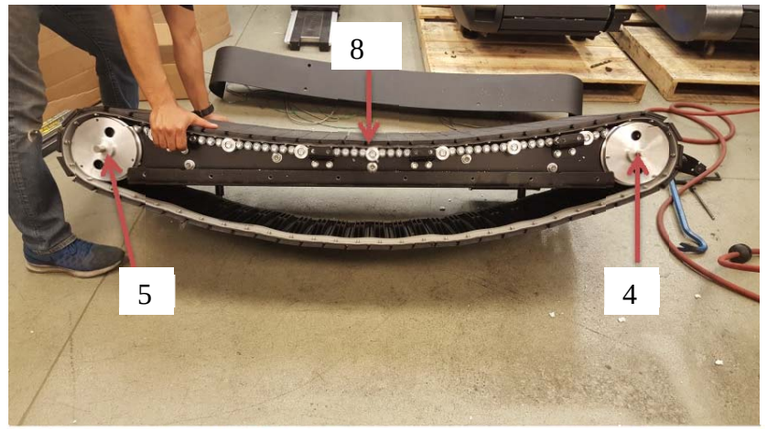
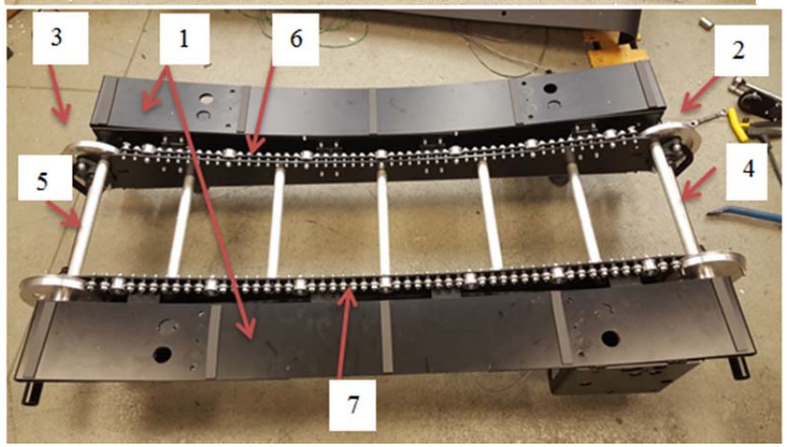
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| powered treadmill, comprising: | treadmill” is literally each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As described in the product literature attached as Exhibit G and as Chapco and Samsara have admitted, the Original and Redesigned TrueForm Runner Treadmills are human powered and non-motorized. | | |
| a frame having a front end and a rear end; | A “frame having a front end and a rear end” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, the frame [1] has a front end [2] and a rear end [3]. |  |  |

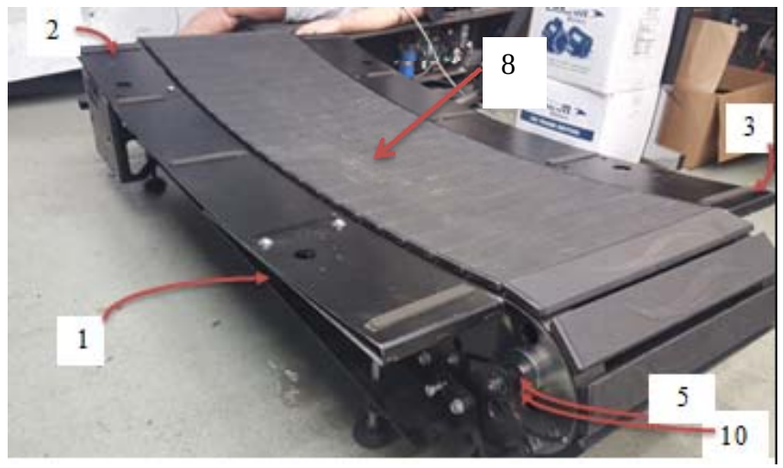
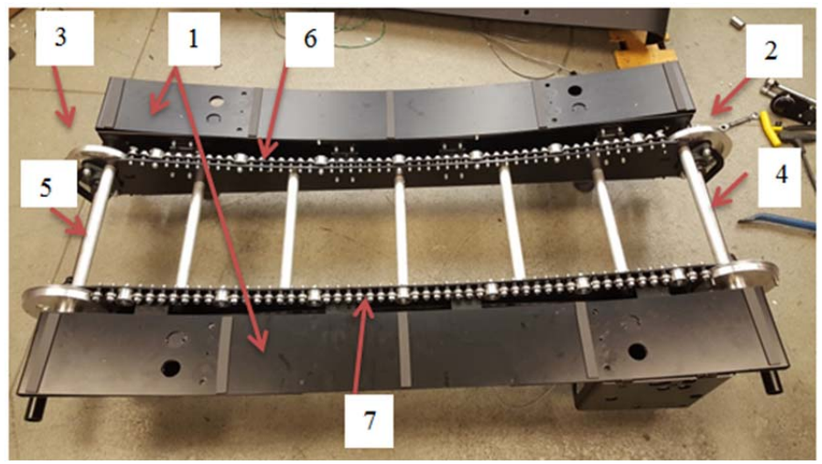
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a first bearing rail having a plurality of bearings, the first bearing rail attached to a left side of the frame; | A “first bearing rail having a plurality of bearings” and “attached to a left side of the frame” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a first bearing rail supporting a plurality of bearings [6] is attached to one side of the frame [1] (i.e., the left side). |  |  |
| a second bearing rail having a plurality of bearings, the second bearing rail attached to a right side of the frame; | A “second bearing rail having a plurality of bearings” and “attached to a right side of the frame” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a second bearing rail supporting a plurality of bearings [7] is attached to the other side of the frame [1] (i.e., the right side). |  |  |

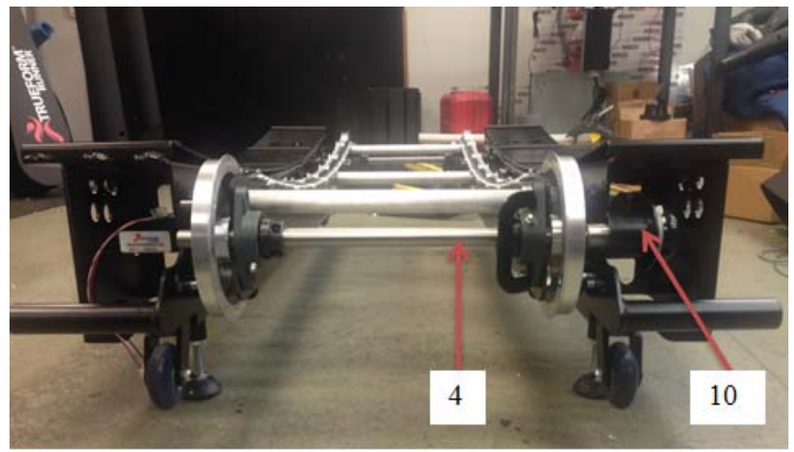
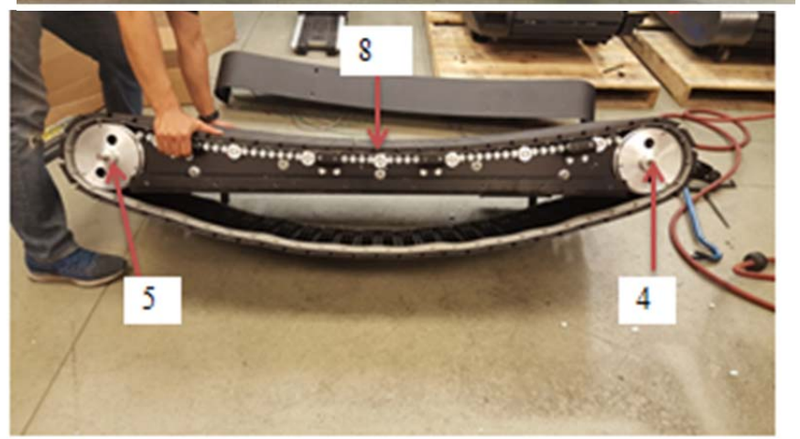
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| a handrail attached to the frame and structured to provide a support structure for a user of the manually powered treadmill; | A “handrail attached to the frame” and “structured to provide a support structure for a user of the manually powered treadmill” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, the manually powered treadmill includes a handrail [15] structured to provide a support structure for a user. | | |
| a pair of wheels mounted to the frame,<br><br>wherein the pair of wheels are mounted so that the pair of wheels are not in contact with a ground surface when the manually powered treadmill is in an operating position; | A “pair of wheels mounted to the frame” that “are not in contact with the ground surface when the manually powered treadmill is in an operating position” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, a pair of wheels [20] are not in contact with a ground surface when | |  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | each of the Original and Redesigned TrueForm Runner Treadmills are in an operating position whereby a user may walk or run on the treadmill (i.e., the operating position). | | |
| at least two support feet coupled to the frame,<br><br>wherein the support feet are vertically adjustable to adjust an incline of the manually powered treadmill relative to the ground surface; | “Support feet coupled to the frame” that are “vertically adjustable relative to the ground surface” are literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, support feet [21] are coupled to the frame [1] using a threaded rod [22]. The threaded nature of the rod [22] allows the rod [22] to be rotatably movable towards the frame [1] and away from the frame [1] to adjust the incline of the treadmill relative to a ground surface. |  |  |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| | |  |  |
| a running belt supported by the first and second bearing rails,<br><br>wherein the running belt follows a curved running surface; | A “running belt” supported by the “first bearing rail” and the “second bearing rail” and following a “curved running surface” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a running belt [8] follows a curved running surface [9]. As also shown, the running | |  |

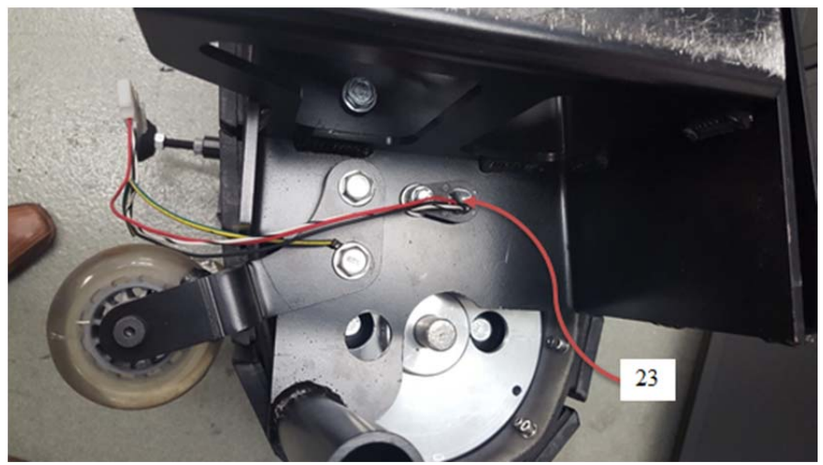
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | belt [8] is supported by the plurality of bearings [6] of the first bearing rail [6] and the plurality of bearing [7] of the second bearing rail.<br><br>The plain and ordinary meaning of “support” does not require that components must be directly or physically connected or touching. “Support” may be provided directly, may be provided indirectly via an intermediary component or series of components, may bear some of the weight of another component or a series of components, and/or may bear all of the weight of another component or series of components. | <br>  |  <br>  |

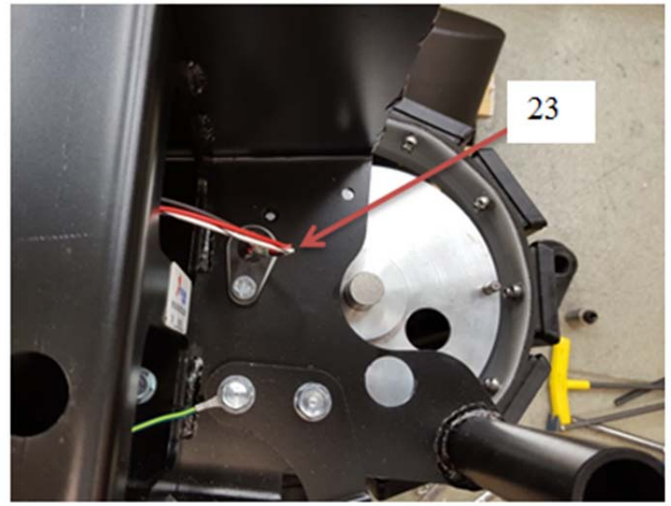
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| | | | |
| and a safety device coupled to the frame and operatively coupled to the running belt,<br><br>wherein the safety device is structured to substantially prevent movement of the running belt in a first direction and permit movement of the running belt in a second direction opposite the first direction. | A “safety device” that is “coupled to the frame” and “operatively coupled to the running belt” to “substantially prevent movement of the running belt in a first direction and permit movement” in a “second direction” is literally in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown in the Original Design, the safety device [10] is coupled to the rear shaft [5], which is coupled to the frame [1]. As shown in the Redesign, the safety device [10] is coupled to the front shaft [4], which is coupled to the frame [1].<br><br>As also shown, the safety device [10] of the Original Design is a Koyo brand with a model number of |  |  |

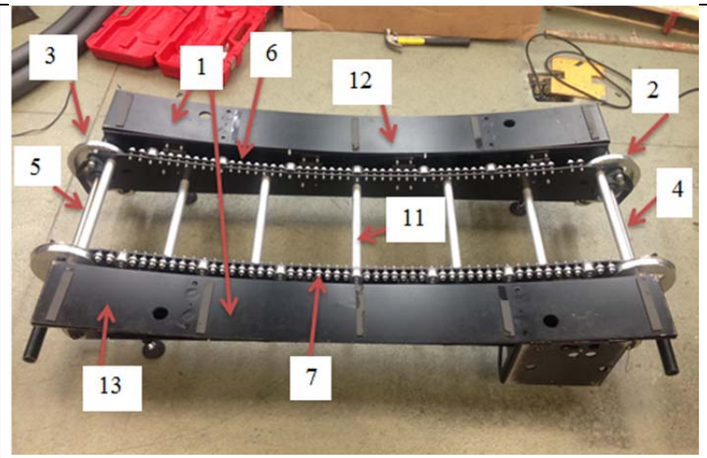
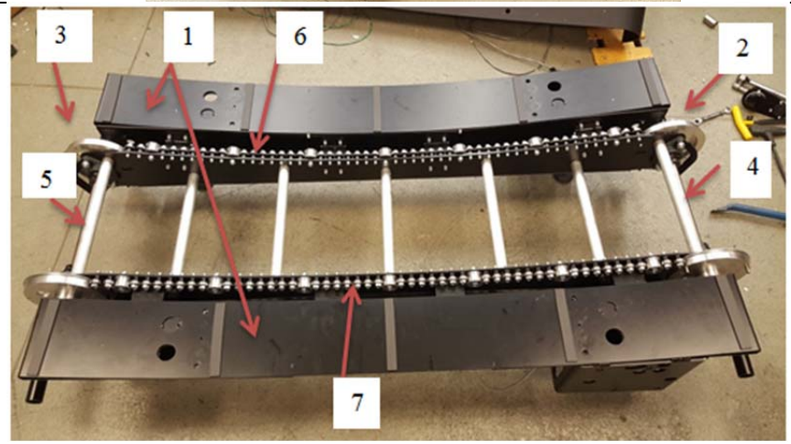
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | RCB-121616 while the safety device [10] of the Redesign is a Koyo brand with a model number of RCB-162117.<br><br>Each of these model numbers corresponds with a “regular clutch and bearing assembly” that “transmits torque between [the] shaft and housing in one direction and allows free overrun in the opposite direction,” as described in the Koyo catalog.<br><br>In regard to the Original Design, because the safety device [10] is coupled to the rear shaft [5] and because the safety device [10] “allows free overrun,” in one rotational direction, the safety device [10] is structured to substantially prevent rotation of the rear shaft [5] in a first rotational direction while permitting rotation of the rear shaft [5] in a second rotational direction opposite the first rotational | |  <br>  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | direction. Because the running belt [8] is disposed about the rear shaft [5], rotational movement of the running belt [8] is affected/constrained by the movement of the rear shaft [5]. Thus, the safety device [10] is structured to substantially prevent movement of the running belt [8] in a first direction and permit movement of the running belt [8] in a second direction that is opposite the first direction.<br><br>In regard to the Redesign, because the safety device [10] is coupled to the front shaft [4] and because the safety device [10] “allows free overrun,” in one rotational direction, the safety device [10] is structured to substantially prevent rotation of the front shaft [4] in a first rotational direction while permitting rotation of the front shaft [4] in a second rotational direction opposite the first rotational | | |

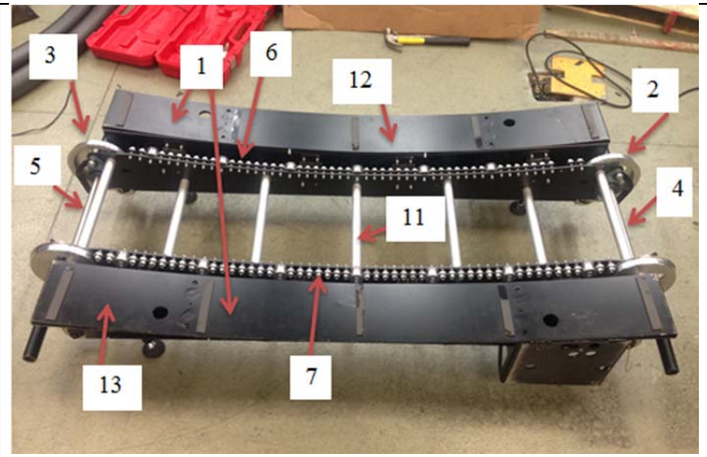
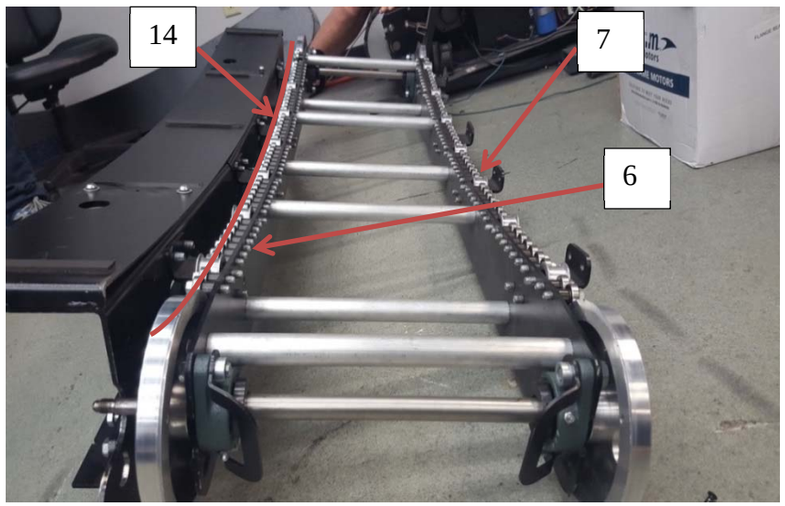
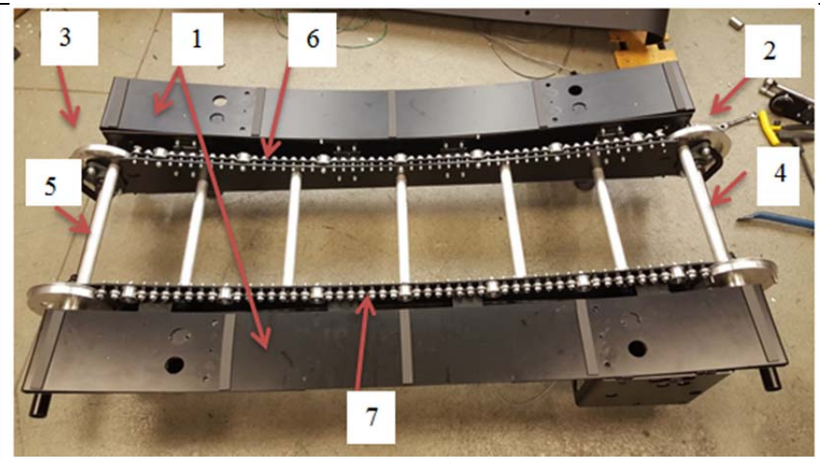
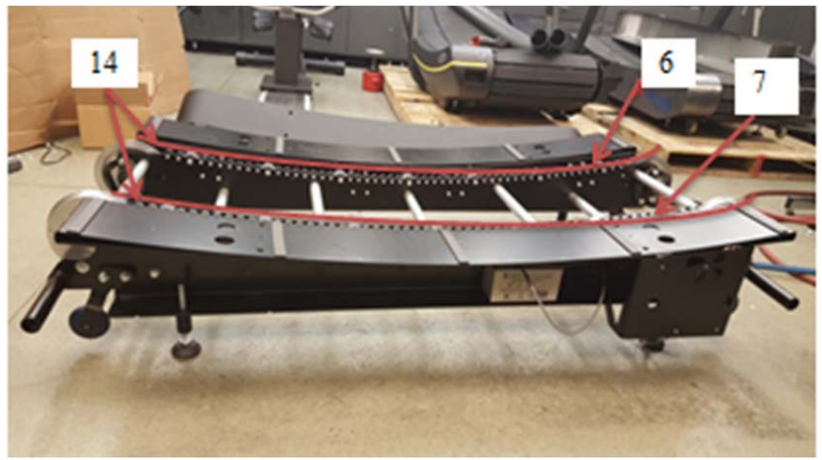
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | direction. Because the running belt [8] is disposed about the front shaft [4], rotational movement of the running belt [8] is affected/constrained by the movement of the front shaft [4]. Thus, the safety device [10] is structured to substantially prevent movement of the running belt [8] in a first direction and permit movement of the running belt [8] in a second direction that is opposite the first direction. | | |

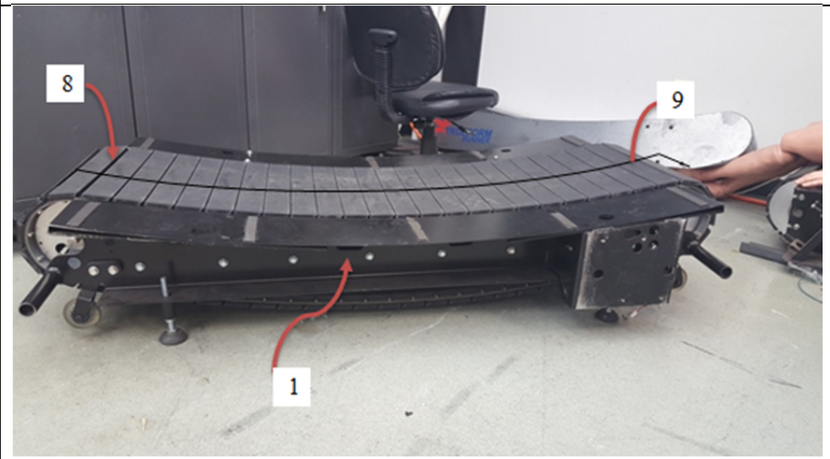
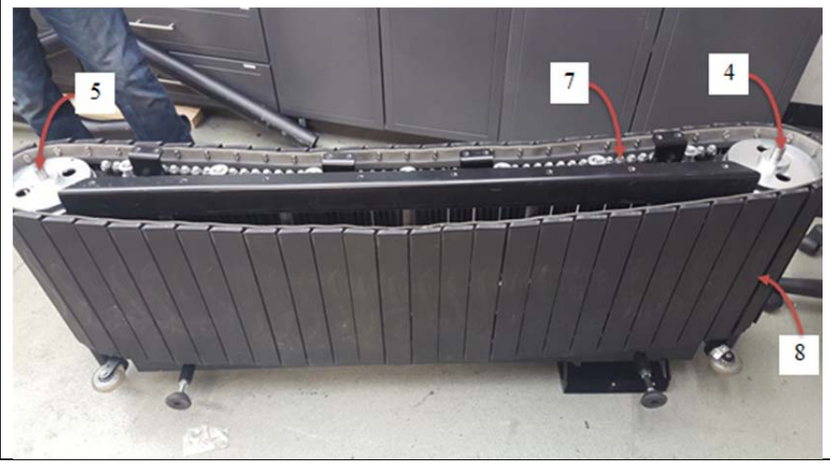
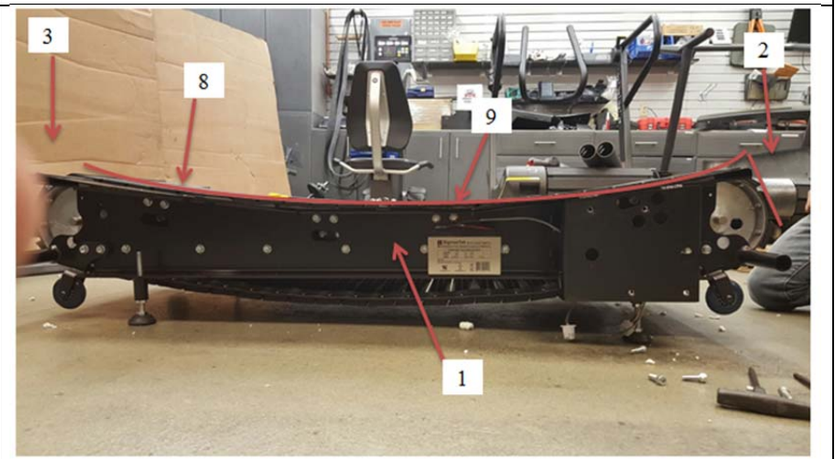
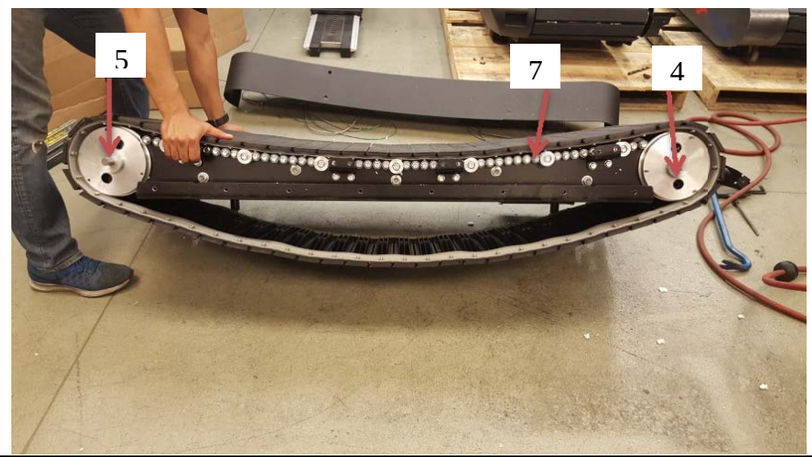
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| | | | |
| 20. The manually powered treadmill of claim 19,<br><br>further comprising a sensor configured to acquire data indicative of a speed of the running belt. | A “sensor configured to acquire data indicative of a speed of the running belt” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, each of the Original and Redesigned TrueForm Runner Treadmills includes a sensor [23] that is configured to acquire data |  | |

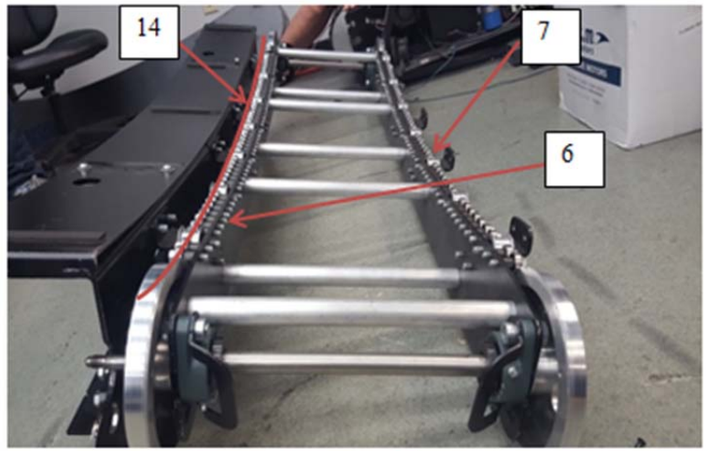
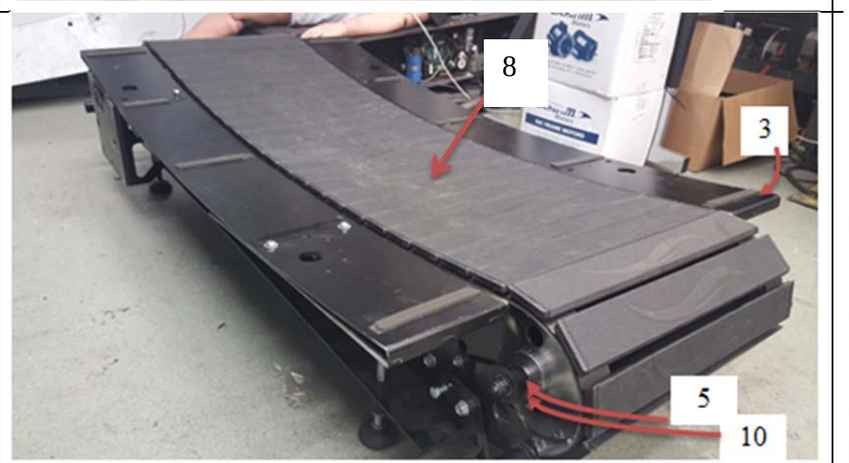
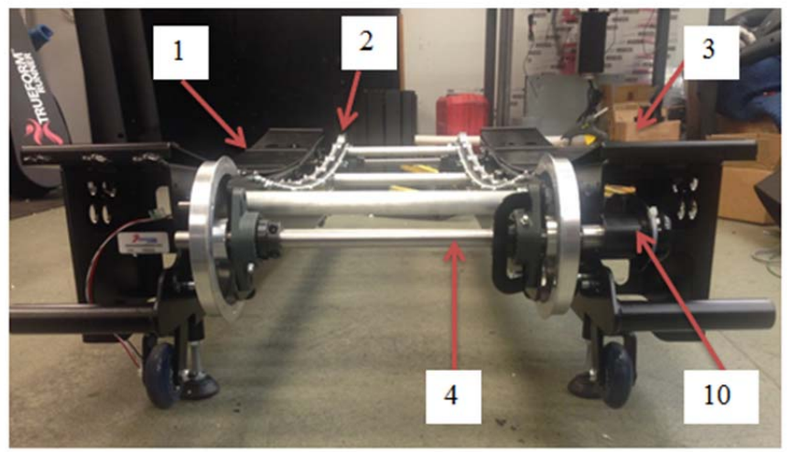
| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | indicative of the speed of the running belt.<br><br>As shown in the bottom picture, Model Number 55505-00-02-A is a Hall Effect Sensor provided by Littelfuse, Inc., which is “primarily for … speed sensing,” as described in the literature. | |  <br> |
| 25. A method, comprising: | | | |

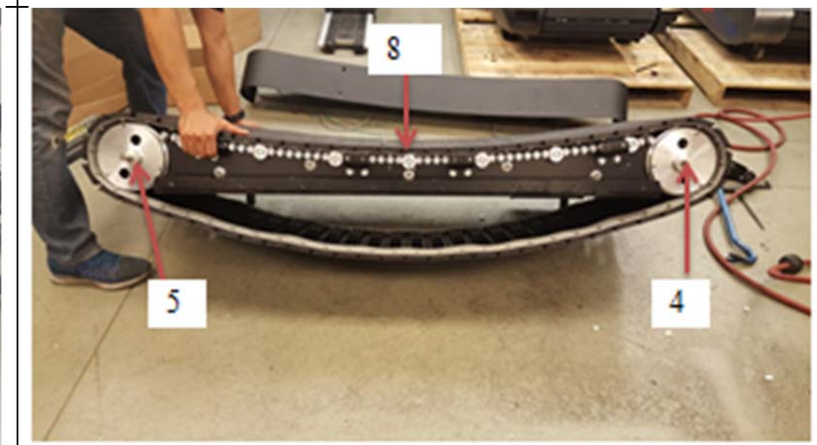
| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| providing a manually powered treadmill, | A “manually powered treadmill” is literally each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As described in the product literature attached as Exhibit G and as Chapco and Samsara have admitted, the Original and Redesigned TrueForm Runner Treadmills are human powered and non-motorized. | | |
| the manually powered treadmill having a frame with a front end and rear end; | A “frame having a front end and a rear end” is literally provided in each of the Original and Redesigned TrueForm Runner Treadmills; Chapco and Samsara agree.<br><br>As shown, the frame [1], which designates the entire frame assembly not a single piece of metal, has a front end [2] and a rear end [3].<br><br>Chapco’s and Samsara’s argument that the Original and Redesigned TrueForm |  |  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | Runner Treadmill does not meet this claim limitation because it has two frames and not one frame is inconsistent with the ’580 patent’s disclosure. The specification of the ’580 patent states that “the frame may have substantially any configuration suitable for providing structure and support for the manual treadmill.” Col. 5, ll. 65-67. Nothing about the plain and ordinary meaning of “frame” requires a single unitary structure. | | |
| providing a first bearing rail and a second bearing rail, the first and second bearing rails each comprising a plurality of bearings and extending longitudinally on the frame,<br><br>wherein the first | A “first bearing rail” having “a plurality of bearings” and a “second bearing rail” having a “plurality of bearings” where “the first and second bearing rails define a curved top profile” and “extend[] longitudinally on the frame” is literally provided in each of the Original and Redesigned TrueForm Runner Treadmills. | | |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| and second bearing rails define a curved top profile; | As shown, a first bearing rail is attached longitudinally to one side of the frame [1] (i.e., the left side), while a second bearing rail is attached longitudinally to the other side of the frame [1] (i.e., the right side. As also shown, the top edge of the first bearing rail to which the plurality of bearings [6] are mounted and the top edge of the second bearing rail to which the plurality of bearings [7] are mounted define a curved top profile [14]. |  <br>  |  <br>  |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| | | | |
| disposing a running belt on the plurality of bearings of the first bearing rail and the second bearing rail such that the running belt follows a top curved running surface corresponding to the curved top profile of the first and second bearing rails; | A “running belt” that is disposed “on the plurality of bearings of the first bearing rail and the second bearing rail such that the running belt follows a top curved running surface corresponding to the curved top profile of the first and second bearing rails” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown, a running belt [8] follows a curved running surface [9]. The running belt [8] is disposed on the first bearing rail and the second bearing rail. Because the curved top profile [14] is proximate the curved running surface [9], the curved running surface [9] corresponds to the curved top profile [14]. |  <br>  |  <br>  |

| **the ’580 patent** | | **Claim Chart Directed To Original Design** | **Claim Chart Directed To Redesign** |
|---|---|---|---|
| | |  | |
| permitting movement of the running belt in a first direction;<br><br>and<br><br>substantially preventing movement of the running belt in a second direction opposite the first direction. | The “running belt” being only permitted to move in one direction and “substantially prevent[ed]” from moving “in a second direction opposite the first direction” is literally present in each of the Original and Redesigned TrueForm Runner Treadmills.<br><br>As shown in the Original Design, the safety device [10] is coupled to the rear shaft [5]; Chapco and Samsara agree. As shown in the Redesign, the safety device [10] is coupled to |  |  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | the front shaft [4]; Chapco and Samsara agree.<br><br>As also shown, the safety device [10] of the Original Design is a Koyo brand with a model number of RCB-121616 while the safety device [10] of the Redesign is a Koyo brand with a model number of RCB-162117.<br><br>Each of these model numbers corresponds with a “regular clutch and bearing assembly” that “transmits torque between [the] shaft and housing in one direction and allows free overrun in the opposite direction,.” As described in the Koyo catalog.<br><br>In regard to the Original Design, because the safety device [10] is coupled to the rear shaft [5] and because the safety device [10] “allows free overrun,” (*id.*), in one rotational direction, the safety device [10] is structured to | |  |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | substantially prevent rotation of the rear shaft [5] in a first rotational direction while permitting rotation of the rear shaft [5] in a second rotational direction opposite the first rotational direction. Because the running belt [8] is disposed about the rear shaft [5], rotational movement of the running belt [8] is affected/constrained by movement of the rear shaft [5]. Thus, the safety device [10] is structured to substantially prevent movement of the running belt [8] in a first direction and permit movement of the running belt [8] in a second direction that is opposite the first direction.<br><br>In regard to the Redesign, because the safety device [10] is coupled to the front shaft [4] and because the safety device [10] “allows free overrun,” (*id.*), in one rotational direction, the safety device [10] is structured to substantially | | |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | prevent rotation of the front shaft [4] in a first rotational direction while permitting rotation of the front shaft [4] in a second rotational direction opposite the first rotational direction. Because the running belt [8] is disposed about the front shaft [4], rotational movement of the running belt [8] is affected/constrained by movement of the front shaft [4]. Thus, the safety device [10] is structured to substantially prevent movement of the running belt [8] in a first direction and permit movement of the running belt [8] in a second direction that is opposite the first direction. | | |

| the ’580 patent | | Claim Chart Directed To Original Design | Claim Chart Directed To Redesign |
|---|---|---|---|
| | | | |

# TRUEFORM™ RUNNER

**The latest innovation in fitness! It's fun, easy to use and safe. The TFR is proven to burn up to 30% more calories than motorized treadmills because it engages more muscles for a superior workout.**

**FEATURES:**

- Non-motorized, powered by you
- Low maintenance
- Easy to move
- Requires no electricity
- Lowest cost of ownership
- Rewards proper running form
- Improves strength & biomechanics
- Safe for all fitness levels
- Facilitates natural running
- For running & walking

**Did you see TFR in the CrossFit Regionals? The ONLY treadmill to EVER be included in a worldwide athletic event!**

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HEALTH A Gym Workout Powered by Your Feet

WHAT'S YOUR WORKOUT? Pro Golfer Gets Back Into the Swing

YOUR HEALTH The Mystery of Chronic Lyme Disease

LIFE | HEALTH | HEALTH & WELLNESS

**Treadmills Unplugged: A Gym Workout Powered by Your Feet**

Green-energy manual treadmills gain ground in high-end clubs and CrossFit Games events

**The TFR featured in the Wall Street Journal! Join the growing trend of function non-motorized equipment! The Number one choice of CrossFit!**

**SPECIFICATIONS:**

- Width: 35"
- Length: 64"
- Height: 50"
- Running Surface: 17" x 64"
- Weight: 325 lbs
- Weight Capacity: 700 lbs
- Drive System: 120 Bearings,14 Guide Rollers
- Frame: Formed & Welded 7 Gauge Steel
- Digital Display: LED W/Rechargeable Battery
- Limited Warranty: 10 years

**For further information on the TrueForm Runner, please contact our Canadian Distributor Dotmar Fitness Equipment Inc. info@dotmarfitness.com or call 905-272-366**

Exhibit G

# TRUEFORM RUNNER

The TrueForm Runner is ideal for serious running; it allows runners and walkers of any size and weight to achieve desired speed without the use of elevation or motor. The TrueForm requires the runner to turn the belt with their own power, which means better results. This leads to increased metabolic expenditure and greater recruitment of posterior and core muscle groups.

The TrueForm has minimal wear and tear on components. The low friction drive system glides on 120 precision ball bearings and 14 guide rollers. The TrueForm is GREEN; it relies 100% on human power.

## SPECIFICATIONS

| | |
|---|---|
| Width | 35" - 35 1/2" |
| Length | 64" |
| Height | 46"- 50" |
| Weight | 325 lbs |
| Running Surface | 17" W x 64" L |
| User Weight Capacity | 700 lbs. |
| Belt Type | 57 Individual Slats |
| Drive System | 120 Precision Ball Bearings,14 Roller Guides |
| Running Surface | Vulcanized Rubber (80 shore A hardness) |
| Drive Motor | Non-motorized |
| Power Supply | None |
| Frame | Formed & Welded 7 Gauge Steel |
| Handrails | 2" OD, 11 Gauge Steel Formed & Welded Tubing |
| Covers | .190 Aluminum Formed & Welded |

## WARRANTY

| | |
|---|---|
| Frame | 10 years |
| Tread Components | 5 years |
| Digital Display | 2 years |
| Labor | 1 year |

## OPTIONS

| | |
|---|---|
| Digital Display | LED - Rechargeable Battery/AC Adapter |
| Enduro | Standard Handrail - 50" H x 351/2"W |
| Low Rider | Low Handrail Model - 46" H x 32" W |
| Performance | Speed Training 50" x351/2" W - Additional Cost |
| Turf | Artificial Sports Turf - Additional Cost |
| Track | Red Running Track - Additional Cost |
| Color | Cost Provided Based on Quality & Color |

*PROUDLY MADE IN THE USA*

LOW RIDER:
Compact unit with low handrails prompts athletes to balance without leaning on rails.

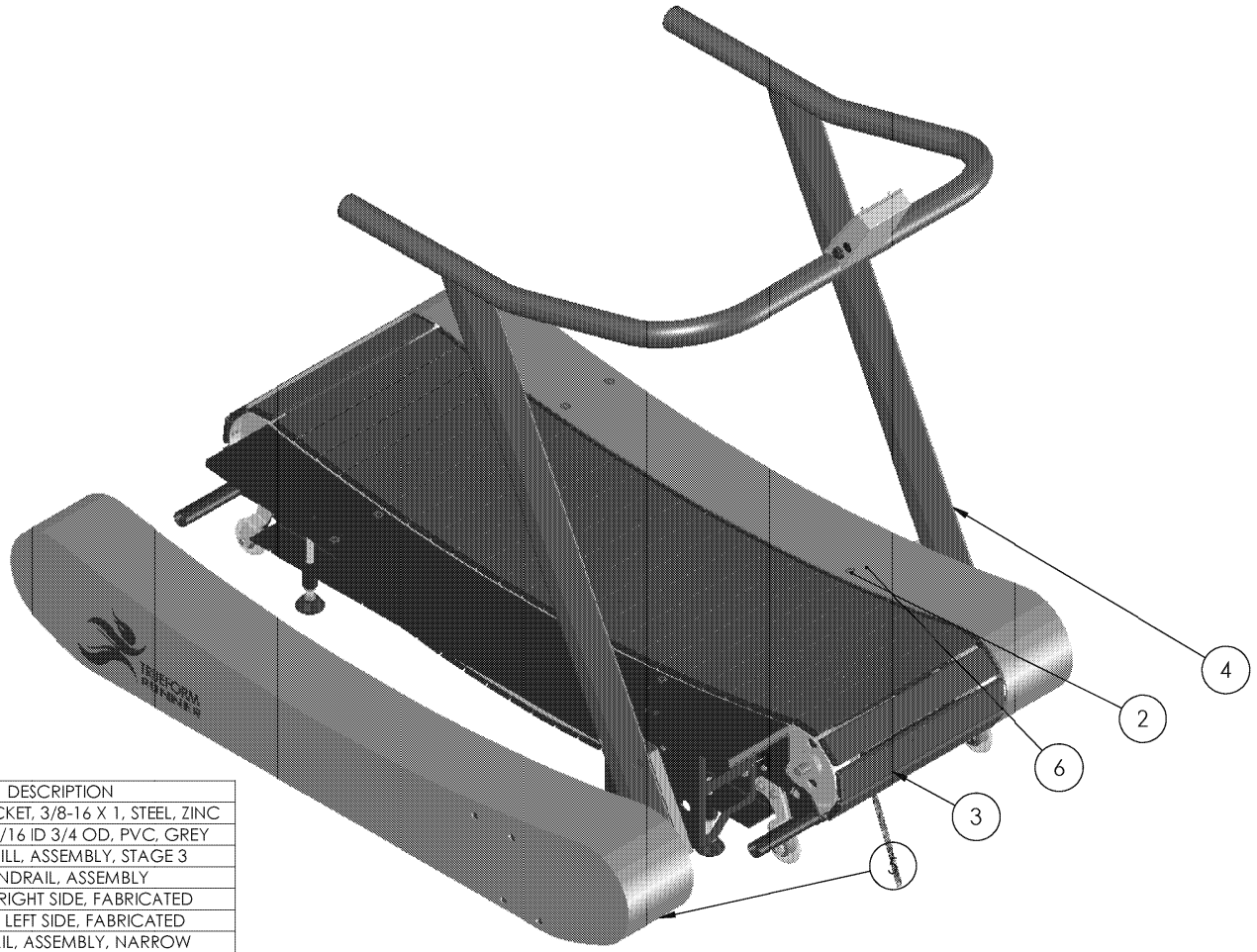
ENDURO:
Standard handrails great for runner rehab and open gym environments.

PERFORMANCE:
High wrap around handrail allows for tethering. Extra clerance is ideal for high-speed training.

*FOR ADDITIONAL INFORMATION ABOUT THE TRUEFORM RUNNER*

Please contact our Canadian Distributor, Dotmar Fitness Equipment Inc.
info@dotmarfitness.com or call 905-272-3663

**Exhibit H**




| ITEM | REV | QTY. | PART NUMBER | DESCRIPTION |
|---|---|---|---|---|
| 1 | | 8 | 90128A624 | SCREW, SOCKET, 3/8-16 X 1, STEEL, ZINC |
| 2 | | 6 | 95611A029 | WASHER, 5/16 ID 3/4 OD, PVC, GREY |
| 3 | | 1 | S007-A00958_S3 | TREADMILL, ASSEMBLY, STAGE 3 |
| 4 | D | 1 | S007-A01248 | HANDRAIL, ASSEMBLY |
| 5 | B | 1 | S007-A02087 | COVER, RIGHT SIDE, FABRICATED |
| 6 | B | 1 | S007-A02303 | COVER, LEFT SIDE, FABRICATED |
| 7 | - | 1 | S007-A03016 | HANDRAIL, ASSEMBLY, NARROW |
| 8 | - | 1 | S007-A03018 | HANDRAIL, ASSEMBLY, WRAPPED |
| 9 | A | 1 | S007-A03310 | READOUT ASSEMBLY |
| 10 | - | 1 | S007-A03489 | COVER PLATE ASSY WITH SCREWS |
| 11 | | 2 | 92217A365 | 4-40 ID 3/8" OD SS FLAT WASHER |
| 12 | - | 1 | NEMA17 | STEP MOTOR |
| 13 | - | 1 | 2481K41 | NEOPRENE ROLLER 55A DUROMETER |
| 14 | B | 1 | S007-D02078 | PLATE, RETAINER, NUT W/ PEMS |
| 15 | - | 1 | S072-D02093 | MOTOR MOUNT BRACKET ACTIVE |
| 16 | | 1 | 91259A165 | 3/16"SHOLDER 1/4 LONG SHOLDER SCREW |
| 17 | - | 1 | 98415T65 | TINSEL WIPER WITH GROUND STRAP |
| 18 | A | 2 | S007-D03763 | STATIC TINSEL WIPER BRACKET |
| 19 | | 2 | 93310A535 | 1/4-20 X 3/8" BHCS |

FLAT BLANK DATA

COMMENTS:

CHAPCO INCORPORATED

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/64
ANG: MACH ±.5° BEND ±.5°
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

CLIENT

PROJECT TRUEFORM

TREADMILL ASSEMBLY STAGE 4

SIZE B | PART NO. S007-A00958_S4 | REV B

ASSY NAME:

DRAWN BY: BDC | DRAW DATE: 12/21/2012 | CHECKED BY: | CHECKED DATE: | SCALE: 1:9 | WEIGHT: 521.74 | SHEET 1 OF 3 | CHAPCO REV.

FILE PATH:
\\Chapserv\CADD-CAM\CADD\TRUEFORM\S007\TREADMILL\TOP LEVEL\S007-A00958_S4 HANDRAILS



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# Exhibit H

| ITEM NO. | QTY. | PART NUMBER | DESCRIPTION |
|---|---|---|---|
| 1 | 1 | S007-A00958_S3 | TREADMILL, ASSEMBLY, STAGE 3 |
| 1.1 | 1 | S007-A00958_S2 | TREADMILL, ASSEMBLY, STAGE 2 |
| 1.1.1 | 1 | S007-A00958_S1 | TREADMILL, ASSEMBLY, STAGE 1 |
| 1.1.1.1 | 2 | S007-D02097 | RAIL, BEARING, CURVED |
| 1.1.1.2 | 7 | S007-D01849 | TIE ROD, 1/2-13 THREADED |
| 1.1.1.3 | 7 | S007-D01782 | TUBE, TIE ROD, BEARING RAIL |
| 1.1.1.4 | 92 | 90096A585 | SCREW, HEX, 5/16-18 X 1.25, TYPE F, ZINC PLATED |
| 1.1.1.5 | 92 | 6082RS | BALL BEARING, 22MM OD x 8MM ID X 7MM, SEALED |
| 1.1.1.6 | 92 | S007-D00930 | SPACER, BALL BEARING |
| 1.1.1.7 | 14 | S007-A00940 | GUIDE ROLLER, ASSEMBLY, K19 |
| 1.1.1.7.1 | 1 | 99142A420 | SNAP RING, .88 DIA x .042 THK |
| 1.1.1.7.2 | 1 | 90134A035 | WASHER, TRIPLE WAVE, 5/8", SPRING STEEL |
| 1.1.1.7.3 | 1 | S007-D03104 | ROLLER, GUIDE, FLAT BELT, +.025" |
| 1.1.1.7.4 | 2 | 38-88-300 | BALL BEARING, 22MM OD x 8MM ID X 7MM, SHROUDED |
| 1.1.1.8 | 14 | S007-D00934 | SPACER, GUIDE ROLLER, FLAT BELT |
| 1.1.1.9 | 4 | S007-D01235 | PULLEY, FLAT, 6 1/2" |
| 1.1.1.10 | 4 | 98296A916 | ROLL PIN, 3/16" X 1.75, STEEL |
| 1.1.1.11 | 1 | S007-D01160 | AXLE, SHAFT |
| 1.1.1.12 | 1 | S007-D03087 | AXLE, SHAFT, SHORT |
| 1.1.1.13 | 4 | UEFT204-12 | BALL BEARING, CAST IRON MNT, 3/4", ACCULOCK |
| 1.1.1.14 | 8 | 92865A314 | BOLT, HEX, 7/16-20 X 1.25, GRADE 5, ZINC PLATED |
| 1.1.1.15 | 8 | 90126A032 | WASHER, 7/16, FLAT, ZINC PLATED |
| 1.1.1.16 | 3 | S007-D02078 | PLATE, RETAINER, NUT W/ PEMS |
| 1.1.1.16.1 | 1 | S007-D02078 | PLATE, RETAINER, NUT |
| 1.1.1.16.2 | 2 | S-0720-1ZI | NUT, PEM, 7/16-20, STEEL, ZINC |
| 1.1.1.17 | 16 | 90096A622 | SCREW, HEX, 3/8-16 X .75, TYPE F, ZINC PLATED |
| 1.1.1.18 | 8 | S007-D01783 | BRACKET, SUPPORT, SIDE |
| 1.1.1.19 | 14 | 95462A033 | NUT, HEX, 1/2-13, GRADE 5, ZINC |
| 1.1.1.20 | 14 | 90126A033 | WASHER, FLAT, 1/2" 1.125OD, ZINC PLATED |
| 1.1.1.21 | 14 | 90096A587 | SCREW, HEX, 5/16-18 X 1.5, TYPE F, ZINC PLATED |
| 1.1.1.22 | 1 | 90759A450 | NUT, 12 POINT, 7/16-20, ALLOY, BLACK OXIDE |
| 1.1.1.23 | 3 | 98381A542 | PIN, DOWEL, .250 X 1, ALLOY STEEL |
| 1.1.1.24 | 1 | 5784SPC | RACE, 3/4 OD 1/2 ID X 1.25", STEEL, GROUND |
| 1.1.2 | 2 | S007-D00943 | BELT, TREADMILL |
| 1.1.3 | 57 | S007-D02744 | TREAD, TREADMILL, W/ OVERMOLD |
| 1.1.4 | 224 | 96562A240 | SCREW, PAN #2, 10-24 X .375, 18-8 SST, PATCH |
| 1.1.5 | 2 | S007-A03865 | - |
| 1.1.5.1 | 1 | S007-D03865 | LINK WASHER DD |
| 1.1.5.2 | 2 | 93705A242 | 10-24 x .5" SS SHCS |
| 1.2 | 4 | 95475A738 | STUD, THREADED, 1/2-13 X 6", STEEL, ZINC |
| 1.3 | 4 | 50609 | FOOT, MOUNTING, 1/2-13, NEOPRENE, 150-600# |
| 1.4 | 8 | 91078A222 | NUT, HEX, JAM, 1/2-13, GRADE 2, ZINC |
| 1.5 | 32 | 90096A622 | SCREW, HEX, 3/8-16 X .75, TYPE F, ZINC PLATED |
| 1.6 | 1 | S007-A01239-R | FRAME, SIDE, WELDMENT RIGHT |
| 1.6.1 | 1 | S007-D00944 | FRAME, SIDE, RAIL |
| 1.6.2 | 1 | S007-D01238 | PLATE, SUPPORT, COVER |
| 1.6.3 | 2 | S007-D01850 | TUBE, FOOT MOUNT |
| 1.6.4 | 2 | 90499A033 | NUT, HEX, 1/2-13, STEEL, PLAIN |
| 1.6.5 | 2 | S007-D02725 | HANDLE, SIDE, FRAME |
| 1.6.6 | 4 | 94579A500 | WELD NUT, OFFSET, 5/6-18, STEEL |
| 1.6.7 | 1 | S007-D02719-R | BRACKET, MOUNTING, HANDRAIL, RIGHT |
| 1.6.7.1 | 1 | S007-D02719-R | BRACKET, MOUNTING, HANDRAIL, RIGHT |
| 1.6.7.2 | 4 | CLS-0616-2 | PEM NUT, 3/8-16 UNC, SS |
| 1.7 | 1 | S007-A01239 | FRAME, SIDE, WELDMENT LEFT |
| 1.7.1 | 1 | S007-D00944 | FRAME, SIDE, RAIL |
| 1.7.2 | 1 | S007-D01238 | PLATE, SUPPORT, COVER |
| 1.7.3 | 2 | S007-D01850 | TUBE, FOOT MOUNT |
| 1.7.4 | 2 | 90499A033 | NUT, HEX, 1/2-13, STEEL, PLAIN |
| 1.7.5 | 1 | S007-D02719-L | BRACKET, MOUNTING, HANDRAIL, LEFT |
| 1.7.5.1 | 1 | S007-D02719-L | BRACKET, MOUNTING, HANDRAIL LEFT |
| 1.7.5.2 | 4 | CLS-0616-2 | PEM NUT, 3/8-16 UNC, SS |
| 1.7.6 | 2 | S007-D02725 | HANDLE, SIDE, FRAME |
| 1.7.7 | 4 | 94579A500 | WELD NUT, OFFSET, 5/6-18, STEEL |
| 1.8 | 2 | S007-A03086-R | WHEEL, MOUNT, ASSEMBLY |
| 1.8.1 | 1 | S007-D01816 | PLATE, WHEEL, MOUNT |
| 1.8.2 | 1 | WH-10670-C75 | WHEEL, 75MM, POLY, 150# |
| 1.8.3 | 1 | S007-D03643 | WHEEL SUPPORT PLATE, SECONDARY mirror |
| 1.8.4 | 2 | 93475A270 | 8MM WASHER SS |
| 1.8.5 | 1 | 92981A220 | 8MM X 35 MM SHOLDER BOLT |

FLAT BLANK DATA

COMMENTS:

CHAPCO INCORPORATED

CLIENT

PROJECT

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/64
ANG: MACH ±.5° BEND ±.5°
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

SIZE B | PART NO. | REV B

ASSY NAME:

DRAWN BY: BDC | DRAW DATE: 12/21/2012 | CHECKED BY: | CHECKED DATE: | SCALE: 1:9 | WEIGHT: | SHEET 2 OF 3 | CHAPCO REV.

FILE PATH:



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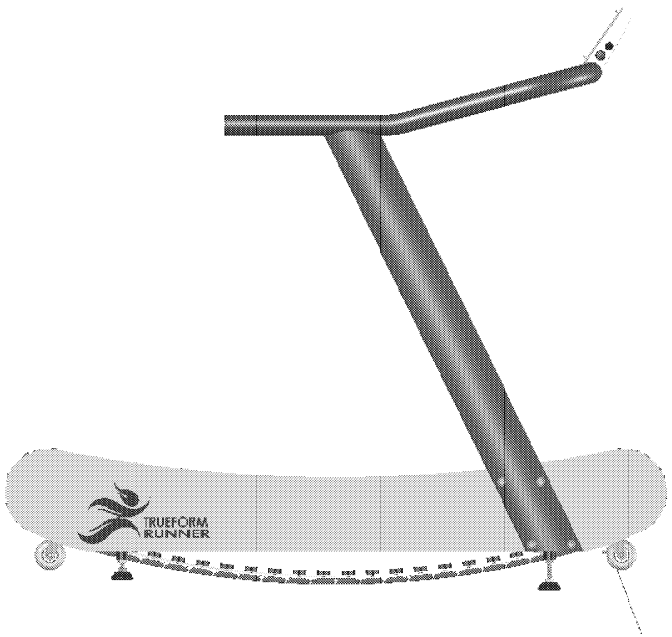
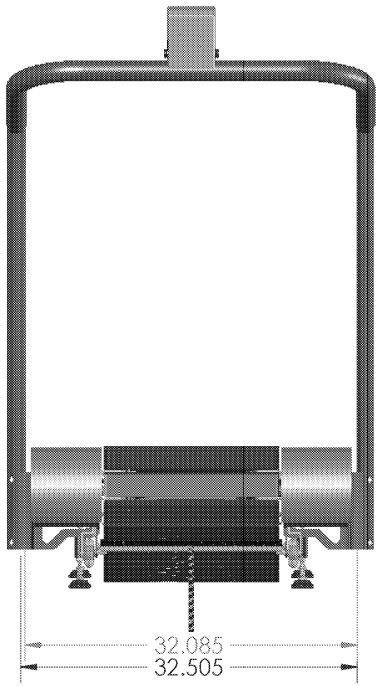
**Exhibit H**



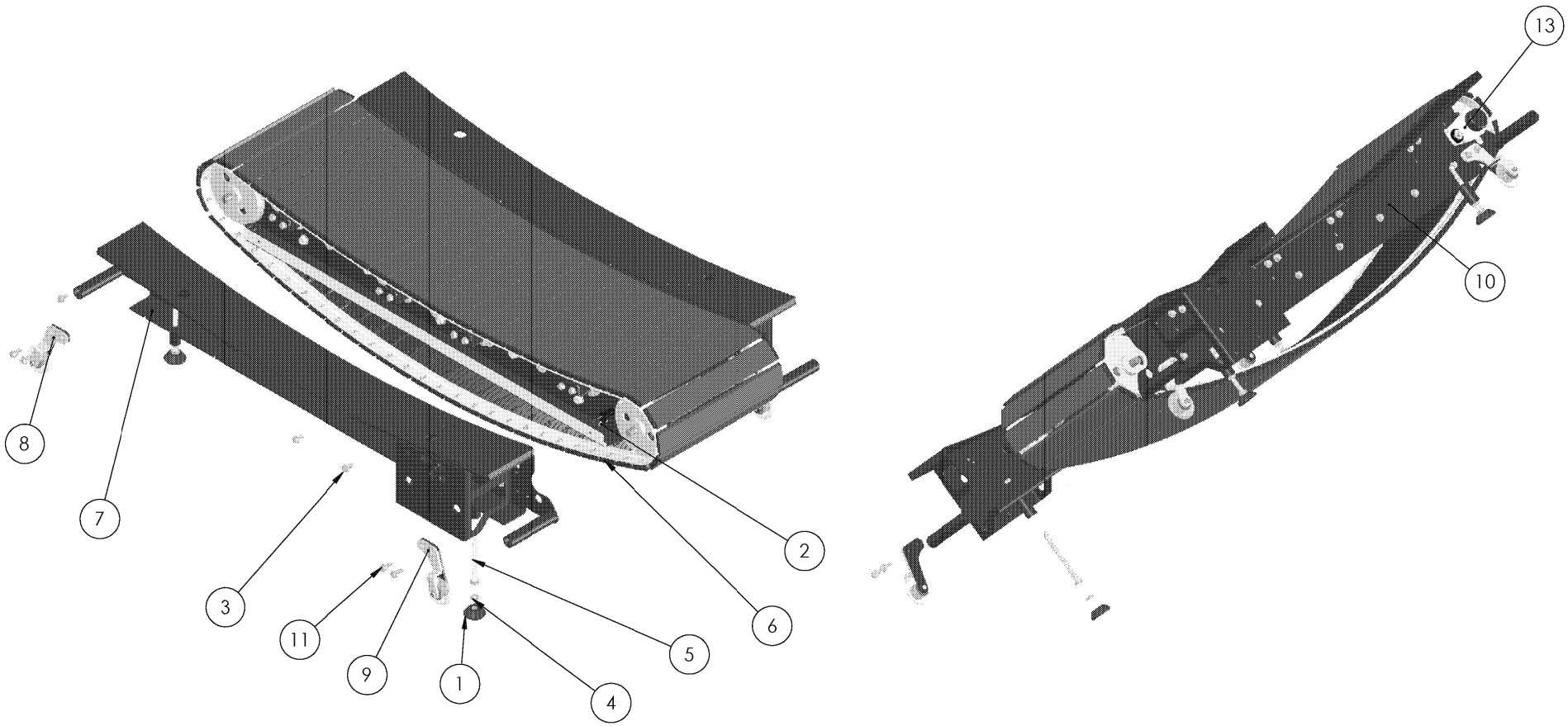



| | | | |
|---|---|---|---|
| FLAT BLANK DATA | CHAPCO INCORPORATED | CLIENT | |
| COMMENTS: | | PROJECT | TRUEFORM |
| | DIMENSIONS ARE IN INCHES<br>TOLERANCES:<br>FRACTIONAL ± 1/64<br>ANG: MACH ±.5° BEND ±.5°<br>TWO PLACE DECIMAL ±.010<br>THREE PLACE DECIMAL ±.005 | MATERIAL | TREADMILL ASSEMBLY STAGE 4 |
| | | FINISH | SIZE: B PART NO.: S007-A00958_S4 REV: B |
| ASSY NAME: | DRAWN BY: BDC DRAW DATE: 12/21/2012 CHECKED BY: | CHECKED DATE: | SCALE: 1:9 WEIGHT: 521.74 SHEET 3 OF 3 CHAPCO REV. |
| | FILE PATH: \\Chapconv\CADD-CAM\CADD\TRUEFORM(S007)\TREADMILL\TOP LEVEL\S007-A00958_S4 HANDRAILS | | |



Confidential-Attorneys Eyes Only

**Exhibit I**




| ITEM | QTY. | PART NUMBER | REV | DESCRIPTION |
|---|---|---|---|---|
| 1 | 4 | 50609 | | FOOT, MOUNTING, 1/2-13, NEOPRENE, 150-600# |
| 2 | 1 | 90096A540 | | SCREW, HEX, 1/4-20 X .75, TYPE F, ZINC PLATED |
| 3 | 32 | 90096A622 | | SCREW, HEX, 3/8-16 X .75, TYPE F, ZINC PLATED |
| 4 | 8 | 91078A222 | | NUT, HEX, JAM, 1/2-13, GRADE 2, ZINC |
| 5 | 4 | 95475A738 | | STUD, THREADED, 1/2-13 X 6", STEEL, ZINC |
| 6 | 1 | S007-A00958_S2 | | TREADMILL, ASSEMBLY, STAGE 2 |
| 7 | 1 | S007-A01239 | H | FRAME, SIDE, WELDMENT RIGHT |
| 8 | 2 | S007-A03086 | C | WHEEL, MOUNT, ASSEMBLY |
| 9 | 2 | S007-A03086 | C | WHEEL, MOUNT, ASSEMBLY |
| 10 | 1 | S007-A01239 | H | FRAME, SIDE, WELDMENT LEFT |
| 11 | 8 | 90096A624 | | SCREW, HEX, 3/8-16 X 1, TYPE F, ZINC PLATED |
| 12 | 1 | S007-D03833 | - | TENSION TOOL 3/4 ASSY |
| 13 | 1 | S007-A03894 | 3 | ONE WAY BEARING ASSY |

FLAT BLANK DATA

COMMENTS:

CHAPCO INCORPORATED

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/64
ANG: MACH ±.5° BEND ±.5°
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

CLIENT

PROJECT: TRUEFORM

TREADMILL ASSEMBLY STAGE 3

SIZE: B | PART NO.: S007-A00958_S3 | REV.: -

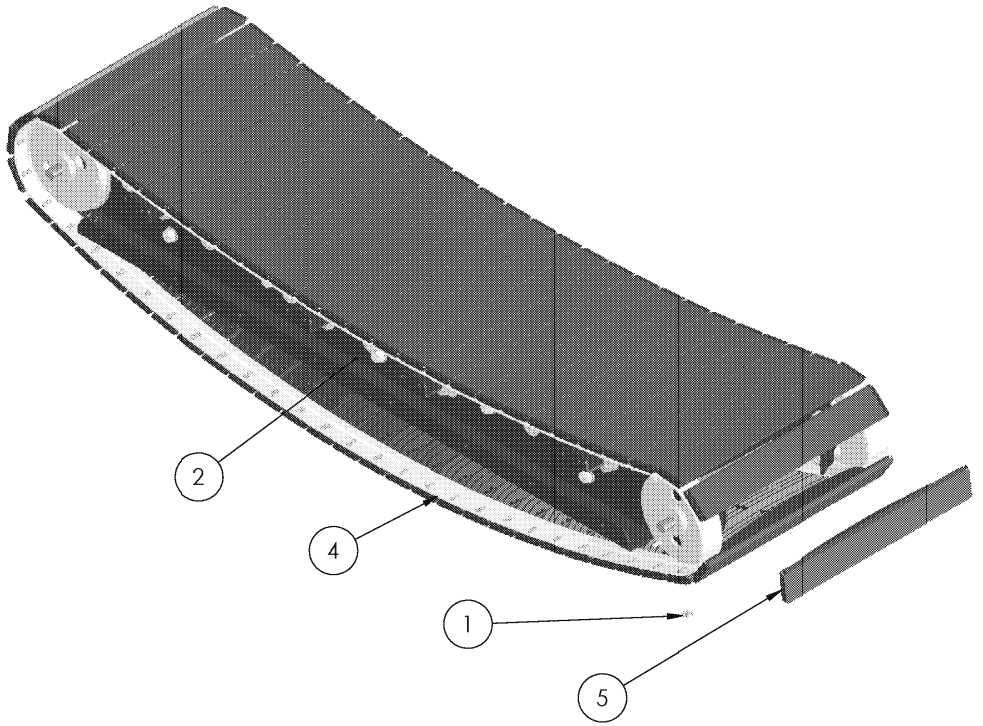
ASSY NAME: | DRAWN BY: BDC | DRAW DATE: 12/21/2012 | CHECKED BY: | CHECKED DATE: | SCALE: 1:8 | WEIGHT: 260.79 | SHEET 1 OF 1 | CHAPCO REV.

FILE PATH: \\chapsrv\cadd-cam\CADD\TRUEFORM\S007\TREADMILL\TOP LEVEL\S007-A00958_S3



Confidential-Attorneys Eyes Only

**Exhibit J**




| ITEM | QTY. | PART NUMBER | REV | DESCRIPTION |
|---|---|---|---|---|
| 1 | 228 | 96562A240 | | SCREW, PAN #2, 10-24 X .375, 18-8 SST, PATCH |
| 2 | 1 | S007-A00958_S1 | | TREADMILL, ASSEMBLY, STAGE 1 |
| 3 | 1 | S007-A02491 | A | HOUSING, ROLLBACK BEARING, BACK ASSEMBLY |
| 4 | 2 | S007-D00943 | G | BELT, TREADMILL |
| 5 | 57 | S007-D02744 | A | TREAD, TREADMILL, W/ OVERMOLD |

FLAT BLANK DATA

COMMENTS:

CHAPCO INCORPORATED

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/64
ANG: MACH ±.5° BEND ±.5°
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

CLIENT

PROJECT: TRUEFORM

TREADMILL ASSEMBLY STAGE 2

SIZE: B | PART NO.: S007-A00958_S2 | REV.: -

ASSY NAME:

DRAWN BY: BDC | DRAW DATE: 7/25/2012 | CHECKED BY: | CHECKED DATE:

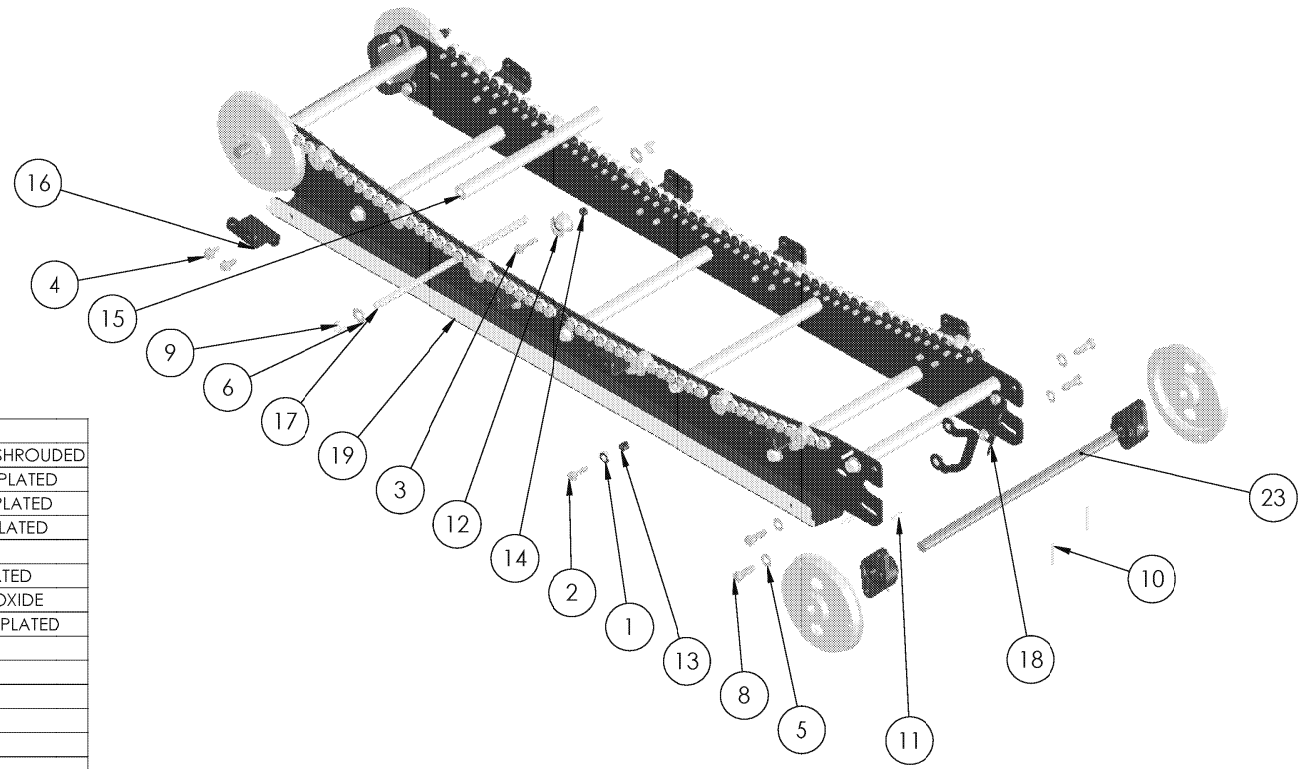
SCALE: 1:8 | WEIGHT: 125.76 | SHEET 1 OF 1 | CHAPCO REV.

FILE PATH: \\Chapserv\cadd-cam\CADD\TRUEFORM(S007)\TREADMILL\TOP LEVEL\S007-A00958_S2



Confidential-Attorneys Eyes Only

**Exhibit K**




| ITEM | REV | QTY. | PART NUMBER | DESCRIPTION |
|---|---|---|---|---|
| 1 | | 92 | 6082RS | BALL BEARING, 22MM OD x 8MM ID X 7MM, SHROUDED |
| 2 | | 92 | 90096A585 | SCREW, HEX, 5/16-18 X 1.25, TYPE F, ZINC PLATED |
| 3 | | 14 | 90096A587 | SCREW, HEX, 5/16-18 X 1.5, TYPE F, ZINC PLATED |
| 4 | | 16 | 90096A622 | SCREW, HEX, 3/8-16 X .75, TYPE F, ZINC PLATED |
| 5 | | 8 | 90126A032 | WASHER, 7/16, FLAT, ZINC PLATED |
| 6 | | 14 | 90126A033 | WASHER, FLAT, 1/2" 1.125OD, ZINC PLATED |
| 7 | | 1 | 90759A450 | NUT, 12 POINT, 7/16-20, ALLOY, BLACK OXIDE |
| 8 | | 8 | 92865A314 | BOLT, HEX, 7/16-20 X 1.25, GRADE 5, ZINC PLATED |
| 9 | | 14 | 95462A033 | NUT, HEX, 1/2-13, GRADE 5, ZINC |
| 10 | | 4 | 98296A916 | ROLL PIN, 3/16" X 1.75, STEEL |
| 11 | | 3 | 98381A542 | PIN, DOWEL, .250 X 1, ALLOY STEEL |
| 12 | C | 14 | S007-A00940 | GUIDE ROLLER, ASSEMBLY, K19 |
| 13 | J | 92 | S007-D00930 | SPACER, BALL BEARING |
| 14 | J | 14 | S007-D00934 | SPACER, GUIDE ROLLER, FLAT BELT |
| 15 | D | 7 | S007-D01782 | TUBE, TIE ROD, BEARING RAIL |
| 16 | D | 8 | S007-D01783 | BRACKET, SUPPORT, SIDE |
| 17 | - | 7 | S007-D01849 | TIE ROD, 1/2-13 THREADED |
| 18 | B | 4 | S007-D02078 | PLATE, RETAINER, NUT W/ PEMS |
| 19 | C | 2 | S007-D02097 | INNER FRAME RAIL, CURVED |
| 20 | - | 1 | S007-T03453 | PLATE, TEMPLATE, RAIL GRINDING |
| 21 | M | 4 | S007-D01235 | PULLEY, FLAT, 6 1/2" |
| 22 | P | 1 | S007-D01160 | AXLE, SHAFT |
| 23 | C | 1 | S007-D03087 | AXLE, SHAFT, SHORT |
| 24 | | 4 | UEFT204-12 | BALL BEARING, CAST IRON MNT, 3/4", ACCULOCK |
| 25 | | 1 | 5784SPC | RACE, 3/4 OD 1/2 ID X 1.25", STEEL, GROUND |
| 26 | - | 1 | - | - |
| 27 | P | 1 | S007-D04470 | AXLE, SHAFT |
| 28 | - | 2 | UCFT204-12 | BEARING ASSEMBLY |

FLAT BLANK DATA

COMMENTS:

CHAPCO INCORPORATED

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/64
ANG: MACH ±.5° BEND ±.5°
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005

MATERIAL

FINISH

CLIENT

PROJECT: TRUEFORM

TREADMILL ASSEMBLY STAGE 1

SIZE: B | PART NO.: S007-A00958_S1 | REV.: -

ASSY NAME: | DRAWN BY: BDC | DRAW DATE: 7/25/2012 | CHECKED BY: | CHECKED DATE: | SCALE: 1:8 | WEIGHT: 80.79 | SHEET 1 OF 2 | CHAPCO REV.

FILE PATH: C:\ASolidworks\TRUEFORM(S007)\TREADMILL\TOP LEVEL\S007-A00958_S1

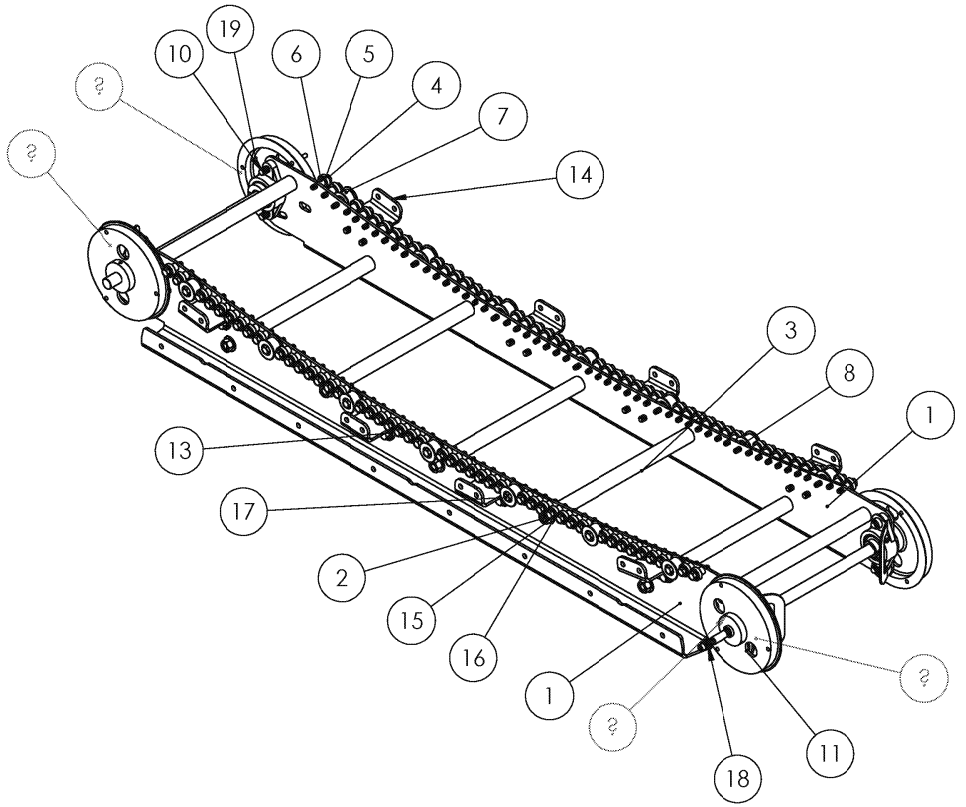


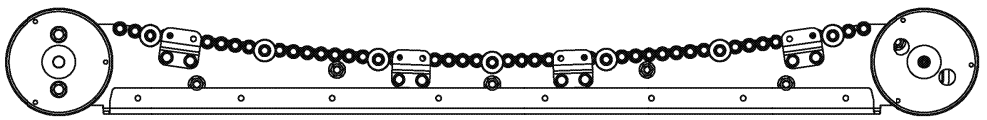
Confidential-Attorneys Eyes Only

# Exhibit K

FOR REFERENCE ONLY

| ITEM | QTY. | REV | PART NUMBER | DESCRIPTION |
|---|---|---|---|---|
| 1 | 2 | C | S007-D02097 | INNER FRAME RAIL, CURVED |
| 2 | 7 | - | S007-D01849 | TIE ROD, 1/2-13 THREADED |
| 3 | 7 | D | S007-D01782 | TUBE, TIE ROD, BEARING RAIL |
| 4 | 92 | | 90096A585 | SCREW, HEX, 5/16-18 X 1.25, TYPE F, ZINC PLATED |
| 5 | 92 | | 6082RS | BALL BEARING, 22MM OD x 8MM ID X 7MM, SHROUDED |
| 6 | 92 | J | S007-D00930 | SPACER, BALL BEARING |
| 7 | 14 | C | S007-A00940 | GUIDE ROLLER, ASSEMBLY, K19 |
| 8 | 14 | J | S007-D00934 | SPACER, GUIDE ROLLER, FLAT BELT |
| 9 | 3 | | 98296A916 | ROLL PIN, 3/16" X 1.75, STEEL |
| 10 | 8 | | 92865A314 | BOLT, HEX, 7/16-20 X 1.25, GRADE 5, ZINC PLATED |
| 11 | 8 | | 90126A032 | WASHER, 7/16, FLAT, ZINC PLATED |
| 12 | 3 | B | S007-D02078 | PLATE, RETAINER, NUT W/ PEMS |
| 13 | 16 | | 90096A622 | SCREW, HEX, 3/8-16 X .75, TYPE F, ZINC PLATED |
| 14 | 8 | D | S007-D01783 | BRACKET, SUPPORT, SIDE |
| 15 | 14 | | 95462A033 | NUT, HEX, 1/2-13, GRADE 5, ZINC |
| 16 | 14 | | 90126A033 | WASHER, FLAT, 1/2" 1.125OD, ZINC PLATED |
| 17 | 14 | | 90096A587 | SCREW, HEX, 5/16-18 X 1.5, TYPE F, ZINC PLATED |
| 18 | 1 | | 90759A450 | NUT, 12 POINT, 7/16-20, ALLOY, BLACK OXIDE |
| 19 | 3 | | 98381A542 | PIN, DOWEL, .250 X 1, ALLOY STEEL |
| 20 | 1 | - | S007-T03453 | PLATE, TEMPLATE, RAIL GRINDING |
| 21 | 3 | M | S007-D01235 | PULLEY, FLAT, 6 1/2" |
| 22 | 1 | P | S007-D01160 | AXLE, SHAFT |
| 23 | 1 | C | S007-D03087 | AXLE, SHAFT, SHORT |
| 24 | 4 | | UEFT204-12 | BALL BEARING, CAST IRON MNT, 3/4", ACCULOCK |
| 25 | 1 | - | - | - |
| 26 | 1 | P | S007-D04470 | AXLE, SHAFT |
| 27 | 2 | - | UCFT204-12 | BEARING ASSEMBLY |



CHAPCO INCORPORATED

CLIENT

PART NO. S007-A00958_S1 REV. -

PROJECT TRUEFORM CHAPCO REV.

TREADMILL ASSEMBLY STAGE 1

MATERIAL

DRAW DATE: 7/25/2012 DRAWN BY: BDC FINISH

DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ± 1/64
ANG: MACH ±.5° BEND ±.5°
TWO PLACE DECIMAL ±.010
THREE PLACE DECIMAL ±.005

NOTES

FILE PATH: C:\ASolidworks\TRUEFORM(S007)\TREADMILL\TOP LEVEL\S007-A00958_S1

SIZE B SHEET 2 OF 2



Confidential-Attorneys Eyes Only SAM0005695