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(54) **SNOWMOBILE CHASSIS**

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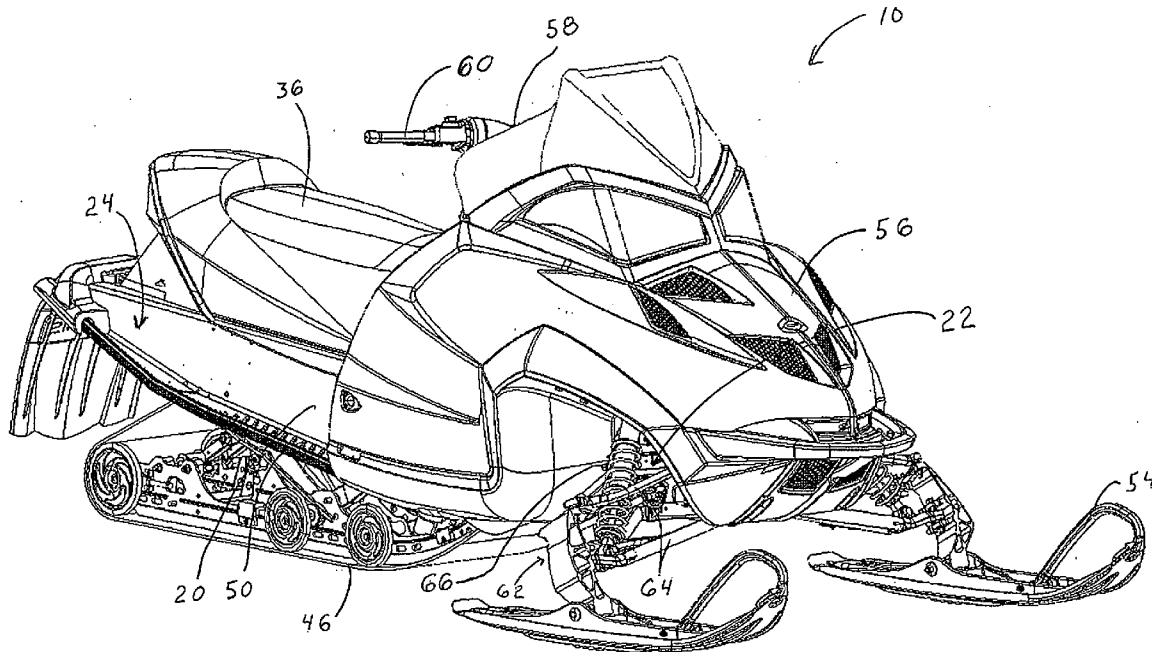
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(57) **ABSTRACT**

Vehicle chassis with effective load sharing joints and reinforcing structure. The chassis of the invention use self piercing rivets and other fabrication techniques to improve their structural and performance characteristics. These improvements result from, among other things, effective load distribution through high-shear resistant fasteners and strengthening of structural elements with reinforcing layers.

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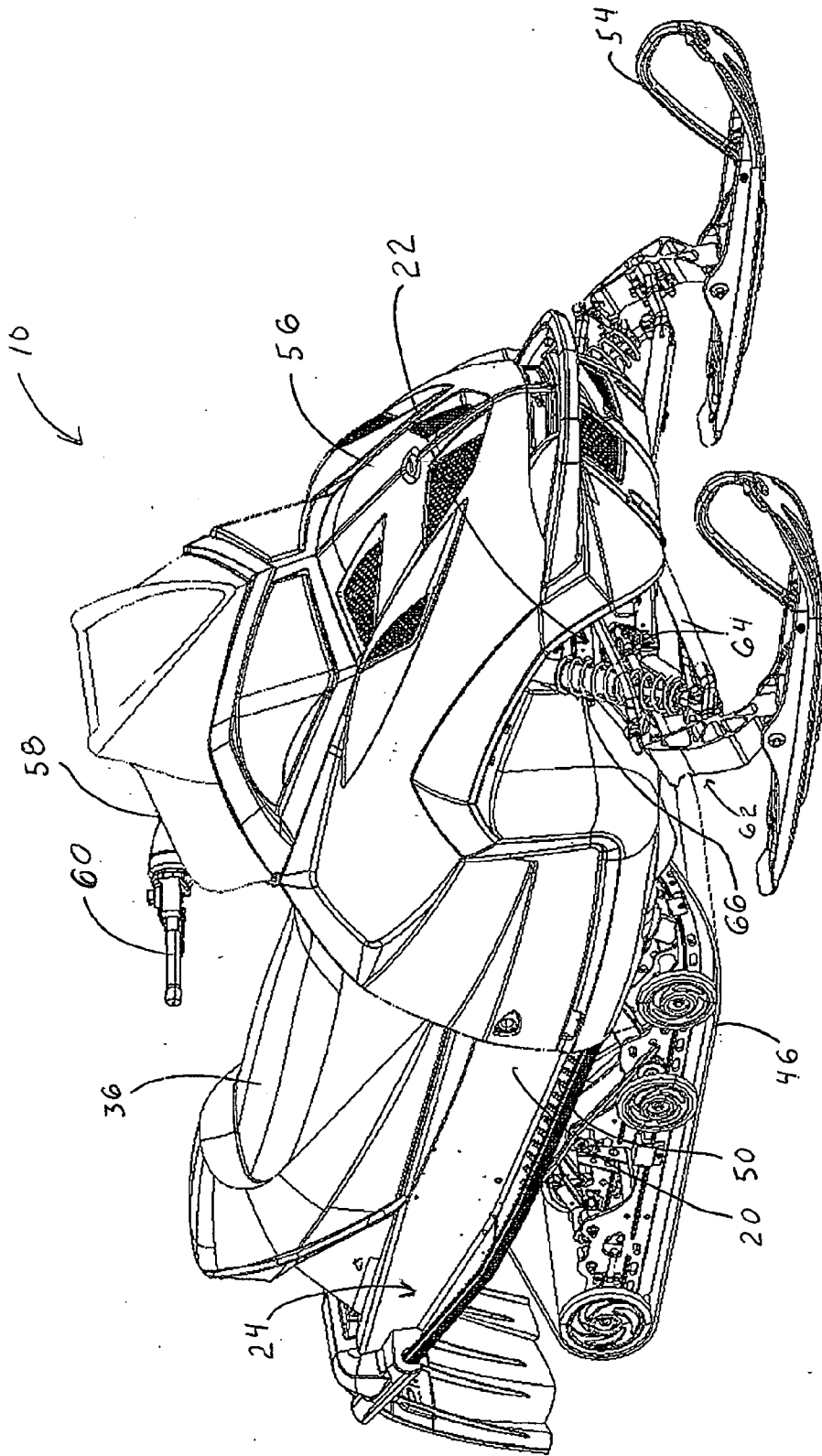


FIG. 1

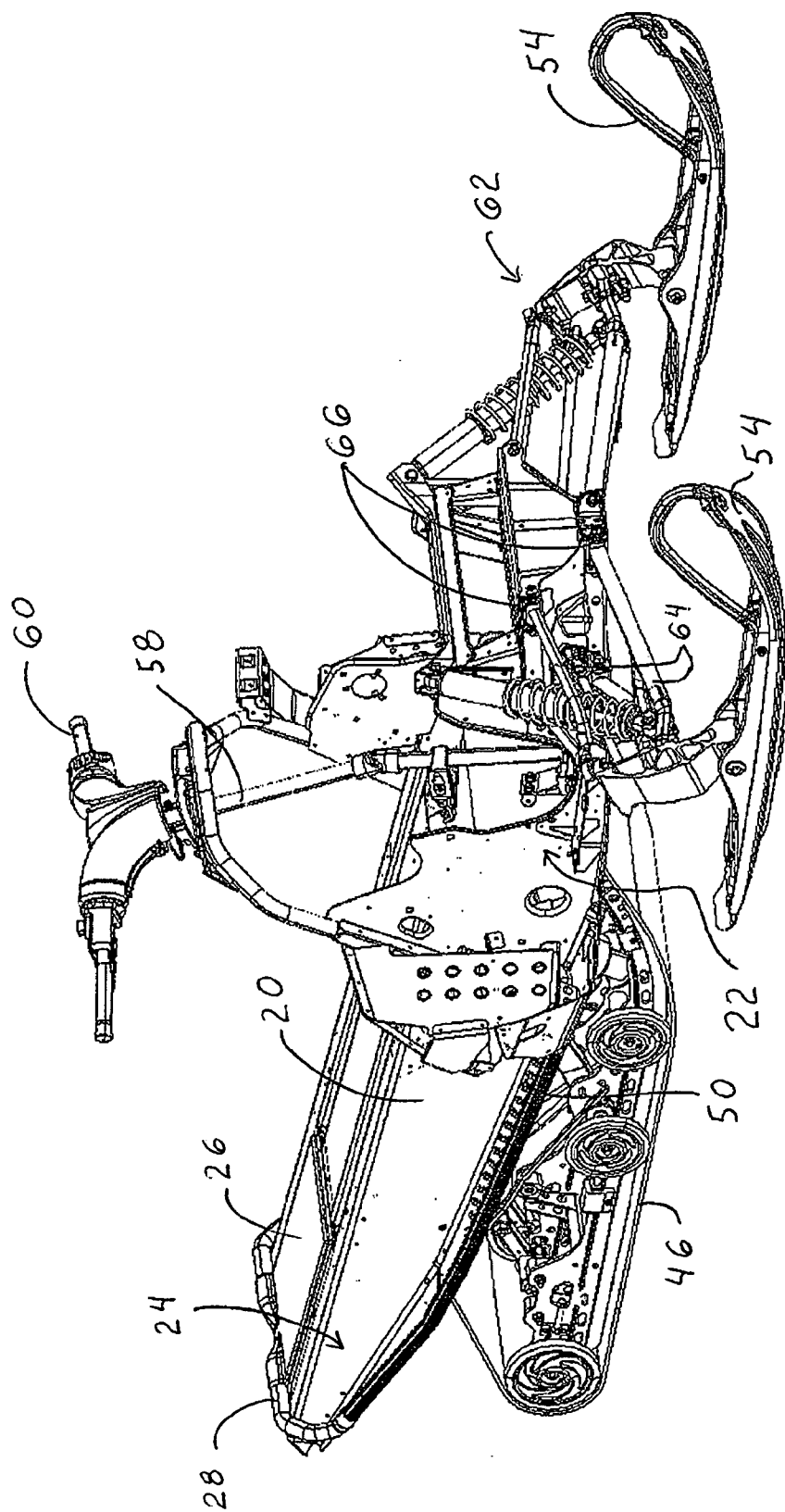


FIG. 2

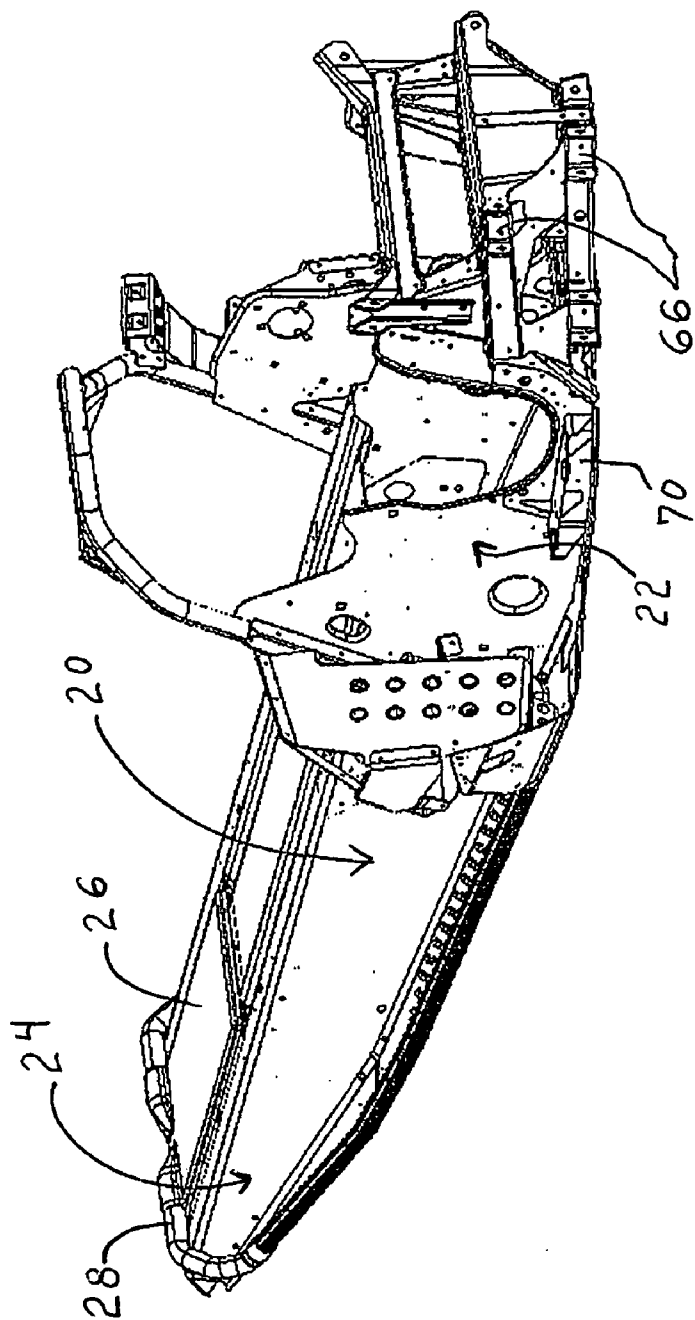


FIG. 3

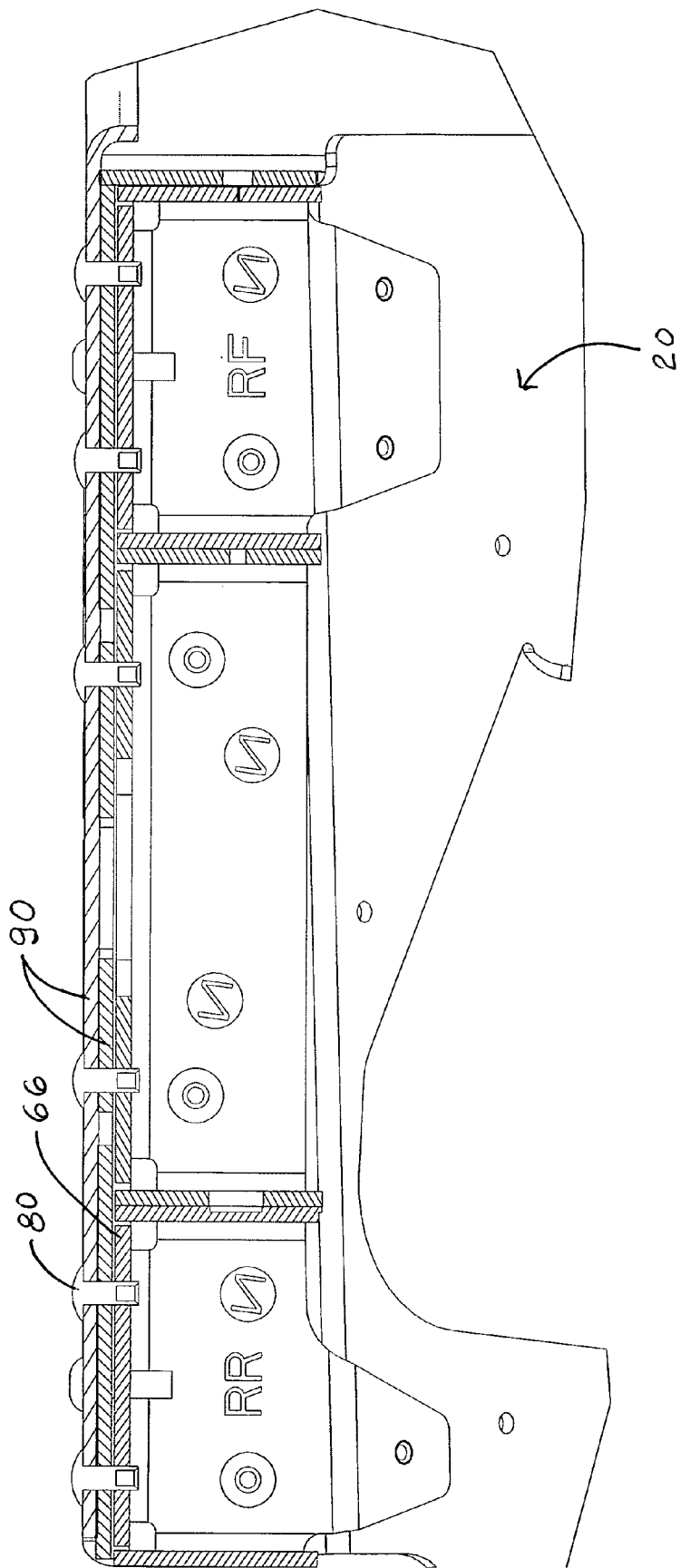


FIG. 4

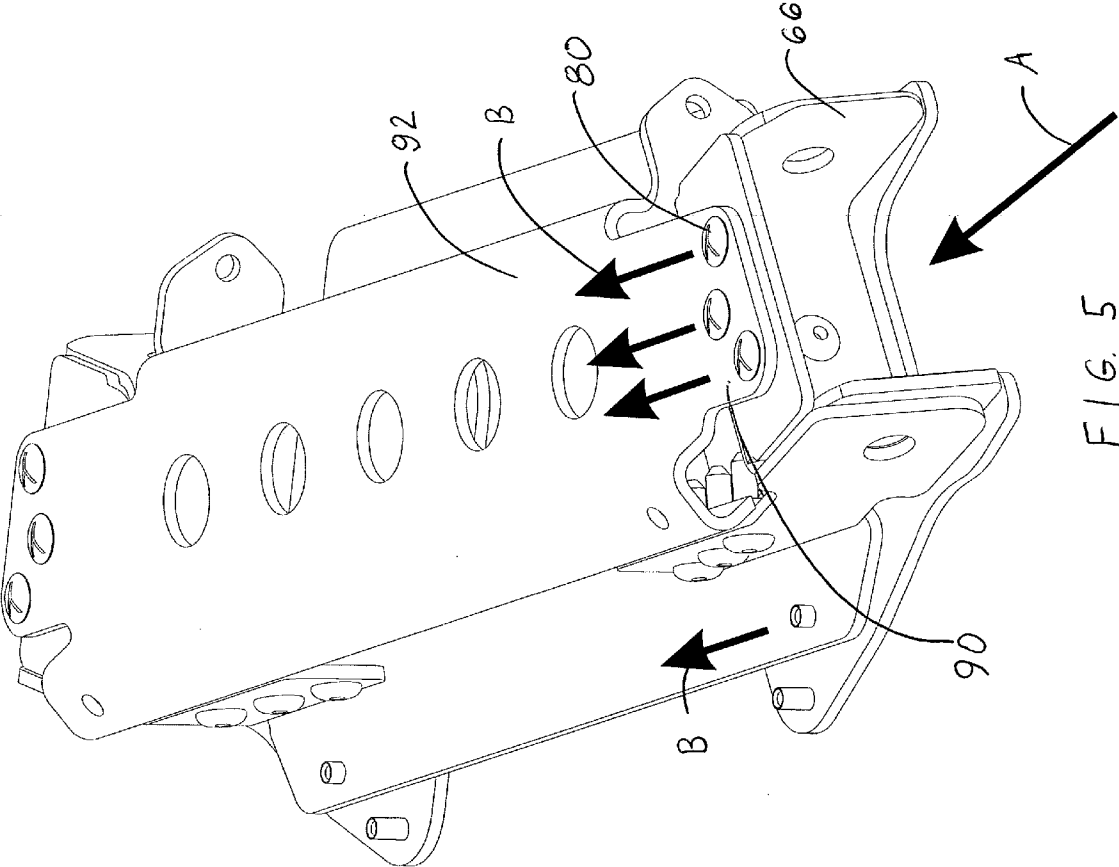


FIG. 5

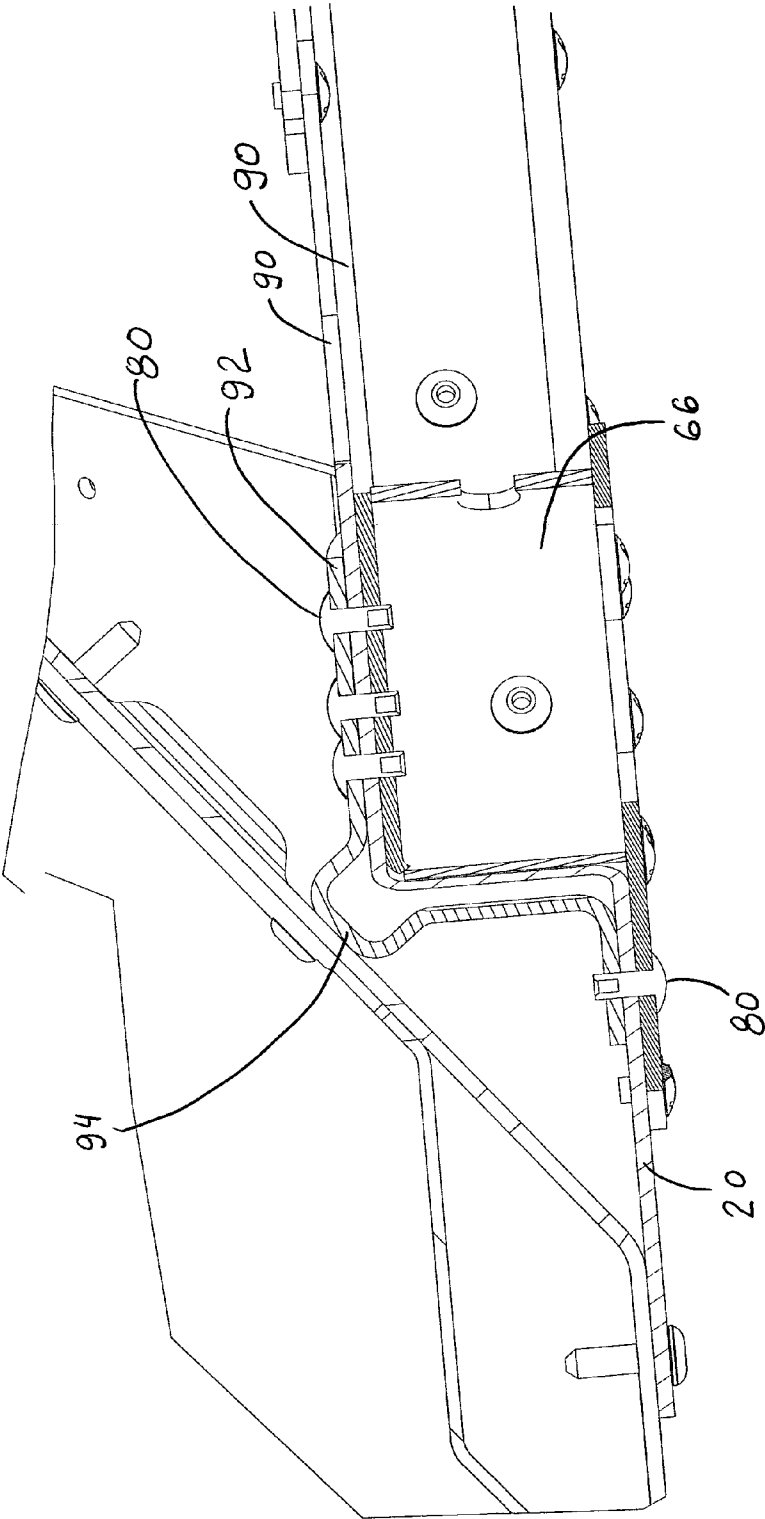


FIG. 6

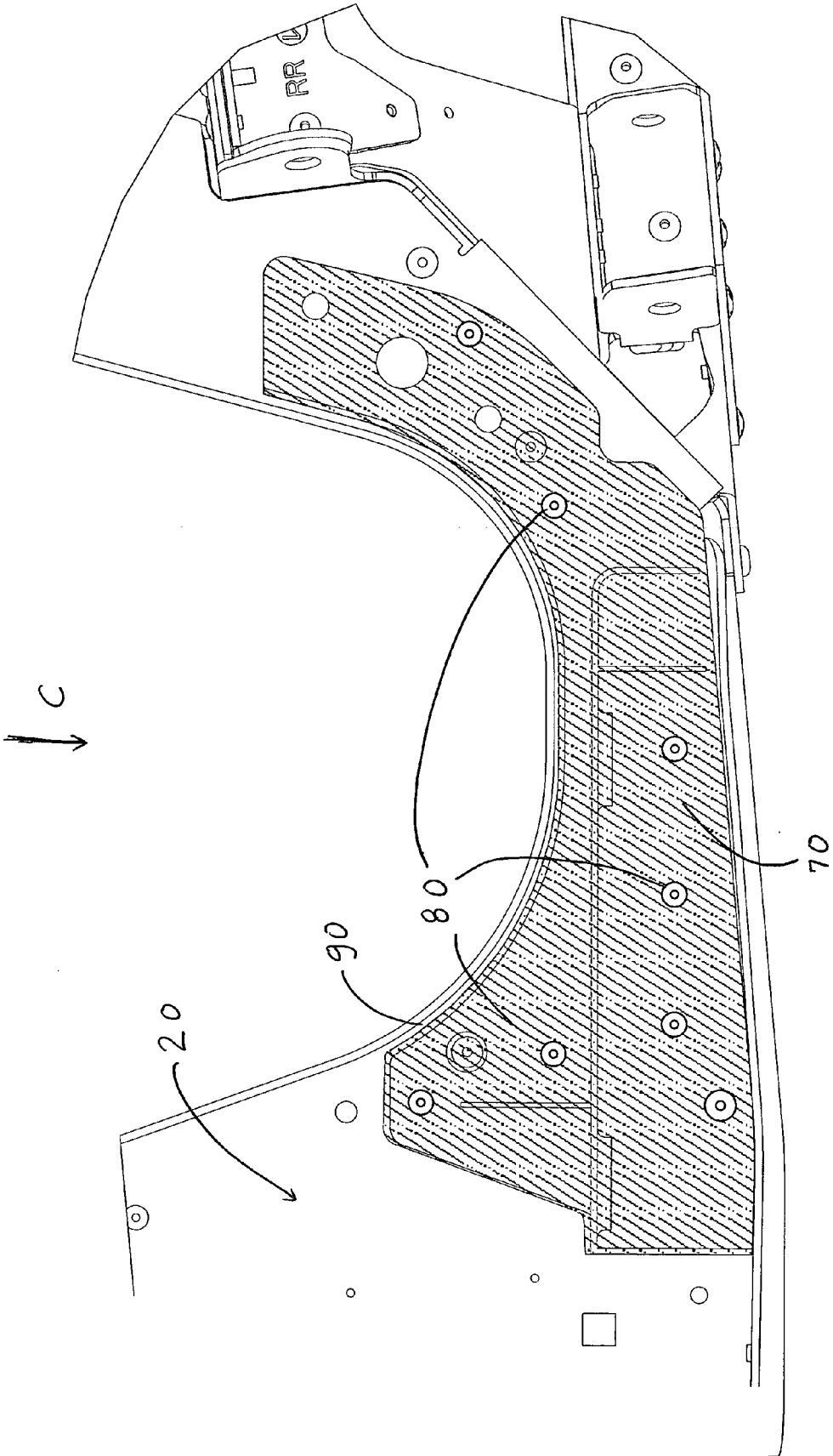


FIG. 7

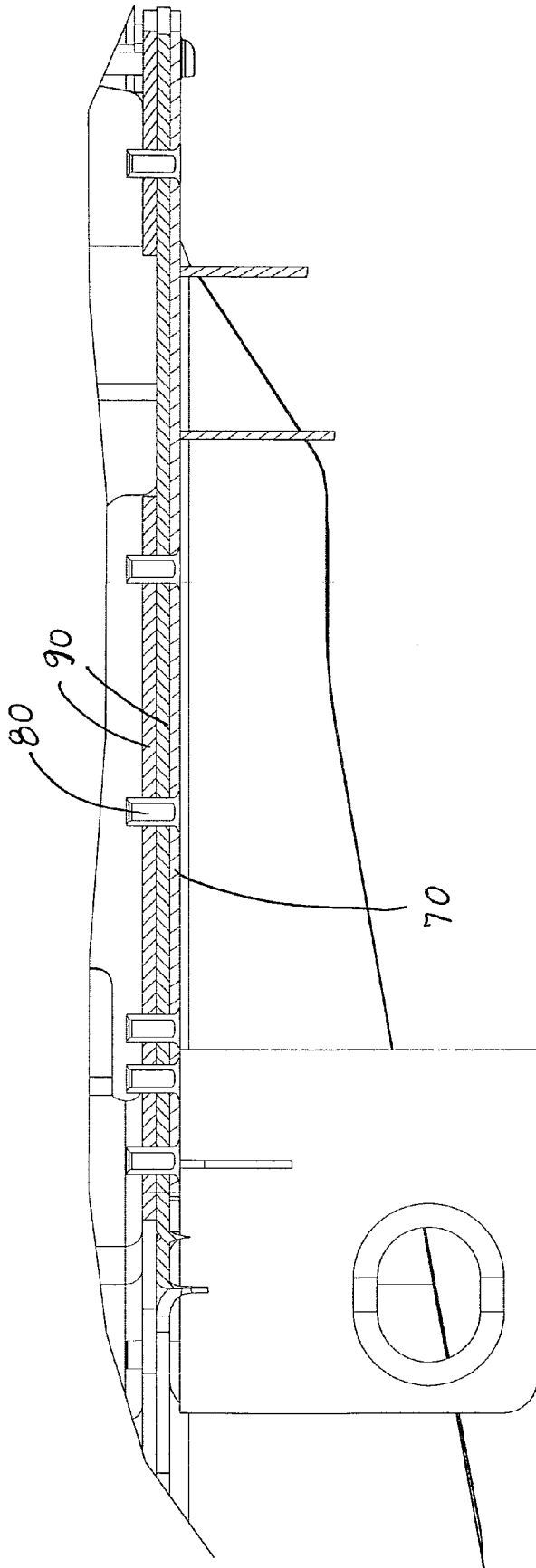
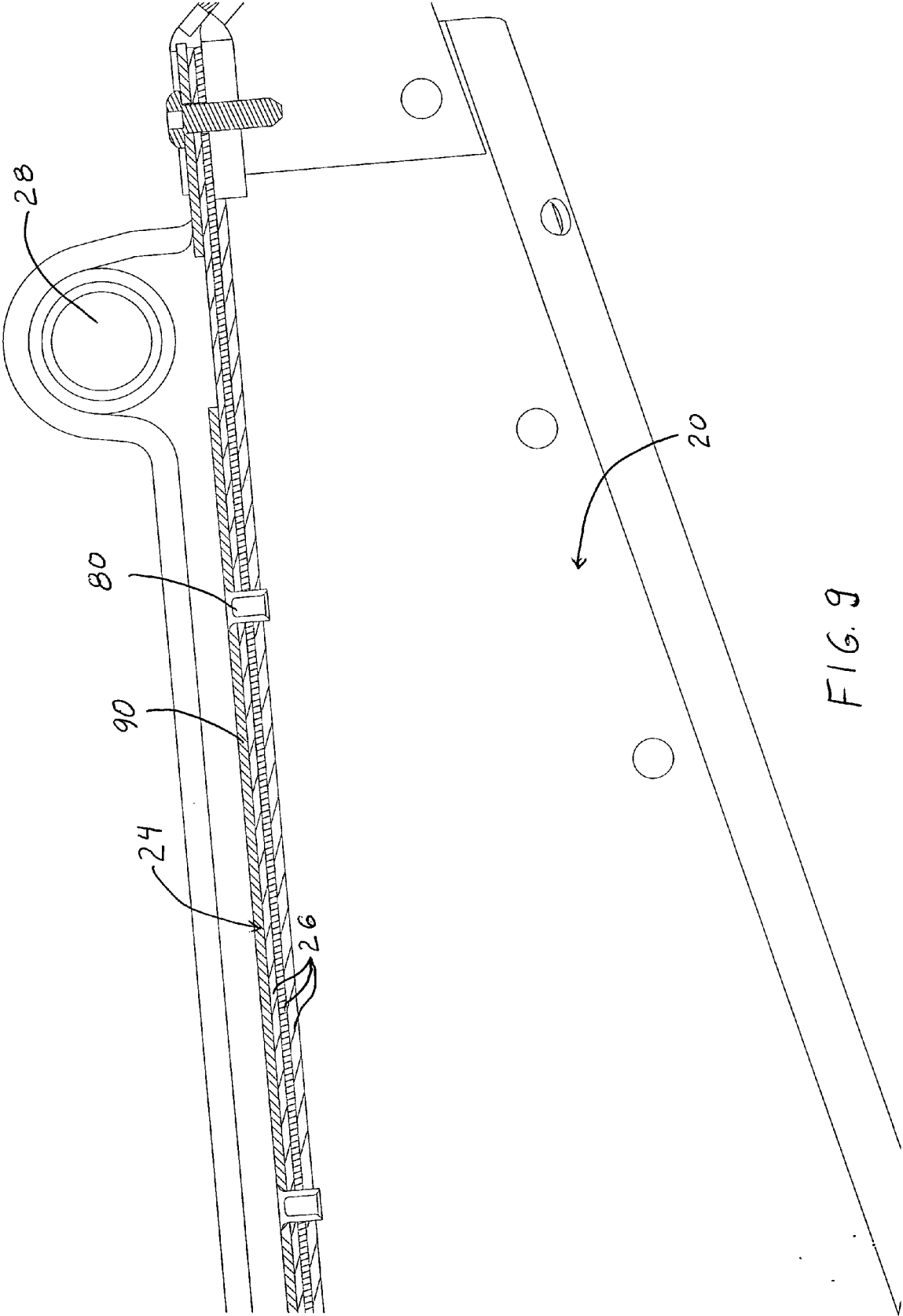


FIG. 8



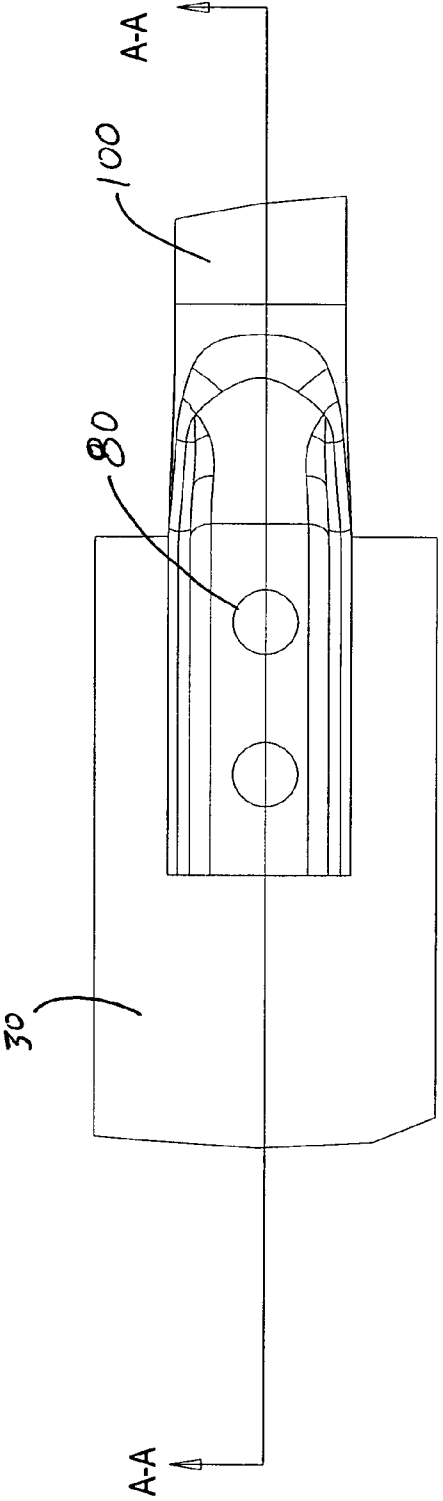


FIG. 10

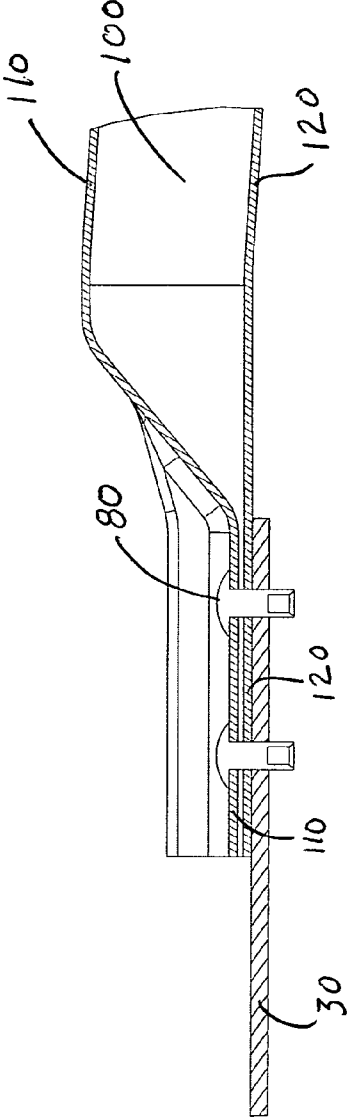


FIG. 11

**SNOWMOBILE CHASSIS**

**FIELD OF THE INVENTION**

[0001] The present invention is related to vehicle chassis. More specifically, the invention is related to a snowmobile chassis constructed with the use of effective load sharing joints and reinforcing structure.

**BACKGROUND OF THE INVENTION**

[0002] A vehicle chassis includes a vehicle's structural elements. These elements may be attached to an underlying frame. In vehicles with unitized or "unibody" construction, the chassis may essentially comprise the frame and include everything but the cosmetic body panels of the vehicle.

[0003] Vehicle chassis elements are frequently constructed of relatively thin sheets of metal. Chassis elements must be constructed to endure significant mechanical loads while being lightweight and non-bulky to allow for flexibility in vehicle construction.

**BRIEF SUMMARY OF THE INVENTION**

[0004] In one embodiment, the invention includes a system for constructing a vehicle. This system may include a first sheet of material, a second sheet of material, a reinforcing third sheet of material, and a self piercing rivet. The reinforcing third sheet of material may be of a different composition than at least one of the first sheet of material or second sheet of material. The self piercing rivet may attach the first sheet of material and the second sheet of material to the third sheet of material to form a joint that allows load sharing or structural reinforcement of at least one of the first sheet of material or the second sheet of material by the third sheet of material.

[0005] In another embodiment the invention includes a snowmobile that includes a chassis made of at least two sheets of chassis material, an engine supported by the chassis, at least one ski supported by the chassis, a steering column operatively connected to the at least one ski for steering the snowmobile and an endless track supported by the chassis and being operatively connected to the engine. This embodiment may further include a third sheet of material of a different composition than at least one of the sheets of chassis material. A self piercing rivet may attach the at least two sheets of chassis material to the third sheet of material.

[0006] Yet another embodiment of the invention may include a snowmobile chassis made of first and second sheets of chassis material being formed of aluminum. This embodiment may further include a third sheet of chassis material being formed to reinforce the first and second chassis sheets and of a material other than aluminum. A self-piercing rivet may join together the first, second, and third sheets of material to allow load sharing and structural reinforcement of the first and second sheets of chassis material.

[0007] Another embodiment of the invention may include a snowmobile that includes a suspension element, a chassis with at least two layers of overlapping chassis material, a mount for attaching the suspension element to the chassis, and a self piercing rivet that attaches the mount to the chassis and fastens together the at least two layers of chassis material.

[0008] Another embodiment of the invention may include a snowmobile chassis that includes at least one layer of chassis material. The embodiment also has a heat exchanger or other chassis element constructed of at least three layers of material and a self piercing rivet that attaches the heat exchanger or other chassis element to the chassis by fastening the cooler to the at least one layer of chassis material.

[0009] Another embodiment of the invention includes a system for attaching a tube to a chassis. This embodiment includes a tube that has opposing sides with a hollow passage between the sides. A portion of the tube may be compressed so that the sides of the tube are adjacent to each other. This embodiment also includes a chassis comprising at least one sheet of material and a self piercing rivet that attaches the sheet of material to the tube at the optionally compressed portion of the tube by fastening the adjacent sides of the tube to the sheet of material.

[0010] In another embodiment of the invention, a method of constructing a snowmobile chassis includes fabricating a chassis element, fabricating a second chassis element, positioning a first layer of chassis material formed of aluminum, layering three sheets of chassis material, two of the sheets being formed of aluminum, one of the sheets being configured to reinforce the two aluminum sheets and of a material other than aluminum, and riveting the three sheets together via a self-piercing rivet to form a joint, the joint allowing load sharing and structural reinforcement of the two aluminum sheets of chassis material.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[0011] FIG. 1 is a perspective view of a snowmobile in accordance with an embodiment of the present invention.

[0012] FIG. 2 is a perspective view of an embodiment of a snowmobile chassis in accordance with the invention.

[0013] FIG. 3 is a perspective view of an embodiment of a snowmobile chassis in accordance with the invention.

[0014] FIG. 4 is a perspective view of an embodiment of a portion of a snowmobile chassis in accordance with the invention.

[0015] FIG. 5 is a perspective view of an embodiment of a portion of a snowmobile chassis in accordance with the invention.

[0016] FIG. 6 is a cross-section of the joint of FIG. 5 taken along the direction indicated by the B arrows in FIG. 5.

[0017] FIG. 7 is a side plan view of an embodiment of a portion of a snowmobile chassis in accordance with the invention.

[0018] FIG. 8 is a cross-section view of the embodiment of FIG. 7 taken from the perspective of arrow C in FIG. 7.

[0019] FIG. 9 is a cross-section view of an embodiment of a portion of a snowmobile chassis in accordance with the invention.

[0020] FIG. 10 is a plan view of another embodiment of the invention.

[0021] FIG. 11 is a cross-section of the embodiment of FIG. 10 taken along line A-A in FIG. 10.

DETAILED DESCRIPTION OF THE  
INVENTION

[0022] The following detailed description should be read with reference to the drawings, in which like elements in different drawings are numbered identically. The drawings, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of the invention. Several forms of the invention have been shown and described, and other forms will now be apparent to those skilled in art. It will be understood that embodiments shown in drawings and described above are merely for illustrative purposes, and are not intended to limit scope of the invention as defined in the claims which follow.

[0023] In the construction of vehicle chassis, it can be useful to employ structural elements formed of relatively thin sheets of material. These elements may, for example, be a beam-like structure that is subjected to any one of, or a combination of, torsional, tensile, compressive or bending loads. Chassis elements may be fabricated by stamping or otherwise cutting the element from a sheet of stock material. Elements may also be fabricated by bending or forming a sheet of material to a desired shape. The chassis may also be fabricated by welding, riveting, bolting, or otherwise fastening constituent chassis elements together to form the desired structure.

[0024] Various construction techniques exist to build such an element that is strong enough to withstand the forces acting on it when used in a vehicle chassis. A box section, where the sheet of material is formed into a beam with a box-shaped cross-sectional frame structure can be formed to strengthen the element. I-section and C-sections, which look like these respective letters in cross-section, are other structures that may be used to create stronger chassis elements from sheets of material. However, these structures may require additional material, increasing vehicle weight and expense, and may take up valuable space that could otherwise be used for other vehicle components.

[0025] One construction technique to strengthen load bearing elements constructed of one or more sheets of material without necessarily creating bulky structures is to attach a layer of reinforcing material to the base sheet or sheets of material to increase its cross-sectional thickness and load bearing capability. Prior art means of attaching these reinforcing layers such as welding, for example, can dramatically reduce the materials' strength through heat damage. It is believed, for example, that the aluminum alloy commonly referred to as Aluminum 5052-H34 has a yield strength reduction of approximately 54% from 31,200 psi to 13,000 psi in the heat affected zone after welding. It should be noted that these heat impacts are localized near any welded seams, which may be the area intended to be strengthened.

[0026] In one embodiment of the invention, a reinforcing material is attached to a chassis formed of two or more layers of base material using one or more self piercing rivets. This construction method has the advantage of having minimal impact on the strength of the underlying and reinforcing sheet or sheets of material as compared to welding.

[0027] Attaching a reinforcing layer using a self piercing rivet may also be superior to using traditional fasteners that

require predrilled holes. Holes formed in the sheets of material for these fasteners are slightly larger than the fasteners themselves, creating "play" between the fastened sheet of metal and the fastener.

[0028] Further fasteners that require predrilled holes, particularly traditional rivets but also many threaded fasteners, may be more likely to fail under shear stresses. Shear stress is stress transverse to the length of the fastener that may be applied when two or more sheets of material joined by the fastener are subjected to forces oriented parallel to the surfaces of the sheets of material. Shear stress can be more easily envisioned as a force that is attempting to cut the fastener transversely.

[0029] The self piercing rivet may also have higher shear strength than many conventional rivets that require predrilled holes. Also, conventional fasteners that require predrilled holes, whether rivets or threaded fasteners, may have problems with the holes expanding creating "play" or "slop" in the joint. This problem increases as more layers of material are joined because the holes for the fasteners must be typically larger to allow for alignment of the holes through each of the several layers of material. Additionally, vibration or movement between the layers of material may cause the holes to widen as the material contacts the fastener(s). By using self piercing rivets, alone or in conjunction with other fastening techniques, the inventor has overcome limitations in prior art chassis manufacturing.

[0030] A snowmobile 10 in accordance with an embodiment of the present invention is shown in FIG. 1. Generally, snowmobile 10 includes a longitudinally extending chassis 20 having a front portion 22 and a rear portion 24. The chassis 20 supports and mounts several vehicle components, including an engine, a seat 36, a drive track 46, a pair of steerable skis 54, and a body assembly 56. In some embodiments, the chassis 20 supports the engine proximate the front portion 22 and the seat 36 proximate the rear portion 24. The seat 36 is adapted to accommodate a rider in straddle fashion, and the engine powers the drive track 46 operatively connected to the chassis 20 proximate the rear portion 24. Means for supporting a rider's feet extending longitudinally below opposite lateral sides of the seat 36 may be provided. In some embodiments, the means may include footrests 50 that extend longitudinally below opposite lateral sides of the seat 36. The chassis front portion 22 may be suitable for mounting the pair of steerable skis 54 and supporting the body assembly 56. The body assembly 56 may contain the engine. A steering post 58 is operatively connected to the pair of skis 54. Means for rotating the steering post 58 to effect steering may be provided, and the means for rotating may be supported by the steering post 58. In some embodiments, the means for rotating may include a steering control, such as handlebars 60, supported by the steering post 58.

[0031] In the exemplary snowmobile shown in FIG. 1 the steerable skis 54 may be attached to a front suspension system 62 that includes an A-arm or wish-bone, henceforth referred to as an A-arm 64 component. The A-arm 64 is pivotally mounted on an A-arm mount 66 that is affixed to the front portion of the chassis 22. The A-arm 64 can be generally referred to as a suspension element. A suspension element can be any structural element that connects the frame or chassis to the components of the vehicle that contact the ground during operation. Suspension elements

are typically movable relative to the chassis or frame and may be connected to a shock absorber assembly that may contain a form of spring and/or a shock or other damping element that controls the rate and quality of this movement. A suspension system other than the A-arm suspension system, such as a trailing arm or strut-type suspension system, may be used without departing from the scope of the invention.

[0032] The vehicle chassis 20 has a longitudinal axis that runs from the front portion 22 of the chassis to the rear portion 24 of the chassis essentially along a line that bisects the chassis.

[0033] FIG. 2 is a perspective view of an embodiment of a snowmobile chassis 20 of the invention with the front suspension 62, drive track 46, and steering post 58 installed. The chassis has a rear portion 24 and a front portion 22. A front suspension 62 suspends a pair of steerable skis 54 from the chassis 20. The front suspension 62 includes two pairs of A-arms 64 that are pivotally mounted on the chassis 20 by A-arm mounts 66. The steerable skis 54 are operatively attached to a steering post 58 that may be turned by the operator using handlebars 60. The chassis includes footrests 50. Also visible in FIG. 2 is a rear heat exchanger 26 and a heat exchanger connecting tube 28 mounted near the top rear of the chassis.

[0034] FIG. 3 is a perspective view of an embodiment of a chassis of the invention. FIG. 3 more clearly shows elements of the chassis that may use the self piercing rivet to reinforce structural elements, distribute stress loads, and join members. For instance the A-arm mounts 66 are fastened to the chassis 20 using three-layer self piercing rivets as shown more clearly in FIGS. 4-6 and described further below. Also a localized steel reinforcement plate 70 is shown attached to the chassis 20 and is shown more clearly in FIG. 7 and described further below.

[0035] FIG. 4 is a perspective view of a portion of an embodiment of a chassis in accordance with the invention. The chassis region shown in FIG. 4 is proximal to the front suspension upper A-arm mounts 66. This portion of the chassis 20 includes two layers of chassis material 90 layered in an overlapping fashion. The A-arm mounts 66 are affixed to the chassis using one or more three-layer self piercing rivets 80. The use of the self piercing rivet 80 allows for secure attachment of potentially dissimilar materials. While other fastening means such as predrilled fasteners or welding may be used in conjunction with the self piercing rivet 80, the self piercing rivet 80 does not weaken the underlying material as may happen with welding due to heat damage. Also the fastening of, for example, steel sheets to aluminum chassis sheets is significantly difficult, if not impossible, through conventional welding techniques, while the self piercing rivet will effectively fasten dissimilar materials.

[0036] FIG. 5 is a perspective view of a portion of an embodiment of a chassis in accordance with the invention. The chassis region shown in FIG. 5 is proximal to the front suspension rear lower A-arm mount 66. In this figure, a layer of metal is not shown to allow for easier display of the joint. There are two layers of chassis metal 90 (one not shown) layered in an overlapping fashion. The A-arm mount 66 is attached to the chassis using one or more three-layer self piercing rivets 80. The A-arm 64 (shown in FIG. 2) that is mounted on this mount is oriented at a skew angle relative to the chassis 20.

[0037] A chassis cross-member 92 configured in this example as a U-channel is oriented generally transverse to the main chassis 20. The load or force applied along arrow A is skew or at an angle not perpendicular to the chassis 20. The joint formed by the three-layer self piercing rivets 80 of this embodiment of the invention transmit this force to the transverse chassis cross member 92. The self piercing rivets 80 help form a joint that is strong enough to redirect the angled force to the chassis cross member 92, which is a stronger member due to its U-shaped configuration, among other factors. This joint can easily be constructed with the use of self piercing rivets which have the advantages described above, among others.

[0038] Arrow A indicates a load or force applied to the lower rear A-arm mount 66 in a direction generally parallel to the lower rear A-arm 64 (shown in FIG. 2). Loads transmitted from the ground through the steerable ski and front suspension to the A-arm must be redirected from this skew angle A to transverse angle B so that the U-channel chassis cross-member 92 can share the load. The three-layer self piercing rivets 80 used to attach the A-arm mount 66 to the chassis 20 allow for the redirection of this load from angle A to angle B because of their high shear strength. There is no requirement that the chassis cross-member be configured as a U-channel, and the three-layer self piercing rivet may be used to redirect forces within the chassis to or from chassis elements of any shape by taking advantage of the high shear strength and other advantageous attributes of the self piercing rivet.

[0039] This application of the self piercing rivet takes advantage of the self piercing rivet's ability to carry a significant load in shear. The force oriented along the arrow A exerts a shear force generally transverse to the self piercing rivets 80. These fasteners can withstand this load and effectively transfer it to the reinforcing layer (not shown) and the chassis 20 through the cross member chassis element 92.

[0040] FIG. 6 is a cross-section of the joint of FIG. 5 taken along the direction indicated by the B arrows in FIG. 5. This cross section shows the cross member chassis element 92, the A-arm mount 66, and two layers of the chassis material 90. The cross member chassis element is formed at region 94 to provide reinforcement in more than one direction. The self piercing rivets 80 secure the chassis element 92 to the chassis 20 one either side of formed region 94 to provide reinforcement and support to the chassis 20 in more than one direction.

[0041] FIG. 7 is a side plan view of a portion of an embodiment of a snowmobile chassis in accordance with the invention. The chassis 20 of this embodiment is made of an aluminum alloy and a reinforcing layer 70 is made of steel. A second layer of aluminum (not shown) is on the other side of the chassis 20. The reinforcing layer 70 is fastened to the chassis material 90 and the second layer of aluminum by one or more self piercing rivets 80. The reinforcing layer 70 and the second layer of aluminum provide additional strength and stability to chassis 20 without significantly increasing the size of the chassis structure in the area. The use of the self piercing rivets 80 for this purpose may reduce or eliminate the need for welding, which is advantageous because welding can reduce the strength of the chassis material 90 or reinforcing layer 70 by heating and weakening the material.

[0042] The use of self piercing rivets may also reduce or eliminate the need for fasteners that require predrilled holes in the chassis 20 and/or the reinforcing material 70. This may reduce production time and costs. Also, these fasteners frequently can become loose as the tolerance or gap between the fastener and the hole through which the fastener is placed expands over time.

[0043] FIG. 8 is a cross-section view taken from the perspective of arrow C in FIG. 7 of the reinforcing layers of the chassis 20. The steel reinforcing layer 70 is shown oriented to the outside of the two layers of chassis material 90, although the layers may be placed in any order or orientation. The three-layer self piercing rivets secure the dissimilar materials for reinforcement of the chassis without the need for welding or pre-drilled holes. This reinforcement layer requires less space than previous structural reinforcement techniques such as C-sections, box-sections and the like.

[0044] FIG. 9 is a cross section of an embodiment of the invention. In this embodiment, self piercing rivets 80 are used to secure a three layer heat exchanger 26 to the chassis 20 by fastening the heat exchanger 26 to a layer of chassis material 90. The region of the chassis shown is generally the rear portion 24. The heat exchanger connecting tube 28 supplies and returns fluid to and from the heat exchanger 26. All of the material being attached by the self piercing rivets 80 in this embodiment is aluminum, but due to the fine tolerances present in the heat exchanger 26 and the relative thinness of the material, the self piercing rivet 80 allows for attachment of the heat exchanger 26 to the chassis 20 without the heat damage potentially associated with welding, for example. The self piercing rivet also allows for a tight tolerance secure attachment that reduces the potential for vibration damage to the heat exchanger 26. The self piercing rivet also allows for attachment of the heat exchanger 26 without pre-drilling holes in the heat exchanger 26 and the attendant costs and potential for manufacturing errors that could result in destruction of the heat exchanger 26. While certain materials of construction are described in association with disclosed embodiments of the invention, it should be understood that other materials of construction including, but not limited to, metals and metal alloys, polymers, reinforced polymers and composite materials may be used without departing from the spirit of the invention or the scope of the claims.

[0045] The heat exchanger 26 or similar element that is attached to the chassis 20 by the self piercing rivet 80 may provide structural integrity to the chassis in a manner similar to the other reinforcing and load sharing joints described herein. In other words, in addition to providing a superior mounting of the heat exchanger 26 to the chassis 20, the self piercing rivet 80 and systems and methods of the invention may use elements mounted to the chassis to reinforce the chassis.

[0046] FIG. 10 is a plan view of another embodiment of the invention. In this embodiment a tube 100 is attached to a sheet of material 30 by self piercing rivets 80.

[0047] FIG. 11 is a cross-section of the embodiment of FIG. 10 taken along line A-A. In this view it is clear that the tube 100 is compressed so the top wall 110 and bottom wall 120 of the tube are flattened against one another and oriented approximately coplanar with the bottom wall 120 of the

tube. The self piercing rivet 80 attaches the tube securely to the sheet of material 30 as described above. This is superior to the traditional method of construction of a tube to a sheet, i.e. welding or bolting. Multi-layer self pierce riveting offers the advantage of a simple, low cost, rigid joint without the side effects of welding or preformed or drilled holes.

[0048] While exemplary embodiments of this invention and methods of practicing the same have been illustrated and described, it should be understood that various changes, adaptations, and modifications may be made therein without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A system for constructing a vehicle comprising:

- a. a first sheet of material;
- b. a second sheet of material;
- c. a third sheet of material of a different composition than at least one of the first sheet of material or second sheet of material; and
- d. a self piercing rivet, the self piercing rivet attaching the first sheet of material and the second sheet of material to the third sheet of material to form a joint that allows load sharing or structural reinforcement of at least one of the first sheet of material or the second sheet of material by the third sheet of material.

2. The system of claim 1, further comprising a fourth sheet of material of a different composition than the third sheet of material, wherein the fourth is attached to the first, second, and third sheets of material by the self piercing rivet.

3. The system of claim 1, further comprising a fourth sheet of material of the same composition than the third sheet of material, wherein the fourth is attached to the first, second, and third sheets of material by the self piercing rivet.

4. The system of claim 1, further comprising a second self piercing rivet that attaches the first sheet of material and the second sheet of material to the third sheet of material to reinforce the joint.

5. A snowmobile comprising:

- a. a chassis including at least two sheets of chassis material;
- b. an engine supported by the chassis;
- c. at least one ski supported by the chassis;
- d. a steering column operatively connected to the at least one ski for steering the snowmobile;
- e. an endless track supported by the chassis and being operatively connected to the engine;
- f. a third sheet of material of a different composition than at least one of the sheets of chassis material; and
- g. a self piercing rivet that attaches the at least two sheets of chassis material to the third sheet of material.

6. The snowmobile of claim 5, wherein the two sheets of chassis material and the third sheet of material are formed at an angle greater than 45 degrees proximate to the rivet.

7. The snowmobile of claim 5, wherein the third sheet of material is formed at an angle greater than 45 degrees to reinforce the chassis in two directions.

8. The snowmobile of claim 5, wherein the third sheet of material reinforces the at least two sheets of chassis material.

- 9. A snowmobile chassis, comprising:
  - a. first and second sheets of chassis material being formed of aluminum;
  - b. a third sheet of chassis material being formed to reinforce the first and second chassis sheets and of a material other than aluminum;
  - c. a self-piercing rivet joining together the first, second, and third sheets of material to allow load sharing and structural reinforcement of the first and second sheets of chassis material.

10. The snowmobile chassis of claim 9, wherein the sheets of chassis material are formed at an angle greater than 45 degrees that provides reinforcement in two directions.

- 11. A snowmobile chassis, comprising:
  - a. a suspension element;
  - b. a mount for attaching the suspension element to a chassis;
  - c. a chassis with at least two layers of overlapping chassis material and a longitudinal chassis axis
  - d. a self piercing rivet that attaches the mount to the chassis and fastens together the at least two layers of chassis material.

12. The snowmobile chassis of claim 11, wherein the suspension element is oriented at a skew angle to the chassis axis.

13. The snowmobile chassis of claim 12, further comprising a chassis element oriented generally transverse to the chassis, wherein the self piercing rivet allows a load from the suspension element to be redirected to the generally transverse chassis element.

14. The snowmobile chassis of claim 12, further comprising a chassis element oriented generally parallel to the axis of chassis, wherein the self piercing rivet allows a load from the suspension element to be redirected to the parallel chassis element.

15. The snowmobile chassis of claim 12, further comprising a chassis element oriented at a skew angle to the longitudinal axis of the chassis, wherein the self piercing rivet allows a load from the suspension element to be redirected to the skew chassis element.

- 16. A snowmobile chassis, comprising:
  - a. a chassis comprising at least one layer of chassis material;
  - b. a heat exchanger constructed of at least two layers of material;

- c. a self piercing rivet that attaches the heat exchanger to the chassis by fastening the heat exchanger to the at least one layer of chassis material.

17. The snowmobile chassis of claim 16, wherein the heat exchanger is constructed of at least three layers of material.

- 18. A system for attaching a tube to a chassis, comprising:
  - a. a tube having opposing, parallel sides, wherein a portion of the tube is compressed so that the sides of the tube are adjacent to each other;
  - b. a chassis comprising at least one sheet of material;

- c. a self piercing rivet that attaches the sheet of material to the tube at the compressed portion of the tube by fastening the adjacent sides of the tube to the sheet of material.

19. A method of constructing a snowmobile chassis, comprising:

- a. fabricating a first chassis element formed of a sheet of material;
- b. fabricating a second chassis element formed of a sheet of material;
- c. layering the first chassis element, second chassis element, and a reinforcing sheet of material of a different composition than at least one of the chassis elements and configured to reinforce at least one of the chassis elements; and
- d. fastening the two chassis elements and the reinforcing sheet of material together via a self-piercing rivet to form a joint, the joint allowing load sharing and structural reinforcement of at least one of the chassis elements.

20. The method of claim 19, wherein the reinforcing sheet stiffens at least one of the chassis elements.

21. The method of claim 19, further comprising the step of layering a second reinforcing sheet of material and riveting the two sheets of reinforcing material and the two chassis elements together via a self piercing rivet to form a joint.

22. The method of claim 19, wherein the layering of the first chassis element, second chassis element, and the reinforcing sheet of material results in a joint wherein the first chassis element, second chassis element, and reinforcing sheet of material are coextensive in the proximity of the joint.

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