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(54) **INTEGRATED TRAIN RAIL SYSTEM WITH TIES AND THERMAL EXPANSION JOINTS**

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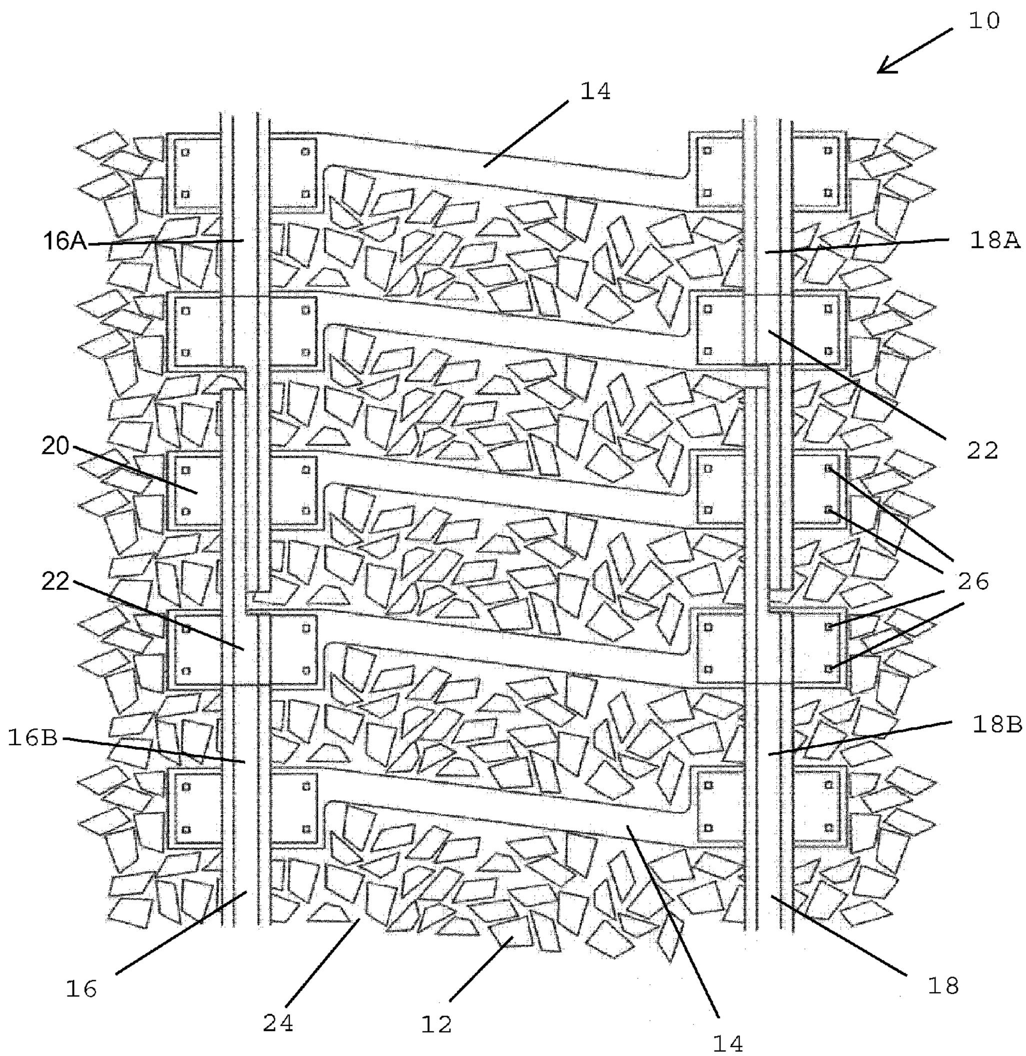
(57) **ABSTRACT**

A railroad tie that is positioned on a rail bed as part of a rail system comprises a first end section, a second end section, and a middle section The middle section extends between and couples the first end section and the second end section The first end section has a first width The second end section has a second width The middle section has a middle width that is at least five percent different than the first width and the second width The middle width can be at least five percent less than the first width and the second width Additionally, the first width can be substantially equal to the second width Further, the middle section can extend away from the first end section at a first angle of between approximately 75 and 95 degrees



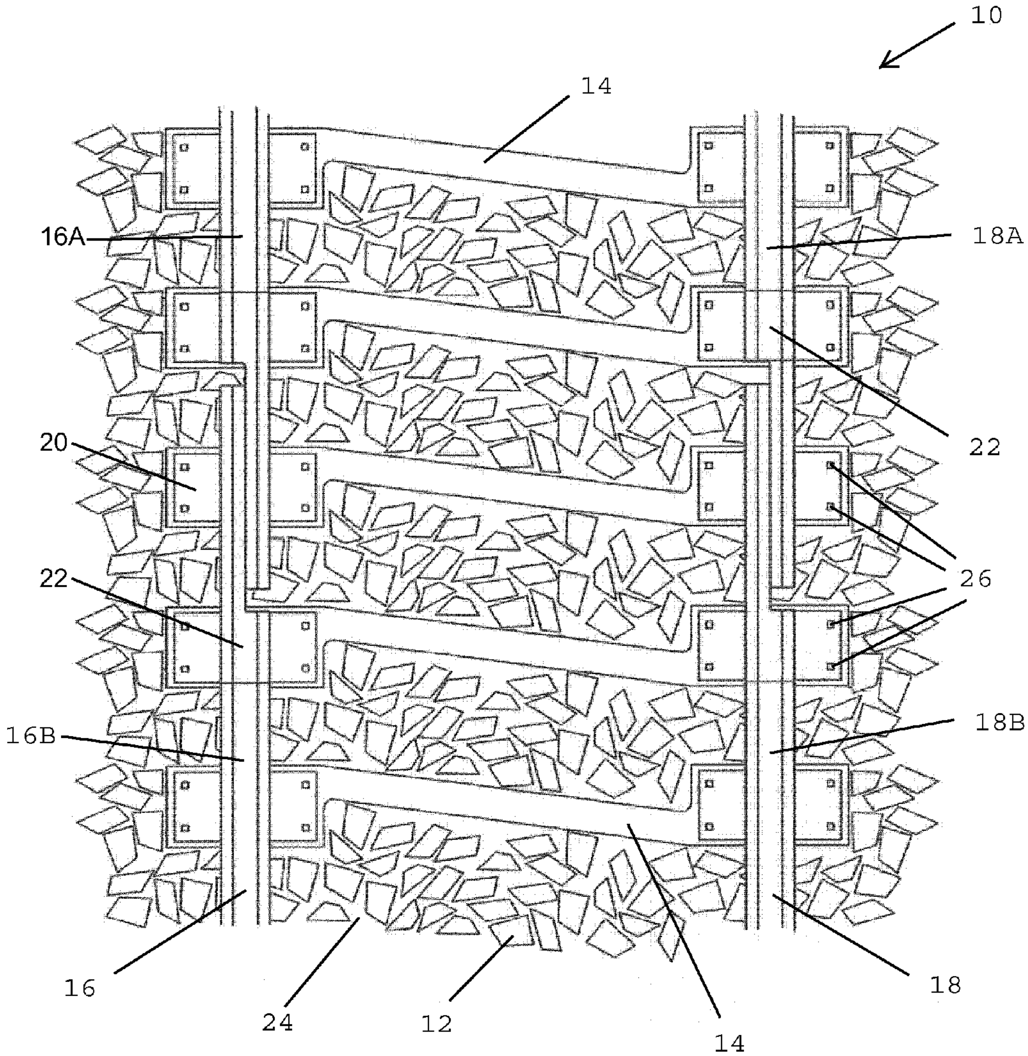
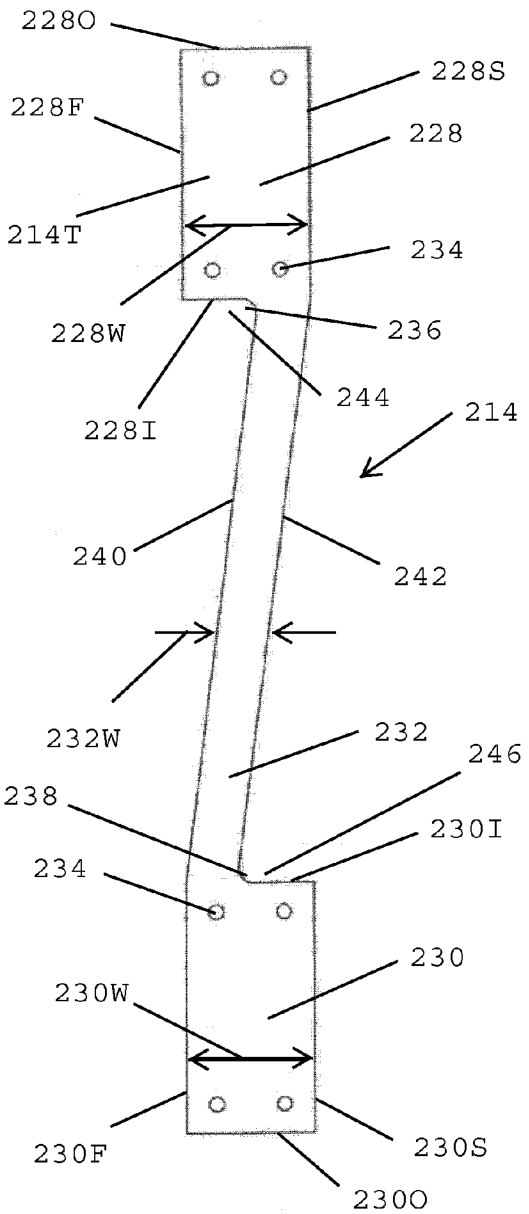


Fig. 1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228S
228F
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214T
234
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236
244
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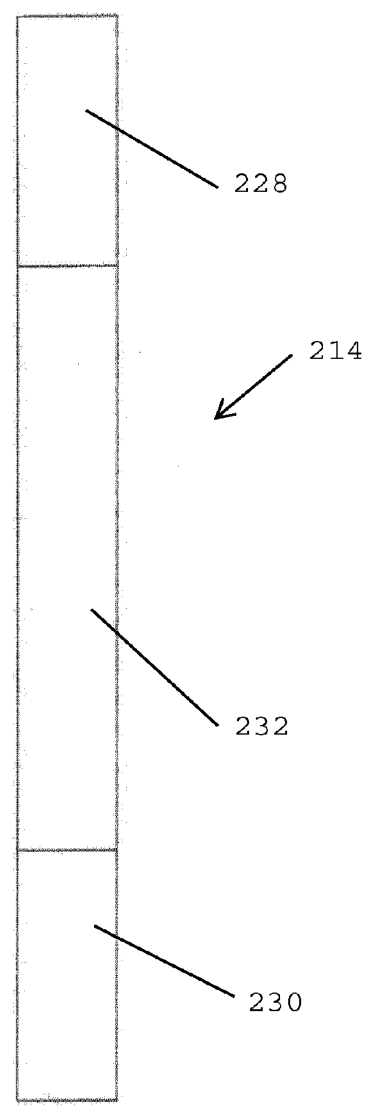
Fig. 2A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214
232
230

Fig. 2B

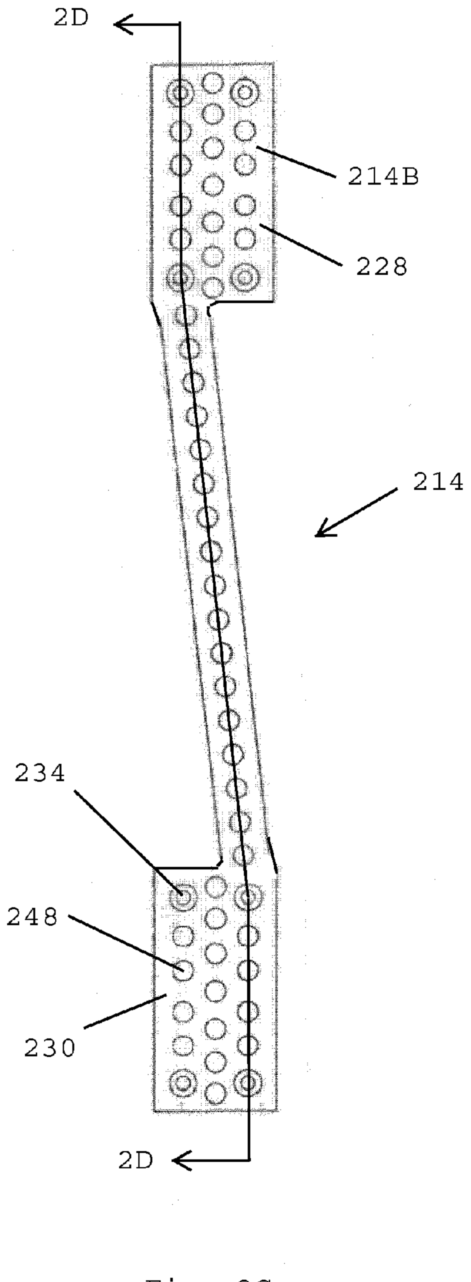


Fig. 2C

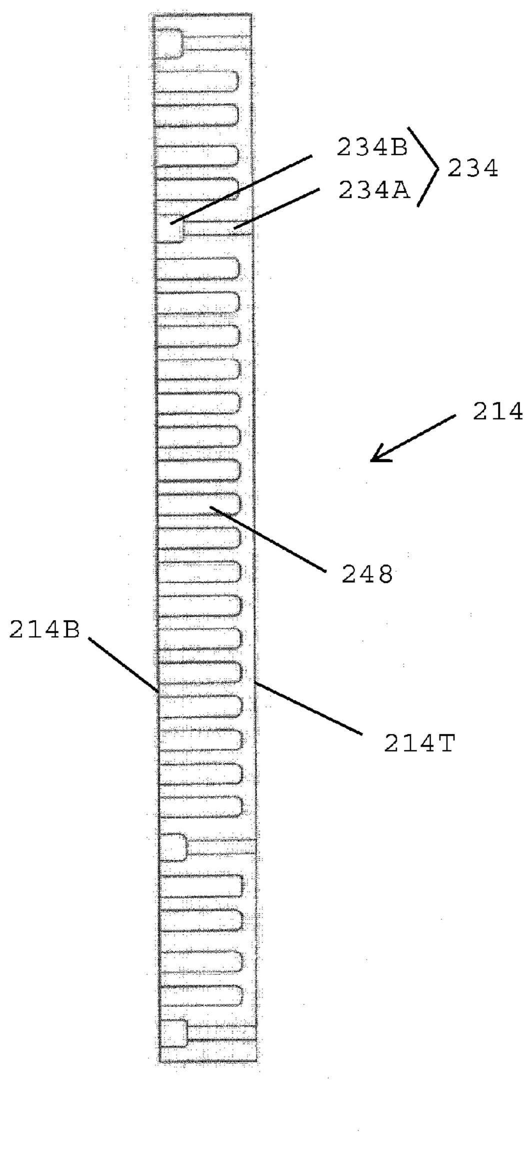
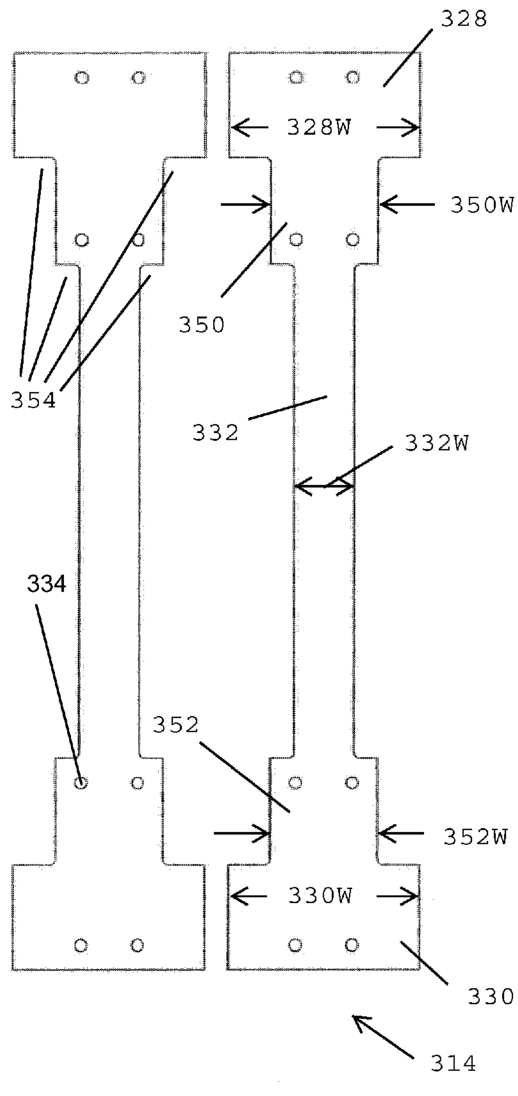


Fig. 2D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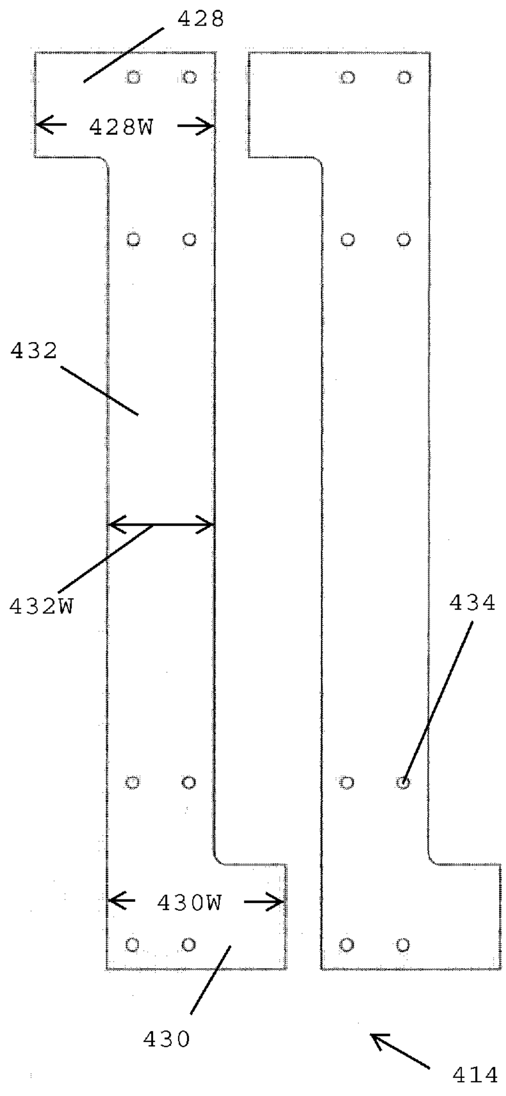
328W
350W
350
354
332
332W
334
352
352W
330W
330
314

Fig. 3


428
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432
432W
434
430W
430
414

Fig. 4

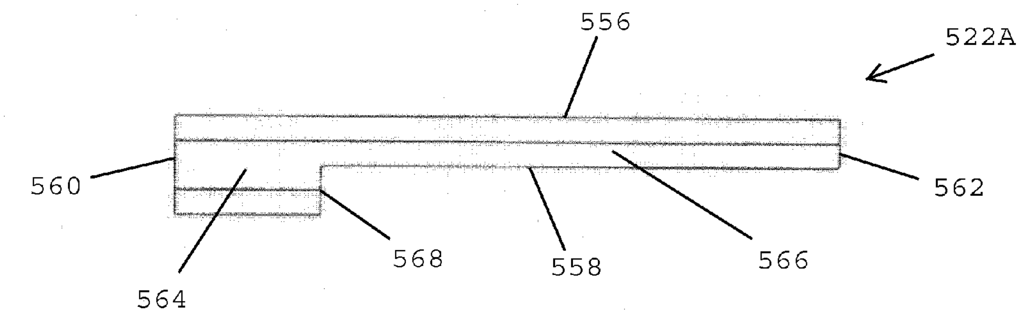

Fig. 5A

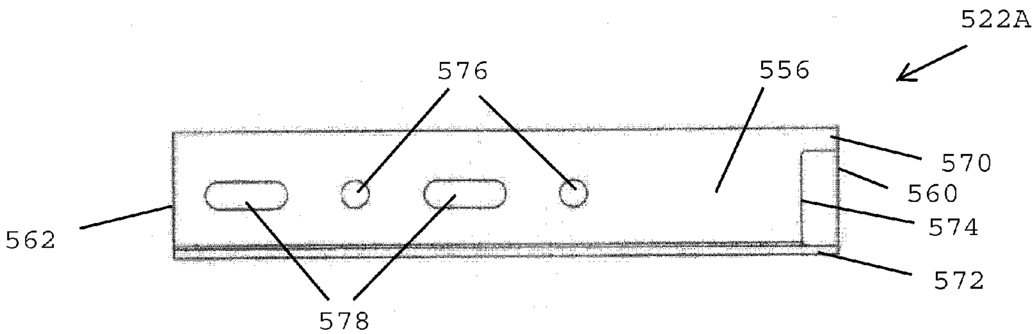

Fig. 5B

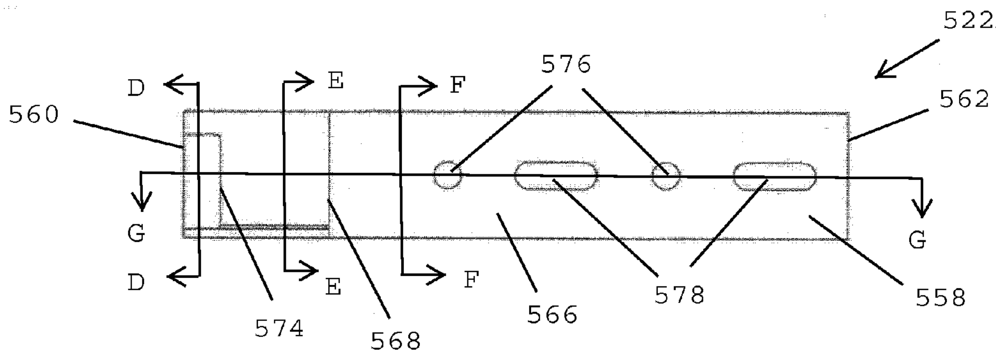

Fig. 5C

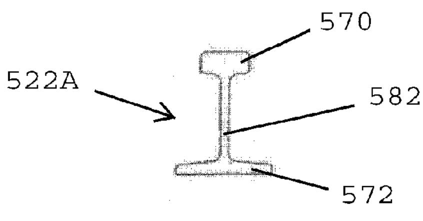

Fig. 5D

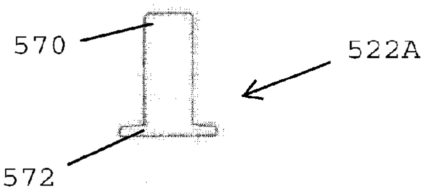

Fig. 5E

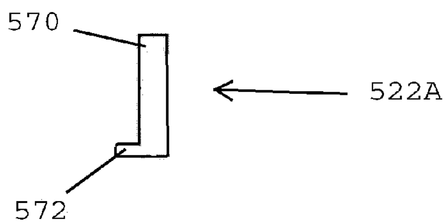

Fig. 5F

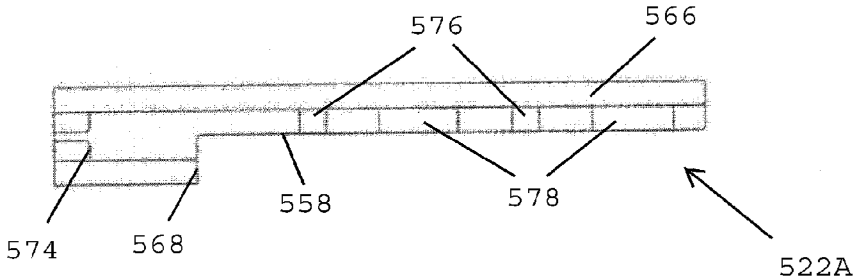

Fig. 5G

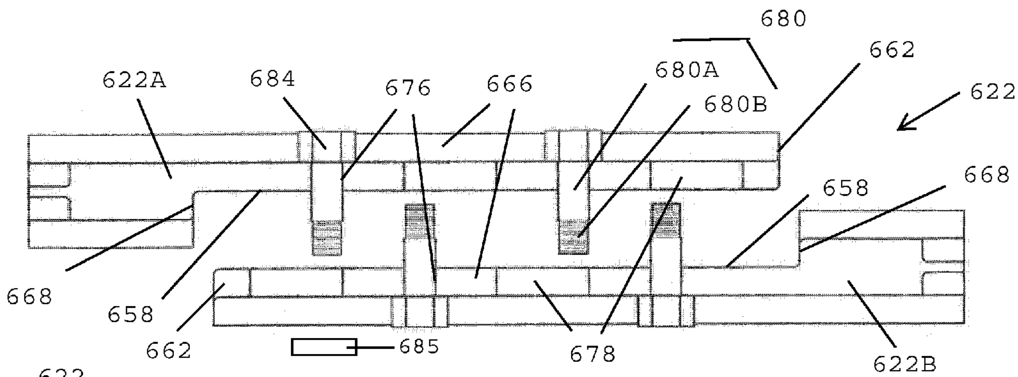

Fig. 6A

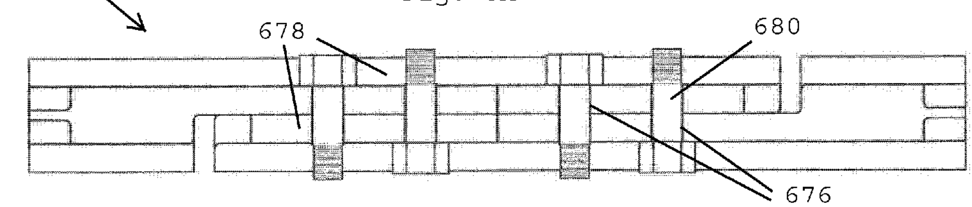

Fig. 6C

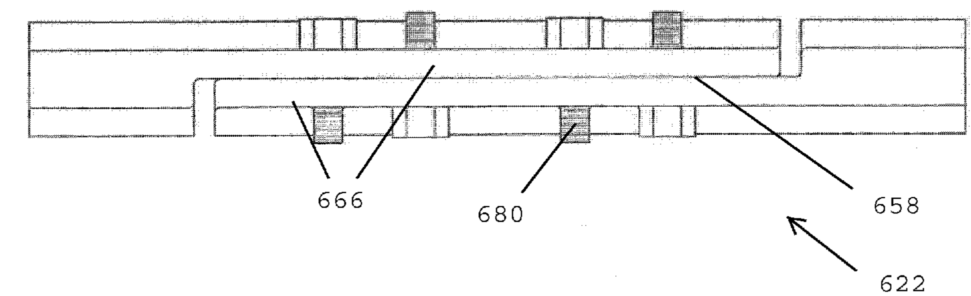

Fig. 6B

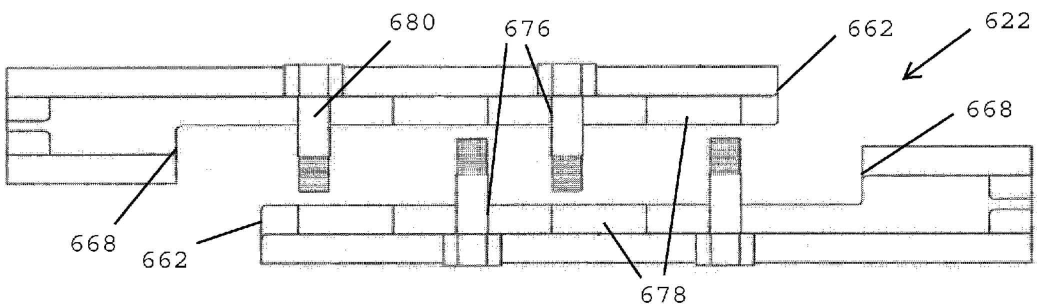

Fig. 6D

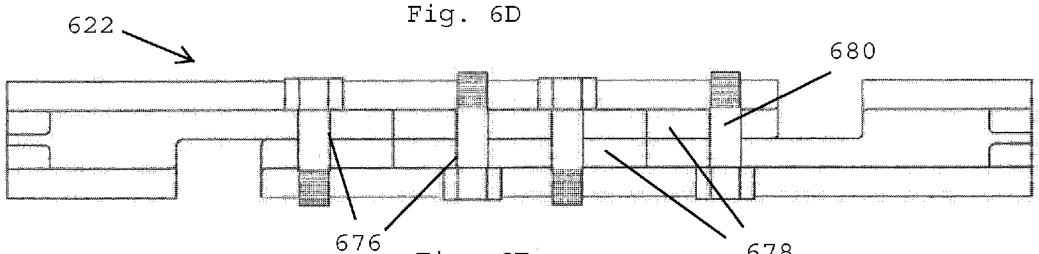

Fig. 6F

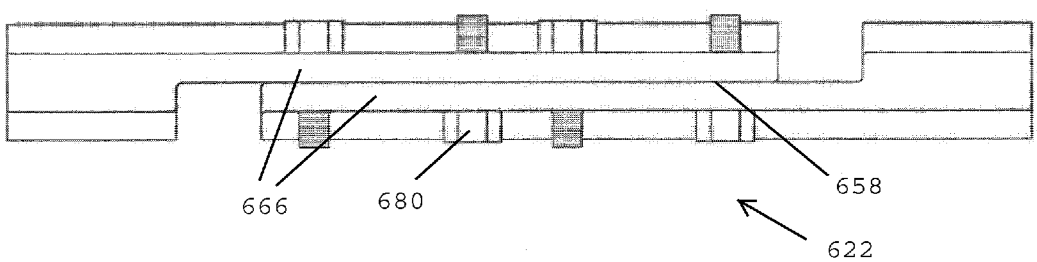

Fig. 6E

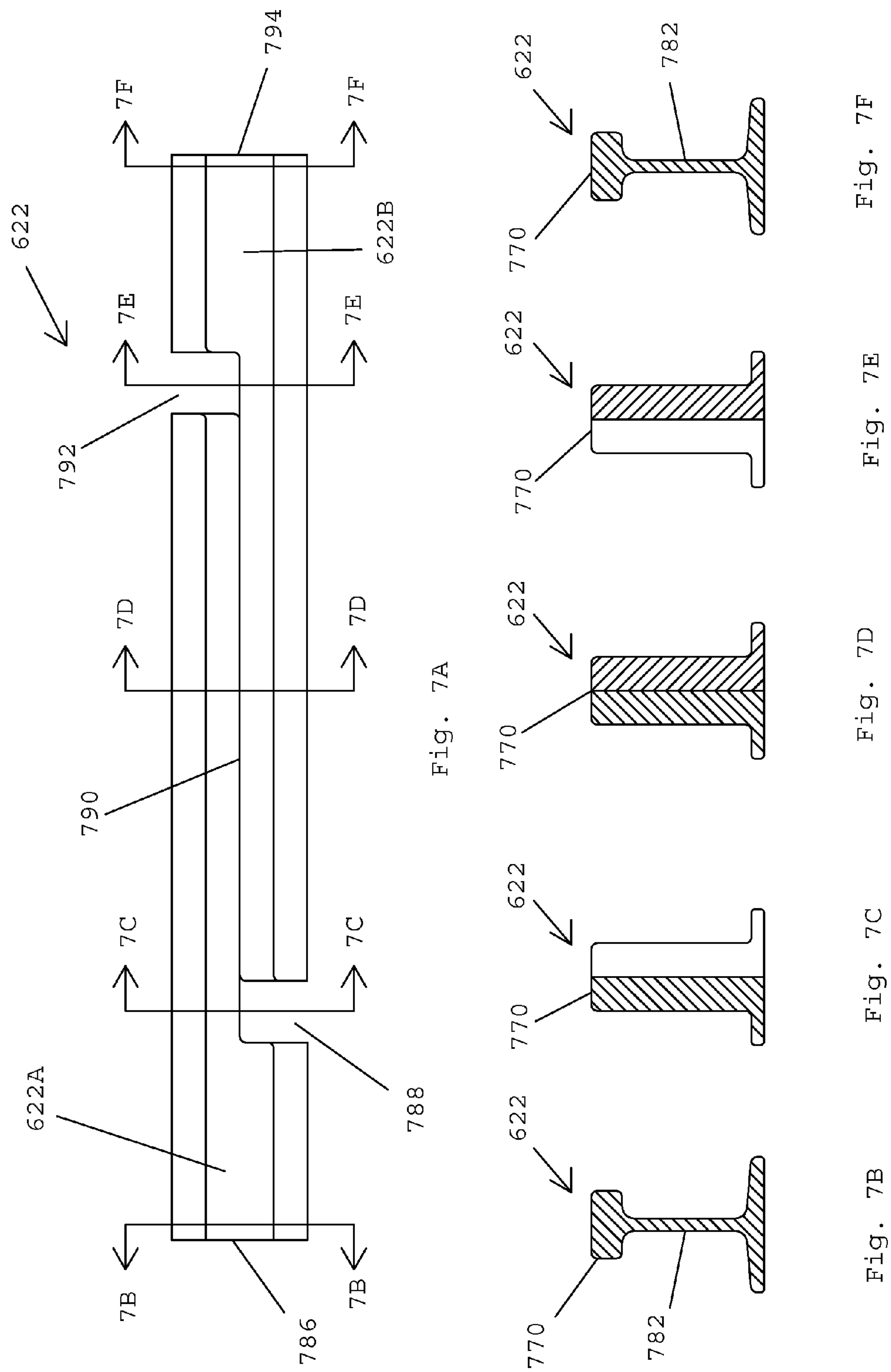

Fig. 7A

Fig. 7B

Fig. 7C

Fig. 7D

Fig. 7E

Fig. 7F

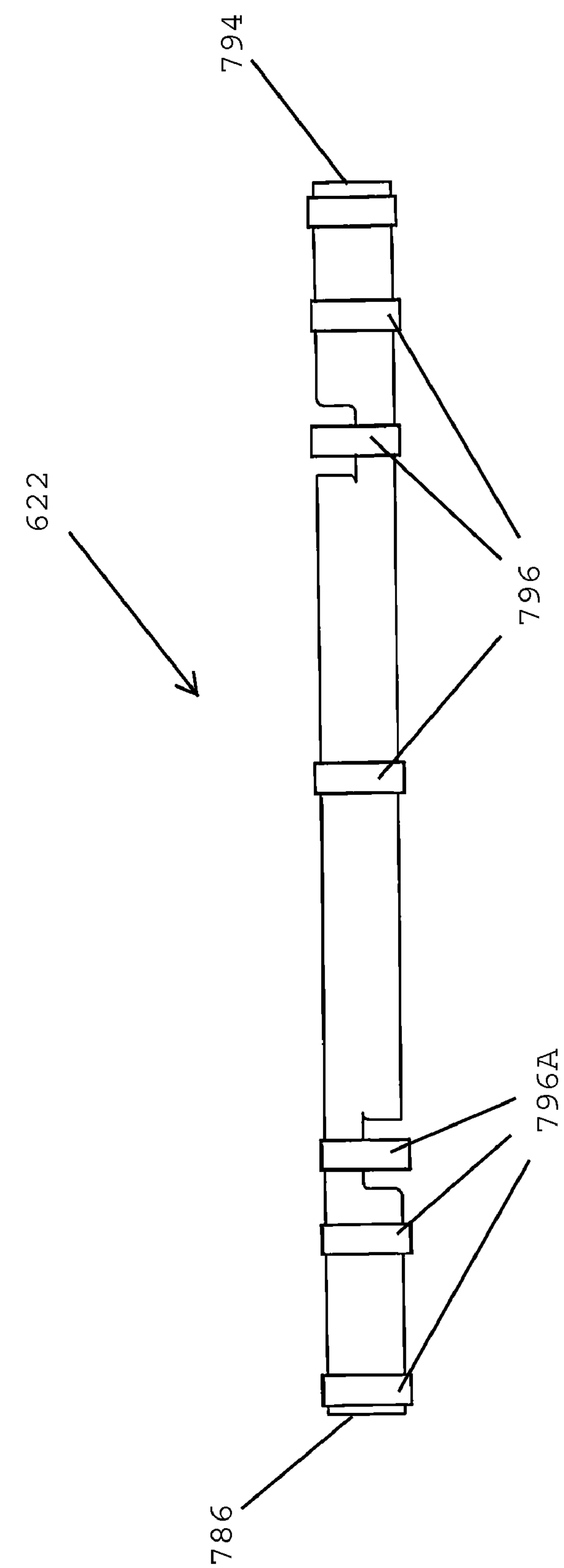

Fig. 7G

INTEGRATED TRAIN RAIL SYSTEM WITH TIES AND THERMAL EXPANSION JOINTS

BACKGROUND

[0001] Conventional train rail systems are comprised of six basic elements: (1) the steel rail; (2) the tie plate of "chair" that the rail sits on; (3) the railroad tie or "sleeper" to which two tie plates are affixed; (4) the fasteners that secure the rail to the tie plate and the railroad tie; (5) a joint system for adjoining consecutive lengths of rail sections; and (6) the foundation/bed of ballast rock within which the railroad ties rest and the track system is held in place.

[0002] Typical railroad ties are generally rectangular in shape and are generally laid transverse to the direction of the rails. Traditionally and most commonly, railroad ties are made of wood, although concrete, plastic and steel railroad ties are currently used as well.

[0003] Wood is the least expensive material used for the manufacturing of railroad ties, but it also has the shortest life cycle before needing replacement. For example, wooden railroad ties are more subject to weather related degradation, can be weakened due to insect attack, and are more likely to release the spike or screws that hold the rail to the tie plate. Additionally, the preservatives used to extend the life of the wood railroad ties can be an environmental contaminant.

[0004] Concrete railroad ties are considerably more expensive than wooden railroad ties and cannot be comingled with other types of railroad ties due to their weight and the different equipment required for handling and installation of the concrete railroad ties. Concrete railroad ties are also susceptible to stress cracking from the wheel loads moving across the railroad tie, do not absorb vibrations as well as other railroad ties, and do not attenuate the wheel to rail noise as well as other types of railroad ties. Further, concrete railroad ties can have accelerated failure due to incorrect cement recipes, insufficient curing time, and/or environmental degradation.

[0005] Plastic railroad ties are more expensive than wood and are not readily available in large quantities. Additionally, plastic railroad ties are more likely than concrete or wood to shift from side loads due to a lower coefficient of friction with the rock ballast.

[0006] Steel railroad ties typically last longer and are less susceptible to weather related degradation than wooden railroad ties. Additionally, steel railroad ties can absorb the thermal stresses, but the relatively lightweight steel ties utilized due to cost concerns results in steel tie systems that do not resist shifting of the rails from accumulated thermal loads. Moreover, steel railroad ties can cause grounding/electrical isolation problems for track signaling systems.

[0007] The predominant means for affixing consecutive sections of steel rail is butt-welding them together for a connected length being as much as a mile or longer. The single piece of welded rail is then installed onto the tie plates and railroad ties. Such continuous welded rail, or CWR, can be stronger than sectioned rail and can be less maintenance intensive. Typical steel rail is made from high quality hot rolled steel. Steel rail is subject to very high stress loads induced by the steel wheels of the train cars and environmental changes in the temperature. Accordingly, CWR faces certain intrinsic and serious problems that do not occur with sectioned rail that uses conventional expansion joints, in that they face significant thermal stresses as the steel used to make the rails expands in length when heated and contracts in length when cooled. Thus, the unsolved problem of thermal stress in CWR systems requires persistent, ongoing repair.

[0008] Thermally induced stress problems in the steel rails are a well recognized and well understood issue in the rail industry. Currently, expensive and elaborate expansion joints are sometimes used in the more vulnerable and valuable track sections of high-speed passenger lines, such as bridges and curves. Full resolution of the thermal stress problem can be accomplished by the frequent use of these types of expansion joints along the full length of track. However, doing so would greatly increase the costs of installing a rail system.

[0009] Therefore, a new rail system is needed that can have a relatively low installed cost; be significantly durable and weather resistant; successfully attenuate vibration and noise; allow for precise rail positioning; eliminate thermally induced stresses without a penalty in cost; not compromise rail strength at the section joints; be impervious to insect attack; eliminate environmental contamination from wood preservatives; greatly reduce track maintenance; increase operational performance; and increase passenger safety.

SUMMARY

[0010] The present invention is directed to a railroad tie that is positioned on a rail bed as part of a rail system. In certain embodiments, the railroad tie comprises a first end section, a second end section, and a middle section. The middle section extends between and couples the first end section and the second end section. The first end section has a first width. The second end section has a second width. Further, the middle section has a middle width that is at least five percent (5%) different than the first width and the second width.

[0011] In certain embodiments, the middle width is at least five percent (5%) less than the first width and the second width. In one such embodiment, the middle width is at least twenty-five percent (25%) less than the first width and the second width. Additionally, in one embodiment, the first width is substantially equal to the second width.

[0012] As a result of this design, (i) the first end section and the middle section cooperate to define a first pocket, and (ii) the second end section and the middle section cooperate to define a second pocket. In such embodiments, the pockets functions to inhibit relative movement between the railroad tie and the rail bed.

[0013] Further, in certain embodiments, the railroad tie is substantially Z-shaped. In such embodiments, the middle section extends away from the first end section at a first angle of between approximately seventy-five (75) and ninety-five (95) degrees. Still further, in one such embodiment, the middle section also extends away from the second end section at a second angle of between approximately seventy-five (75) and ninety-five (95) degrees.

[0014] Alternatively, in one embodiment, the railroad tie can be substantially dumbbell shaped. In such embodiment, the railroad tie further includes a first intermediate section and a second intermediate section. The first intermediate section is positioned between the first end section and the middle section. Additionally, the first intermediate section has a first intermediate width that is different than the first width and the middle width. Further, the second intermediate section is positioned between the second end section and the middle section. The second intermediate section has a second intermediate width that is different than the second width and the middle width.

[0015] In some embodiments, the railroad tie further includes a bottom surface and a top surface. In certain embodiments, the bottom surface has one or more cavities that each has an area at its opening that is at least approximately eighty (80) square millimeters. Further, the cavities can be substantially evenly spaced along the bottom surface. Additionally, in one such embodiment, the one or more cavities do not extend through the top surface.

[0016] Additionally, the present invention is directed to a rail system including a rail bed, a plurality of railroad ties that are positioned on the rail bed, and a pair of spaced apart rails that are coupled to the plurality of railroad ties. In some embodiments, the railroad ties have features as described above.

[0017] Still further, the present invention is directed to a rail joint for joining together a first rail section and a second rail section of a rail system that supports a rail vehicle, wherein the first rail section and the second rail section are positioned substantially along the same line. In certain embodiments, the rail joint comprises a first joint member and a second joint member. The second joint member is selectively coupled to the first joint member such that the second joint member at least partially overlaps the first joint member. In one embodiment, each joint member is designed to individually support the weight of the rail vehicle.

[0018] In certain embodiments, the first joint member is fixedly secured to the first rail section and the second joint member is fixedly secured to the second rail section.

[0019] Yet further, in some embodiments, the first joint member includes a first aperture and a first slot and the second joint member includes a second aperture and a second slot. In such embodiments, the rail joint further comprises a pair of connectors that extend through the first joint member and the second joint member to selectively couple the first joint member to the second joint member. For example, one connector can extend substantially through the first aperture and the second slot, and the other connector can extend substantially through the second aperture and the first slot. The connectors cooperate to allow relative translational movement between the first joint member and the second joint member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] The novel features of this invention, as well as the invention itself, both as to its structure and its operation, will be best understood from the accompanying drawings, taken in conjunction with the accompanying description, in which similar reference characters refer to similar parts, and in which:

[0021] FIG. **1** is a top view of an embodiment of a portion of a rail system having features of the present invention;

[0022] FIG. **2**A is a top view of an embodiment of a railroad tie having features of the present invention;

[0023] FIG. **2**B is a side view of the railroad tie illustrated in FIG. **2**A;

[0024] FIG. **2**C is a bottom view of the railroad tie illustrated in FIG. **2**A;

[0025] FIG. **2**D is a cross-sectional side view of the railroad tie taken along line **2**D-**2**D in FIG. **2**C;

[0026] FIG. **3** is a top view of another embodiment of a railroad tie having features of the present invention;

[0027] FIG. **4** is a top view of still another embodiment of a railroad tie having features of the present invention;

[0028] FIG. **5**A is a top view of an embodiment of a half expansion joint having features of the present invention;

[0029] FIG. **5**B is a side view of the half expansion joint illustrated in FIG. **5**A;

[0030] FIG. **5**C is a side view of the half expansion joint illustrated in FIG. **5**A;

[0031] FIG. **5**D is a cross-sectional end view of the half expansion joint cut along line **5**D-**5**D in FIG. **5**C;

[0032] FIG. **5**E is a cross-sectional end view of the half expansion joint cut along line **5**E-**5**E in FIG. **5**C;

[0033] FIG. **5**F is a cross-sectional end view of the half expansion joint cut along line **5**F-**5**F in FIG. **5**C;

[0034] FIG. **5**G is cross-sectional top view of the half expansion joint cut along line **5**G-**5**G in FIG. **5**C;

[0035] FIG. **6**A is a partially exploded top view of a rail expansion joint cut along line **5**F-**5**F having features of the present invention, wherein the rail expansion joint is being positioned in a contracted configuration;

[0036] FIG. **6**B is a top view of the rail expansion joint illustrated in FIG. **6**A;

[0037] FIG. **6**C is a cross-sectional top view cut along line **5**G-**5**G of the rail expansion joint of FIG. **6**B;

[0038] FIG. **6**D is a partially exploded top view of the rail expansion joint cut along line **5**G-**5**G illustrated in FIG. **6**A, wherein the rail expansion joint is being positioned in an expanded configuration;

[0039] FIG. **6**E is a top view of the rail expansion joint illustrated in FIG. **6**D;

[0040] FIG. **6**F is a cross-sectional top view cut along line **5**G-**5**G of the rail expansion joint of FIG. **6**E;

[0041] FIG. **7**A is a top view of the rail expansion joint illustrated in FIG. **6**A;

[0042] FIG. **7**B is a cross-sectional end view of the rail expansion joint cut along line **7**B-**7**B in FIG. **7**A;

[0043] FIG. **7**C is a cross-sectional end view of the rail expansion joint cut along line **7**C-**7**C in FIG. **7**A;

[0044] FIG. **7**D is a cross-sectional end view of the rail expansion joint cut along line **7**D-**7**D in FIG. **7**A;

[0045] FIG. **7**E is a cross-sectional end view of the rail expansion joint cut along line **7**E-**7**E in FIG. **7**A;

[0046] FIG. **7**F is a cross-sectional end view of the rail expansion joint cut along line **7**F-**7**F in FIG. **7**A; and

[0047] FIG. **7**G is a simplified top view of the rail expansion joint illustrated in FIG. **7**A and a portion of a rail vehicle.

DESCRIPTION

[0048] FIG. **1** is a top view of an embodiment of a portion of a rail system **10** having features of the present invention. As illustrated, the rail system **10** includes a rail bed **12**, a plurality of railroad ties **14** that are positioned on and/or within the rail bed **12**, a first rail **16** and a spaced apart second rail **18** that are supported on the railroad ties **14**, a plurality of tie plates **20** that couple the first rail **16** and the second rail **18** to the railroad ties **14**, and one or more rail joints **22**. As discussed in greater detail herein, the design of the various components of the rail system **10** can be varied to suit the specific design requirements of the rail system **10**.

[0049] As an overview, the rail system **10** of the present invention includes various features that enable the production and operation of a rail system **10** that has a reduced cost, higher strength, greater system integrity, is longer lasting, is safer, performs better, and that eliminates the need for almost constant maintenance.

[0050] In one embodiment, the rail bed **12** is made up of a plurality of ballast rocks that cooperate with the railroad ties **14** to inhibit the rails **16**, **18** from moving or shifting relative to a surface **24**, e.g., the ground, upon which the rail system **10** is situated. The ballast rocks in the rail bed **12** (also referred to herein as the ballast rock bed) have a tendency to settle and subside over time due to use, weathering effects, thermally induced loads and lateral forces toward the center of a curve as trains go through. Maintenance of the ballast rock bed **12** and keeping up the edges of the ballast rock bed **12** on the outside of the ends of the railroad ties **14**, i.e. maintaining the integrity and positioning of the ballast rocks that make up the rail bed **12**, is vital to maintaining the integrity of the rail system **10**. For example, when forces parallel to the length of the railroad ties **14** occur, it is the friction force due to the weight of the railroad ties **14** and the rails **16**, **18** plus any resistance by the ballast rocks of the rail bed **12** outside the ends of the railroad ties **14** that prevent shifting of the rails **16**, **18** relative to the surface **24**. Stated another way, correcting subsidence of the ballast rock bed **12** along the edges of the rail bed **12** outside the ends of the railroad ties **14** and keeping the ballast rock bed **12** intact is an important maintenance function in order to preserve the integrity of the rail system **10**.

[0051] As illustrated in FIG. **1**, the railroad ties **14** are positioned on and/or within the rail bed **12**. The railroad ties **14** (five of which are shown in FIG. **1**) are substantially evenly spaced apart from each other within the rail bed **12** with a plurality of ballast rocks positioned around and between each of the railroad ties **14**. As noted above, the railroad ties **14** and the ballast rocks of the rail bed **12** cooperate to inhibit the rails **16**, **18** from moving or shifting relative to the surface **24** on which the rail system **10** is situated. Stated another way, the railroad ties **14** are uniquely designed to interact with the ballast rocks of the rail bed **12** so that the railroad ties **14** will not shift relative to the surface **24** due the forces that act upon the railroad ties **14** from the movement of trains along the rails **16**, **18**.

[0052] The rails **16**, **18** are coupled to and are supported by the railroad ties **14** via the tie plates **20**. In particular, in the embodiment illustrated in FIG. **1**, there are two tie plates **20** secured to each railroad tie **14**, with one tie plate **20** being secured to each railroad tie **14** near either end of the railroad tie **14**. The rails **16**, **18** are mounted on the railroad ties **14** via the tie plates **20** such that the first rail **16** is mounted near one end of the railroad tie **14** and the second rail **18** is mounted near the other end of the railroad tie **14**.

[0053] The tie plates **20** are secured to the railroad ties **14** with one or more fasteners **26**. Stated another way, the rail system **10** includes one or more fasteners **26** that are designed to secure the rails **16**, **18** to each of the tie plates **20** and each of the railroad ties **14**. As illustrated in this embodiment, each tie plate **20** can be secured to a single railroad tie **14** with four fasteners **26**. Alternatively, each tie plate **20** can be secured to a single railroad tie **14** with more than four or less than four fasteners **26**. In certain embodiments, the fasteners **26** are carriage bolts that have a smooth, semi-spherical head above a lower square shoulder. Alternatively, a different type of fastener **26** may also be used without altering the breadth and scope of the present invention.

[0054] The one or more rail joints **22** are designed to couple together adjacent sections of rail. In particular, FIG. **1** illustrates that the first rail **16** includes a first rail section **16**A and a second rail section **16**B that are positioned substantially along a single line, wherein the first rail section **16**A and the second rail section **16**B are selectively coupled together with a rail joint **22**. Somewhat similarly, FIG. **1** illustrates that the second rail **18** includes a third rail section **18**A and a fourth rail section **18**B that are positioned substantially along a single line, wherein the third rail section **18**A and the fourth rail section **18**B are selectively coupled together with a rail joint **22**. As an overview, the rail joints **22**, as will be discussed in greater detail below, are uniquely designed to compensate for the possible thermal expansion of the rails **16**, **18** while maintaining the integrity and safety of the rail system **10**.

[0055] FIG. **2**A is a top view of an embodiment of a railroad tie **214** having features of the present invention. The design of the railroad tie **214** can be varied to suit the particular requirements of the rail system **10** (illustrated in FIG. **1**). In this embodiment, the railroad tie **214** has a shape that is similar to that of a narrow or tall "Z" shape, and the railroad tie **214** includes a first end section **228**, a spaced apart second end section **230**, and a middle section **232** that extends between and couples the first end section **228** and the second end section **230**.

[0056] In this embodiment, the first end section **228** has a first width **228**W and the second end section **230** has a second width **230**W. As illustrated, the first width **228**W and the second width **230**W can be substantially equal. Alternatively, the railroad tie **214** can be designed so that the first width **228**W is greater than or less than the second width **230**W. Further, the middle section **232** has a middle width **232**W that is different than the first width **228**W and the second width **230**W. In different embodiments, the middle width **232**W can be 5%, 10%, 15%, 25%, 40%, 50% or some other percent different than the first width **228**W and/or the second width **230**W. As illustrated, the middle width **232**W can be less than the first width **228**W and the second width **230**W. Alternatively, the middle width **232**W can be greater than the first width **228**W and/or greater than the second width **230**W.

[0057] As illustrated in FIG. **2**A, the first end section **228** is substantially rectangular in shape and includes a first side **228**F, an opposed second side **228**S that is substantially parallel to the first side **228**F, an outer end **228**O, and an opposed inner end **228**I that is substantially parallel to the outer end **228**O. Somewhat similarly, the second end section **230** is substantially rectangular in shape and includes a first side **230**F, an opposed second side **230**S that is substantially parallel to the first side **230**F, an outer end **230**O, and an opposed inner end **230**I that is substantially parallel to the outer end **230**O. Alternatively, the first end section **228** and the second end section **230** can be designed to have a different shape.

[0058] In this embodiment, each end section **228**, **230** includes a plurality of fastener apertures **234** that are each adapted to receive one of the fasteners **26** (illustrated in FIG. **1**) that are utilized to secure the tie plate **20** (illustrated in FIG. **1**) to the railroad tie **214**. In particular, as illustrated, each end section **228**, **230** can include four fastener apertures **234** that are positioned in a substantially rectangular shaped orientation relative to each other so as to each receive one of the fasteners **26** that are utilized to secure the tie plate to the railroad tie **214**. In certain alternative embodiments, the end sections **228**, **230** can be designed to include more than four or less than four fastener apertures **234**, the fastener apertures **234** can have a different orientation relative to each other, and/or the fastener apertures **234** can be positioned on a different part of the railroad tie **214**.

[0059] As illustrated in FIG. **2**A, the middle section **232** is substantially rectangular in shape and extends away from and between the inner end **228**I of the first end section **228** and the inner end **230**I of the second end section **230**. In particular, in this embodiment, the middle section **232** extends away from the inner end **228**I of the first end section **228** near the second side **228**S of the first end section **228**, and the middle section **232** extends away from the inner end **230**I of the second end section **230** near the first side **230**F of the second end section **230**, so as to form the substantially narrow "Z" shape of the railroad tie **214**.

[0060] In some embodiments, the middle section **232** extends away from the first end section **228** at a first angle **236** of between approximately 75 and 95 degrees, and the middle section **232** extends away from the second end section **230** at a second angle **238** of between approximately 75 and 95 degrees. In one such embodiment, the middle section **232** extends away from the first end section **228** at a first angle **236** of approximately 85 degrees, and the middle section **232** extends away from the second end section **230** at a second angle **238** of approximately 85 degrees. In alternative embodiments, the middle section **232** can have a different shape, the middle section **232** can be oriented differently relative to the first end section **228** and the second end section **230**, and/or the middle section **232** can extend away from the first end section **228** and the second end section **230** at different positions. For example, the middle section **232** can extend away from the first end section **228** at a first angle **236** of less than 75 degrees or greater than 95 degrees, and the middle section **232** can extend away from the second end section **230** at a second angle **238** of less than 75 degrees or greater than 95 degrees. Further, the middle section **232** can extend away from the inner end **228**I of the first end section **228** near the first side **228**F of the first end section **228**, and the middle section **232** can extend away from the inner end **230**I of the second end section **230** near the second side **230**S of the second end section **230**, so as to form a reversed narrow "Z" shape of the railroad tie **214**.

[0061] Additionally, as illustrated in FIG. **2**A, the middle section **232** of the railroad tie **214** has a first vertical face **240** and an opposed second vertical face **242** that intersect respectively with the inner end **228**I of the first end section **228** and the inner end **230**I of the second end section **230** with curved surfaces. The "Z" shaped profile or footprint of the railroad tie **214** creates a first pocket **244** in the area where the inner end **228**I of the first end section **228** meets with the first vertical face **240** of the middle section **232**, and creates a second pocket **246** where the inner end **230**I of the second end section **230** meets with the second vertical face **242** of the middle section **232**. After the railroad ties **214** have been installed on the rail bed **12** (illustrated in FIG. **1**) and ballast rocks have been filled in and around the assembled railroad ties **214** and up to a top surface **214**T of the railroad ties **214**, the first pocket **244** and the second pocket **246** provide a hook into and across the greater majority of the rail bed **12** in both directions perpendicular to the rails **16**, **18** (illustrated in FIG. **1**). These two pockets **244**, **246** of each railroad tie **214** provide far superior grip into the ballast rocks of the rail bed **12** so as to inhibit relative movement or shifting between the railroad ties **214** and the rail bed **12** when or if side loads are introduced to the rail system **10**.

[0062] In certain embodiments, the railroad tie **214** is a single, contiguous piece and not an assembly of numerous pieces. Alternatively, the first end section **228**, the second end section **230** and the middle section **232** can be formed separately and subsequently fixedly secured together to form the completed railroad tie **214**.

[0063] One method of manufacturing the railroad tie **214** would be conventional injection molding of the railroad tie **214** from virgin or recycled plastic. Another method of manufacturing the railroad tie **214** would be compression or ram-molding technique that would use a combination of finely ground plastic and sand as the material to be molded. In the compression or ram-molding technique a certain measure of the ground plastic would be uniformly mixed with an appropriate amount of conventional sand and then loaded within the lower cavity half of the mold pair. The upper mold half would be driven down and into the lower mold half with enough force to compress the sand and ground plastic mixture to create a cold flow of the plastic around the sand particles and binding them together. This process requires no added heat or cooling for the mixed plastic and sand or for the finished product. Similar compression or ram molding as described herein is known in other applications and results in a very tough finished product that is resistant to impact damage, equally capable of handling tension and compression loads as well as wood or plastic ties, resistant to weather damage, resistant to insect destruction, creates precision finished parts, quick to manufacture with no curing time required, long life cycle, does not generate any environmental contamination, can be fabricated from recycled or virgin plastics and has a lower anticipated cost than wood ties that have been treated with preservatives. Additional combinations of different materials can be used in the compression molding of the railroad ties **214** such as chipped ABS plastic from car bumpers, crumb rubber from tires and others. Still alternatively, another method can be utilized to fabricate the railroad tie **214** or other materials could be used without altering the breadth and scope of the present invention.

[0064] FIG. **2**B is a side view of the railroad tie **214** illustrated in FIG. **2**A. In particular, FIG. **2**B illustrates that the railroad tie **214** is designed to have a substantially uniform thickness or height throughout the first end section **228**, the second end section **230** and the middle section **232**. Alternatively, the first end section **228**, the second end section **230** and the middle section **232** can be designed so that one or more of the sections **228**, **230**, **232** have a different thickness than the other sections **228**, **230**, **232**.

[0065] FIG. **2**C is a bottom view of the railroad tie **214** illustrated in FIG. **2**A. As illustrated in FIG. **2**C, the railroad tie **214** further includes a bottom surface **214**B having the plurality of fastener apertures **234** and one or more cavities **248**.

[0066] As noted above, the plurality of fastener apertures **234** are each adapted to receive one of the fasteners **26** (illustrated in FIG. **1**) that are utilized to secure the tie plate **20** (illustrated in FIG. **1**) to the railroad tie **214**. In particular, as illustrated, each end section **228**, **230** can include four fastener apertures **234** that are positioned in a substantially rectangular shaped orientation relative to each other so as to each receive one of the fasteners **26** that are utilized to secure the tie plate to the railroad tie **214**. In certain alternative embodiments, the end sections **228**, **230** can be designed to include more than four or less than four fastener apertures **234**, the fastener apertures **234** can have a different orientation relative to each other, and/or the fastener apertures **234** can be positioned on a different part of the railroad tie **214**.

[0067] In the embodiment illustrated in FIG. **2**C, the railroad tie **214** includes numerous cavities **248** that are substantially evenly spaced apart along the bottom surface **214**B of the railroad tie **214**. In certain embodiments, the cavities **248**

are substantially circular shaped and can be at least approximately one centimeter or ten millimeters (0.39 inches) in diameter. Stated another way, in such embodiments, the cavities **248** can be at least approximately 0.80 square centimeters or eighty square millimeters. In particular, FIG. **2**C illustrates that the railroad tie **214** can include 47 cavities **248** that are at least approximately one centimeter in diameter. In certain alternative embodiments, the railroad tie **214** can be designed to include more than or less than 47 cavities **248**, the cavities **248** can be designed to have a different size or shape, and/or the cavities **248** can have a different positioning along the bottom surface **214**B of the railroad tie **214**. For example, the cavities **248** can have a diameter that is at least approximately 0.5 centimeters, 0.75 centimeters, 1.25 centimeters, 1.5 centimeters, 2 centimeters, or some other size. Further, the cavities **248** can be square shaped, rectangle shaped, hexagon shaped, octagon shaped, oval shaped, or some other shape. In an embodiment that includes numerous cavities **248** that are substantially square shaped, the openings to the cavities **248** can have sides that are approximately 0.9 centimeters or nine millimeters in length to result in the same approximate area at the opening, e.g., approximately eighty square millimeters, as the cavities **248** discussed above.

[0068] The intent of the cavities **248** is to reduce the total volume and weight of the railroad tie **214** for ease of manufacture, lower cost of manufacturing with less material, shorter cycle time, generate more consistent material thickness throughout the railroad tie **214**, and provide slight recesses for grabbing on to the sharp edges and points of the ballast rocks of the rail bed **12** (illustrated in FIG. **1**) upon which the bottom surface **214**B of the railroad tie **214** rests when installed. Stated another way, the cavities **248** cooperate with the pockets **244**, **246** (illustrated in FIG. **2**A) of each railroad tie **214** to provide far superior grip into the ballast rocks of the rail bed **12** so as to inhibit relative movement or shifting between the railroad ties **214** and the rail bed **12** when or if side loads are introduced to the rail system **10** (illustrated in FIG. **1**).

[0069] FIG. **2**D is a cross-sectional side view of the railroad tie **214** cut along line 2D-2D in FIG. **2**C. As illustrated in FIG. **2**D, the fastener apertures **234** are designed to extend fully through the bottom surface **214**B and the top surface **214**T of the railroad tie **214**. In particular, the fastener aperture **234** includes a cylindrical pathway **234**A that extends away from the top surface **214**T of the railroad tie **214**, and a shorter, wider diameter cylindrical recess **234**B that is positioned adjacent to the bottom surface **214**B of the railroad tie **214**. The cylindrical pathway **234**A and the cylindrical recess **234**B are substantially concentric with each other. The fastener apertures **234** are designed so that the shank of the fastener **234** (illustrated in FIG. **1**), e.g., the carriage bolt, would pass though the cylindrical pathway **234**A and into the cylindrical recess **234**B. The overall length of the fastener **234** would be just less than the height of the railroad tie **214** plus the thickness of the tie plate **20** (illustrated in FIG. **1**). The fastener **234** would include a threaded portion that would reside in the cylindrical recess **234**B, which would have a sufficient diameter for a conventional threaded nut to be fastened onto the threaded portion of the fastener **234** with a conventional socket without interference. When assembled, no portion of the fasteners **234**, i.e. not the carriage bolt or the threaded nut, would extend below the bottom surface **214**B of the railroad tie **214**.

[0070] Additionally, as illustrated in FIG. **2**D, the cavities **248** can be substantially cylindrical shaped and can penetrate the bottom surface **214**B of the railroad tie **214** for a distance somewhat less than the overall vertical height of the railroad tie **214**. Stated another way, the cavities **248** do not extend through the top surface **214**T of the railroad tie **214**. In alternative, non-exclusive embodiments, the cavities **248** have a depth that is approximately 60, 70, 80, or 90 percent of the overall vertical height of the railroad tie **214**.

[0071] FIG. **3** is a top view of another embodiment of a pair of railroad ties **314** having features of the present invention. This embodiment can provide similar functional benefits as described herein above for the railroad tie **214** illustrated in FIG. **2**A. In this embodiment, the railroad ties **314** again include a first end section **328**, a spaced apart second end section **330**, and a middle section **332** that extends between and couples the first end section **328** and the second end section **330**. Additionally, the railroad ties **314** can further include a first intermediate section **350** that is positioned substantially between the first end section **328** and the middle section **332**, and a second intermediate section **352** that is positioned substantially between the second end section **330** and the middle section **332**. As illustrated, the railroad ties **314** can have a shape that is somewhat similar to that of dumbbell weights.

[0072] In this embodiment, the first end section **328** has a first width **328**W and the second end section **330** has a second width **330**W. As illustrated, the first width **328**W and the second width **330**W can be substantially equal. Alternatively, the railroad tie **314** can be designed so that the first width **328**W is greater than or less than the second width **330**W. Further, the middle section **332** has a middle width **332**W that is different than the first width **328**W and the second width **330**W. In different embodiments, the middle width **332**W can be 5%, 10%, 15%, 25%, 40%, 50% or some other percent different than the first width **328**W and/or the second width **330**W. As illustrated, the middle width **332**W can be less than the first width **328**W and the second width **330**W. Alternatively, the middle width **332**W can be greater than the first width **328**W and/or greater than the second width **330**W.

[0073] Additionally, the first intermediate section **350** has a first intermediate width **350**W that is different than the first width **328**W and the middle width **332**W, and the second intermediate section **352** has a second intermediate width **352**W that is different than the second width **330**W and the middle width **332**W. As illustrated, the first intermediate width **350**W can be less than the first width **328**W and greater than the middle width **332**W, and the second intermediate width **352**W can be less than the second width **330**W and greater than the middle width **332**W. Alternatively, the first intermediate width **350**W can be greater than the first width **328**W and/or less than the middle width **332**W, and the second intermediate width **352**W can be greater than the second width **330**W and/or less than the middle width **332**W. Further, in this embodiment, the first intermediate width **350**W and the second intermediate width **352**W are substantially equal. In alternative embodiments, the first intermediate width **350**W can be greater than or less than the second intermediate width **352**W.

[0074] As illustrated in FIG. **3**, the first end section **328** is substantially rectangular in shape, the second end section **330** is substantially rectangular in shape, the first intermediate section **350** is substantially rectangular in shape and extends substantially perpendicularly away from the first end section

328 toward the second end section **330** from a center of the first end section **328**, the second intermediate section **352** is substantially rectangular in shape and extends substantially perpendicularly away from the second end section **330** toward the first end section **328** from a center of the second end section **330**, and the middle section **332** is substantially rectangular in shape and extends substantially perpendicularly between the first intermediate section **350** and the second intermediate section **352** from a center of the first intermediate section **350** to a center of the second intermediate section **352**. In alternative embodiments, the first end section **328**, the second end section **330**, the first intermediate section **350**, the second intermediate section **352** and the middle section **332** can have different shapes, the sections **328**, **330**, **332**, **350**, **352** can be oriented differently relative to each other, and/or the sections **328**, **330**, **332**, **350**, **352** can extend away from each other at different positions.

[0075] Further, in this embodiment, the different sections **328**, **330**, **332**, **350**, **352** of the railroad tie **314** cooperate to form eight pockets **354** in order to provide far superior grip into the ballast rocks of the rail bed **12** (illustrated in FIG. **1**) so as to inhibit relative movement or shifting between the railroad ties **314** and the rail bed **12** when or if side loads are introduced to the rail system **10** (illustrated in FIG. **1**).

[0076] Although not shown herein, this railroad tie **314** could also include molded in cavities similar to the cavities **248** found in the railroad tie **214** illustrated in FIG. **2**C.

[0077] In this embodiment, each tie plate **20** (illustrated in FIG. **1**) is again secured to the railroad tie **314** with four fasteners **26** (illustrated in FIG. **1**), which extend through the four fastener apertures **334** that are shown near either end of the railroad tie **314**. In particular, two fastener apertures **334** are positioned within each end section **328**, **330** and two fastener apertures **334** are positioned within each intermediate section **350**, **352**. Alternatively, each tie plate **20** can be secured to the railroad tie **314** with more than four or less than four fasteners **26**, and/or the fastener apertures **334** that are adapted to receive the fasteners **26** can be positioned in different areas of the railroad tie **314**.

[0078] FIG. **4** is a top view of still another embodiment of a pair of railroad ties **414** having features of the present invention. This embodiment can provide similar functional benefits as described herein above for the railroad tie **214** illustrated in FIG. **2**A. As illustrated, the railroad ties **414** can have a shape that could be described as an erect or straight "Z" shape. In this embodiment, the railroad ties **414** again include a first end section **428**, a spaced apart second end section **430**, and a middle section **432** that extends between and couples the first end section **428** and the second end section **430**.

[0079] In this embodiment, the first end section **428** has a first width **428**W and the second end section **430** has a second width **430**W. As illustrated, the first width **428**W and the second width **430**W can be substantially equal. Alternatively, the railroad tie **414** can be designed so that the first width **428**W is greater than or less than the second width **430**W. Further, the middle section **432** has a middle width **432**W that is different than the first width **428**W and the second width **430**W. In different embodiments, the middle width **432**W can be 5%, 10%, 15%, 25%, 40%, 50% or some other percent different than the first width **428**W and/or the second width **430**W. As illustrated, the middle width **432**W can be less than the first width **428**W and the second width **430**W. Alternatively, the middle width **432**W can be greater than the first width **428**W and/or greater than the second width **430**W.

[0080] As illustrated in FIG. **4**, the first end section **428** is substantially rectangular in shape, the second end section **430** is substantially rectangular in shape, and the middle section **432** is substantially rectangular in shape and extends substantially perpendicularly between the first end section **428** and the second end section **430** from near a side of the first end section **428** to near a side of the second end section **430**. In alternative embodiments, the first end section **428**, the second end section **430**, and the middle section **432** can have different shapes, the sections **428**, **430**, **432** can be oriented differently relative to each other, and/or the sections **428**, **430**, **432** can extend away from each other at different positions.

[0081] Further, in this embodiment, the different sections **428**, **430**, **432** of the railroad tie **414** cooperate to form two pockets **454** in order to provide far superior grip into the ballast rocks of the rail bed **12** (illustrated in FIG. **1**) so as to inhibit relative movement or shifting between the railroad ties **414** and the rail bed **12** when or if side loads are introduced to the rail system **10** (illustrated in FIG. **1**).

[0082] Although not shown herein, this railroad tie **414** could also include molded in cavities similar to the cavities **248** found in the railroad tie **214** illustrated in FIG. **2**C.

[0083] In this embodiment, each tie plate **20** (illustrated in FIG. **1**) is again secured to the railroad tie **414** with four fasteners **26** (illustrated in FIG. **1**), which extend through the four fastener apertures **434** that are shown near either end of the railroad tie **414**. In particular, two fastener apertures **434** are positioned within each end section **428**, **430** and four fastener apertures **434** are positioned within the middle section **432** with two of the fastener apertures **434** being positioned near each end section **428**, **430**. Alternatively, each tie plate **20** can be secured to the railroad tie **414** with more than four or less than four fasteners **26**, and/or the fastener apertures **434** that are adapted to receive the fasteners **26** can be positioned in different areas of the railroad tie **414**.

[0084] FIG. **5**A is a top view of an embodiment of a half expansion joint **522**A having features of the present invention. The design of the half expansion joint **522**A can be varied to suit the specific design of the rails **16**, **18** (illustrated in FIG. **1**) and to suit the specific requirements of the rail system **10** (illustrated in FIG. **1**). In particular, the half expansion joint **522**A is designed so that at least a portion of the half expansion joint **522**A has a cross-sectional shape that matches the cross-sectional shape of the rails **16**, **18** with which the half expansion joint **522**A will be used.

[0085] Additionally, in use, and as will be discussed in detail below, the half expansion joint **522**A is designed to be utilized with a second half expansion joint **622**B (illustrated in FIG. **6**A) that can be substantially identical in design in order to form a complete rail joint **622** (illustrated in FIG. **6**A). For example, in joining together the first rail section **16**A (illustrated in FIG. **1**) and the second rail section (illustrated in FIG. **1**) of the first rail **16**, one of the half expansion joints **522**A, **622**B will be fixedly secured, e.g., via butt-welding, to the first rail section **16**A and the other half expansion joint **522**A, **622**B will be fixedly secured to the second rail section **16**B.

[0086] As an overview, the half expansion joint **522**A is designed to have sufficient strength throughout its length to independently support the weight of a train or other rail vehicle as it moves over the rail joint **622**, even in those portions of the rail joint **622** where the half expansion joints **522**A, **622**B do not overlap.

[0087] As shown in the embodiment illustrated in FIG. 5A, the half expansion joint 522A includes a first side 556, a second side 558, a first end 560, a second end 562, a front section 564 that extends away from the first end 560, an overlap section 566 that extends between the front section 564 and the second end 562, and a first vertical face 568 that defines part of the front section 564 and that forms a portion of the border between the front section 564 and the overlap section 566. Stated another way, the front section 564 extends from the first end 560 to the first vertical face 568, and the overlap section 566 extends from the first vertical face 568 to the second end 562.

[0088] As viewed from the top view, as illustrated in FIG. 5A, the first side 556 of the half expansion joint 522A is substantially linear along the entire length of the first side 556. In contrast, as viewed from the top view, the second side 558 includes a stepped portion that is formed by the first vertical face 568 such that the width of the overlap section 566 is approximately one-half the width of the front section 564.

[0089] FIG. 5B is a side view of the half expansion joint 522A illustrated in FIG. 5A. In particular, FIG. 5B illustrates certain features of the half expansion joint 522A as viewed from the first side 556 of the half expansion joint 522A. As illustrated in FIG. 5B, the half expansion joint 522A further includes a head 570, a foot 572, a second vertical face 574, a pair of joint apertures 576, and a pair of joint slots 578. In alternative embodiments, the half expansion joint 522A can include more or less than two joint apertures 576 and/or more or less than two joint slots 578.

[0090] During use, the head 570 of the half expansion joint 522A will cooperate with the top of the rails 16, 18 to form a substantially uniform surface along which the wheels of the train will ride. Additionally, the foot 572 of the half expansion joint 522A coincides with the bottom of the rails 16, 18 and is secured to the railroad ties 14 (illustrated in FIG. 1) in a similar manner as the rails 16, 18 are secured to the railroad ties 14.

[0091] As illustrated, the second vertical face 574 is positioned near the first end 560 of the half expansion joint 522A. The second vertical face 574 and the first vertical face 568 (illustrated in FIG. 5A) help to define the portions of the half expansion joint 522A where the cross-section of the half expansion joint 522A varies from the first end 560 to the second end 562.

[0092] In the embodiment illustrated in FIG. 5B, the pair of joint apertures 576 extend fully through the half expansion joint 522A from the first side 556 to the second side 558 (illustrated in FIG. 5C). In this embodiment, the joint apertures 576 are substantially circular in shape and are each adapted to receive a connector 680 (illustrated in FIG. 6A) in order to selectively couple the first half expansion joint 622A (illustrated in FIG. 6A) to the second half expansion joint 622B (illustrated in FIG. 6A). Alternatively, the joint apertures 576 can be designed to have a different shape.

[0093] Additionally, in the embodiment illustrated in FIG. 5B, the pair of joint slots 578 extend fully through the half expansion joint 522A from the first side 556 to the second side 558. In this embodiment, the joint slots 578 have ends that are substantially semi-circular in shape and that are substantially identical in diameter to the joint apertures 576. The joint slots 578 are also each adapted to receive a portion of the connector 680 in order to selectively couple the first half expansion joint 622A to the second half expansion joint 622B. Alternatively, the joint slots 578 can be designed so that the ends have a different shape.

[0094] FIG. 5C is a side view of the half expansion joint 522A illustrated in FIG. 5A. In particular, FIG. 5C illustrates certain features of the half expansion joint 522A as viewed from the second side 558 of the half expansion joint 522A. As viewed from the second side 558 of the half expansion joint 522A, the joint apertures 576 and the joint slots 578 are visible to demonstrate that the joint apertures 576 and the joint slots 578 do extend fully through the half expansion joint 522A from the first side 556 (illustrated in FIG. 5B) to the second side 558. Additionally, in FIG. 5C, both the first vertical face 568 and the second vertical face 574 are visible. Further, with the overlap section 566 extending from the first vertical face 568 to the second end 562, FIG. 5C illustrates that the joint apertures 576 and the joint slots 578 are all positioned within the overlap section 566 of the half expansion joint 522A.

[0095] In one non-exclusive embodiment, the half expansion joint 522A has three different cross-sections as one moves from the first end 560 to the second end 562 of the half expansion joint, as illustrated in FIGS. 5D-5F. In particular, FIG. 5D is a cross-sectional end view of the half expansion joint 522A cut along line 5D-5D in FIG. 5C; FIG. 5E is a cross-sectional end view of the half expansion joint 522A cut along line 5E-5E in FIG. 5C; and FIG. 5F is cross-sectional end view of the half expansion joint 522A cut along line 5F-5F in FIG. 5C.

[0096] FIG. 5D illustrates the first cross-section of the half-expansion joint 522A, which extends from the first end 560 (illustrated in FIG. 5C) to the second vertical face 574 (illustrated in FIG. 5C). The first cross-section, as illustrated in FIG. 5D, is designed to match the cross-sectional profile of the rail section 16A, 16B, 18A, 18B (illustrated in FIG. 1) to which the half expansion joint 522A is being fixedly secured in order to enable a smooth transition for the train as it travels from the rail section 16A, 16B, 18A, 18B to the half expansion joint 522A and/or from the half expansion joint 522A to the rail section 16A, 16B, 18A, 18B.

[0097] In the embodiment illustrated herein, the first cross-section includes the head 570, the foot 572 and a web 582 that extends between the head 570 and the foot 572. As shown, the foot 572 is somewhat wider than the head 570 and the web 582 is substantially narrower than both the head 570 and the foot 572. This first cross-section is a profile of a typical Vignoles or flat bottom rail.

[0098] FIG. 5E illustrates the second cross-section of the half expansion joint 522A, which extends from the second vertical face 574 (illustrated in FIG. 5C) to the first vertical face 568 (illustrated in FIG. 5C). In the second cross-section, the web portion is essentially eliminated, and the half expansion joint 522A maintains the same width from the head 570 all the way down to the foot 572. Stated another way, in the second cross-section, the vertical edges of the head 570 have been extended down to intersect with the foot 572 of the half expansion joint 522A. In particular, in the transition zone, the unique design of the half expansion joint 522A includes this second cross-section wherein the web portion has been fully extended to the outer edges of the head 570. This widened cross-section for the full rail height is sufficient for the half expansion joint 522A to carry fully loaded rail cars.

[0099] FIG. 5F illustrates the third cross-section of the half expansion joint 522A, which extends from the first vertical face **568** (illustrated in FIG. **5**C) to the second end **562** (illustrated in FIG. **5**C). As such, the third cross-section is present through the entire length of the overlap section **566** (illustrated in FIG. **5**A) of the half expansion joint **522**A. The third cross-section essentially encompasses the same profile as the second cross-section as found in FIG. **5**E, but the profile has been vertically cut in half. Accordingly, in the third cross-section, the head **570** as it extends all the way down to the foot **572** has a width that is approximately one-half of the width of the head **570** in the second cross-section. Further, in the third cross-section, the foot **572** has a width that is approximately one-half of the width of the foot **572** in the second cross-section.

[0100] FIG. **5**G is cross-sectional top view of the half expansion joint **522**A cut along line **5**G-**5**G in FIG. **5**C. In particular, FIG. **5**G illustrates the view of the half expansion joint **522**A that has been cut through the vertical axis of the half expansion joint **522**A and through the centers of the joint apertures **576** and the joint slots **578**. This view also reveals that the second side **558** is substantially planar in the vertical direction as it extends from the top of the head **570** (illustrated in FIG. **5**B) of the half expansion joint **522**A all the way to the bottom surface of the foot **572** (illustrated in FIG. **5**B) of the half expansion joint **522**A.

[0101] It is anticipated that half expansion joint **522**A would be cast or forged pieces from steel of a quality equal or superior to the steel rail to which it will be welded. Prior to welding to the steel rail section, it is anticipated that the vertical face of the second side **558** of the overlap section **566** and the horizontal interior surfaces of the joint aperture **576** and the joint slots **578** would be machined to precision tolerances to facilitate the interface or matching up with another half expansion joint that has been pre-welded to a different section of steel rail.

[0102] The half expansion joint **522**A has a certain symmetrical shape and features such that two sections of steel rail, each with a half expansion joint **522**A pre-welded to one end, can be interfaced in a co-planar relationship with each second side **558** of the overlap section **566** and about the common vertical and longitudinal centerlines of the steel rails.

[0103] FIG. **6**A is a partially exploded top view of a rail expansion joint **622** cut along section line **5**G-**5**G having features of the present invention, wherein the rail expansion joint is being positioned in a contracted configuration. In particular, FIG. **6**A illustrates a first half expansion joint **622**A and a second half expansion joint **622**B (also referred to herein as joint members) that are being selectively and slidingly coupled together to form the rail expansion joint **622**. As noted above, in this embodiment, the first half expansion joint **622**A and the second half expansion joint **622**B are substantially identical in design in order to form the complete rail expansion joint **622**. Further, each of the half expansion joints **622**A, **622**B are substantially identical in design to the half expansion joint **522**A described in detail above in relation to FIGS. **5**A-**5**G. To complete the rail expansion joint **622**, a coupling assembly **684** must be utilized that allows for the two half expansion joints **622**A, **622**B to slide relative to one another and still maintain the co-planar relationship of the second side **658** of the overlap section **666** of each of the joint members **622**A, **622**B.

[0104] As an overview, the rail expansion joint **622** of the present invention is uniquely designed such that the first joint member **622**A can be selectively coupled to the second joint member **622**B such that the first joint member **622**A at least partially overlaps the second joint member **622**B, i.e. the overlap section **666** of the first joint member **622**A at least partially overlaps the overlap section **666** of the second joint member **622**B in a co-planar fashion, wherein each joint member **622**A, **622**B is designed to individually support the weight of the train or other rail vehicle as it moves along the rail expansion joint **622**.

[0105] Additionally, the joint members **622**A, **622**B can slide relative to each other from the contracted configuration, illustrated in FIGS. **6**A-**6**C, to an expanded configuration, illustrated in FIGS. **6**D-**6**F, or anywhere in between, as a means of compensating for the thermal expansion and contraction of the rail sections **16**A, **16**B, **18**A, **18**B (illustrated in FIG. **1**) due to temperature changes in the surrounding environment. This unique design allows for the railcar wheel to smoothly transition from one section of rail to the next without having to bridge across a physical gap. With conventional expansion joints it is the vertical displacement cycle of the rail car steel wheels slightly dropping off the end of one rail and then being lifted up by the beginning of the next rail that causes damage to the wheel, introduces impact loads to the rails, joints, ties and rail bed and causes the clickity-clack aural signature.

[0106] As illustrated in FIG. **6**A, the coupling assembly **684** includes the joint apertures **676** and joint slots **678** that are present in each of the half expansion joints **622**A, **622**B, and a plurality of connectors **680** that are adapted to extend through the joint apertures **676** and the joint slots **678**. In certain embodiments, the connectors **680** can be conventional UNC screw type bolt fasteners that can be used to assemble the half expansion joints **622**A, **622**B into a fully functional rail expansion joint **622**. In one such embodiment, each connector **680** would be a conventional threaded fastener with a hex head and a smooth or unthreaded portion known as the shank **680**A and a threaded portion **680**B. The length of the shank **680**A away from the bottom of the hex head would a small amount more, estimated to be 0.013 centimeters (0.005 inches), than twice the through dimension of joint apertures **676** and joint slots **678** and never less than twice that same through dimension. The threaded portion **680**B of the connectors **680** would have slightly smaller diameter than the shank **680**A and be fully threaded up to where the shank **680**A commences. In alternative embodiments, a different type of connector **680** can be used.

[0107] Additionally, each connector **680** can include a conventional nut **685** (only one is illustrated in FIG. **6**A) and a flat washer (not shown) that would go over the threaded portion to engage to the bottom the shank **680**A. The length of the threaded portion **680**B would be somewhat longer than the height of the nut and the thickness of the washer.

[0108] In the embodiment illustrated in FIG. **6**A, the coupling assembly **684** includes four connectors **680** for selectively and slidingly coupling the first joint member **622**A to the second joint member **622**B. Alternatively, the coupling assembly **684** can be designed to include more than four or less than four connectors **680**. It should be noted that in certain embodiments, the connectors **680** are not fully tightened so that the expansion joints **622**A and **622**B can slide relative to each other.

[0109] After the rail expansion joint **622** has been assembled, it is anticipated that some means would be used to prevent the nut from backing off the threaded portion **680**B and to thwart vandalism. Employing an orbital riveter on the back end of the threaded portion **680**B would be such a means for preventing the nut from loosening due to vibration and prevent easy disassembly or vandalism.

[0110] To be positioned in the contracted configuration, illustrated in FIGS. **6**A-**6**C, each of the connectors **680** extends through one of the joint apertures **676** and is lined up to extend through one of the joint slots **678** at a semi-circular end of the joint slot **678** such that the second end **662** of one joint member **622**A, **6226** will be at its closest point to the first vertical face **668** of the other joint member **662**A, **662**B.

[0111] As a result of the symmetry of the half expansion joints **622**A, **622**B, each of the connectors **680** that extend through one of the joint apertures **676** will be in alignment with the end of the opposing joint slot **678** that allows the second end **662** of one joint member **622**A, **622**B to be at its closest point to the first vertical face **668** of the other joint member **662**A, **662**B.

[0112] When being installed, the gap distance between the first vertical face **668** of one joint member **622**A, **622**B and the second end **662** of the other joint member **622**A, **662**B in a fully assembled rail joint **622** is dependent upon the ambient temperature and the actual rail temperature. Additionally, the distance between rail expansion joints **622** is dependent upon the climatic zone in which the rail system is installed. The greater the expected temperature variation that the steel rail will see, the shorter the distance between the expansion joints **622**. For the upper Central Plains of North America spacing in the range of **200** feet would be anticipated.

[0113] FIG. **6**B is a top view of the rail expansion joint **622** illustrated in FIG. **6**A. In FIG. **6**B, the connectors **680** are fully positioned through the corresponding joint apertures **676** (illustrated more clearly in FIG. **6**C) and joint slots **678** (illustrated more clearly in FIG. **6**C) such that the second sides **658** of the overlapping sections **666** of the joint members **622**A, **622**B are in a co-planar relationship with each other with the rail expansion joint **622** in the contracted configuration.

[0114] FIG. **6**C is cross-sectional top view cut along line **5**G-**5**G as found in FIG. **5**C of the rail expansion joint **622** illustrated in FIG. **6**B. In particular, FIG. **6**C illustrates a top view of the rail expansion joint **622** that has been cut through the joint apertures **676** and the joint slots **678** to more fully demonstrate the positioning of the connectors **680** through the joint apertures **676** and the joint slots **678**.

[0115] FIG. **6**D is a partially exploded top view cut along line **5**G-**5**G as found in FIG. **5**C of the rail expansion joint **622** illustrated in FIG. **6**A, wherein the rail expansion joint is being positioned in an expanded configuration.

[0116] To be positioned in the expanded configuration, illustrated in FIGS. **6**D-**6**F, each of the connectors **680** extends through one of the joint apertures **676** and is lined up to extend through one of the joint slots **678** at a semi-circular end of the joint slot **678** such that the second end **662** of one joint member **622**A, **622**B will be at its farthest point to the first vertical face **668** of the other joint member **662**A, **662**B.

[0117] As a result of the symmetry of the half expansion joints **622**A, **622**B, each of the connectors **680** that extend through one of the joint apertures **676** will be in alignment with the end of the opposing joint slot **678** that allows the second end **662** of one joint member **622**A, **622**B to be at its farthest point to the first vertical face **668** of the other joint member **662**A, **6628**.

[0118] FIG. **6**E is a top view of the rail expansion joint **622** illustrated in FIG. **6**D. In FIG. **6**E, the connectors **680** are fully positioned through the corresponding joint apertures **676** (illustrated more clearly in FIG. **6**F) and joint slots **678** (illustrated more clearly in FIG. **6**F) such that the second sides **658** of the overlapping sections **666** of the joint members **622**A, **622**B are in a co-planar relationship with each other with the rail expansion joint **622** in the expanded configuration.

[0119] FIG. **6**F is a cross-sectional top view of the rail expansion joint **622** illustrated in FIG. **6**E. In particular, FIG. **6**F illustrates a top view of the rail expansion joint **622** that has been cut through the joint apertures **676** and the joint slots **678** along line **5**G-**5**G as found in FIG. **5**C to more fully demonstrate the positioning of the connectors **680** through the joint apertures **676** and the joint slots **678**.

[0120] FIG. **7**A is a top view of the rail expansion joint **622** illustrated in FIG. **6**A, wherein the first half expansion joint **622**A and the second half expansion joint. **622**B have been fully coupled together to form the assembled rail expansion joint **622**. In particular, FIG. **7**A illustrates that the rail expansion joint **622** includes a first end **786**, a first gap **788**, an overlap area **790**, a second gap **792**, and a second end **794**. As will discussed in detail below, the rail expansion joint **622** has different cross-sections as one moves from the first end **786**, past the first gap **788**, the overlap area **790** and the second gap **792** to the second end **794**.

[0121] As will be demonstrated herein below, the rail expansion joint **622** is designed such that each half expansion joint **622**A, **622**B is able to individually support the weight of a rail vehicle **796**, a portion of which is illustrated in FIG. **7**G.

[0122] FIG. **7**B is a cross-sectional end view of the rail expansion joint **622** cut along line **7**B-**7**B in FIG. **7**A. In particular, FIG. **78** illustrates the cross-section of the rail expansion joint **622** near the first end **786** (illustrated in FIG. **7**A) of the rail expansion joint **622**. As shown, the rail expansion **622** has a cross-section near the first end **786** that is substantially identical to the cross-section of the rail section **16**A, **16**B, **18**A, **18**B (illustrated in FIG. **1**) to which the rail expansion joint **622** is being secured.

[0123] The resistance to bending of the rail sections **16**A, **16**B, **18**A, **18**B between two consecutive railroad ties **14** (illustrated in FIG. **1**) is dependent on the height, the shape and thickness of the head and the foot of the rail section **16**A, **16**B, **18**A, **18**B and the thickness of the web between the head and the foot. Assuming that the rail sections **16**A, **16**B, **18**A, **18**B to which the rail expansion joint **622** is secured has a substantially standard rail cross-section, the typical web thickness is approximately 1.27 centimeters (or 0.5 inches) and the typical head thickness is approximately seven centimeters (or 2.75 inches). Accordingly, the cross-section of the rail expansion joint **622** near the first end **786**, as illustrated in FIG. **7**B, has a web **782** thickness of approximately 1.27 centimeters (or 0.5 inches) and a head **770** thickness is approximately seven centimeters (or 2.75 inches). Therefore, the ability of the rail expansion joint **622** near the first end **786** to support the weight of the rail vehicle **796** and to resist bending is substantially similar to that of a typical rail section **16**A, **16**B, **18**A, **18**B.

[0124] FIG. **7**C is a cross-sectional end view of the rail expansion joint cut along line **7**C-**7**C in FIG. **7**A. In particular, FIG. **7**C illustrates the cross-section of the rail expansion joint **622** in the first gap **788** (illustrated in FIG. **7**A), wherein a rail vehicle **796** (a portion of which is illustrated in FIG. **7**G) riding along the rail sections **16**A, **16**B, **18**A, **18**B (illustrated in FIG. **1**) and the rail expansion joint **622** will only be supported by the first half expansion joint **622**A (illustrated in FIG. **7**A).

[0125] The cross-section of the rail expansion joint **622** within the first gap **788** has a thickness from the head **770** downward of approximately one-half the thickness of a typical head, or approximately 3.5 centimeters (or 1.375 inches). As can be easily seen, the thickness of the rail expansion joint **622** within the first gap **788** is substantially greater than the thickness of the web of a typical rail. Accordingly, the ability of the rail expansion joint **622** within the first gap **788** to support the weight of the rail vehicle **796** and to resist bending is not any less than a typical rail section **16**A, **16**B, **18**A, **18**B.

[0126] FIG. 7D is a cross-sectional end view of the rail expansion joint cut along line **7**D-**7**D in FIG. **7**A. In particular, FIG. **7**D illustrates the cross-section of the rail expansion joint **622** in the overlap area **790** (illustrated in FIG. **7**A), wherein the rail vehicle **796** (a portion of which is illustrated in FIG. **7**G) will be supported by both half expansion joints **622**A, **622**B (illustrated in FIG. **7**A).

[0127] The cross-section of the rail expansion joint **622** within the overlap area **790** has a thickness from the head **770** downward of approximately the thickness of a typical head, or approximately seven centimeters (or 2.75 inches). As can be easily seen, the thickness of the rail expansion joint **622** within the overlap section **790** is substantially greater than the thickness of the web of a typical rail. Accordingly, the ability of the rail expansion joint **622** within the overlap section **790** to support the weight of the rail vehicle **796** and to resist bending is significantly increased as compared to a typical rail section **16**A, **16**B, **18**A, **18**B (illustrated in FIG. **1**).

[0128] FIG. 7E is a cross-sectional end view of the rail expansion joint cut along line **7**E-**7**E in FIG. **7**A. In particular, FIG. **7**E illustrates the cross-section of the rail expansion joint **622** in the second gap **792** (illustrated in FIG. **7**A), wherein the rail vehicle **796** (a portion of which is illustrated in FIG. **7**G) riding along the rail sections **16**A, **16**B, **18**A, **18**B (illustrated in FIG. **1**) and the rail expansion joint **622** will only be supported by the second half expansion joint **622**B (illustrated in FIG. **7**A).

[0129] The cross-section of the rail expansion joint **622** within the second gap **792** has a thickness from the head **770** downward of approximately one-half the thickness of a typical head, or approximately 3.5 centimeters (or 1.375 inches). As can be easily seen, the thickness of the rail expansion joint **622** within the second gap **792** is substantially greater than the thickness of the web of a typical rail. Accordingly, the ability of the rail expansion joint **622** within the second gap **792** to support the weight of the rail vehicle **796** and to resist bending is not any less than a typical rail section **16**A, **16**B, **18**A, **18**B.

[0130] FIG. 7F is a cross-sectional end view of the rail expansion joint cut along line **7**F-**7**F in FIG. **7**A. In particular, FIG. **7**F illustrates the cross-section of the rail expansion joint **622** near the second end **794** (illustrated in FIG. **7**A) of the rail expansion joint **622**. As shown, the rail expansion **622** has a cross-section near the second end **794** that is substantially identical to the cross-section of the rail section **16**A, **16**B, **18**A, **18**B (illustrated in FIG. **1**) to which the rail expansion joint **622** is being secured.

[0131] Accordingly, the cross-section of the rail expansion joint **622** near the second end **794**, as illustrated in FIG. **7**F, has a web **782** thickness of approximately 1.27 centimeters (or 0.5 inches) and a head **770** thickness is approximately seven centimeters (or 2.75 inches), just as that of a typical rail section. Therefore, the ability of the rail expansion joint **622** near the second end **794** to support the weight of the rail vehicle **796** and to resist bending is substantially similar to that of a typical rail section **16**A, **16**B, **18**A, **18**B.

[0132] FIG. **7**G is a simplified top view of the rail expansion joint **622** illustrated in FIG. **7**A and a portion of the rail vehicle **796**. In particular, FIG. **7**G illustrates a wheel **796**A (although illustrated as a rectangle the contact between the wheel and the rail is nominally a line across the top surface of the rail) of the rail vehicle **796** at different positions along the length of the rail expansion joint **622** from the first end **786** to the second end **794**. Stated another way, FIG. **7**G illustrates the surface contact area that the wheel **796**A "sees" as it passes through the length of the rail expansion joint **622**. As demonstrated, at no time is the wheel **796**A unsupported as it passes through the rail expansion joint **622**. In fact, as the wheel **796**A passes along the length of the rail expansion joint **622**, the wheel **796**A is always and continuously supported as by at least one, if not both of the half expansion joints **622**A, **622**B (illustrated in FIG. **7**A of the rail expansion joint **622**.

[0133] Furthermore, referring back to FIG. **1**, it should be noted that that there is a railroad tie **14** intentionally positioned underneath the center of the assembled rail joint **22** and the length of the rail joint **22** itself is such that the beginning of each half expansion joint has a railroad tie **14** underneath it as well. This spacial relationship between the railroad ties, the length of the half joints, the overlap portion and the anticipated amount of expansion/contraction per rail joint **22** is by design such that there is no reduction in rail strength as the rail car/wheel passes through the entire rail joint **22**.

[0134] While a number of exemplary aspects and embodiments of a rail system **10** have been discussed above, those of skill in the art will recognize certain modifications, permutations, additions and sub-combinations thereof. It is therefore intended that the following appended claims and claims hereafter introduced are interpreted to include all such modifications, permutations, additions and sub-combinations as are within their true spirit and scope.

What is claimed is:

1. A railroad tie that is positioned on a rail bed as part of a rail system, the railroad tie comprising;

a first end section having a first width;

a spaced apart second end section having a second width; and

a middle section that extends between and that couples the first end section and the second end section, the middle section having a middle width that is at least five percent different than the first width and the second width,

2. The railroad tie of claim **1** wherein the middle Width is at least five percent less than the first width and the second width.

3. The railroad tie of claim **1** wherein the middle width is at least twenty-five percent less than the first width and the second width.

4. The railroad tie of claim **1** wherein the first width is substantially equal to the second width.

5. The railroad tie of claim **1** further comprising a bottom surface having one or more cavities that are at least approximately eighty square millimeters in area.

6. The railroad tie of claim **5** further comprising a top surface, wherein the one or more cavities do not extend through the top surface.

7. The railroad tie of claim **1** that is substantially Z-shaped

8. The railroad tie of claim **1** that is substantially dumbbell shaped.

9. The railroad tie of claim **1** wherein the middle section extends away from the first end section at a first angle of between approximately seventy-five and ninety-five degrees, and wherein the middle section extends away from the second end section at a second angle of between approximately seventy-five and ninety-five degrees.

10. The railroad tie of claim **1** wherein the first end section and the middle section cooperate to define a first pocket and the second end section and the middle section cooperate to define a second pocket, and wherein the first pocket and the second pocket inhibit relative movement between the railroad tie and the rail bed.

11. The railroad tie of claim **1** further comprising a first intermediate section that is positioned between the first end section and the middle section and a second intermediate section that is positioned between the second end section and the middle section, and wherein the first intermediate section has a first intermediate width that is different than the first width and the middle width, and wherein the second intermediate section has a second intermediate width that is different than the second width and the middle width.

12. A rail system comprising:

a rail bed:

a plurality of railroad ties that are positioned on the rail bed, the railroad ties having features as described in claim **1**; and

a pair of spaced apart rails that are coupled to the plurality of railroad ties.

13. A railroad tie that is positioned on a rail bed as part of a rail system, the railroad tie comprising:

a top surface; and

a bottom surface having a plurality of cavities, wherein at least one of the cavities has an area at an opening to the cavity that is at least approximately eighty square millimeters, wherein the plurality of cavities do not extend through the top surface.

14. The railroad tie of claim **13** wherein the cavities are substantially evenly spaced along the bottom surface.

15. The railroad tie of claim **13** further comprising a first end section, a spaced apart second end section, and a middle section that extends between and that couples the first end section and the second end section, the middle section cooperating with the first end section to form a first pocket and cooperating with the second end section to form a second pocket, wherein the first pocket and the second pocket inhibit relative movement between the railroad tie and the rail bed.

16. The railroad tie of claim **15** wherein the middle section extends away from the first end section at a first angle of between approximately seventy-five and ninety-five degrees, and wherein the middle section extends away from the second end section at a second angle of between approximately seventy-five and ninety-five degrees.

17. The railroad tie of claim **15** wherein the first end section has a first width, the second end section has a second width and the middle section has a middle width that is at least five percent less than the first width and the second width.

18. A rail system comprising:

a rail bed;

a plurality of railroad ties that are positioned on the rail bed, the railroad ties having features as described in claim and

a pair of spaced apart rails that are coupled to the plurality of railroad ties.

19. A rail joint for joining together a first rail section and a second rail section of a rail system that supports a rail vehicle, the first rail section and the second rail section being positioned substantially along the same line, the rail joint comprising;

a first joint member;

a second joint member that is selectively coupled to the first joint member such that the second joint member at least partially overlaps the first joint member, wherein each joint member is designed to individually support the weight of the rail vehicle.

20. The rail joint of claim **19** wherein the first joint member is fixedly secured to the first rail section and the second joint member is fixedly secured to the second rail section.

21. The rail joint of claim **19** wherein the first joint member includes a first aperture and a first slot and the second joint member includes a second aperture and a second slot, and further comprising a pair of connectors that extend through the first joint member and the second joint member to selectively couple the first joint member to the second joint member, wherein one connector extends substantially through the first aperture and the second slot, and the other connector extends substantially through the second aperture and the first slot.

22. The rail joint of claim **21** wherein the connectors cooperate to allow relative translational movement between the first joint member and the second joint member.

23. The rail joint of claim **21** wherein the apertures are substantially circular in shape and the slots have ends that are substantially semi-circular in shape, and wherein the diameter of the apertures is substantially equal to the diameter of the ends of the slots.

24. A rail system comprising:

a first rail that includes a first rail section and a second rail section that is positioned substantially along the same line as the first rail section;

a second rail that is spaced apart from the first rail; and

a rail joint that is positioned substantially between the first rail section and the second rail section and that couples the first rail section to the second rail section, the rail joint having features as described in claim **19**.

25. The rail system of claim **24** wherein the second rail includes a third rail section and a fourth rail section that is positioned substantially along the same line as the third rail section, and further comprising a second rail joint that is positioned substantially between the third rail section and the fourth rail section and that couples the third rail section to the fourth rail section, the second rail joint having features as described in claim **19**.

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