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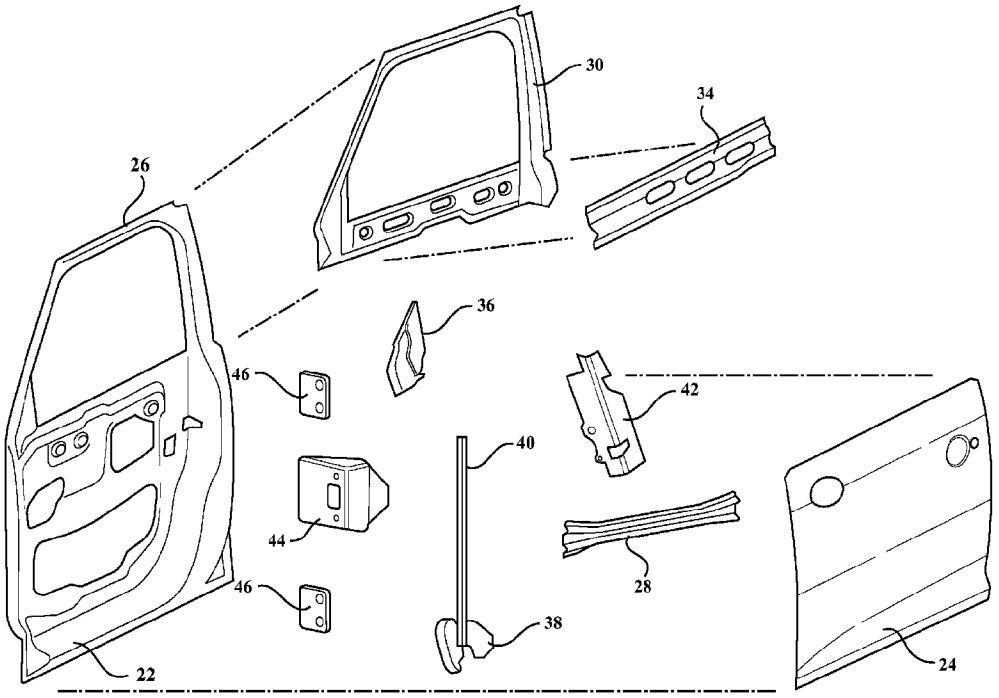

(57) Abrégé/Abstract:
A door assembly for a vehicle is provided. The door assembly includes an inner panel and an outer panel which are joined together to define a central space therebetween. The central space has a front which faces towards the front of a vehicle and a back which faces towards a back of the vehicle. Both the inner and outer panels are made of aluminum, and at least one reinforcement beam made of steel is disposed in the central space between the aluminum inner and outer panels to provide the door assembly with increased impact resistance.

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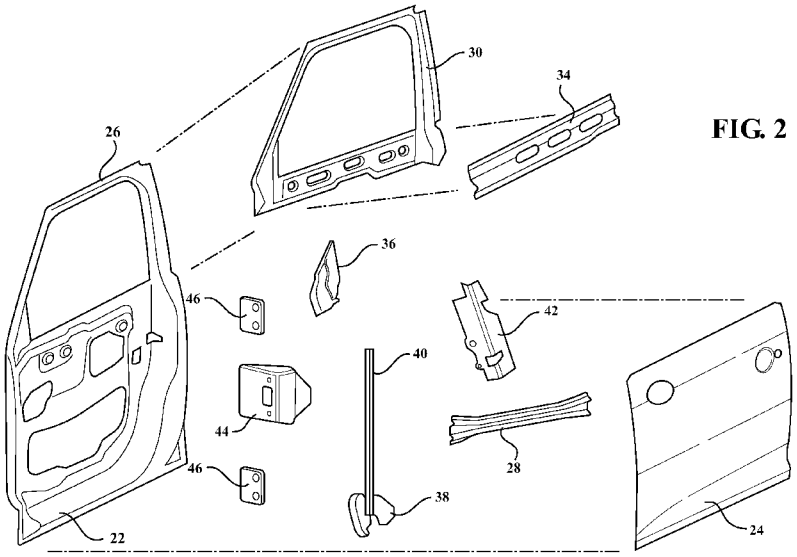

FIG. 2

(57) **Abstract**: A door assembly for a vehicle is provided. The door assembly includes an inner panel and an outer panel which are joined together to define a central space therebetween. The central space has a front which faces towards the front of a vehicle and a back which faces towards a back of the vehicle. Both the inner and outer panels are made of aluminum, and at least one reinforcement beam made of steel is disposed in the central space between the aluminum inner and outer panels to provide the door assembly with increased impact resistance.

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VEHICLE DOOR

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This PCT Patent Application claims the benefit of U.S. Provisional Patent Application Serial No. 61/674,547 filed July 23, 2012 entitled "Vehicle Door".

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention is generally related to vehicle doors and more particularly to vehicle door assemblies that include components made of different materials.

2. Related Art

[0003] Vehicle doors typically include an outer panel, an inner panel spaced laterally from the outer panel to provide a central space (also known as a window receiving well) and a window frame secured to the outer panel. Various components, such as a latch mechanism and a window channel, are secured to at least one of the inner and outer panels within the central space. Historically, all of these components, including the inner and outer panels, were formed of steel. However, more recently, in order to improve a vehicle's fuel economy and performance, some vehicle door manufacturers have used aluminum rather than steel to form the above-listed components. Although aluminum is generally lighter than steel, there are certain drawbacks to producing doors substantially entirely of aluminum. For example, a greater volume of aluminum may be required to provide an all-aluminum door with sufficient resistance to side impacts.

[0004] One known bi-metallic door assembly includes a large metal plate which is sandwiched between aluminum inner and outer panels. However, the weight savings from

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this approach are limited and this approach may be too costly for some mass manufacturing applications.

[0005] There is a significant and continuing need for a cost effective approach to reduce the weight of door assemblies without compromising their side impact resistance.

SUMMARY OF THE INVENTION

[0006] One aspect of the present invention provides for a door assembly for a vehicle. The door assembly includes an inner panel which is made of aluminum and an outer panel which is also made of aluminum. The aluminum inner and outer panels are joined together to define a central space between the inner and outer panels, and the central space has a front which faces towards the front of a vehicle and a back which faces towards a back of a vehicle. The door assembly also includes at least one reinforcement beam which is made of steel and extends lengthwise between the front and back of the central space between the aluminum inner and outer panels to provide improved impact resistance to the door assembly. The door assembly according to this aspect of the present invention is advantageous because it provides a cost effective weight or mass reduction without compromising the impact resistance of the door assembly.

[0007] According to another aspect of the present invention, in combination, all of the metal components attached to the aluminum inner and/or outer panels and located in the central space between said aluminum inner and outer panels are greater than 35% steel by mass and less than 65% aluminum by mass. Because the metal components are relatively smaller by volume than the aluminum inner and outer panels, the additional mass to the door assembly from the steel components in the central space is not significant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] These and other features and advantages of the present invention will be readily appreciated, as the same becomes better understood by reference to the following

detailed description when considered in connection with the accompanying drawings wherein:

[0009] Figure 1 is an elevation and perspective view of a first exemplary embodiment of a door assembly;

[0010] Figure 2 is an exploded view of the first exemplary embodiment of the door assembly;

[0011] Figure 3 is a fragmentary view of the first exemplary embodiment of the door assembly;

[0012] Figure 4 is an exploded view of a second exemplary embodiment of the door assembly; and

[0013] Figure 5 is an exploded view of a third exemplary embodiment of the door assembly.

DESCRIPTION OF THE ENABLING EMBODIMENT

[0014] Referring to the Figures, wherein like numerals represent corresponding parts throughout the several views, a first exemplary embodiment of a door assembly **20** for a vehicle is generally shown in Figures 1-3, a second exemplary embodiment of a door assembly **120** for a vehicle (not shown) is generally shown in Figure 4 and a third exemplary embodiment of a door assembly **220** for a vehicle is generally shown in Figures 5. As discussed in further detail below, each of the exemplary door assemblies **20, 120, 220** includes both aluminum components and steel components. This provides the door assemblies **20, 120, 220** with weight or mass savings without compromising their side impact resistance while also reinforcing certain portions of the door assemblies **20, 120, 220** that are particularly susceptible to damage. Additionally, the use of steel for certain components of the door assemblies **20, 120, 220** may provide for cost savings as compared to all-aluminum door assemblies. Even further, the use of steel for certain portions also

allows for a reduction in the thickness of the aluminum components without compromising the structural integrity of the door assemblies **20, 120, 220**. As such, the weight and cost effectiveness of the door assemblies **20, 120, 220** are both optimized without compromising their structural integrities and resistance to side impact forces. As used herein, the terms aluminum and steel are meant to include these metals in their pure forms as well as alloys thereof.

[0015] The door assemblies **20, 120, 220** of the exemplary embodiments are front driver-side doors of passenger vehicles. However, the door assemblies **20, 120, 220** could alternately be configured for use as passenger side or for rear vehicle doors. The door assemblies **20, 120, 220** may also be configured to be applied to the full range of segments of passenger vehicles as well as other types of vehicles including, for example, pick-up trucks, sport utility vehicles, cross-over vehicles, heavy trucks, personal transport vehicles, etc.

[0016] An exploded view of the first exemplary embodiment of the door assembly **20** is shown in Figure 2. The door assembly **20** of this exemplary embodiment has a so-called "frame behind glass" architecture. As shown, the door assembly **20** includes an inner panel **22** and an outer panel **24** which are joined together (see Figures 1 and 3) to define a central space having a front which faces towards the front of the vehicle and a back which faces towards the back of the vehicle. The inner and outer panels **22, 24** are made of aluminum. Since these components are by volume the largest components of the door assembly **20**, the use of aluminum for these panels **22, 24** allows for significant weight reduction as compared to door assemblies with steel inner and outer panels. In this exemplary embodiment, the inner panel **22** includes a window portion **26** formed integrally therewith, which allows for cost effective mass savings and may also offer better sealing options to the vehicle body (not shown).

[0017] The door assembly **20** further includes a reinforcement beam **28** in the form of a door beam **28** which extends lengthwise between the front and the back of the central space between the inner and outer panels **22, 24**. In other words, the door beam **28** extends in a lengthwise direction which corresponds to a forward and backward direction of the vehicle. The door beam **28** is made of steel to provide improved side impact reinforcement to the door assembly **20**. Specifically, in the event of a side impact collision, the door beam **28** absorbs energy from the impact forces to prevent collapse and failure of the other portions of the entire door assembly **20**, thereby protecting any occupants seated in the vehicle.

[0018] The door assembly **20** of this exemplary embodiment includes a window frame **30** which is formed as a separate component from the inner and outer panels **22, 24** and is attached to at least one of the panels **22, 24**. The window frame **30** and the window portion **26** of the aluminum inner panel **22** together receive a window **32** (see Figures 1 and 3) when it is in a "full up" position. In the exemplary embodiment, the window frame **30** is formed of one integral piece of material. However, it should be appreciated that the window frame **30** could alternately be formed of multiple pieces which are formed separately and subsequently joined together. A belt reinforcement piece **34** is attached to the lower portion of the window frame **30** to reinforce the area where the window frame **30** is attached to one of the inner and outer panels **22, 24**.

[0019] Within the central space between the inner and outer panels **22, 24**, the door assembly **20** includes an upper and lower hinge reinforcement pieces **36, 38** which are attached to at least one of the inner and outer panels **22, 24**. The upper and lower hinge reinforcement pieces **36, 38** are attached to and provide reinforcement to one or both of the inner and outer panels **22, 24** in the areas of the hinges (not shown) which join the door assembly **20** to the vehicle body (not shown). A window channel **40** for guiding movement

of the window **32** from the "full up" position to a "partial down" position or a "full down" position is also disposed within the central space between the inner and outer panels **22, 24**. In the first exemplary embodiment, the window channel **40** is coupled to one of the panels **22, 24** through the lower hinge reinforcement piece **38**.

[0020] A latch reinforcement piece **42** and a check link reinforcement piece **44** are also located within the central space between the inner and outer panels **22, 24** and joined to one of the panels **22, 24** for providing reinforcement in the area of a latch mechanism (not shown) and a check link (not shown) respectively. Even further, a pair of vertically spaced stud plate assemblies **46** are also attached to either the inner or the outer panel **22, 24** and are located within the central space.

[0021] In this exemplary embodiment, the window frame **30**; the upper and lower hinge reinforcement pieces **36, 38**; the window channel **40**; the check link reinforcement piece **44**; the latch reinforcement piece **42**; and the stud plate assemblies **46** are all formed of steel. Because these components are relatively small in volume they do not significantly increase the weight or mass of the door assembly **20** but they do provide increased strength to the areas of the inner and outer panels **22, 24** that may be susceptible to damage. Because these components provide reinforcement in areas of the inner and outer panels **22, 24** may be particularly susceptible to damage, the inner and outer door panels **22, 24** may be formed of a thinner piece of aluminum as compared to the inner and outer door panels **22, 24** of all aluminum door assemblies **20**. Rather than steel, the at least the upper hinge reinforcement piece **36** may be made out of magnesium. The window frame **30** may also be made of aluminum for additional weight or mass savings.

[0022] The combination of all of the metal components attached to at least one of the aluminum inner and outer panels **22, 24** and located in the central space between the inner and outer panels **22, 24** are greater than 35% steel by mass, less than 65% aluminum

by mass and less than 5% magnesium by mass. This has been found to provide the door assembly **20** with reduced weight or mass without compromising its side impact resistance.

[0023] Each of the aforementioned components of the door assembly **20** is preferably formed separately. Any suitable forming process or combination of processes may be employed for any or all of the components including, for example, stamping, roll-forming, extruding, casting and machining. The door beam **28** is preferably shaped through hot stamping process and then may be heat treated to achieve desired strength and hardness characteristics depending upon the specific application. The various components of the door assembly **20** (including the inner and outer panels **22, 24**; the door beam **28**; the window frame **30**; the belt reinforcement piece **34**; the upper and lower hinge reinforcement pieces **36, 38**; the window channel **40**; the latch reinforcement piece **42**; the check link reinforcement piece **44**; and the stud plate assemblies **46**) may be interconnected with one another through a range of different processes including, for example, welding, brazing, adhesives, rivets, mechanical fasteners, etc.

[0024] Referring now to Figure 4, the second exemplary embodiment of the door assembly **120** is generally shown, wherein like numerals separated by a factor of **100** are used to identify similar features as described above. This embodiment is similar to the above discussed first exemplary embodiment except the door assembly **120** includes a header assembly **148** in place of the window frame **30** and the upper and lower hinge reinforcement pieces **136, 138** are formed as one piece of material which is a part of the header assembly **148** rather than as separate components that are located in the central space between the aluminum inner and outer door panels **122, 124**. In this exemplary embodiment, all of the features of the header assembly **148** are formed of steel to provide increased strength to the upper portion of the door assembly **120**. Alternately, the

components of the header assembly may be formed of aluminum and magnesium rather than of steel.

[0025] Referring now to Figure 5, the third exemplary embodiment of the door assembly **220** is generally shown, wherein like numerals separated by a factor of **200** are used to identify similar features as described above. This exemplary embodiment is similar to the first exemplary embodiment described above except the window frame **30** is built into a mid-plane assembly **250** which includes door inner surround **230**, the check link reinforcement piece **244** and the upper hinge reinforcement piece **236**. The latch reinforcement **242** is also formed integrally with the steel door inner surround **230**. In this embodiment, the aluminum door inner mid panel **222** and steel door inner surround **230** are formed in place of the aluminum inner panel **22** and the window frame **30** of the above-discussed first exemplary embodiment, which provides for increased strength to the door assembly **220**.

[0026] With reference to the first exemplary embodiment shown in Figures 1-3, another aspect of the present invention is a method of making a door assembly **20** for a vehicle. The method of the exemplary embodiment includes the step of preparing an inner panel **22** made of aluminum and an outer panel **24** made of aluminum. The aluminum inner and outer panels **22, 24** may be formed through any suitable process including, for example, stamping, roll-forming, extrusion and casting. The method proceeds with the step of joining the aluminum panels **22, 24** together such that a central space is defined between the panels **22, 24** and wherein the central space has a front and a back. The method continues with the step of joining at least one reinforcement beam **28** made of steel to at least one of the aluminum inner and outer panels **22, 24** in the central space such that the at least one reinforcement beam **28** extends lengthwise between the front and back of the central space for increasing the impact resistance of the door assembly **20**.

[0027] The method may further include the step of attaching at least one metal component to at least one of the aluminum inner and outer panels **22, 24** and wherein all metal components attached to at least one of the inner and outer panels **22, 24** and located in the central space are greater than 35% steel by mass and less than 65% aluminum by mass.

[0028] The method may still further include the step of attaching a window channel **40** made of steel to at least one of the aluminum inner and outer panels **22, 24** in the central space for guiding movement of a window **32** and for providing increased impact resistance to the door assembly **20**.

[0029] The method may additionally include the step of attaching a window frame **30** made of steel to at least one of the aluminum inner and outer panels **22, 24**.

[0030] Additionally, the method may include the step of attaching at least one hinge reinforcement piece **36, 38** to at least one of the aluminum inner and outer panels **22, 24** within the central space.

[0031] Obviously, many modifications and variations of the present invention are possible in light of the above teachings and may be practiced otherwise than as specifically described while within the scope of the appended claims.

CLAIMS

1. A door assembly for a vehicle, comprising:

a door support structure including no more than two panels, said no more than two panels including an inner-most structural panel made of aluminum and an outer-most structural panel made of aluminum;

said aluminum inner-most and outer-most panels being joined together and defining a central space between said aluminum inner and outer panels, said central space having a front and a back;

at least one reinforcement beam made of a single monolithic piece of steel and extending lengthwise between said front and back of said central space between said aluminum inner-most and outer-most panels and fixed with at least one of said inner-most and outer-most panels for providing increased impact resistance to said door assembly;

said at least one reinforcement beam having a circumferentially continuous outer peripheral free edge bounding a volume;

said volume of said at least one steel reinforcement beam being less than a volume of said aluminum inner-most panel and being less than a volume of said aluminum outer-most panel;

a window channel, at least one latch reinforcement piece, and at least one check link reinforcement disposed in said central space between said aluminum inner-most and outer-most panels;

a window frame made of steel and a belt reinforcement piece attached with at least one of said inner-most and outer-most panels; and

said at least one reinforcement beam, said window channel, said at least one latch reinforcement piece, said at least one check link reinforcement, said window frame, and said belt reinforcement piece being, in combination, greater than 35% steel by mass, less than 65% aluminum by mass, and less than 5% magnesium by mass for reinforcing said aluminum inner-most and outer-most panels.

2. The door assembly as set forth in claim 1 wherein said at least one reinforcement beam in said central space between said aluminum inner-most and outer-most panels is a door beam.

3. The door assembly as set forth in claim 1 wherein said at least one hinge reinforcement piece is made of steel and positioned in said central space between said aluminum inner-most and outer-most panels.

4. The door assembly as set forth in claim 1 wherein said at least one latch reinforcement piece is made of steel and positioned in said central space between said aluminum inner-most and outer-most panels.

5. The door assembly as set forth in claim 1 further including a mid plane assembly made of steel and positioned at least partially in said central space between said aluminum inner-most and outer-most panels.

6. The door assembly as set forth in claim 1 wherein said at least one check link reinforcement piece is made of steel and positioned at least partially in said central space between said aluminum inner-most and outer-most panels.

7. The door assembly as set forth in claim 1 further including a plurality of reinforcement pieces disposed in said central space and each being smaller by volume than said aluminum inner-most panel and smaller by volume than said aluminum outer-most panel.

8. A method of making a door assembly for a vehicle, comprising the steps of:

preparing an inner-most panel made of aluminum and an outer-most panel made of aluminum;

joining said aluminum panels together such that a central space is defined between the panels and the central space has a front and a back to form a door support structure which includes no more panels than the inner-most and outer-most panels;

attaching a window channel, at least one latch reinforcement piece, and at least one check link reinforcement to one of the inner-most and outer-most panels and inside the central space for guiding a window into and out of the central space;

joining at least one reinforcement beam made as a single monolithic piece of steel and having a circumferentially continuous outer peripheral free edge that bounds a volume to at least one of the aluminum inner-most and outer-most panels in the central space such that the at least one reinforcement beam extends lengthwise between the front and back of the central space for increasing the impact resistance of the door assembly, wherein the volume of the

steel reinforcement beam is less than a volume of the aluminum inner-most panel and is less than a volume of the aluminum outer-most panel;

fixing a window frame made of steel and a belt reinforcement piece with at least one of the inner-most and outer-most panels; and

the at least one reinforcement beam, the window channel, the at least one latch reinforcement piece, the at least one check link reinforcement, the window frame, and the belt reinforcement piece being, in combination, greater than 35% steel by mass, less than 65% aluminum by mass, and less than 5% magnesium by mass for reinforcing the aluminum inner-most and outer-most panels.

9. The method of making a door assembly as set forth in claim 8 further including attaching at least one other metal component to at least one of the aluminum inner-most and outer-most panels and wherein in combination all metal components attached to at least one of the aluminum inner-most and outer-most panels and located in the central space between the aluminum inner-most and outer-most panels are greater than 35% steel by mass and less than 65% aluminum by mass.

10. The method of making a door assembly as set forth in claim 8 further including the step of attaching at least one hinge reinforcement piece to at least one of the aluminum inner-most and outer-most panels within the central space between the aluminum inner-most and outer-most panels.

11. The method of making a door assembly as set forth in claim 8 further including the step of disposing a plurality of reinforcement pieces made of steel between the aluminum inner-most panel and the aluminum outer-most panel, and each of the reinforcement pieces being smaller by volume than the aluminum inner-most panel and smaller by volume than the aluminum outer-most panel.

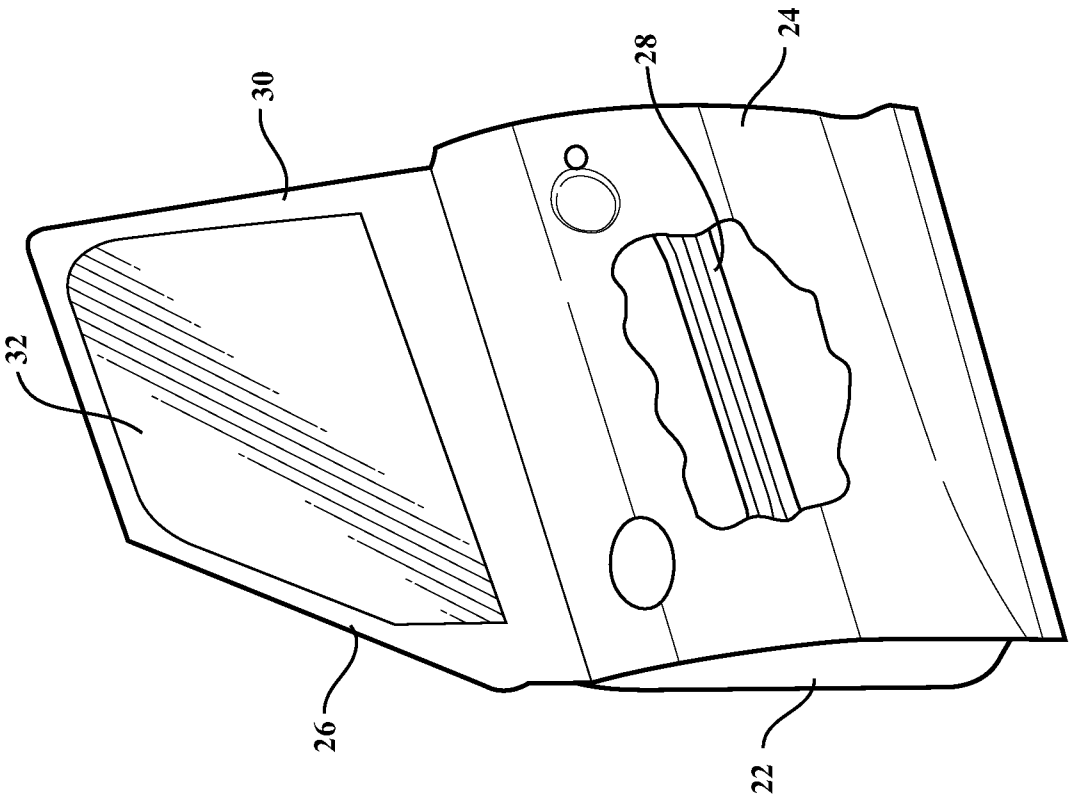


FIG. 3

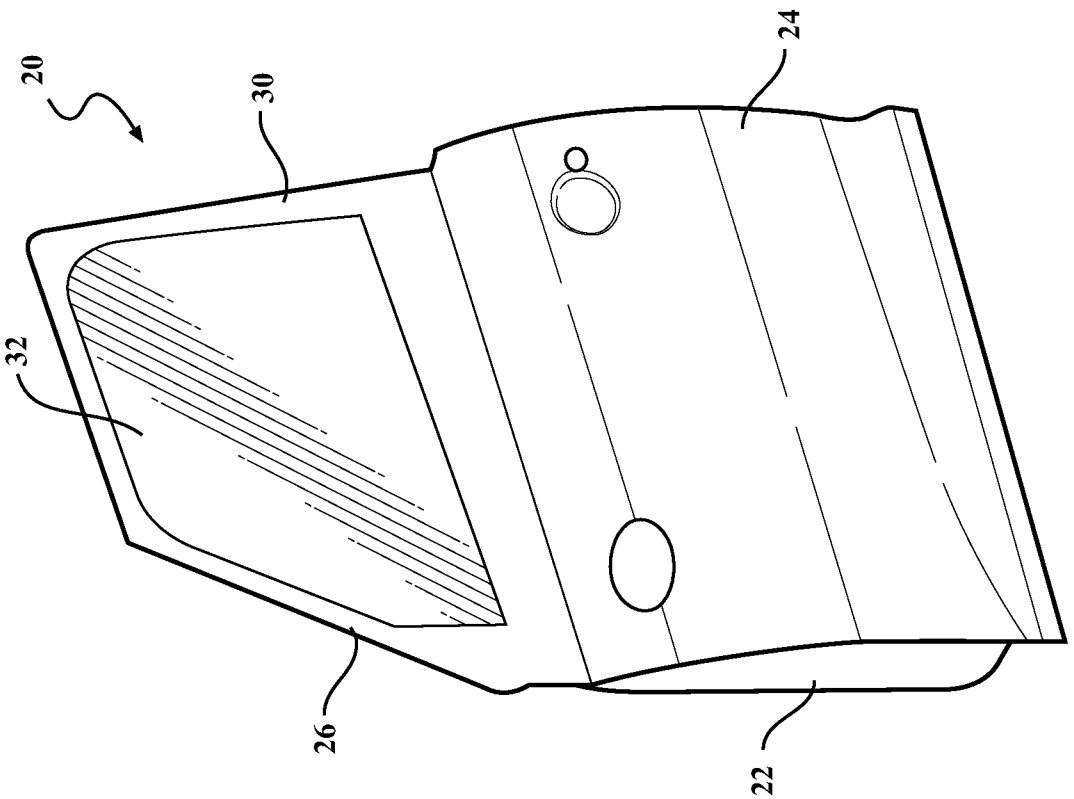
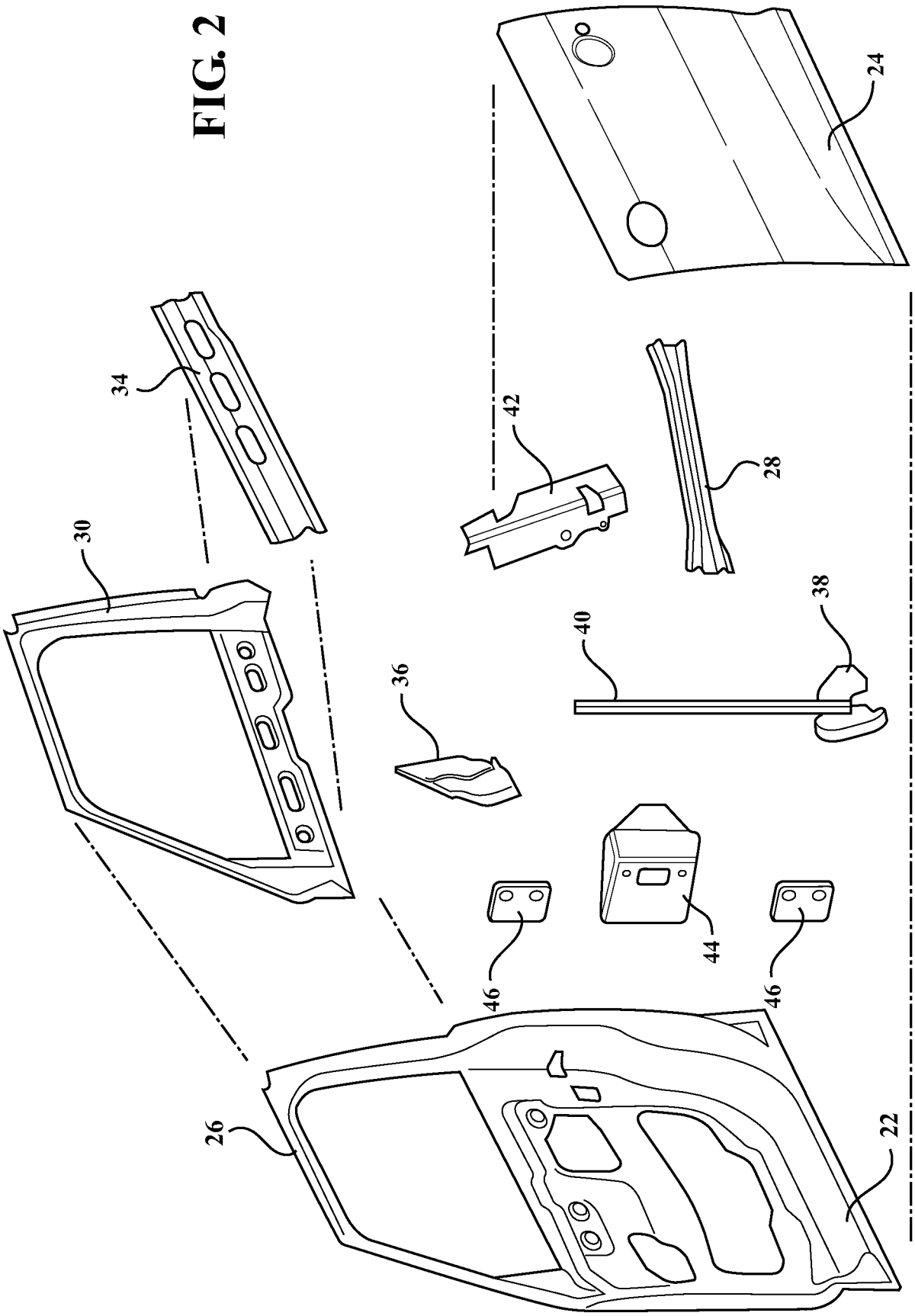


FIG. 1

FIG. 2



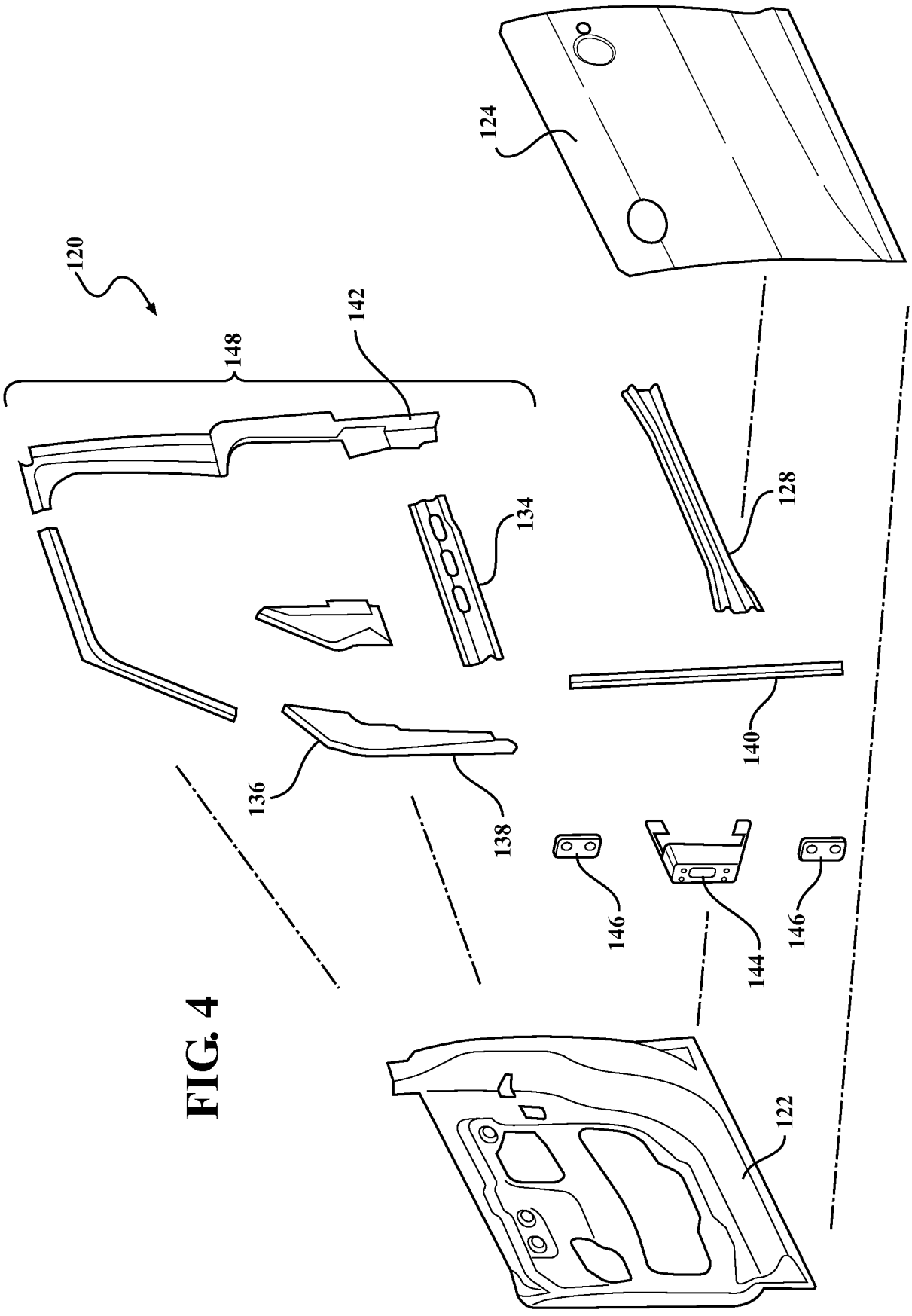


FIG. 4

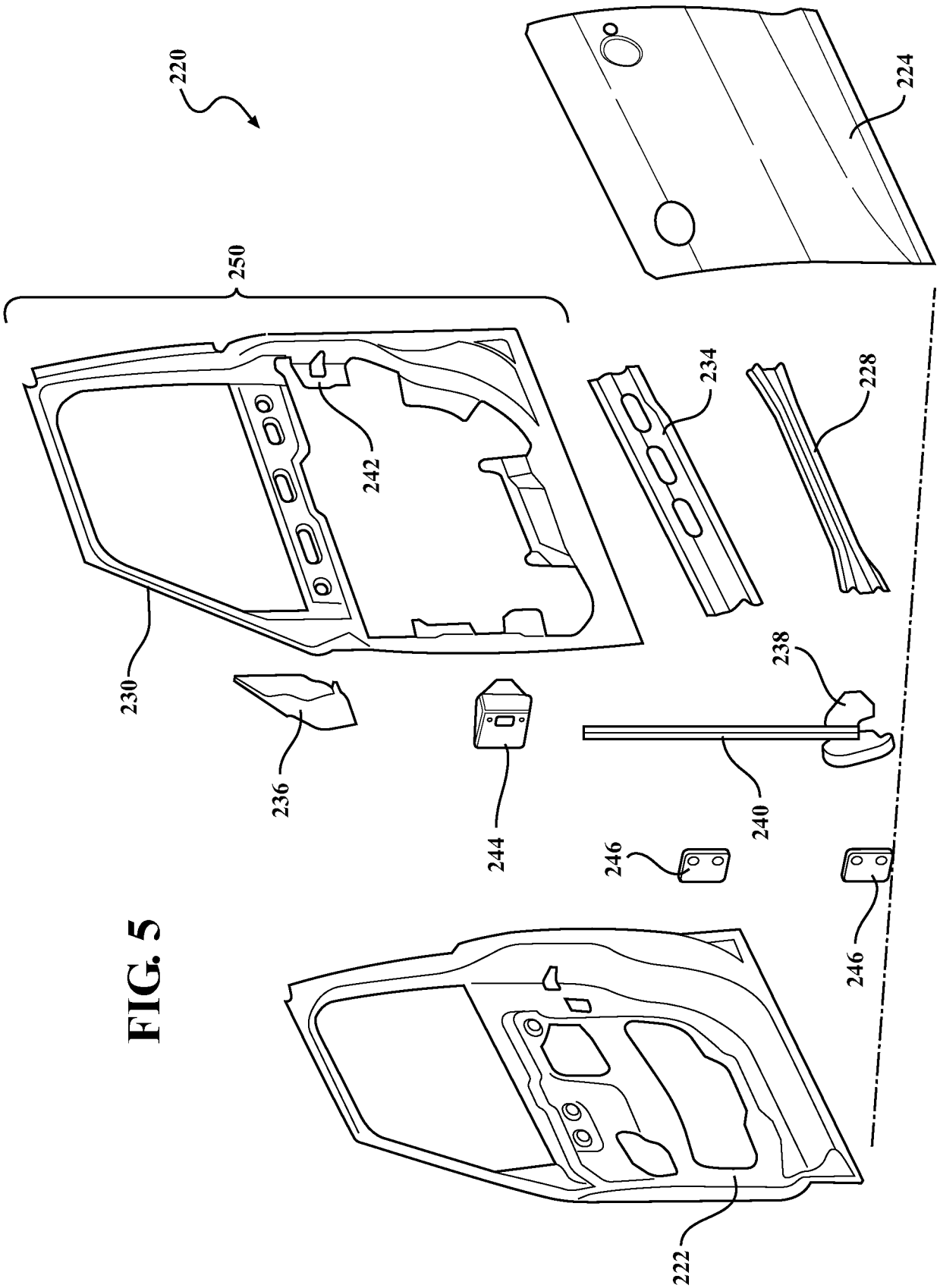
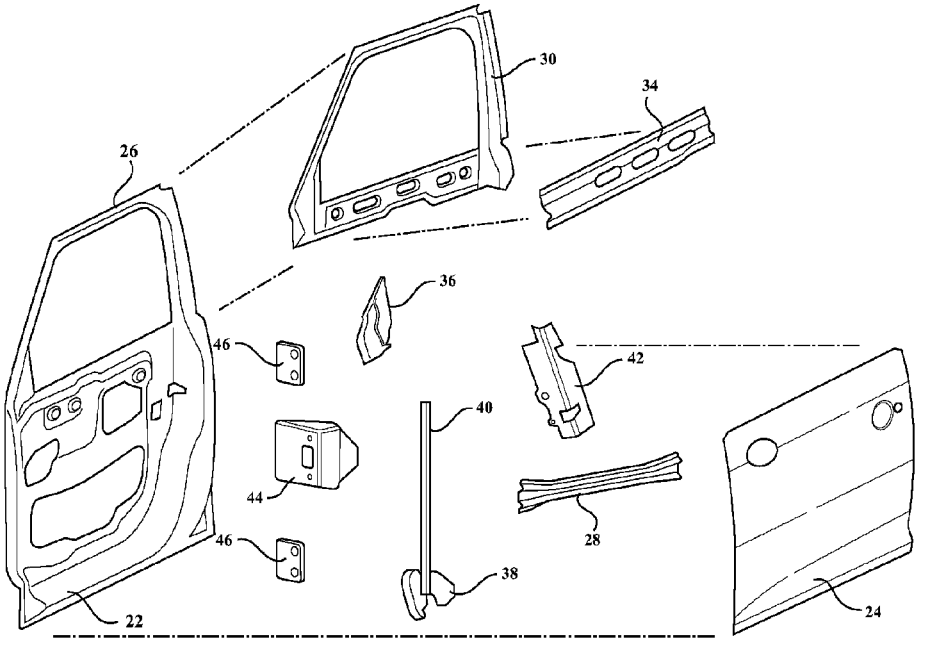


FIG. 5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