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(71) Applicant: **Nabtesco Corporation**
Tokyo 102-0093 (JP)

(72) Inventors:
• **KUROMITSU, Masaru**
Kobe-shi,
Hyogo 651-2271 (JP)
• **TAKASHIMA, Yoji**
Kobe-shi,
Hyogo 651-2271 (JP)
• **NAKAGAWA, Hiroshi**
Kobe-shi,
Hyogo 651-2271 (JP)

- **TAKAHASHI, Akira**
Kobe-shi,
Hyogo 651-2271 (JP)
- **MIYAUCHI, Tatsuo**
Kobe-shi,
Hyogo 651-2271 (JP)
- **HAMASAKI, Mitsuyoshi**
Kobe-shi,
Hyogo 651-2271 (JP)
- **TANAKA, Genpei**
Kobe-shi,
Hyogo 651-2271 (JP)
- **MIZUFUNE, Toru**
Kobe-shi,
Hyogo 651-2271 (JP)

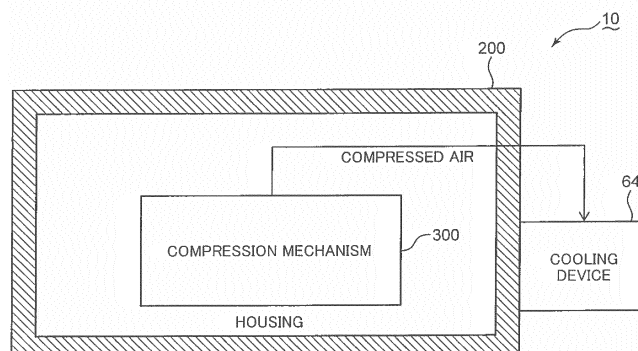
(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(54) **AIR COMPRESSION DEVICE**

(57) The present application discloses an air compression device which includes a compression mechanism configured to compress air and generate com-

pressed air, a housing in which the compression mechanism is housed, and a cooling device configured to cool the compressed air outside the housing.

FIG. 1



Description

Technical Field

[0001] The present invention relates to an air compression device which generates compressed air.

Background Art

[0002] An air compression device which generates compressed air is used for various uses. The compressed air generated by the air compression device mounted to a vehicle (a railroad vehicle, for example) may be supplied to a brake device which applies braking force to the vehicle or to pneumatic equipment which opens and closes a door of a vehicle in some cases.

[0003] Patent Literature 1 proposes an air compression device mounted to a railroad vehicle. The air compression device includes a housing in which a compression mechanism which compresses air is housed. A housing by which a compression mechanism is enclosed can appropriately protect the compression mechanism from a flipped stone or other flying objects during travel of a vehicle. In addition, the housing can prevent leakage of a sound generated by a compression mechanism (sound isolating function). Further, the housing can protect a compression mechanism from dust which causes breakdown of the compression mechanism (dustproof function).

[0004] A compression mechanism, typically, performs rotational movement, to generate compressed air. Rotational movement of the compression mechanism causes vibration, so that the compression mechanism is a source of vibration. Accordingly, if the air compression device is mounted directly in a vehicle, vibration is easily transmitted to a vehicle through a housing in which the compression mechanism is housed. More specifically, vibration of the compression mechanism is transmitted to a housing supporting the compression mechanism, and then is transmitted to a frame of a vehicle connected with the housing. Vibration transmission to a vehicle gives unpleasantness to a passenger in a vehicle. That is, riding comfort is degraded.

Citation List

Patent Literature

[0005] Patent Literature 1: Japanese Utility Model Registration Publication No. 3150077

Summary of Invention

[0006] It is an object of the present invention to provide an air compression device which allows reduction of vibration transmitted to a vehicle.

[0007] An air compression device according to one aspect of the present invention includes: a compression

mechanism configured to compress air and generate compressed air; a housing in which the compression mechanism is housed; and a cooling device configured to cool the compressed air, outside the housing.

[0008] In the above-described air compression device, because of provision of the cooling device outside the housing, there is no need to save a space where the cooling device is to be arranged in the housing, so that the housing can be designed to be smaller. Downsizing of the housing allows reduction in amplification of vibration of the compression mechanism, which results in reduction in vibration transmitted to a vehicle.

[0009] The objects, features, and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

Brief Description of Drawings

[0010]

FIG. 1 is a schematic view of an air compression device according to a first embodiment.

FIG. 2 is a schematic view of an air compression device according to a second embodiment.

FIG. 3 is a schematic view of an air compression device according to a third embodiment

FIG. 4A is a schematic perspective view of an air compression device according to a fourth embodiment.

FIG. 4B is another schematic perspective view of the air compression device shown in FIG. 4A.

FIG. 5 is a schematic perspective view of a plate member used in manufacture of a top plate of the air compression device shown in FIG. 4A (a fifth embodiment).

FIG. 6 is a schematic plan view of a first plate member of the air compression device shown in FIG. 4A.

FIG. 7 is a schematic perspective view of the first plate member shown in FIG. 6.

FIG. 8 is a schematic perspective view of the top plate of the air compression device shown in FIG. 4A.

FIG. 9 is a schematic perspective view of an exemplary framework structure incorporated in a housing of the air compression device shown in FIG. 4A (a sixth embodiment).

FIG. 10 is a schematic perspective view of a holding plate portion of the framework structure shown in FIG. 9.

FIG. 11 is another schematic perspective view of the air compression device shown in FIG. 4A (a seventh embodiment).

FIG. 12 is another schematic perspective view of the air compression device shown in FIG. 4A (an eighth embodiment).

FIG. 13A is a schematic perspective view of a cooling air flow adjusting box of the air compression device

shown in FIG. 12.

FIG. 13B is a schematic back view of the cooling air flow adjusting box shown in FIG. 13A.

FIG. 14A is another schematic perspective view of the framework structure shown in FIG. 9 (a ninth embodiment).

FIG. 14B is another schematic perspective view of the framework structure shown in FIG. 14A (the ninth embodiment).

FIG. 15 is a schematic plan view showing an internal configuration of the air compression device shown in FIG. 4A (a tenth embodiment).

FIG. 16 is a schematic cross-sectional view of a suction guide structure of the air compression device shown in FIG. 15.

FIG. 17 is a schematic enlarged perspective view of a part of a guide pipe for guide in the air compression device shown in FIG. 15.

Description of Embodiments

<First Embodiment>

[0011] The present inventors have found that a small housing tends to have high stiffness. In addition, the present inventors have found that when a compression mechanism which is a source of vibration is arranged in a housing, downsizing of the housing could reduce amplification of vibration of the compression mechanism, so that vibration transmitted to a vehicle could be kept at a low level. In a first embodiment, an exemplary air compression device which is constructed based on those findings will be described.

[0012] FIG. 1 is a conceptual view of an air compression device 10 according to the first embodiment. Referring to FIG. 1, the air compression device 10 will be described.

[0013] The air compression device 10 includes a housing 200, a compression mechanism 300, and a cooling device 64. The compression mechanism 300 is arranged within the housing 200. The compression mechanism 300 compresses air and generates compressed air in the housing 200. The compression mechanism 300 may include a general scroll compressor. Alternatively, the compression mechanism 300 may include a general rotary compressor. Further alternatively, the compression mechanism 300 may include a general swing compressor. Further alternatively, the compression mechanism 300 may include a general reciprocating compressor. Principles of the present embodiment are not limited to any specific techniques for generating compressed air.

[0014] As described above, compressed air is generated by a compressing operation of the compression mechanism 300, so that compressed air has a high temperature. The cooling device 64 is used for cooling compressed air.

[0015] The cooling device 64 is arranged outside the housing 200. Accordingly, a designer who designs the

air compression device 10 need not save a space where the cooling device 64 is to be arranged in the housing 200. Thus, a designer can give a small dimension value to the housing 200. Downsizing of the housing 200 allows reduction in amplification of vibration of the compression mechanism 300, so that vibration transmitted to a vehicle can be reduced. Also, the housing 200 has a soundproof function and a dustproof function for the compression mechanism 300. The cooling device 64 may be held directly by the housing 200. Alternatively, the cooling device 64 may be held by other holding members. Principles of the present embodiment are not limited to any specific configuration for holding the cooling device 64.

[0016] Compressed air generated by the compression mechanism 300 flows into the cooling device 64 through an appropriate pipeline extending between the compression mechanism 300 and the cooling device 64. The compression mechanism 300 which compresses air and generates compressed air becomes high in temperature. Accordingly, a housing space covered with the housing 200 in which the compression mechanism 300 is housed is likely to be higher in temperature than an external environment provided outside the housing 200. A temperature in an external environment provided outside the housing 200 is lower than that in an internal space of the housing 200, so that the cooling device 64 installed outside the housing 200 can more efficiently cool compressed air, as compared to a case in which the cooling device 64 is installed in an internal space of the housing 200.

[0017] The cooling device 64 may include a pipe body which meanders while circulating compressed air. In order to more efficiently cool compressed air, the pipe body may be formed of a material having high thermal conductivity and be improved in terms of heat dissipation. Additionally, many heat-dissipating fins may be attached to the pipe body. Alternatively, the cooling device 64 may have any other configuration that can cool compressed air. Principles of the present embodiment are not limited to any specific configuration of the cooling device 64.

<Second embodiment>

[0018] In addition to the cooling device, other various devices may be arranged outside the housing. In a second embodiment, an exemplary air compression device which includes a controller arranged outside the housing, will be described. In a case where the controller is provided in a housing which transmits vibration thereof at a low level, a designer need not enhance a shock-proof function of internal electronic equipment.

[0019] FIG. 2 is a conceptual view of an air compression device 11 according to the second embodiment. Reference signs used in common with the first embodiment are used for elements which are conceptually common to those in the first embodiment. Referring to FIG. 2, the air compression device 11 will be described.

[0020] In the same manner as in the first embodiment,

the air compression device 11 includes the housing 200, the compression mechanism 300, and the cooling device 64. Description in the first embodiment is also applied to those elements.

[0021] The air compression device 11 further includes a controller 62. The controller 62 is electrically connected to the compression mechanism 300 by an appropriate signal line. The compression mechanism 300 compresses air and generates compressed air under control of the controller 62.

[0022] The controller 62 is arranged outside the housing 200. Accordingly, a designer who designs the air compression device 11 need not save a space where the controller 62 is to be arranged in the housing 200. As a result, a designer can give a small dimension value to the housing 200. Downsizing of the housing 200 allows reduction in vibration transmitted to a vehicle. The controller 62 may be held directly by the housing 200. Alternatively, the controller 62 may be held by other holding members. Principles of the present embodiment are not limited to any specific configuration for holding the controller 62.

<Third embodiment>

[0023] A designer who designs an air compression device can design a small housing having high stiffness based on the design principles described in connection with the above-described embodiments. A designer may incorporate techniques for reducing vibration transmission in a connecting portion which connects a housing to a vehicle. In a third embodiment, techniques for reducing vibration transmission from an air compression device to a vehicle will be described.

[0024] FIG. 3 is a conceptual view of an air compression device 100 according to the third embodiment. Reference signs used in common with the second embodiment are used for elements which are common similar to those in the second embodiment. Referring to FIG. 3, the air compression device 100 will be described.

[0025] The air compression device 100 is mounted to a vehicle TCH. The vehicle TCH may be any of various apparatuses which use compressed air (a railroad vehicle, a large truck, or a mobile construction machine). Principles of the present embodiment are not limited to any specific kind of the vehicle TCH.

[0026] A mounting position of the air compression device 100 to the vehicle TCH may be determined in conformity with a design of the vehicle TCH. If the vehicle TCH is a railroad vehicle, the air compression device 100 may be fixed to a frame of a passenger car (that is, an underside of a floor of the vehicle TCH). Principles of the present embodiment are not limited to any specific mounting position of the air compression device 100 to the vehicle TCH.

[0027] In the same manner as in the second embodiment, the air compression device 100 is provided with the housing 200, the compression mechanism 300, the

controller 62, and the cooling device 64. Description in the second embodiment is also applied to those elements.

[0028] The air compression device 100 is further provided with a connecting structure 400. The connecting structure 400 is used for connecting the housing 200 and the vehicle TCH. The housing 200 includes a top plate 210 which faces an underside of a floor of the vehicle TCH. The top plate 210 is attached to a frame of the vehicle TCH using the connecting structure 400.

[0029] The compression mechanism 300 is housed in the housing 200. Accordingly, the compression mechanism 300 is positioned under the top plate 210. As described in connection with the first embodiment, the compression mechanism 300 may include a scroll compressor, a rotary compressor, a swing compressor, or a reciprocating compressor.

[0030] The compression mechanism 300 may be a combination of any of the above-stated compressors and a motor. A compressor and a motor may be aligned on a common horizontal plane. In this case, the compressor may be directly connected to the motor. Alternatively, the compressor and the motor may be vertically aligned. In this case, the compression mechanism 300 may include a transmission mechanism which transmits driving force from the motor to the compressor. If the compressor and the motor are vertically aligned, a designer can give a small value to an area of the housing 200 on a horizontal plane. This makes it possible to reduce a horizontal footprint of the air compression device 100 placed under a floor of the vehicle TCH. In a case where many machines should be placed under a floor of the vehicle TCH, respective spaces where machines are to be placed can be provided. Principles of the present embodiment are applicable to various configurations of the compression mechanism 300. Therefore, principles of the present embodiment are not limited to any specific configuration of the compression mechanism 300.

[0031] Compressed air is used for operating various pneumatic equipment mounted in the vehicle TCH (pneumatic equipment used for a brake device which causes braking force to act on the vehicle TCH, or pneumatic equipment used for opening and closing a door of the vehicle TCH, for example). Principles of the present embodiment are not limited to any specific use of compressed air.

[0032] The connecting structure 400 is arranged between the top plate 210 and the vehicle TCH. The connecting structure 400 includes a vibration isolator 410 which is in contact with the top plate 210. The compression mechanism 300 becomes as a source of vibration which generates vibration during generation of compressed air. The vibration isolator 410 reduces amplification of vibration transmitted from the compression mechanism 300 to the vehicle TCH. The vibration isolator 410 may include a general vibration isolating component which is formed of a material such as rubber or resin. Principles of the present embodiment are not limited to

any specific component used as the vibration isolator 410.

<Fourth embodiment>

[0033] A designer can design various air compression devices based on the design principles described in connection with the third embodiment. In a fourth embodiment, an exemplary air compression device will be described.

[0034] FIGs. 4A and 4B are schematic perspective views of an air compression device 100A according to the fourth embodiment. Referring to FIGs. 3 to 4B, the air compression device 100A will be described.

[0035] The air compression device 100A includes a housing 200A and a connecting structure 400A. The housing 200A corresponds to the housing 200 described with reference to FIG. 3. The connecting structure 400A corresponds to the connecting structure 400 described with reference to FIG. 3. A compression mechanism (not shown) which generates compressed air is housed in the housing 200A.

[0036] The housing 200A includes a top plate 210A (refer to FIG. 4A), a substantially rectangular right panel 220 (refer to FIG. 4A), and a substantially rectangular left panel 230 (refer to FIG. 4B). The top plate 210A corresponds to the top plate 210 described with reference to FIG. 3. The top plate 210A lies substantially horizontally as a whole, whereas the right panel 220 and the left panel 230 are erected substantially vertically.

[0037] The top plate 210A includes a main plate portion 211 (refer to FIG. 4A) and outer edge ribs 212 and 213 (refer to FIGs. 4A and 4B). The main plate portion 211 forms a substantially rectangular upper surface of the housing 200A. The outer edge rib 212 is bent downward from the main plate portion 211, and is connected to the right panel 220. A bending line 214 (refer to FIG. 4A) formed between the outer edge rib 212 and the main plate portion 211 forms one of corner lines of the housing 200A. The outer edge rib 213 is bent downward from the main plate portion 211, and is connected to the left panel 230. A bending line 215 (refer to FIG. 4B) formed between the outer edge rib 213 and the main plate portion 211 forms another one of the corner lines of the housing 200A.

[0038] As shown in FIG. 4A, the top plate 210A forms a front corner line 216 and a rear corner line 217. The front corner line 216 extends between respective front ends of the bending lines 214 and 215. The rear corner line 217 extends between respective rear ends (ends opposite to front ends) of the bending lines 214 and 215. The bending lines 214 and 215, the front corner line 216, and the rear corner line 217 form a substantially rectangular outline of an upper surface of the housing 200A.

[0039] The connecting structure 400A includes a right connecting structure 401 and a left connecting structure 402. As shown in FIG. 4A, the right connecting structure 401 includes vibration isolating rubbers 411 and 412 and a frame member 420. The vibration isolating rubber 411

is arranged in a corner formed by the bending line 214 and the front corner line 216. The vibration isolating rubber 412 is arranged in a corner formed by the bending line 214 and the rear corner line 217. The frame member 420 has a substantially C-shaped cross section. The frame member 420 is arranged along the bending line 214. The left connecting structure 402 includes vibration isolating rubbers 413 and 414 and a frame member 430. The vibration isolating rubber 413 is arranged in a corner formed by the bending line 215 (refer to FIG. 4B) and the front corner line 216. The vibration isolating rubber 414 is arranged in a corner formed by the bending line 215 and the rear corner line 217. The frame member 430 has a substantially C-shaped cross section. As shown in FIG. 4B, the frame member 430 is arranged along the bending line 215.

[0040] The vibration isolating rubbers 411, 412, 413, and 414 may be formed of rubber which can reduce amplification of vibration. The vibration isolating rubbers 411, 412, 413, and 414 correspond to the vibration isolator 410 described with reference to FIG. 3.

[0041] As shown in FIG. 4A, the frame member 420 of the right connecting structure 401 includes a lower frame portion 421, an upper frame portion 422, and an intermediate frame portion 423. The vibration isolating rubbers 411 and 412 are interposed between the top plate 210A and the lower frame portion 421. The right connecting structure 401 is appropriately fixed to the housing 200A by a screw FXT which penetrates the top plate 210A, the vibration isolating rubbers 411 and 412, and the lower frame portion 421. The upper frame portion 422 is connected to a vehicle (not shown). The intermediate frame portion 423 holds the upper frame portion 422 in a position separated by some distance from the lower frame portion 421.

[0042] Through holes 424 and 425 are formed in the upper frame portion 422. The through holes 424 and 425 are used for connecting the right connecting structure 401 and a vehicle (not shown). A designer may determine positions of the through holes 424 and 425 in conformity with a configuration of a vehicle. Thus, principles of the present embodiment are not limited to any specific positions of the through holes 424 and 425.

[0043] A designer may form only one of the through holes 424 and 425. Alternatively, an additional through hole may be formed in the upper frame portion 422. Principles of the present embodiment are not limited to how many through holes are to be formed in the upper frame portion 422.

[0044] According to the present embodiment, an operator can mount the air compression device 100A to a vehicle by inserting an appropriate fixing tool such as a screw into each of the through holes 424 and 425. Alternatively, a designer may provide an engaging structure which can engage with a vehicle, in the upper frame portion. Principles of the present embodiment are not limited to any specific configuration for connection between the upper frame portion and a vehicle.

[0045] As shown in FIG. 4A, the frame member 430 of the left connecting structure 402 includes a lower frame portion 431, an upper frame portion 432, and an intermediate frame portion 433. The vibration isolating rubbers 413 and 414 are interposed between the top plate 210A and the lower frame portion 431. The left connecting structure 402 is appropriately fixed to the housing 200A by a screw (not shown) which penetrates the top plate 210A, the vibration isolating rubbers 413 and 414, and the lower frame portion 431. The upper frame portion 432 is connected to a vehicle (not shown). The intermediate frame portion 433 holds the upper frame portion 432 in a position separated by some distance from the lower frame portion 431.

[0046] Through holes 434 and 435 are formed in the upper frame portion 432. The through holes 434 and 435 are used for connecting the left connecting structure 402 and a vehicle (not shown). A designer may determine positions of the through holes 434 and 435 in conformity with a configuration of a vehicle. Thus, principles of the present embodiment are not limited to any specific positions of the through holes 434 and 435.

[0047] A designer may form only one of the through holes 434 and 435. Alternatively, an additional through hole may be formed in the upper frame portion 432. Principles of the present embodiment are not limited to how many through holes are to be formed in the upper frame portion 432.

[0048] According to the present embodiment, an operator can mount the air compression device 100A to a vehicle by inserting an appropriate fixing tool such as a screw into each of the through holes 434 and 435. Alternatively, a designer may provide an engaging structure which can engage with a vehicle, in the upper frame portion. Principles of the present embodiment are not limited to any specific configuration for connection between the upper frame portion and a vehicle.

<Fifth embodiment>

[0049] In a case where the design principles of the air compression device described in connection with the fourth embodiment are employed, while a corner of a top plate is required to have high mechanical strength in order to bear a weight of an air compression device, a central portion of the top plate is not required to have such high mechanical strength as that of the corner. According to a fifth embodiment, techniques for manufacturing a top plate having suitable mechanical strength will be described.

[0050] FIG. 5 is a schematic perspective view of a plate member used in manufacture of the top plate 210A. Referring to FIGs. 4A and 5, the top plate 210A will be described.

[0051] As shown in FIG. 5, the top plate 210A includes a rectangular first plate member 240 and a rectangular second plate member 250. The first plate member 240 is bigger than the second plate member 250. As shown

in FIG. 4A, the second plate member 250 is arranged at an almost center of the first plate member 240 on which a cutting process and a bending process are performed, and is surrounded by the first plate member 240.

[0052] FIG. 6 is a schematic plan view of the first plate member 240 which is provided before a bending process is performed. Referring to FIGs. 4A to 6, processes performed on the first plate member 240 will be described.

[0053] A solid line in FIG. 6 shows a cutting line or an outer-shape line. A dotted line in FIG. 6 means a bending line.

[0054] Four corners of the first plate member 240 in a rectangular shape shown in FIG. 5 are cut, so that four recessed corners 241, 242, 243, and 244 which are recessed so as to be substantially right-angled are formed. The bending line 214 described with reference to FIG. 4A extends between the recessed corners 241 and 242. The outer edge rib 212 described with reference to FIG. 4A is a rectangular area which protrudes toward an outer edge of the first plate member 240 from the bending line 214. The bending line 215 described with reference to FIG. 4B extends between the recessed corners 243 and 244. The outer edge rib 213 described with reference to FIG. 4B is a rectangular area which protrudes toward an outer edge of the first plate member 240 from the bending line 215.

[0055] The front corner line 216 described with reference to FIG. 4A extends between the recessed corners 241 and 243. The rear corner line 217 described with reference to FIG. 4A extends between the recessed corners 242 and 244. A substantially rectangular area surrounded by the bending lines 214 and 215, the front corner line 216, and the rear corner line 217 is used as a part of the main plate portion 211 (refer to FIG. 4A) which faces an underside of a floor of a vehicle when the air compression device 100A is arranged under a floor of a vehicle (not shown). In the present embodiment, an example of a facing surface is shown by an upper surface of the main plate portion 211.

[0056] As shown in FIG. 6, the first plate member 240 includes outer edge ribs 218 and 219. The outer edge rib 218 is a rectangular area which protrudes toward an outer edge of the first plate member 240 from the front corner line 216. The outer edge rib 219 is a rectangular area which protrudes toward an outer edge of the first plate member 240 from the rear corner line 217. A perforation process may be performed on each of the outer edge ribs 212, 213, 218, and 219. An operator who assembles the air compression device 100A may compose the top plate 210A of the housing 200A by inserting an appropriate fixing tool such as a screw into a through hole formed in each of the outer edge ribs 212, 213, 218, and 219.

[0057] Cutting lines 245 and 246 which are substantially parallel to the bending line 214 are formed within an area surrounded by the bending lines 214 and 215, the front corner line 216, and the rear corner line 217. The cutting line 245 is formed closer to the bending line

214 than the cutting line 246.

[0058] Cutting lines 247 and 248 which are substantially perpendicular to the cutting line 245 are formed between the cutting lines 245 and 246. The cutting lines 247 and 248 extend substantially parallel to the front corner line 216. A plate piece in an area surrounded by the cutting lines 245, 246, 247, and 248 are removed from the first plate member 240.

[0059] Cutting lines 261 and 262 which are perpendicular to the cutting line 245 and extend toward an outer edge of the first plate member 240 from both ends of the cutting line 245, respectively, are further formed. The cutting line 261 extends from a front end of the cutting line 245. The cutting line 262 extends from a rear end of the cutting line 245.

[0060] A bending line 271 extending between respective distal ends of the cutting lines 261 and 262 is further formed. A substantially rectangular area surrounded by the cutting lines 245, 261, and 262 and the bending line 271 is used as an inner edge rib 281 which reinforces the top plate 210A.

[0061] Cutting lines 263 and 264 which are perpendicular to the cutting line 246 and extend toward an outer edge of the first plate member 240 from both ends of the cutting line 246, respectively, are further formed. The cutting line 263 extends from a front end of the cutting line 246. The cutting line 264 extends from a rear end of the cutting line 246.

[0062] A bending line 272 extending between respective distal ends of the cutting lines 263 and 264 is further formed. A substantially rectangular area surrounded by the cutting lines 246, 263, and 264 and the bending line 272 is used as an inner edge rib 282 which reinforces the top plate 210A.

[0063] A bending line 273 extending between respective front ends of the cutting lines 245 and 246 is further formed. The bending line 273 is arranged in line with the cutting lines 261 and 263. A substantially rectangular area surrounded by the cutting lines 245, 246, and 247 and the bending line 273 is used as an inner edge rib 283.

[0064] A bending line 274 extending between respective rear ends of the cutting lines 245 and 246 is further formed. The bending line 274 is arranged in line with the cutting lines 262 and 264. A substantially rectangular area surrounded by the cutting lines 245, 246, and 248 and the bending line 274 is used as an inner edge rib 284.

[0065] FIG. 7 is a schematic perspective view of the first plate member 240 on which a cutting process and a bending process are performed. Referring to FIGs. 4A and 7, the first plate member 240 will be further described.

[0066] As shown in FIG. 7, the first plate member 240 is bent along the bending line 214. As a result, the outer edge rib 212 which is bent at a substantially right angle with respect to the main plate portion 211 is formed.

[0067] The first plate member 240 is bent along the bending line 215. As a result, the outer edge rib 213 which is bent at a substantially right angle with respect to the main plate portion 211 is formed.

[0068] The first plate member 240 is bent along the front corner line 216. As a result, the outer edge rib 218 which is bent at a substantially right angle with respect to the main plate portion 211 is formed.

[0069] The first plate member 240 is bent along the rear corner line 217. As a result, the outer edge rib 219 which is bent at a substantially right angle with respect to the main plate portion 211 is formed.

[0070] The outer edge ribs 212, 213, 218, and 219 form a substantially rectangular outline of an outer shape of the top plate 210A.

[0071] The first plate member 240 is bent along the bending line 271. As a result, the inner edge rib 281 which is bent at a substantially right angle with respect to the main plate portion 211 is formed.

[0072] The first plate member 240 is bent along the bending line 272. As a result, the inner edge rib 282 which is bent at a substantially right angle with respect to the main plate portion 211 is formed.

[0073] The first plate member 240 is bent along the bending line 273. As a result, the inner edge rib 283 which is bent at a substantially right angle with respect to the main plate portion 211 is formed.

[0074] The first plate member 240 is bent along the bending line 274. As a result, the inner edge rib 284 which is bent at a substantially right angle with respect to the main plate portion 211 is formed.

[0075] As a result of a bending process for forming the inner edge ribs 281, 282, 283, and 284, a substantially rectangular opening 280 formed by the bending lines 271, 272, 273, and 274 and the cutting lines 261, 262, 263, and 264 is formed.

[0076] As shown in FIG. 4A, the second plate member 250 blocks the opening 280 (refer to FIG. 7). The connecting structure 400A is connected to the first plate member 240 and a vehicle, but is not connected to the second plate member 250. As a result, the second plate member 250 is subjected to a lighter mechanical load than that upon the first plate member 240. Accordingly, an operator who manufactures the top plate 210A can connect the second plate member 250 to the first plate member 240 with the use of such a simple connecting technique as spot welding. An operator may perform a bending process or a cutting process on the second plate member 250 before attaching the second plate member 250 to the opening 280. Principles of the present embodiment are not limited to any specific process performed on the second plate member 250.

[0077] FIG. 8 is a schematic perspective view of the top plate 210A. Referring to FIGs. 4A and 8, the top plate 210A will be described.

[0078] As shown in FIG. 8, the top plate 210A includes first extension ribs 291, 292, 293, and 294 and second extension ribs 295, 296, 297, and 298. Each of the first extension ribs 291, 292, 293, and 294 and the second extension ribs 295, 296, 297, and 298 is welded to a lower surface of the main plate portion 211 at substantially right angles. Each of the first extension ribs 291,

292, 293, and 294 and the second extension ribs 295, 296, 297, and 298 may be a short metal piece. A length of a segment for a welding process by which the first extension ribs 291, 292, 293, and 294 and the second extension ribs 295, 296, 297, and 298 are attached to the main plate portion 211 is so short that an operator can easily increase mechanical strength of the top plate 210A by welding the first extension ribs 291, 292, 293, and 294 and the second extension ribs 295, 296, 297, and 298 to the main plate portion 211.

[0079] The first extension rib 291 extends between a right end of the inner edge rib 283 and the outer edge rib 212. The first extension rib 291 is arranged in line with the inner edge rib 283, and is connected to the outer edge rib 212 at substantially right angles. The first extension rib 292 extends between a right end of the inner edge rib 284 and the outer edge rib 212. The first extension rib 292 is arranged in line with the inner edge rib 284, and is connected to the outer edge rib 212 at substantially right angles. The first extension rib 293 extends between a left end of the inner edge rib 283 and the outer edge rib 213. The first extension rib 293 is arranged in line with the inner edge rib 283, and is connected to the outer edge rib 213 at substantially right angles. The first extension rib 294 extends between a left end of the inner edge rib 284 and the outer edge rib 213. The first extension rib 294 is arranged in line with the inner edge rib 284, and is connected to the outer edge rib 213 at substantially right angles. A set of the first extension ribs 291, 292, 293, and 294 is substantially parallel to a set of the outer edge ribs 218 and 219. In the present embodiment, an example of a first direction is shown by a direction in which the outer edge ribs 218 and 219 extend (in other words, a direction in which the front corner line 216 and the rear corner line 217 extend). An example of a first outer rib is shown by one of the outer edge ribs 218 and 219. An example of a first inner rib is shown by one of the inner edge ribs 283 and 284 which are substantially parallel to the set of the outer edge ribs 218 and 219.

[0080] The second extension rib 295 extends between the first extension rib 291 and the outer edge rib 218. The second extension rib 295 is arranged in line with the inner edge rib 281, and is connected to the outer edge rib 218 and the first extension rib 291 at substantially right angles. The second extension rib 296 extends between the first extension rib 292 and the outer edge rib 219. The second extension rib 296 is arranged in line with the inner edge rib 281, and is connected to the outer edge rib 219 and the first extension rib 292 at substantially right angles. The second extension rib 297 extends between the first extension rib 293 and the outer edge rib 218. The second extension rib 297 is arranged in line with the inner edge rib 282, and is connected to the outer edge rib 218 and the first extension rib 293 at substantially right angles. The second extension rib 298 extends between the first extension rib 294 and the outer edge rib 219. The second extension rib 298 is arranged in line with the inner edge rib 282, and is connected to the outer

edge rib 219 and the first extension rib 294 at substantially right angles. A set of the second extension ribs 295, 296, 297, and 298 is substantially parallel to a set of the outer edge ribs 212 and 213 which extend at substantially right angles with respect to the set of outer edge ribs 218 and 219. In the present embodiment, an example of a second direction is shown by a direction in which the outer edge ribs 212 and 213 extend (in other words, a direction in which the bending lines 214 and 215 extend). An example of a second outer rib is shown by one of the outer edge ribs 212 and 213. An example of a second inner rib is shown by one of the inner edge ribs 281 and 282 which are substantially parallel to the set of the outer edge ribs 212 and 213.

[0081] The top plate 210A includes vibration isolating rubbers 251, 252, 253, and 254. Similar to the vibration isolating rubbers 411, 412, 413, and 414 described with reference to FIG. 4A, the vibration isolating rubbers 251, 252, 253, and 254 may be formed of rubber which can reduce amplification of vibration.

[0082] The vibration isolating rubber 251 is arranged in a substantially rectangular area surrounded by the first extension rib 291, the second extension rib 295, and the outer edge ribs 212 and 218. In the main plate portion 211, a substantially rectangular area surrounded by the first extension rib 291, the second extension rib 295, and the outer edge ribs 212 and 218 is interposed between the vibration isolating rubbers 411 and 251. The vibration isolating rubber 252 is arranged in a substantially rectangular area surrounded by the first extension rib 292, the second extension rib 296, and the outer edge ribs 212 and 219. In the main plate portion 211, a substantially rectangular area surrounded by the first extension rib 292, the second extension rib 296, and the outer edge ribs 212 and 219 is interposed between the vibration isolating rubbers 412 and 252. The vibration isolating rubber 253 is arranged in a substantially rectangular area surrounded by the first extension rib 293, the second extension rib 297, and the outer edge ribs 213 and 218. In the main plate portion 211, a substantially rectangular area surrounded by the first extension rib 293, the second extension rib 297, and the outer edge ribs 213 and 218 is interposed between the vibration isolating rubbers 413 and 253. The vibration isolating rubber 254 is arranged in a substantially rectangular area surrounded by the first extension rib 294, the second extension rib 298, and the outer edge ribs 213 and 219. In the main plate portion 211, a substantially rectangular area surrounded by the first extension rib 294, the second extension rib 298, and the outer edge ribs 213 and 219 is interposed between the vibration isolating rubbers 414 and 254. Respective vibration isolating rubbers provided in four corners of the top plate 210A can damp vibration of a compression mechanism housed in the housing 200A before the vibration is transmitted to a vehicle via the housing 200A.

<Sixth embodiment>

[0083] A designer may design various framework structures for supporting the top plate described in connection with the fifth embodiment. In a sixth embodiment, an exemplary framework structure will be described.

[0084] FIG. 9 is a schematic perspective view of an exemplary framework structure 500 incorporated into the housing 200A. Referring to FIGs. 8 and 9, the framework structure 500 will be described.

[0085] The framework structure 500 includes a bottom plate 510, an intermediate plate 520, a first column 531, a second column 532, a third column 533, a fourth column 534, an intermediate column 535, a first intermediate frame 536, and a second intermediate frame 537. Similar to the top plate 210A described with reference to FIG. 8, the bottom plate 510 has a substantially rectangular shape. The bottom plate 510 lies substantially horizontally under the top plate 210A. The intermediate plate 520 lies substantially horizontally between the top plate 210A and the bottom plate 510.

[0086] The first column 531, the second column 532, the third column 533, and the fourth column 534 extend upward from four corners of the bottom plate 510, respectively. An upper end of the first column 531 is inserted into a substantially rectangular area surrounded by the first extension rib 291, the second extension rib 295, and the outer edge ribs 212 and 218 (refer to FIG. 8). An upper end of the second column 532 is inserted into a substantially rectangular area surrounded by the first extension rib 292, the second extension rib 296, and the outer edge ribs 212 and 219 (refer to FIG. 8). An upper end of the third column 533 is inserted into a substantially rectangular area surrounded by the first extension rib 293, the second extension rib 297, and the outer edge ribs 213 and 218 (refer to FIG. 8). An upper end of the fourth column 534 is inserted into a substantially rectangular area surrounded by the first extension rib 294, the second extension rib 298, and the outer edge ribs 213 and 219 (refer to FIG. 8).

[0087] The first intermediate frame 536 extends substantially horizontally between the first column 531 and the third column 533. The first intermediate frame 536 is positioned substantially immediately under the outer edge rib 218 described with reference to FIG. 8. Similar to the outer edge rib 218, the first intermediate frame 536 extends in a direction in which the front corner line 216 extends. The second intermediate frame 537 extends substantially horizontally between the second column 532 and the fourth column 534. The second intermediate frame 537 is positioned substantially immediately under the outer edge rib 219 forming a contour line which is an opposite side with respect to a contour line of an outer shape of the top plate 210A, the contour line being formed by the outer edge rib 218. Similar to the outer edge rib 219, the second intermediate frame 537 extends in a direction in which the rear corner line 217 extends. In the present embodiment, an example of a first outer rib is

shown by one of the outer edge ribs 218 and 219. An example of a third outer rib is shown by the other of the outer edge ribs 218 and 219.

[0088] The intermediate plate 520 is supported by the first intermediate frame 536 and the second intermediate frame 537. Various devices arranged within the housing 200A are mounted in the intermediate plate 520.

[0089] The intermediate plate 520 includes a connecting plate portion 521, a left support plate 522, and a holding plate portion 523. The holding plate portion 523 is positioned under the connecting plate portion 521 and the left support plate 522. Each of the connecting plate portion 521 and the left support plate 522 is formed to be substantially T-shaped (in plan view). The connecting plate portion 521 and the left support plate 522 are held by the holding plate portion 523.

[0090] FIG. 10 is a schematic perspective view of the holding plate portion 523. Referring to FIGs. 9 and 10, the intermediate plate 520 will be further described.

[0091] The holding plate portion 523 includes a lower plate 524, a frame rib 525, a lattice rib 526, and ear portions 541, 542, 543, and 544. The lower plate 524 lies under the connecting plate portion 521 (refer to FIG. 9) and the left support plate 522 (refer to FIG. 9). The frame rib 525 protrudes upward from a rectangular perimeter of the lower plate 524. The lattice rib 526 is erected within a rectangular space surrounded by the frame rib 525, and forms a plurality of rectangular spaces within the frame rib 525. The connecting plate portion 521 and the left support plate 522 are welded to upper edges of the lattice rib 526, the frame rib 525, and the ear portions 541, 542, 543, and 544.

[0092] As shown in FIG. 9, the ear portion 541 protrudes forward from the frame rib 525, and is joined to the first intermediate frame 536 near the first column 531. The ear portion 542 protrudes backward from the frame rib 525, and is joined to the second intermediate frame 537 near the second column 532. The ear portion 543 protrudes forward from the frame rib 525, and is joined to the first intermediate frame 536 near the third column 533. The ear portion 544 protrudes backward from the frame rib 525, and is joined to the second intermediate frame 537 near the fourth column 534.

[0093] A vibration isolating piece which can reduce amplification of vibration may be arranged between each of the ear portions 541 and 543 and the first intermediate frame 536. A vibration isolating piece which can reduce amplification of vibration may be arranged between each of the ear portions 542 and 544 and the second intermediate frame 537. Principles of the present embodiment are not limited to any specific configuration for connection between each of the ear portions 541 and 543 and the first intermediate frame 536, and connection between each of the ear portions 542 and 544 and the second intermediate frame 537.

<Seventh embodiment>

[0094] A designer can mount various devices in the framework structure described in connection with the sixth embodiment. In a seventh embodiment, various devices mounted in the framework structure will be described.

[0095] FIG. 11 is a schematic perspective view of the air compression device 100A. Referring to FIGs. 3 to 4B, 9, and 11, a configuration of an outer surface of the housing 200A will be described.

[0096] As shown in FIG. 4A, the housing 200A includes a fixed wall 550 and a revolving wall 560. The fixed wall 550 blocks a substantially rectangular area which is surrounded by the first column 531 (refer to FIG. 9), the third column (refer to FIG. 9), the first intermediate frame (refer to FIG. 9), and the top plate 210A. An operator who assembles the housing 200A may use a screw in attaching the fixed wall 550 to the first column 531, the third column 533, the first intermediate frame 536, and the top plate 210A. In this case, the fixed wall 550 can be easily detached from the framework structure 500 (refer to FIG. 9). An operator who checks and/or repairs the air compression device 100A can detach the fixed wall 550 from the framework structure 500, and can reach various devices arranged between the top plate 210A and the intermediate plate 520.

[0097] As shown in FIG. 4A, the revolving wall 560 is fixed under the fixed wall 550. The revolving wall 560 includes a substantially rectangular base frame 561, a substantially rectangular revolving frame 562, two hinges 563, three lever locks 564, and many slats 565. The base frame 561 is fixed to the first column 531 (refer to FIG. 9), the third column 533 (refer to FIG. 9), and the first intermediate frame 536 (refer to FIG. 9) by an appropriate fixing tool such as a screw. The two hinges 563 are attached to upper edges of the base frame 561 and the revolving frame 562. The revolving frame 562 can revolve upward and downward about the hinges 563. The three lever locks 564 join respective lower edges of the base frame 561 and the revolving frame 562. An operator can unlock the lever locks 564 without using a dedicated tool such as a driver or a wrench. Thereafter, an operator causes the revolving frame 562 to revolve upward, to thereby reach various devices arranged between the bottom plate 510 (refer to FIG. 9) and the intermediate plate 520 (refer to FIG. 9). The lever locks 564 may be commercially-available lock components. Principles of the present embodiment are not limited to any specific configuration of the lever lock 564. The slats 565 are fixed to the revolving frame 562. The slats 565 extend substantially horizontally within the revolving frame 562. The slats 565 are vertically aligned. Air outside the housing 200A can flow into the housing 200A through a space between every adjacent ones of the slats 565. Air flowing into the housing 200A may be utilized for cooling a compression mechanism (not shown).

[0098] As shown in FIG. 11, the air compression device

100A includes a dehumidifying device 610 and a controller 620. The dehumidifying device 610 blocks a substantially rectangular space surrounded by the bottom plate 510 (refer to FIG. 9), the second intermediate frame 537 (refer to FIG. 9), the fourth column 534 (refer to FIG. 9), and the intermediate column 535 (refer to FIG. 9). The dehumidifying device 610 dehumidifies compressed air which is generated by a compression mechanism (not shown) in the housing 200A. The dehumidifying device 610 may include a general dehumidifying mechanism which has a hollow-fiber membrane. Principles of the present embodiment are not limited to any specific configuration of the dehumidifying device 610.

[0099] The controller 620 accommodates various electrical elements (not shown) and various circuits (not shown) for controlling various devices arranged in the housing 200A. The controller 620 blocks a substantially rectangular space surrounded by the bottom plate 510 (refer to FIG. 9), the second intermediate frame 537 (refer to FIG. 9), the second column 532 (refer to FIG. 9), and the intermediate column 535 (refer to FIG. 9). The controller 620 corresponds to the controller 62 described with reference to FIG. 3.

[0100] As shown in FIG. 11, the housing 200A includes a duct wall 570. The duct wall 570 blocks a part of a substantially rectangular space surrounded by the top plate 210A, the second intermediate frame 537 (refer to FIG. 9), the second column 532 (refer to FIG. 9), and the fourth column 534 (refer to FIG. 9). The duct wall 570 includes a base plate 571 and a duct portion 572. The base plate 571 is fixed to the top plate 210A, the second column 532, and the fourth column 534. An elongated opening area 573 extending substantially horizontally is formed in the base plate 571. The opening area 573 is used for delivering air which is used for cooling a compression mechanism (not shown) in the housing 200A. The duct portion 572 surrounds the opening area 573.

[0101] As shown in FIG. 11, the air compression device 100A includes a guide pipe 630 which guides compressed air to an outside of the housing 200A. A base end of the guide pipe 630 is connected to a compression mechanism (not shown) in the housing 200A. As shown in FIG. 11, the guide pipe 630 bends leftward within a substantially rectangular space surrounded by the duct portion 572, and penetrates the duct portion 572. Accordingly, a distal end of the guide pipe 630 appears outside the duct portion 572.

[0102] As shown in FIG. 4B, the air compression device 100A includes a cooling device (aftercooler) 640 arranged outside the housing 200A. The cooling device 640 corresponds to the cooling device 64 described with reference to FIG. 3. The cooling device 640 is arranged behind the duct wall 570. The cooling device 640 includes a cooling pipe 641 and a protective frame 642. An upstream end of the cooling pipe 641 is connected to a downstream end of the guide pipe 630. A downstream end of the cooling pipe 641 is connected to the dehumidifying device 610. Accordingly, compressed air can flow

into the dehumidifying device 610 from the guide pipe 630 through the cooling pipe 641. The cooling pipe 641 extends horizontally, and guides compressed air gradually downward while meandering. As described above, the cooling device 640 is arranged behind the duct wall 570, so that compressed air flowing along the cooling pipe 641 is cooled by air discharged from the duct portion 572.

[0103] The protective frame 642 surrounds an area where the cooling pipe 641 is extended. Accordingly, the cooling pipe 641 is appropriately protected from a flying foreign object (a stone, for example).

[0104] As shown in FIG. 11, the air compression device 100A includes an external cooling mechanism 650. The external cooling mechanism 650 includes four fan devices 651. The fan devices 651 are fixed to the base plate 571 under the duct portion 572. The external cooling mechanism 650 blows out air toward the cooling pipe 641 (refer to FIG. 4B). As a result, compressed air flowing along the cooling pipe 641 is sufficiently cooled. Compressed air which is cooled flows into the dehumidifying device 610. Compressed air which is dehumidified by the dehumidifying device 610 may be subsequently contained in a storage tank. Compressed air in the storage tank is consumed in accordance with operations of pneumatic equipment mounted in a vehicle (not shown).

<Eighth embodiment>

[0105] A designer can place various devices such as a compressor and a motor in a housing. In an eighth embodiment, an exemplary internal configuration of an air compression device will be described.

[0106] FIG. 12 is a schematic perspective view of an air compression device 100A. The air compression device 100A will be described with reference to FIGs. 3, 4A, 9, 10, and 12.

[0107] As shown in FIG. 12, the air compression device 100A includes a compression mechanism 300A and an internal cooling mechanism 660. The compression mechanism 300A generates compressed air. The internal cooling mechanism 660 cools the compression mechanism 300A. The compression mechanism 300A corresponds to the compression mechanism 300 described with reference to FIG. 3.

[0108] The compression mechanism 300A includes a compressor 310, a motor 320, and a transmission mechanism 330. The compressor 310 compresses air, and generates compressed air. The compressor 310 is arranged between the top plate 210A and the intermediate plate 520. The compressor 310 may be fixed directly to an upper surface of the connecting plate portion 521. Alternatively, a vibration isolating member which can reduce amplification of vibration may be arranged between the compressor 310 and the connecting plate portion 521. Principles of the present embodiment are not limited to any specific configuration for connection between the compressor 310 and the connecting plate portion 521.

In the present embodiment, an example of a first mounting surface is shown by an upper surface of the connecting plate portion 521.

[0109] The motor 320 is arranged between the bottom plate 510 (refer to FIG. 9) and the intermediate plate 520. The motor 320 may be fixed directly to a lower surface of the lower plate 524 described with reference to FIG. 10. Alternatively, a vibration isolating member which can reduce amplification of vibration may be arranged between the motor 320 and the lower plate 524. Principles of the present embodiment are not limited to any specific configuration for connection between the motor 320 and the lower plate 524. In the present embodiment, an example of a second mounting surface is shown by a lower surface of the lower plate 524.

[0110] A configuration of the intermediate plate 520 described in connection with the sixth embodiment allows simultaneous perforation of the connecting plate portion 521 and the lower plate 524, so that accuracy in a positional relationship between the compressor 310 and the motor 320 is extremely high in a case where both of the compressor 310 and the motor 320 are mounted in the intermediate plate 520.

[0111] The motor 320 generates driving force for driving the compressor 310 in accordance with a control signal output from the controller 620. The compressor 310 and the motor 320 are vertically aligned, so that a designer can give a small value to an area of a horizontal section of the housing 200A.

[0112] The transmission mechanism 330 transmits driving force from the motor 320 to the compressor 310. The right panel 220 described with reference to FIG. 4A is erected adjacently to the transmission mechanism 330, and is fixed to the framework structure 500 (refer to FIG. 9) by a screw. The right panel 220 can be easily detached from the framework structure 500, and so an operator can easily reach the transmission mechanism 330.

[0113] The transmission mechanism 330 includes an upper pulley 331, a lower pulley 332, an endless belt 333, and a tension pulley 334. The upper pulley 331 is attached to the compressor 310. The lower pulley 332 is attached to the motor 320. The endless belt 333 is looped over the upper pulley 331, the lower pulley 332, and the tension pulley 334 so as to be put around those pulleys. The tension pulley 334 applies appropriate tensile force to the endless belt 333.

[0114] The internal cooling mechanism 660 includes a fan device 661 and a cooling air flow adjusting box 662. The fixed wall 550 includes a flat plate 551 and a swelling wall 552. The flat plate 551 partially closes a space surrounded by the first column 531 (refer to FIG. 9), the third column 533 (refer to FIG. 9), the first intermediate frame 536 (refer to FIG. 9), and the top plate 210A. The swelling wall 552 is attached to the flat plate 551 with the use of an appropriate fixing tool such as a commercially-available lever lock or screw. The swelling wall 552 swells outward from the flat plate 551. The fan device 661 is attached to the swelling wall 552 through an opening area

(not shown) formed in the flat plate 551. Accordingly, a designer need not give a large dimension value to the framework structure 500 (refer to FIG. 9).

[0115] Similar to the motor 320, the fan device 661 may operate under control of the controller 620. When the fan device 661 operates, air within the housing 200A is sucked by the fan device 661. During the sucking, air outside the housing 200A flows into the housing 200A through the revolving wall 560. Air flowing into the housing 200A is sucked by the fan device 661 through a clearance which is narrow and horizontally long and is formed between the intermediate plate 520 and the first intermediate frame 536. The fan device 661 delivers sucked air to the cooling air flow adjusting box 662.

[0116] The cooling air flow adjusting box 662 is arranged between the fan device 661 and the compressor 310. The cooling air flow adjusting box 662 adjusts a shape of a flow region of the cooling air blown from the fan device 661.

[0117] FIG. 13A is a schematic perspective view of the cooling air flow adjusting box 662. FIG. 13B is a schematic back view of the cooling air flow adjusting box 662. Referring to FIGs. 11 to 13B, the cooling air flow adjusting box 662 will be described.

[0118] As shown in FIGs. 13A and 13B, the cooling air flow adjusting box 662 includes a front plate 671, a rear plate 672, and an outer circumferential plate 673. The front plate 671 is arranged to face the fan device 661 (refer to FIG. 12). The front plate 671 includes an outer edge 674 and an inner edge 675. The outer edge 674 forms a substantially rectangular outline of the front plate 671. The inner edge 675 forms a substantially circular opening area. A diameter of the opening area formed by the inner edge 675 is substantially equal to a rotation diameter of a fan blade of the fan device 661. Otherwise, the diameter of the opening area is set to be slightly larger than a rotation diameter of a fan blade. Accordingly, cooling air generated by the fan device 661 can efficiently flow into the cooling air flow adjusting box 662.

[0119] The rear plate 672 is erected between the front plate 671 and the compressor 310 (refer to FIG. 12). The rear plate 672 includes an outer edge 676 and an inner edge 677. Similar to the outer edge 674 of the front plate 671, the outer edge 676 of the rear plate 672 forms a substantially rectangular outline of the rear plate 672. Similar to many general compressors, the compressor 310 has a substantially rectangular outline in cross section on a virtual vertical plane including a rotation axis of the compressor 310. The inner edge 677 of the rear plate 672 forms a substantially rectangular opening area which is formed to be matched with the sectional shape and the sectional size of the compressor 310. The outer circumferential plate 673 is connected to the outer edges 674 and 676 of the front plate 671 and the rear plate 672. Accordingly, the cooling air which flows into a substantially circular opening area formed by the inner edge 675 of the front plate 671, flows out from a substantially rectangular opening area formed by the inner edge 677 of

the rear plate 672, and thereby the cooling air hits the compressor 310 efficiently. Therefore, the compressor 310 is efficiently cooled.

[0120] A cooling air generated by the fan device 661 flows toward the compressor 310 through the cooling air flow adjusting box 662. The cooling air collides against the compressor 310. As a result, the cooling air can absorb heat from the compressor 310.

[0121] As shown in FIG. 12, the compressor 310 is arranged between the cooling air flow adjusting box 662 and the duct wall 570. Accordingly, the cooling air generated by the fan device 661 flows toward the duct wall 570 after absorbing heat from the compressor 310. Thereafter, the cooling air is discharged from the duct portion 572 formed in the duct wall 570.

<Ninth embodiment>

[0122] The internal configuration described in connection with the eighth embodiment contributes to reduction in an area of a horizontal section of a housing. In a ninth embodiment, design techniques for reducing a value of a dimension along a height of a housing will be described.

[0123] FIGs. 14A and 14B are schematic perspective views of the framework structure 500. Referring to FIGs. 10, 14A, and 14B, a relationship between the motor 320 and the bottom plate 510 will be described.

[0124] As shown in FIG. 14A, the motor 320 includes a motor housing 321, two connecting brackets 322, a front fin group 323, a rear fin group 324, an upper fin group 325, and a lower fin group 326. A generating mechanism which generates driving force for driving the compressor 310 (refer to FIG. 14B) (that is, a mechanism which is incorporated in a general motor, such as a rotary core, a stator core, or a coil) is housed in the motor housing 321.

[0125] Each of the front fin group 323, the rear fin group 324, the upper fin group 325, and the lower fin group 326 includes many fins. The front fin group 323, the rear fin group 324, the upper fin group 325, and the lower fin group 326 promote heat dissipation from the motor housing 321.

[0126] The front fin group 323 protrudes forward from the motor housing 321. The rear fin group 324 protrudes backward from the motor housing 321. The front fin group 323 and the rear fin group 324 are positioned between the upper fin group 325 and the lower fin group 326 as for vertical positions thereof, while protruding horizontally, so that those fin groups are separated by sufficient distance from the bottom plate 510 and the intermediate plate 520 (refer to FIG. 14B). Accordingly, the front fin group 323 and the rear fin group 324 do not interfere with the bottom plate 510 and the intermediate plate 520.

[0127] The two connecting brackets 322 include flat upper surfaces 327, respectively. The upper surfaces 327 are connected to a lower surface of the lower plate 524 described with reference to FIG. 10. An upper edge of each of fins of the upper fin group 325 protruding up-

ward is positioned under the upper surfaces 327. Accordingly, the motor 320 is fixed to a lower surface of the lower plate 524 without interference between the upper fin group 325 and the lower plate 524.

[0128] The bottom plate 510 includes a reinforcing rib 511, a second reinforcing rib 512, and a flat plate 513. The flat plate 513 closes a rectangular area having four corners formed of the first column 531, the second column 532, the third column 533, and the fourth column 534. The reinforcing rib 511 and the second reinforcing rib 512 protrude upward from the flat plate 513. The reinforcing rib 511 extends substantially parallel to the first intermediate frame 536. The second reinforcing rib 512 extends substantially perpendicularly to the reinforcing rib 511.

[0129] As shown in FIG. 14B, the second reinforcing rib 512 is positioned to the left of the motor housing 321. Accordingly, the second reinforcing rib 512 does not interfere with the motor housing 321.

[0130] As shown in FIG. 14A, the flat plate 513 includes a facing area 514 and a peripheral area 515. The facing area 514 faces the lower fin group 326 protruding downward. The peripheral area 515 surrounds the facing area 514. The reinforcing rib 511 protrudes upward in the peripheral area 515. Accordingly, the reinforcing rib 511 does not interfere with the lower fin group 326.

[0131] The reinforcing rib 511 and the second reinforcing rib 512 are formed in positions where those ribs do not interfere with the lower fin group 326, so that a designer may give a large value to a height dimension of each of the reinforcing rib 511 and the second reinforcing rib 512. Accordingly, the bottom plate 510 can have sufficiently high mechanical strength. Even though each of the reinforcing rib 511 and the second reinforcing rib 512 has a large height dimension in order to achieve sufficiently high mechanical strength of the bottom plate 510, a designer can arrange the bottom plate 510 near the motor 320 because the reinforcing rib 511 and the second reinforcing rib 512 do not interfere with the lower fin group 326. Thus, a designer can give a small value to a height dimension of the framework structure 500.

<Tenth embodiment>

[0132] A designer may arrange a plurality of compressors in a housing. In a case where an air compression device includes a plurality of compressors, the air compression device can generate a large amount of compressed air in a short time. In a tenth embodiment, an air compression device including a plurality of compressors will be described.

[0133] FIG. 15 is a schematic plan view showing an internal configuration of an air compression device 100A. Referring to FIG. 15, the air compression device 100A will be further described.

[0134] The air compression device 100A includes a compression mechanism 340 and an internal cooling mechanism 670. The compression mechanism 340 gen-

erates compressed air. The internal cooling mechanism 670 cools the compression mechanism 340. The compression mechanism 340 is in a mirror-image relationship to the compression mechanism 300A described in connection with the eighth embodiment. Thus, description about the compression mechanism 300A in the eighth embodiment is also applied to the compression mechanism 340. The internal cooling mechanism 670 is identical to the internal cooling mechanism 660 described in connection with the eighth embodiment in terms of configuration. Accordingly, description about the internal cooling mechanism 660 in the eighth embodiment is also applied to the internal cooling mechanism 670.

[0135] The compression mechanism 340 includes a compressor 350. Similar to the compressor 310 of the compression mechanism 300A, the compressor 350 generates compressed air. The compressor 310 includes a port wall 311. The compressor 350 includes a port wall 351. The port wall 311 of the compressor 310 faces the port wall 351 of the compressor 350. In each of the port walls 311 and 351, a suction port (not shown) into which air outside the housing 200A flows and a delivery port (not shown) from which compressed air is discharged are formed.

[0136] The air compression device 100A further includes a suction guide structure 700 arranged between the port walls 311 and 351. Air outside the housing 200A flows into each of the compressors 310 and 350 through the suction guide structure 700. Each of the compressors 310 and 350 compresses outer air flown thereinto through the suction guide structure 700, to generate compressed air. Compressed air is delivered to an outside of the housing 200A through the guide pipe 630 described in connection with the seventh embodiment.

[0137] FIG. 16 is a schematic cross-sectional view of the suction guide structure 700. Referring to FIGs. 4A, 15, and 16, the suction guide structure 700 will be described.

[0138] As shown in FIG. 4A, the fixed wall 550 includes a filter cover 553. The filter cover 553 is arranged within a chevron-shaped recessed area formed by the swelling wall 552. Similar to the swelling wall 552, the filter cover 553 is attached to the flat plate 551. An operator can detach the filter cover 553 from the flat plate 551.

[0139] As shown in FIG. 16, the suction guide structure 700 includes a suction duct 710, a filter device 720, and a trim seal 731. The filter device 720 is arranged between the filter cover 553 and the suction duct 710. The trim seal 731 is a rubber ring member which connects the filter device 720 to the suction duct 710 in an airtight manner.

[0140] The suction duct 710 is a hollow box member formed in a substantially rectangular-parallelepiped shape. When the compressors 310 and 350 are activated, a negative-pressure environment is generated in the suction duct 710. As a result, outer air outside the housing 200A flows into the housing 200A through the filter cover 553. Thereafter, the outer air passes through the filter

device 720. The filter device 720 removes airborne dust in the outer air flowing in. The air purified by the filter device 720 flows into the suction duct 710.

[0141] The suction guide structure 700 further includes two supply pipes 711 and 712 and two trim seals 732 and 733. The trim seal 732 is used for connecting the supply pipe 711 and the suction duct 710. The trim seal 733 is used for connecting the supply pipe 712 and the suction duct 710.

[0142] The supply pipe 711 extends from the trim seal 732 attached to the suction duct 710, and is connected to the port wall 311 of the compressor 310. The outer air purified by the filter device 720 flows into the compressor 310 through the suction duct 710 and the supply pipe 711.

[0143] The supply pipe 712 extends from the trim seal 733 attached to the suction duct 710, and is connected to the port wall 351 of the compressor 350. The outer air purified by the filter device 720 flows into the compressor 350 through the suction duct 710 and the supply pipe 712.

[0144] FIG. 17 is a schematic enlarged perspective view of a part of the guide pipe 630 which guides air compressed by the compression mechanisms 300A and 340 to an outside of the housing 200A. Referring to FIGs. 15 and 17, the guide pipe 630 will be described.

[0145] As shown in FIG. 15, the guide pipe 630 includes discharge pipes 631 and 632, a confluence portion 680, and a confluence pipe 633. The discharge pipe 631 guides compressed air generated by the compressor 310 to the confluence portion 680 arranged near the fixed wall 550. The discharge pipe 632 guides compressed air generated by the compressor 350 to the confluence portion 680. The confluence pipe 633 extends from the confluence portion 680 toward the duct wall 570 arranged opposite to the fixed wall 550, and is connected to the cooling device 640 outside the housing 200A.

[0146] The guide pipe 630 provides a long flow path to compressed air in the housing 200A. The cooling air generated by the internal cooling mechanisms 660 and 670 flows within the housing 200A until the cooling air is discharged from the duct portion 572. Accordingly, compressed air can be subjected to cooling by cooling air generated by the internal cooling mechanisms 660 and 670, for a long time in the housing 200A.

[0147] As shown in FIG. 17, the confluence portion 680 includes a manifold 681 and two check valves 682 and 683. Each of the check valves 682 and 683 is attached to the manifold 681. The discharge pipe 631 is connected to the check valve 682. Compressed air which flows along the discharge pipe 631 flows into the manifold 681 through the check valve 682. The check valve 682 interrupts a flow of the compressed air returned from the manifold 681 to the discharge pipe 631. The discharge pipe 632 is connected to the check valve 683. Compressed air which flows along the discharge pipe 632 flows into the manifold 681 through the check valve 683. The check valve 683 interrupts a flow of the compressed air returned from the manifold 681 to the discharge pipe 632.

[0148] A confluence inner pipe (not shown), which joins

two flows of the compressed air, is formed in the manifold 681. The compressed air joined by the confluence inner pipe is discharged from the manifold 681 through the confluence pipe 633. The confluence pipe 633 is connected to the cooling device 640 (refer to FIG. 15).

[0149] As shown in FIG. 15, the air compression device 100A includes two fixing pieces 690. As shown in FIG. 17, the port wall 311 includes a fixing base 312 which protrudes toward the port wall 351 of the compressor 350. One of the fixing pieces 690 is fixed onto the fixing base 312. Also the other fixing piece 690 for the compressor 350, similar to the fixing piece 690 for the compressor 310, is attached to a fixing base (not shown) which protrudes from the port wall 351. In the present embodiment, an example of a fixing member is shown by the fixing piece 690.

[0150] As shown in FIG. 15, each of the discharge pipes 631 and 632 bends toward the fixed wall 550 from a base end thereof which is connected to the port wall 311 or 351. The two fixing pieces 690 fix the discharge pipes 631 and 632, respectively, in paths from portions bending with respect to base ends toward the fixed wall 550. Accordingly, vibration caused by the compressors 310 and 350 does not apply excessively large load upon the guide pipe 630.

[0151] In the present embodiment, the guide pipe 630 is entirely formed of a metal pipe member. Alternatively, a part of the guide pipe 630 may be formed of a pipe member having low stiffness, such as rubber or resin.

[0152] A designer can design various air compression devices in accordance with the design principles described in connection with the above various embodiments. A part of various features described in connection with one of the above various embodiments may be applied to the air compression device described in connection with another embodiment.

[0153] The exemplary air compression device described in connection with the above various embodiments has mainly the following features.

[0154] The air compression device according to one aspect of the above embodiments includes: a compression mechanism configured to compress air and generate compressed air; a housing in which the compression mechanism is housed; and a cooling device configured to cool the compressed air, outside the housing.

[0155] According to the above-described configuration, the cooling device cools compressed air outside the housing, so that a designer who designs an air compression device need not save a space for housing a cooling device, in a housing. Accordingly, a designer can give a small dimension value to a housing. As a result, a housing can have high stiffness. Downsizing of a housing allows reduction in amplification of vibration of a compression mechanism, so that an amount of vibration transmitted to a vehicle can be kept at a low level.

[0156] Relating to the above-described configuration, the air compression device may further include a controller configured to control the compression mechanism.

The controller may be arranged outside the housing.

[0157] According to the above-described configuration, the controller is arranged outside the housing, so that a designer who designs an air compression device need not save a space for housing a cooling device, in a housing. Accordingly, a designer can give a small dimension value to a housing. As a result, a housing can have high stiffness. Downsizing of a housing allows reduction in amplification of vibration of a compression mechanism, so that an amount of vibration transmitted to a vehicle can be kept at a low level. Also, by providing the controller in such a housing as is low in a level of vibration transmission, it is possible to eliminate a need of enhancing a shock-proof property of internal electronic equipment.

[0158] Relating to the above-described configuration, the air compression device may further include a connecting structure configured to connect the housing to an underside of a floor of a vehicle. The housing may include a top plate facing the underside of the floor. The connecting structure may include a vibration isolator which is in contact with the top plate and is configured to reduce vibration transmission from the compression mechanism to the vehicle.

[0159] According to the above-described configuration, the connecting structure includes the vibration isolator which is in contact with the top plate of the housing and is configured to reduce vibration transmission from the compression mechanism to the underside of the floor of the vehicle, so that vibration transmitted to the vehicle is reduced.

[0160] Relating to the above-described configuration, the top plate may include a first plate member and a second plate member, the first plate member including a facing surface which faces the underside of the floor, the second plate member blocking a rectangular opening which is formed in the facing surface. The first plate member may include an outer edge rib and an inner edge rib, the outer edge rib being bent from the facing surface and forming a rectangular outline of the top plate, the inner edge rib being bent from the facing surface and forms a contour of the opening. The connecting structure may connect the first plate member to the underside of the floor.

[0161] According to the above-described configuration, the first plate member of the top plate includes the outer edge rib and the inner edge rib which are bent with respect to the facing surface, so that a designer who designs an air compression device can easily form a robust structure. The connecting structure connects the first plate member to the vehicle. Accordingly, the air compression device is appropriately held by the vehicle.

[0162] Relating to the above description, the outer edge rib may include a first outer rib extending in a first direction and a second outer rib extending in a second direction which is different from the first direction. The inner edge rib may include a first inner rib extending in the first direction and a second inner rib extending in the

second direction. The top plate may include a first extension rib which is extended from the first inner rib in the first direction and a second extension rib which is extended from the second inner rib in the second direction. The vibration isolator may include a vibration isolating rubber which is arranged in a rectangular area surrounded by the first outer rib, the second outer rib, the first extension rib, and the second extension rib.

[0163] According to the above-described configuration, the rectangular area where the vibration isolating rubber is arranged is surrounded by the first outer rib, the second outer rib, the first extension rib, and the second extension rib, to thereby have high stiffness. Accordingly, vibration transmitted to the vehicle is appropriately reduced.

[0164] Relating to the above-described configuration, the outer edge rib may include a third outer rib forming a contour line which is an opposite side with respect to a contour line formed by the first outer rib. The housing may include a bottom plate lying under the top plate, a first intermediate frame extending in the first direction between the bottom plate and the top plate immediately under the first outer rib, a second intermediate frame extending in the first direction between the bottom plate and the top plate immediately under the third outer rib, and an intermediate plate supported by the first intermediate frame and the second intermediate frame. The compression mechanism may include a compressor arranged between the top plate and the intermediate plate, and a motor arranged between the bottom plate and the intermediate plate.

[0165] According to the above-described configuration, the compressor is arranged between the top plate and the intermediate plate while the motor is arranged between the bottom plate and the intermediate plate, so that a designer who designs an air compression device can give a small dimension value to an area of a housing in a horizontal plane. As a result, a horizontal footprint of the air compression device installed under the floor of the vehicle can be reduced, which allows provision of a space where another equipment can be installed under the floor of the vehicle.

[0166] Relating to the above-described configuration, the intermediate plate may include a holding plate portion and a connecting plate portion, the holding plate portion being joined to the first intermediate frame and the second intermediate frame, the connecting plate portion being held by the holding plate portion. The connecting plate portion may include a first mounting surface to which the compressor is mounted. The holding plate portion may include a second mounting surface opposite to the first mounting surface.

[0167] According to the above-described configuration, the motor is mounted in the second mounting surface opposite to the first mounting surface, so that error factors related to relative positions of the compressor and the motor are reduced.

[0168] Relating to the above-described configuration,

the motor may include a motor housing in which a generating mechanism configured to generate driving force for driving the compressor is incorporated, and a plurality of fins protruding downward from the motor housing. The bottom plate may include a facing area facing the plurality of fins, a peripheral area around the facing area, and a reinforcing rib protruding upward from the peripheral area.

[0169] With the above-described configuration, the reinforcing rib protrudes upward from the peripheral area around the facing area which faces the plurality of fins, so that interference between the reinforcing rib and the plurality of fins is unlikely to occur. Accordingly, a designer can set an amount of protrusion of the reinforcing rib at a large value. As a result, stiffness of the housing is increased. In addition, a designer can set a height dimension of the housing at a small value.

Industrial Applicability

[0170] Principles of the above-described embodiments are suitably utilized in various technical fields which need compressed air.

Claims

1. An air compression device comprising:

a compression mechanism configured to compress air and generate compressed air;
a housing in which the compression mechanism is housed; and
a cooling device configured to cool the compressed air, outside the housing.

2. The air compression device according to claim 1, further comprising a controller configured to control the compression mechanism, wherein the controller is arranged outside the housing.

3. The air compression device according to claim 1 or 2, further comprising a connecting structure configured to connect the housing to an underside of a floor of a vehicle, wherein the housing includes a top plate facing the underside of the floor, and the connecting structure includes a vibration isolator which is in contact with the top plate and is configured to reduce vibration transmission from the compression mechanism to the vehicle.

4. The air compression device according to claim 3, wherein the top plate includes a first plate member and a second plate member, the first plate member includ-

ing a facing surface which faces the underside of the floor, the second plate member blocking a rectangular opening which is formed in the facing surface, the first plate member includes an outer edge rib and an inner edge rib, the outer edge rib being bent from the facing surface and forming a rectangular outline of the top plate, the inner edge rib being bent from the facing surface and forming a contour of the opening, and
the connecting structure connects the first plate member to the underside of the floor.

5. The air compression device according to claim 4, wherein the outer edge rib includes a first outer rib extending in a first direction and a second outer rib extending in a second direction which is different from the first direction, the inner edge rib includes a first inner rib extending in the first direction and a second inner rib extending in the second direction, the top plate includes a first extension rib which is extended from the first inner rib in the first direction and a second extension rib which is extended from the second inner rib in the second direction, and the vibration isolator includes a vibration isolating rubber which is arranged in a rectangular area surrounded by the first outer rib, the second outer rib, the first extension rib, and the second extension rib.

6. The air compression device according to claim 5, wherein the outer edge rib includes a third outer rib forming a contour line which is an opposite side with respect to a contour line formed by the first outer rib, the housing includes a bottom plate lying under the top plate, a first intermediate frame extending in the first direction between the bottom plate and the top plate immediately under the first outer rib, a second intermediate frame extending in the first direction between the bottom plate and the top plate immediately under the third outer rib, and an intermediate plate supported by the first intermediate frame and the second intermediate frame, and the compression mechanism includes a compressor arranged between the top plate and the intermediate plate and a motor arranged between the bottom plate and the intermediate plate.

7. The air compression device according to claim 6, wherein the intermediate plate includes a holding plate portion and a connecting plate portion, the holding plate portion being joined to the first intermediate frame and the second intermediate frame, the connecting plate portion being held by the holding plate portion, the connecting plate portion includes a first mounting surface to which the compressor is mounted,

the holding plate portion includes a second mounting surface opposite to the first mounting surface, and the motor is mounted to the second mounting surface.

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8. The air compression device according to claim 6 or 7, wherein

the motor includes a motor housing in which a generating mechanism configured to generate driving force for driving the compressor is incorporated and a plurality of fins protruding downward from the motor housing, and

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the bottom plate includes a facing area facing the plurality of fins, a peripheral area around the facing area, and a reinforcing rib protruding upward from the peripheral area.

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FIG. 1

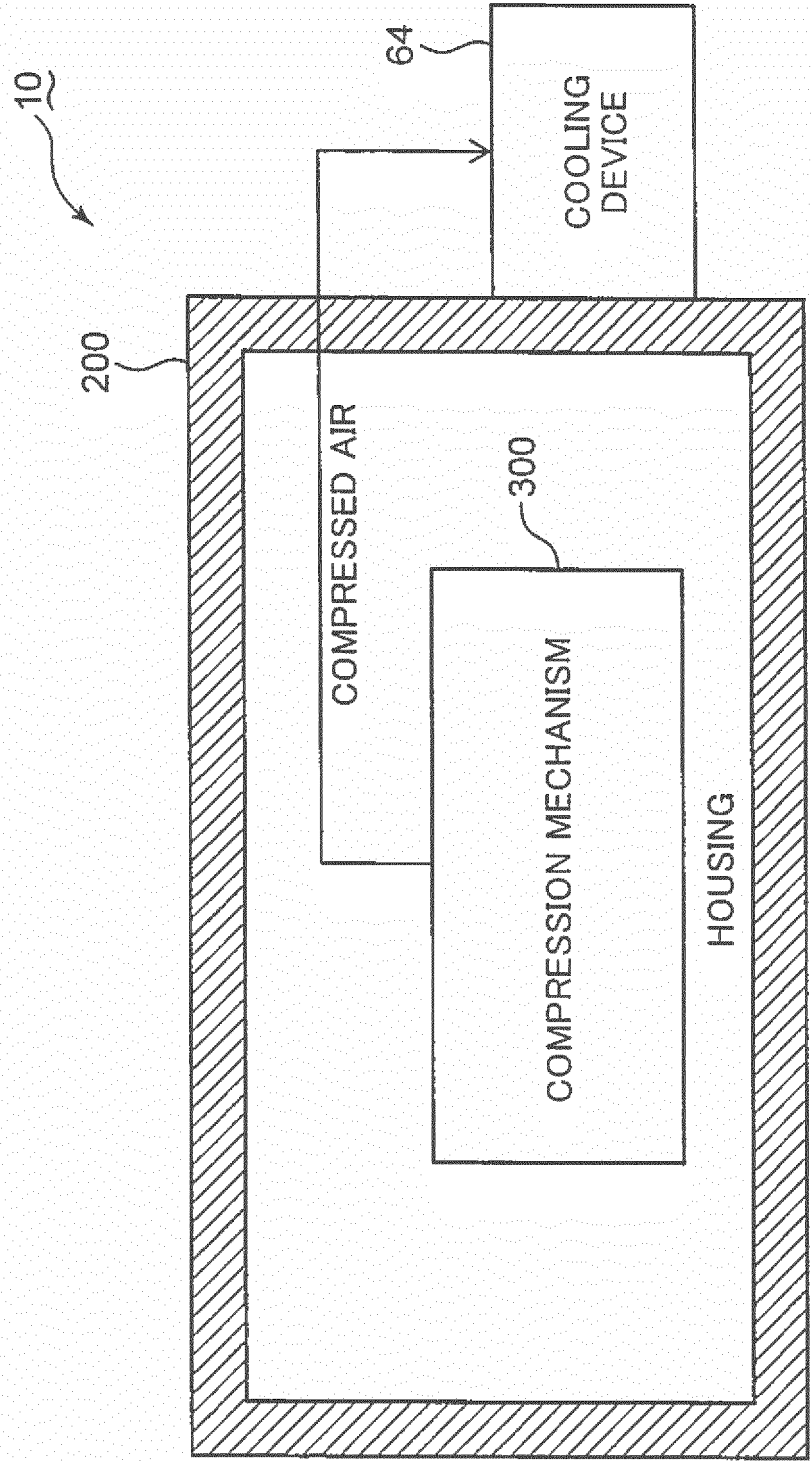


FIG. 2

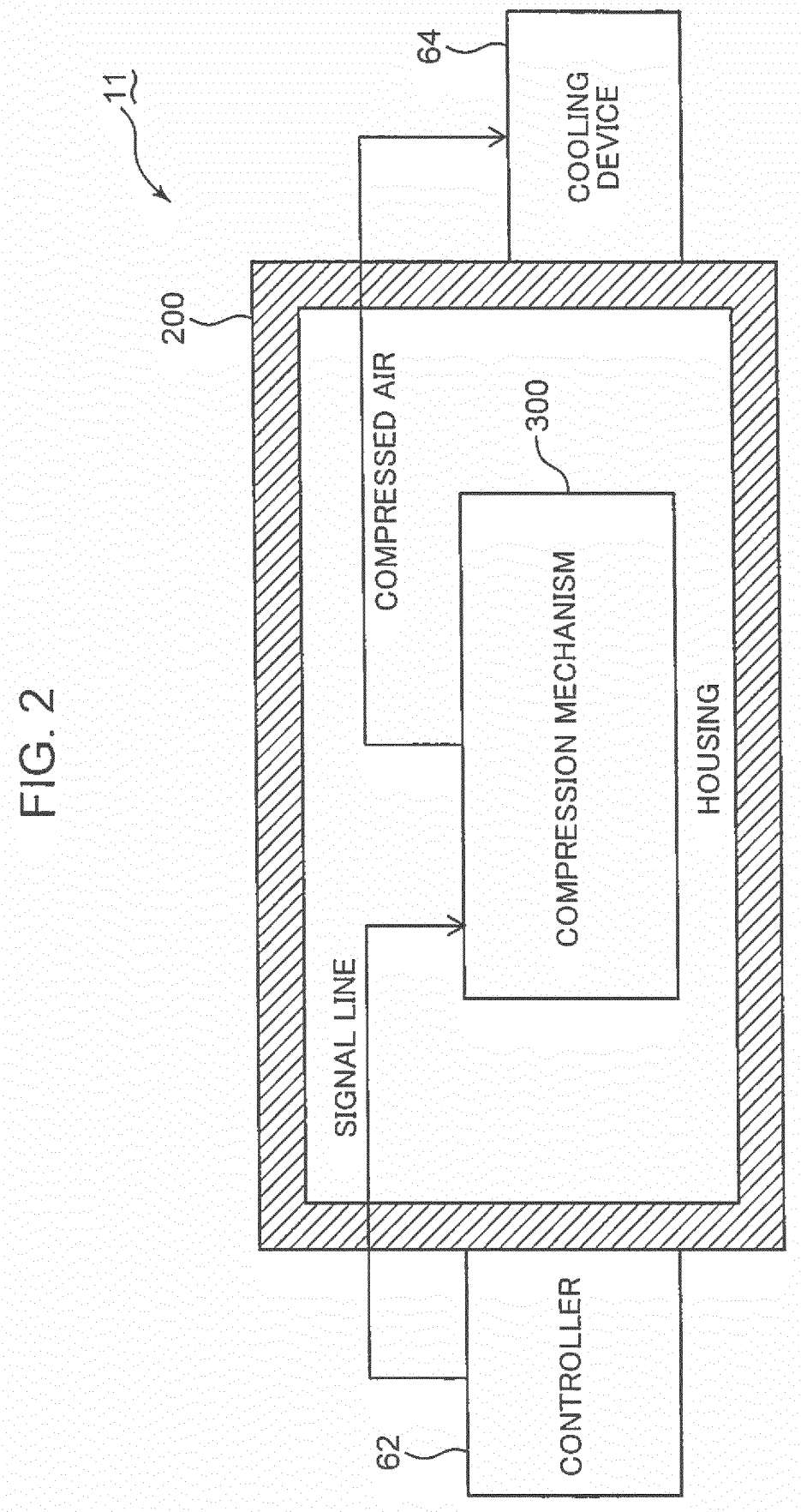
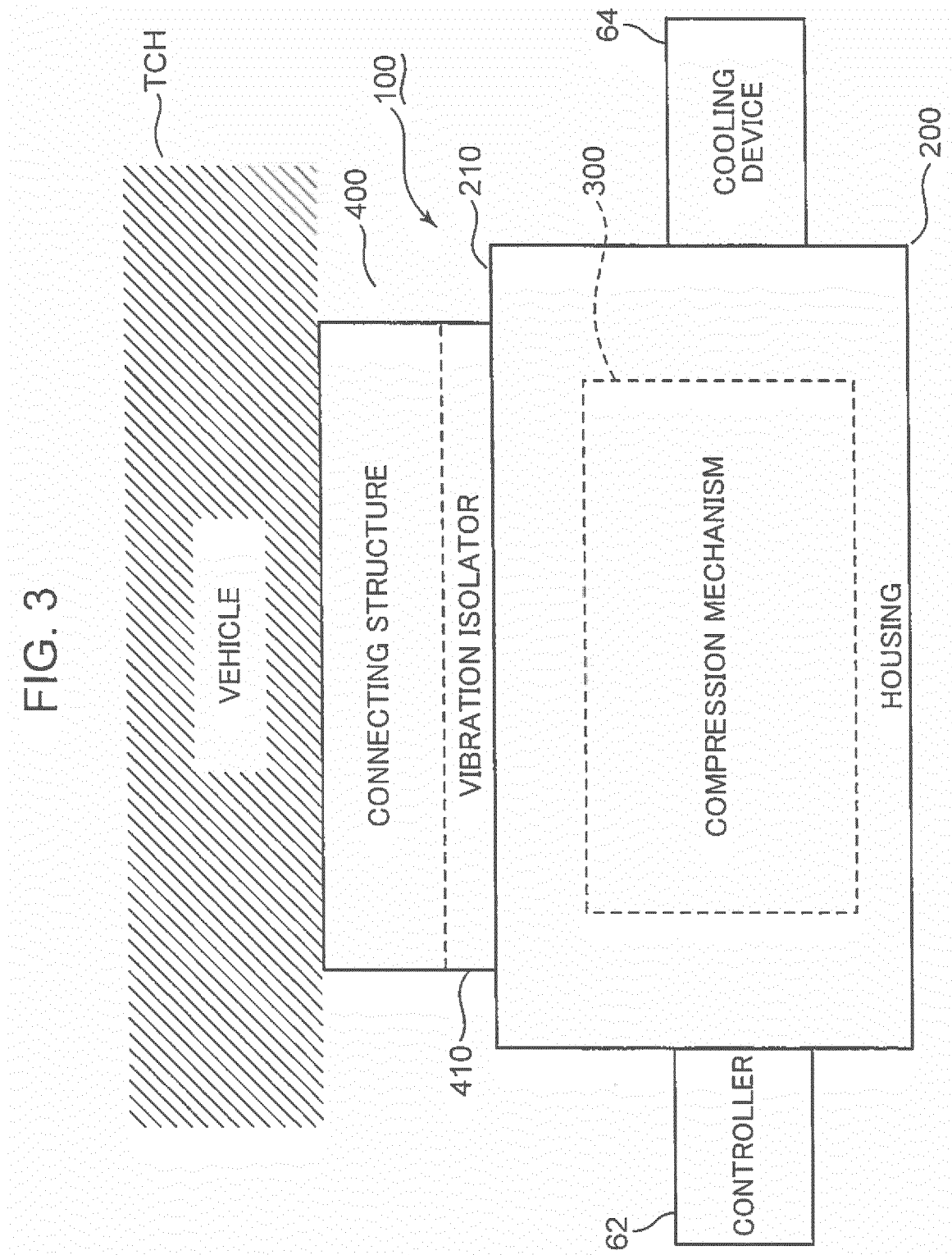


FIG. 3



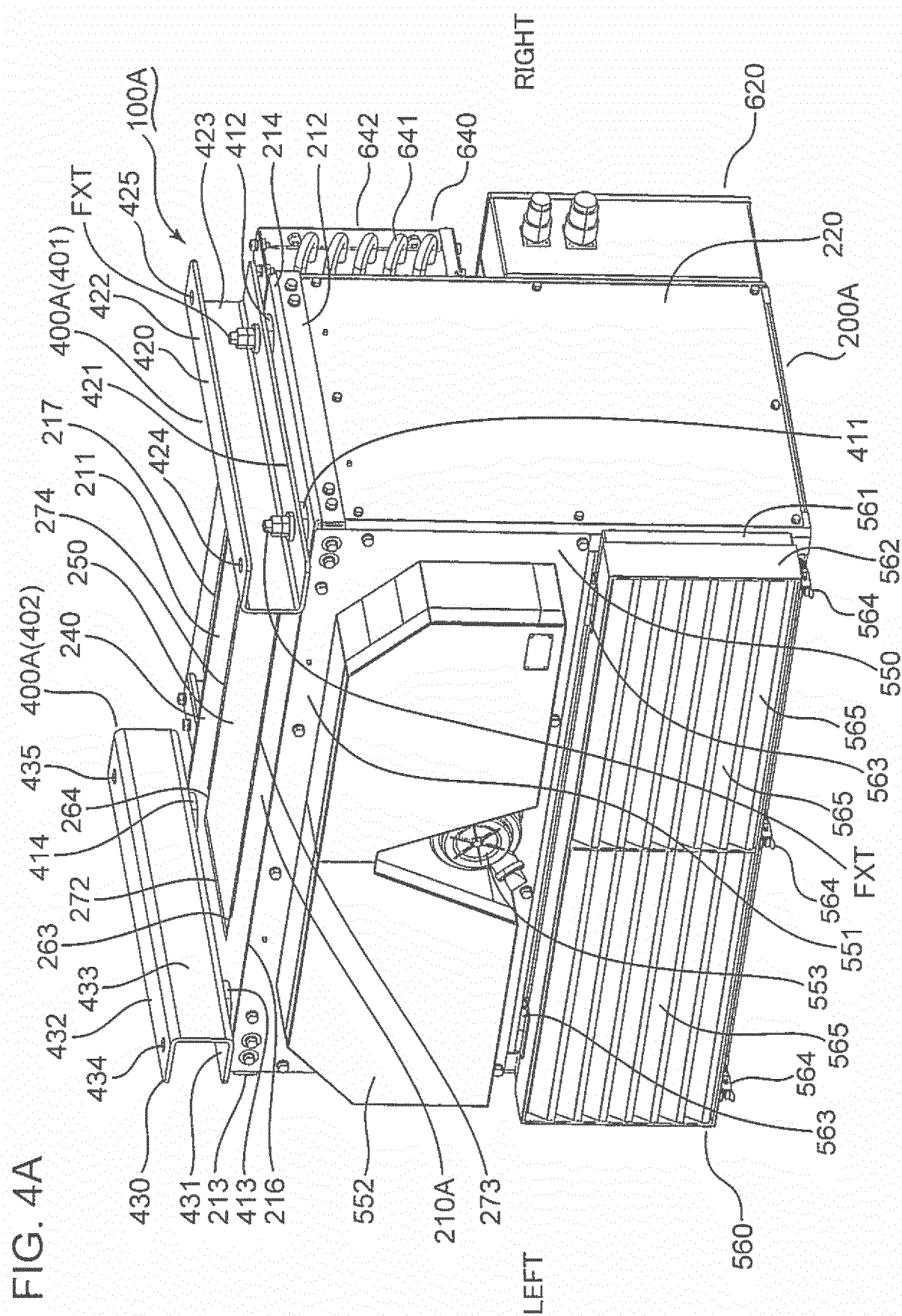
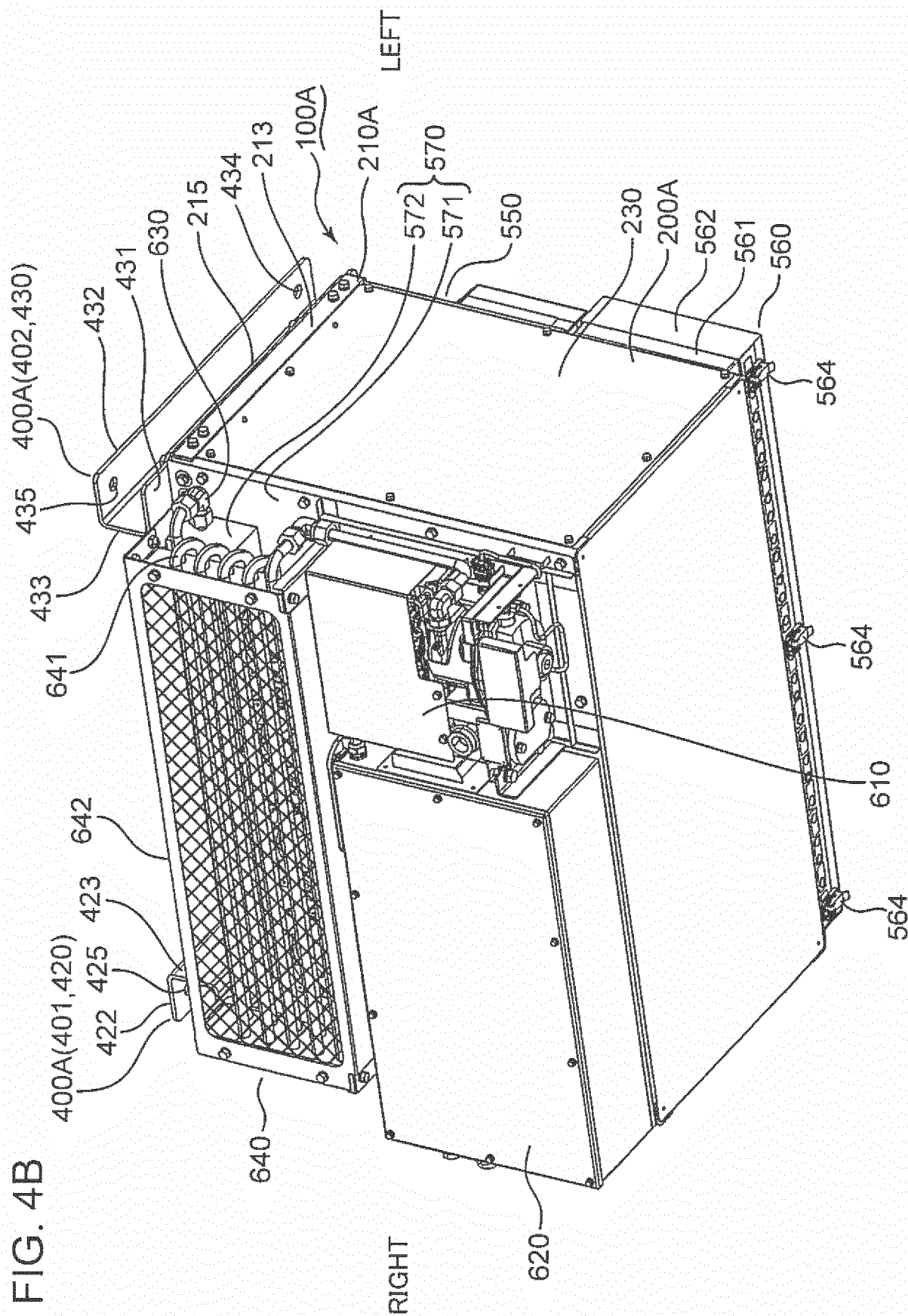
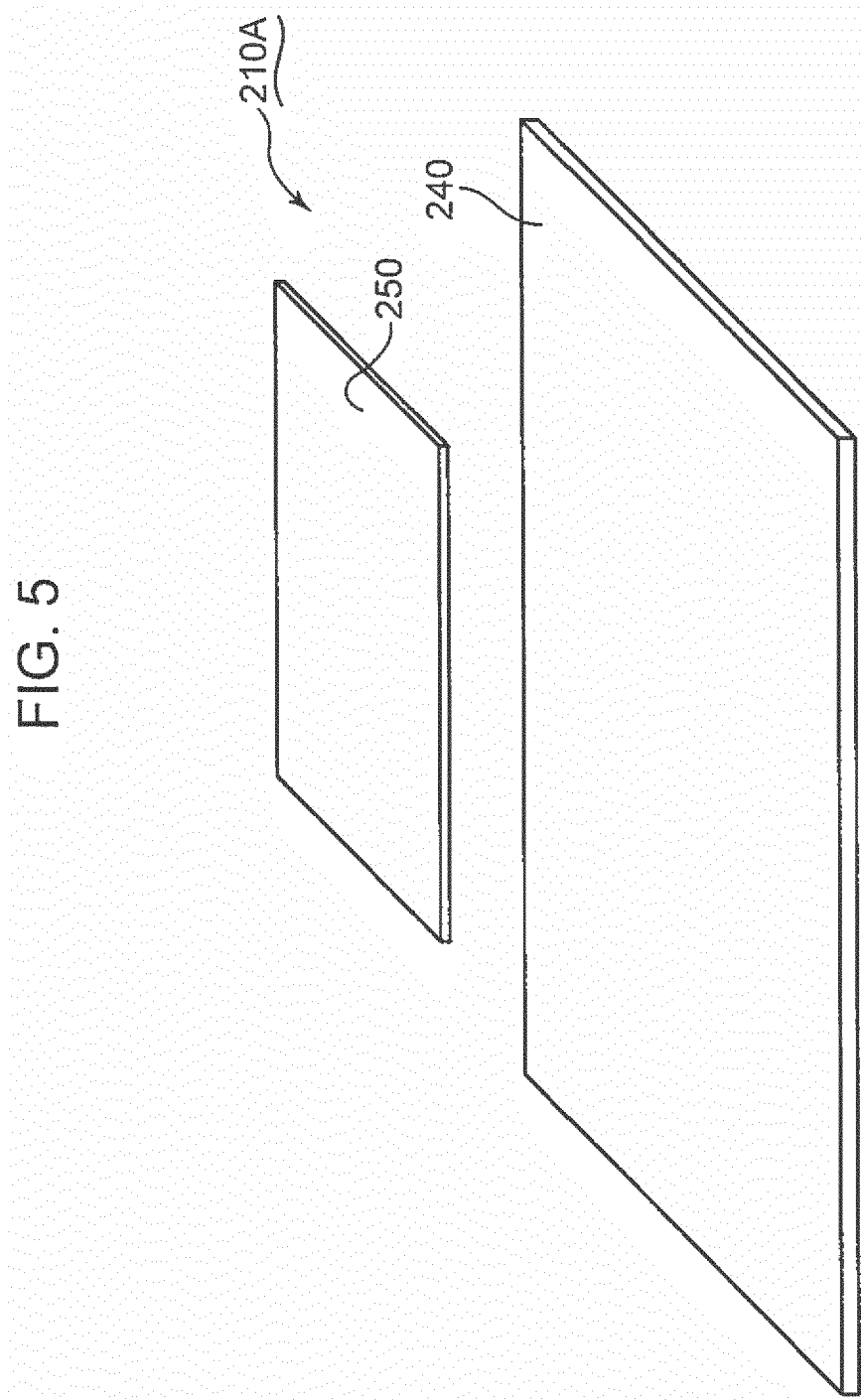


FIG. 4B





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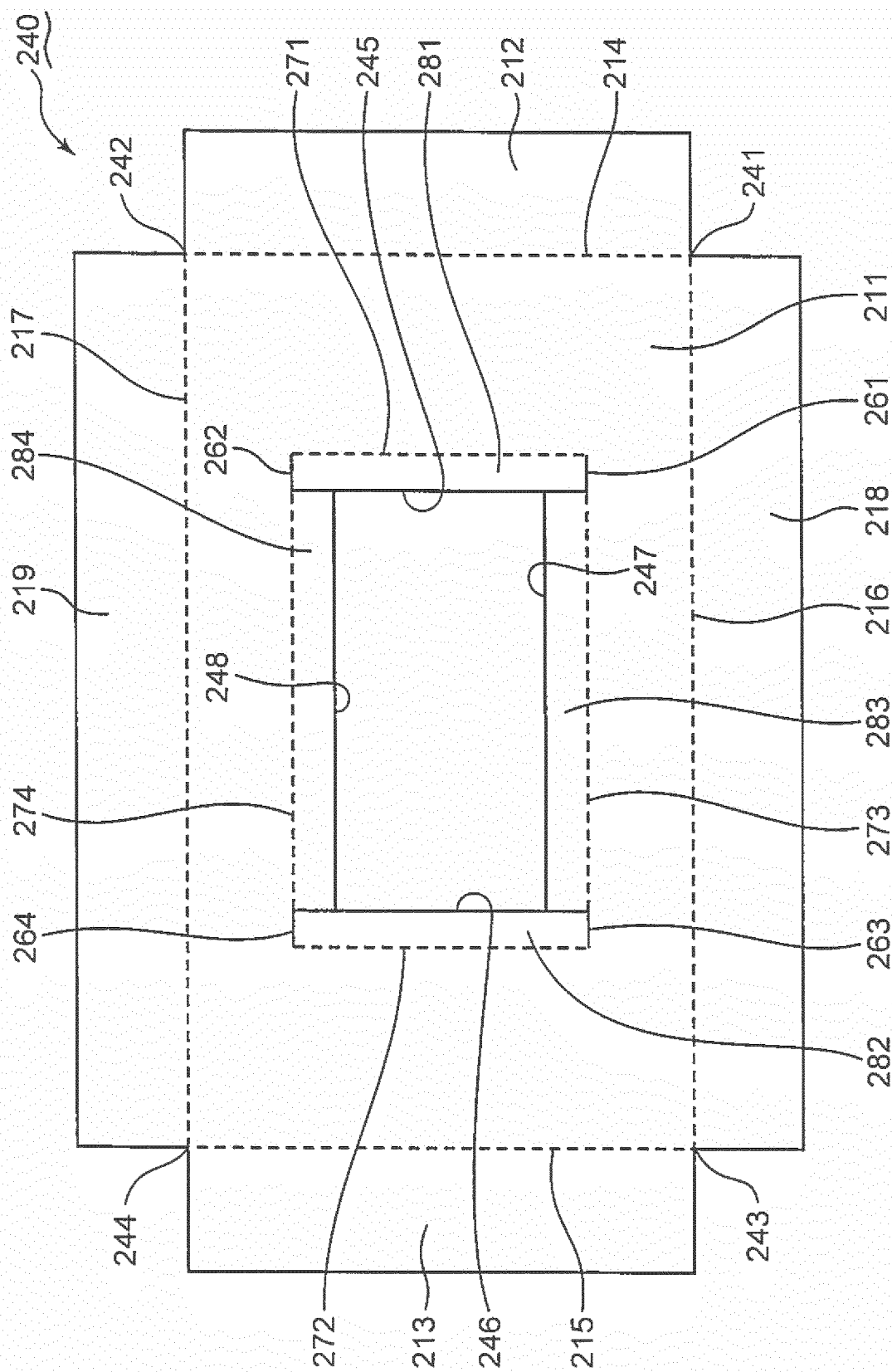
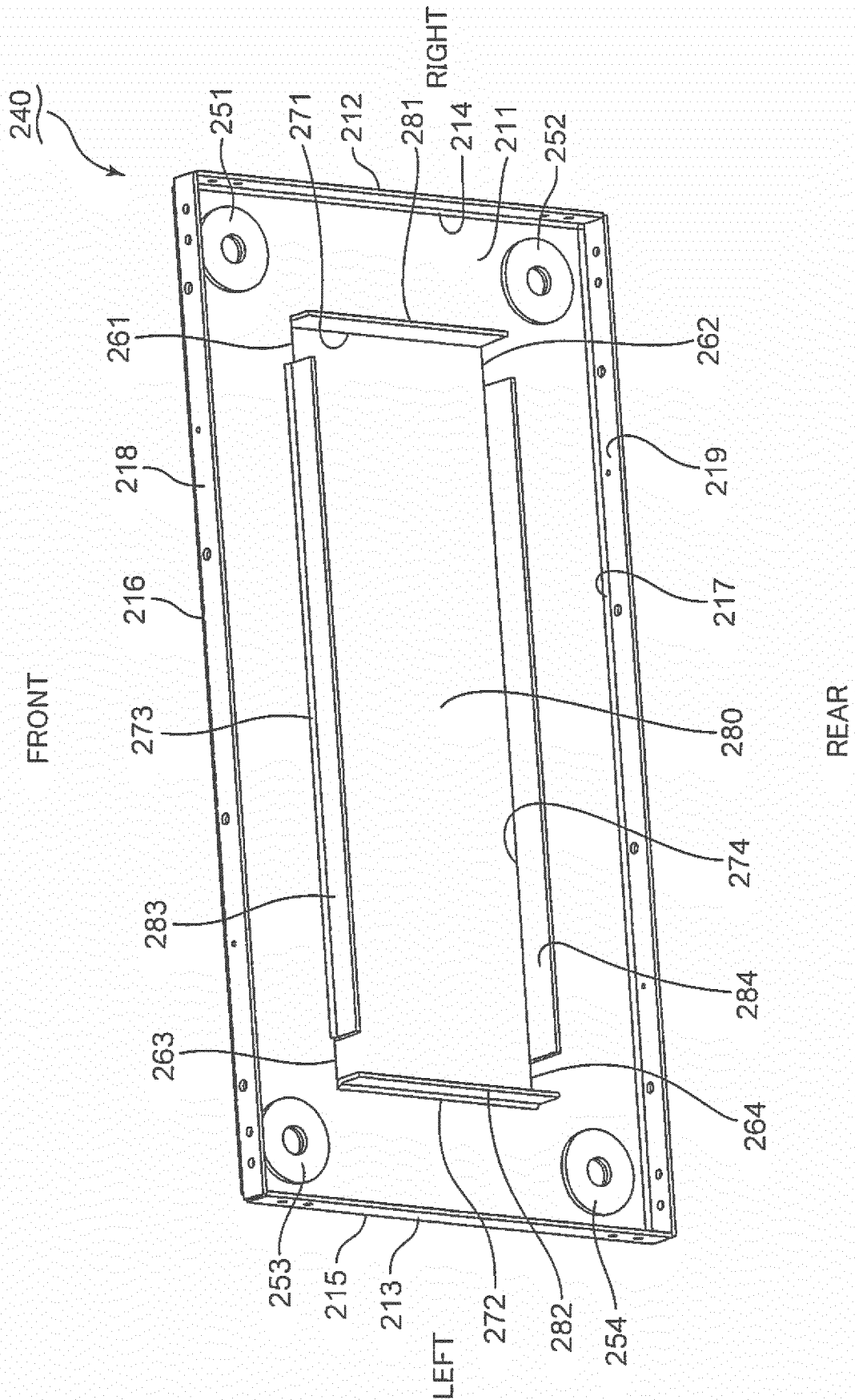


FIG. 7



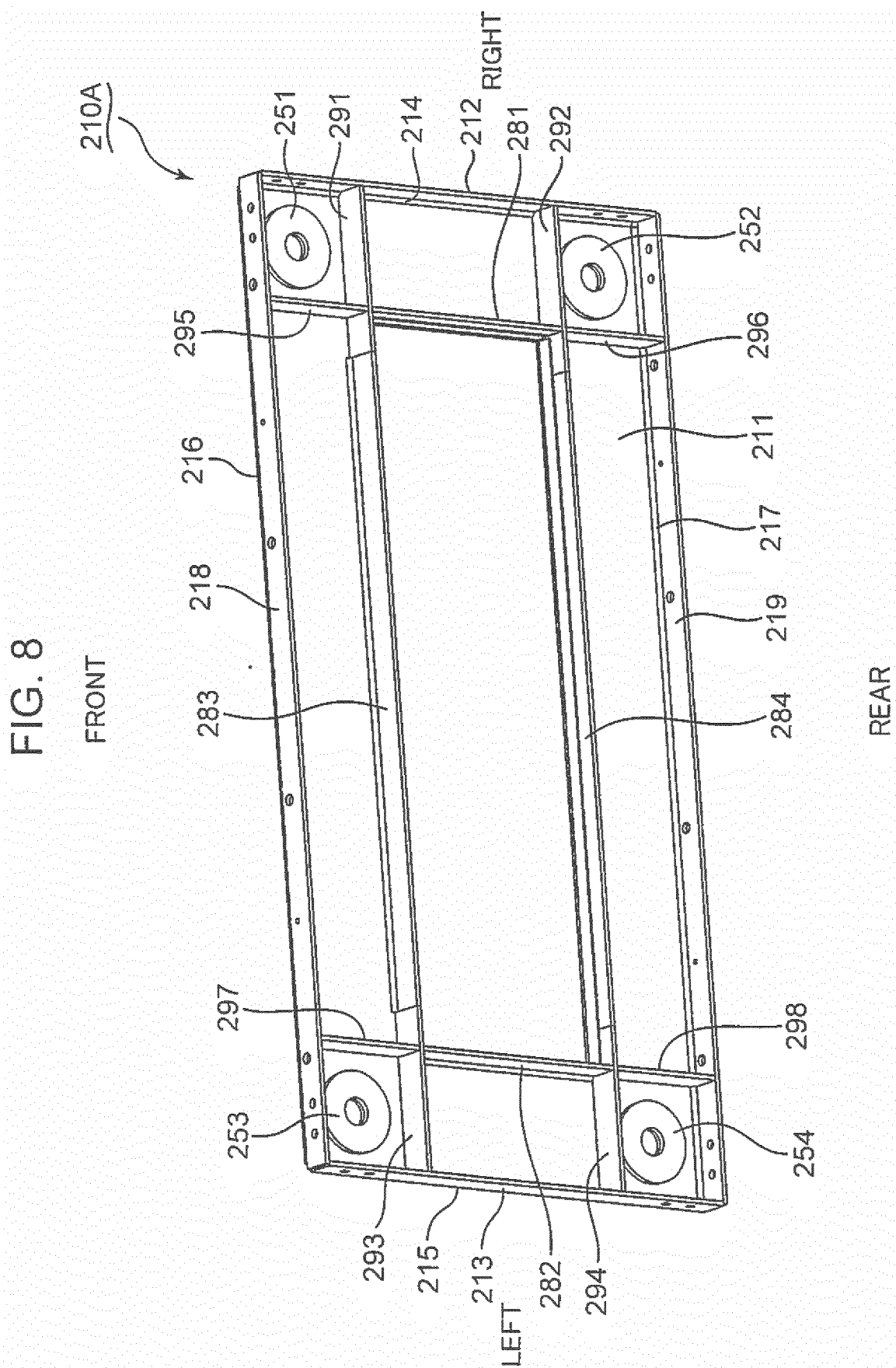


FIG. 9

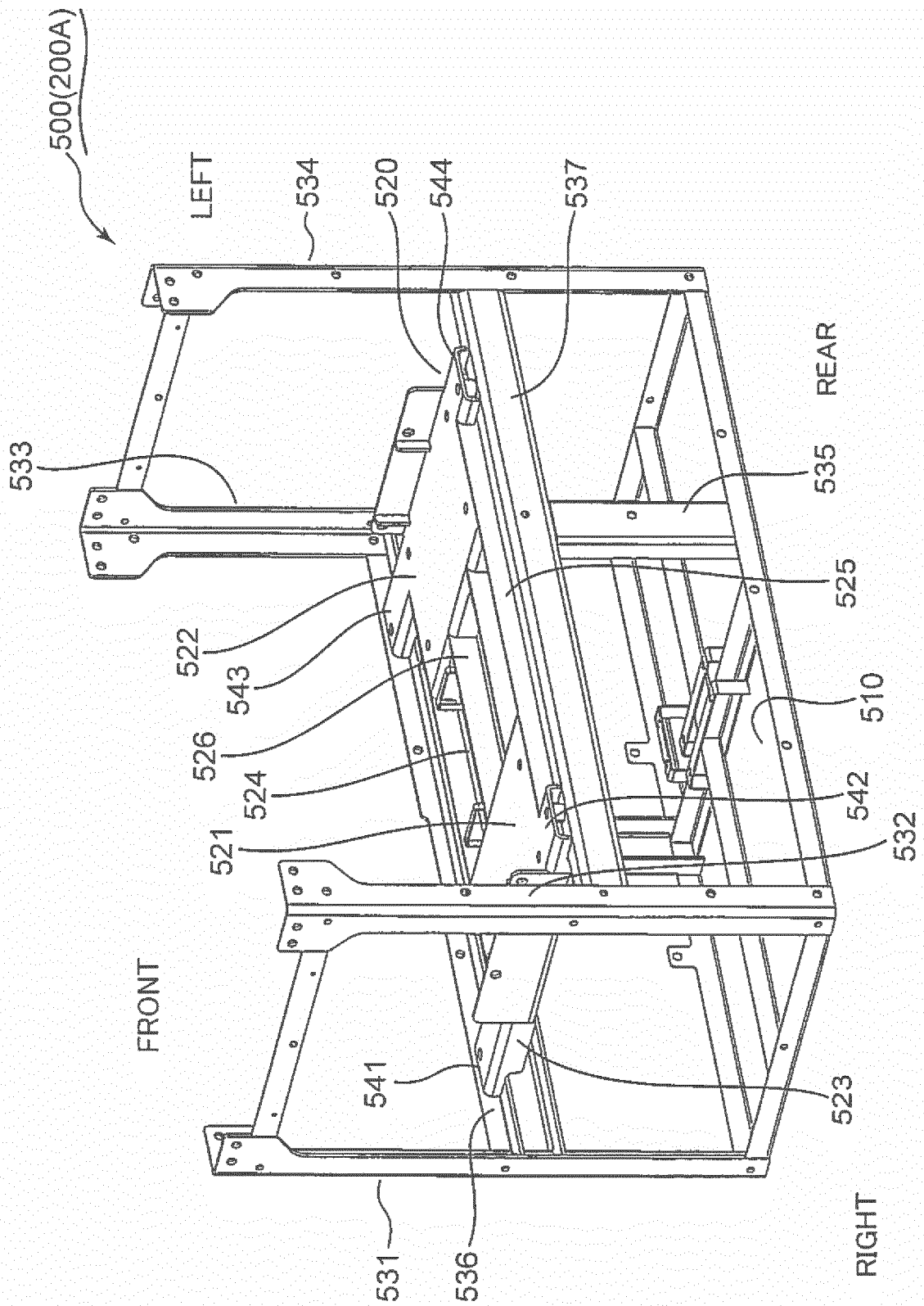
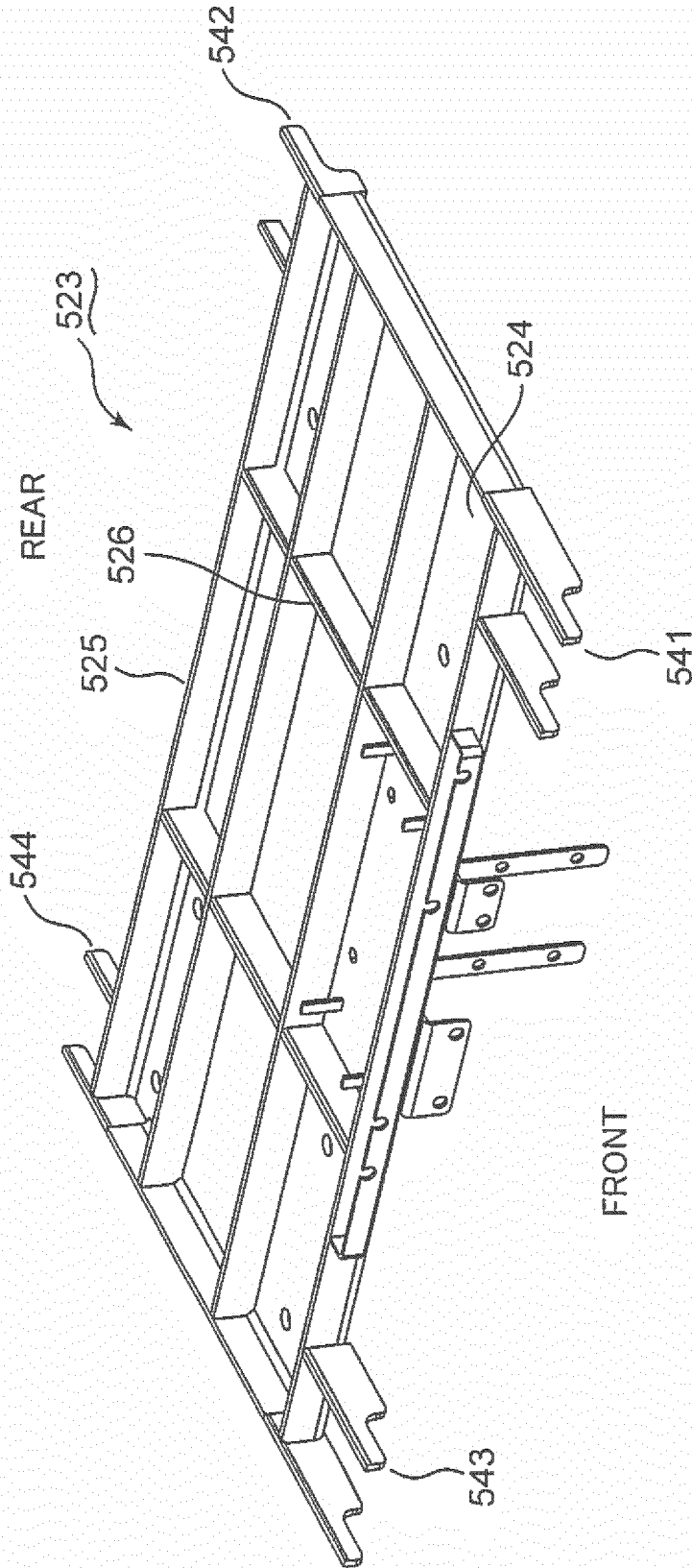


FIG. 10



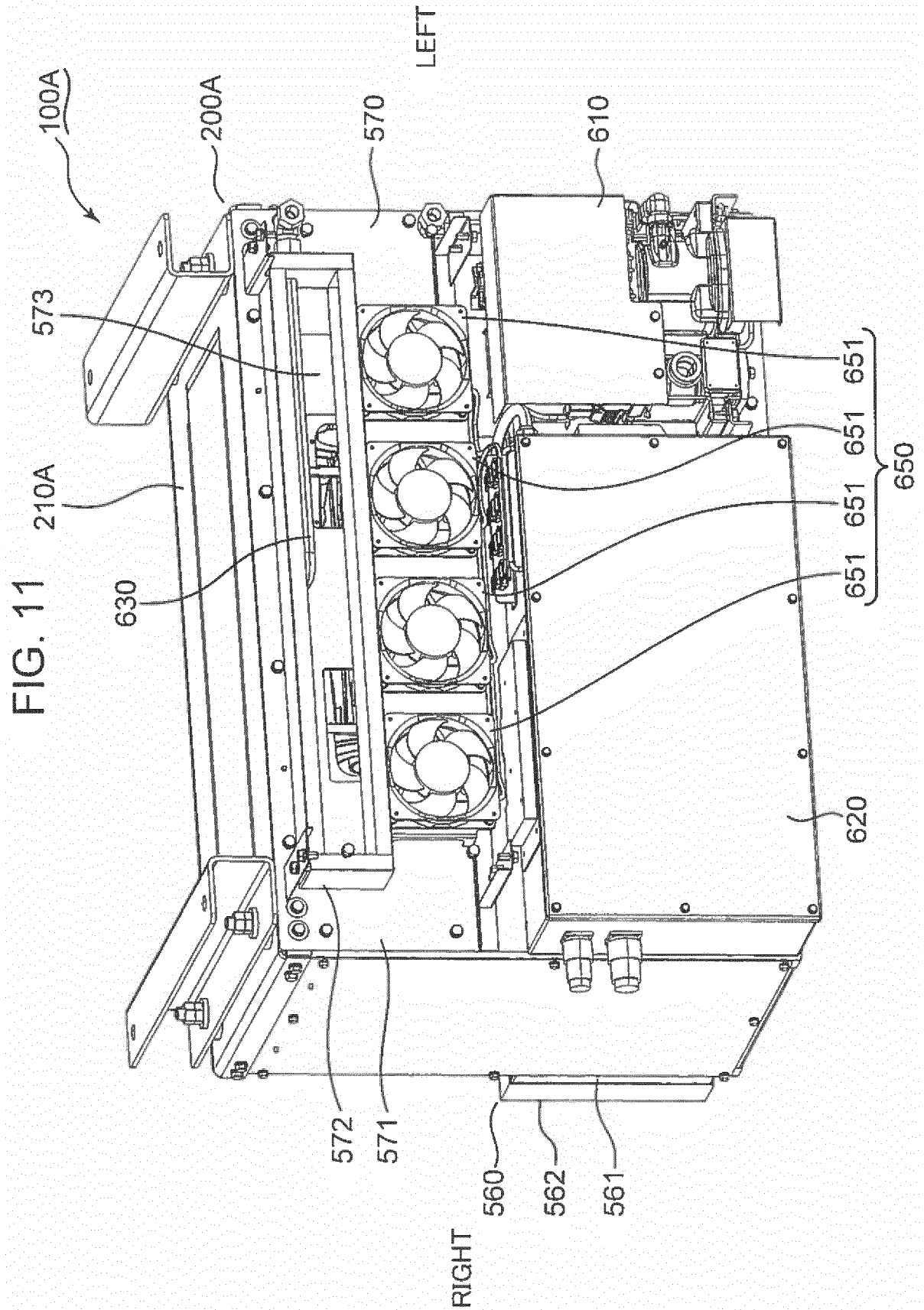


FIG. 12

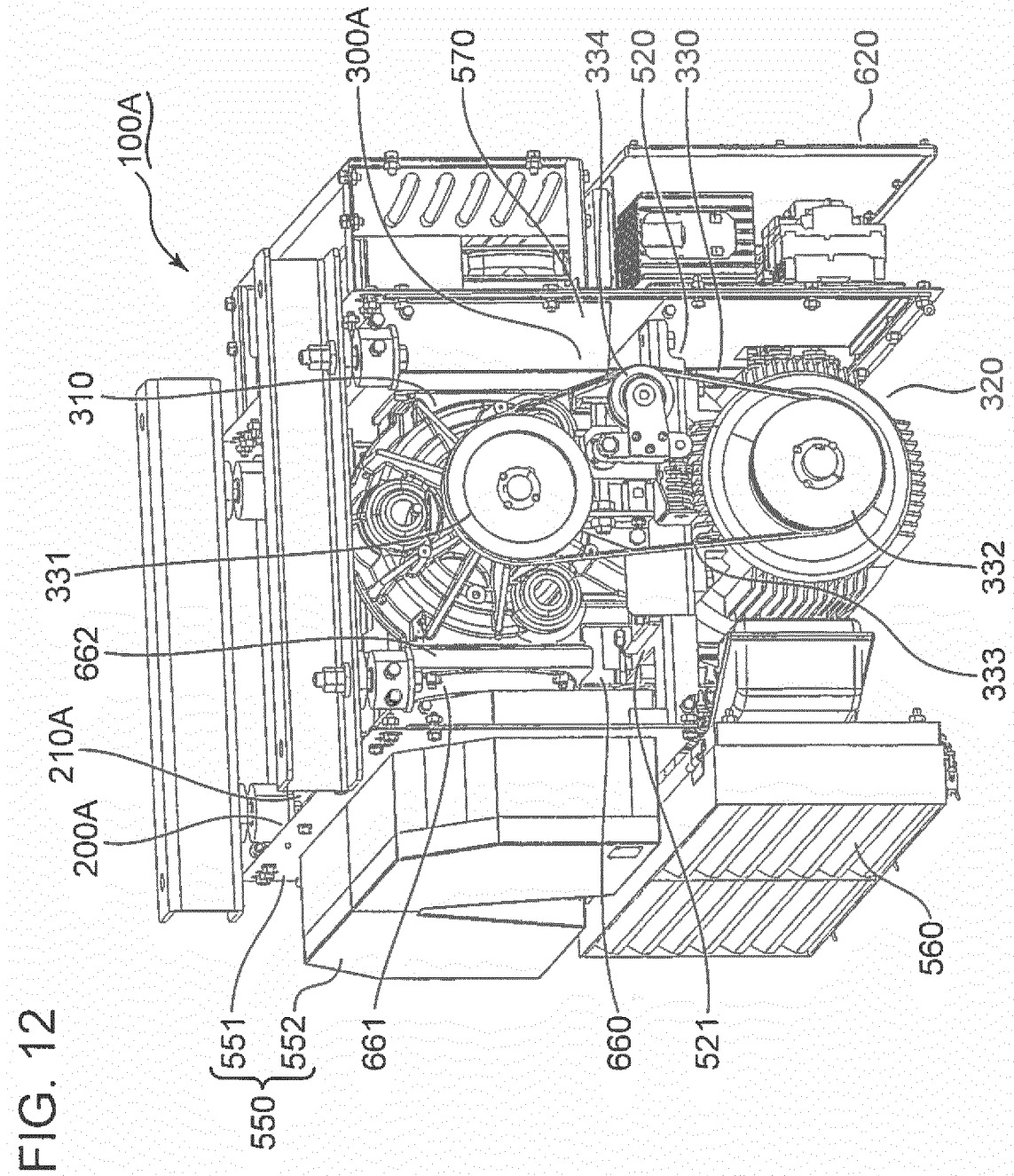


FIG. 13A

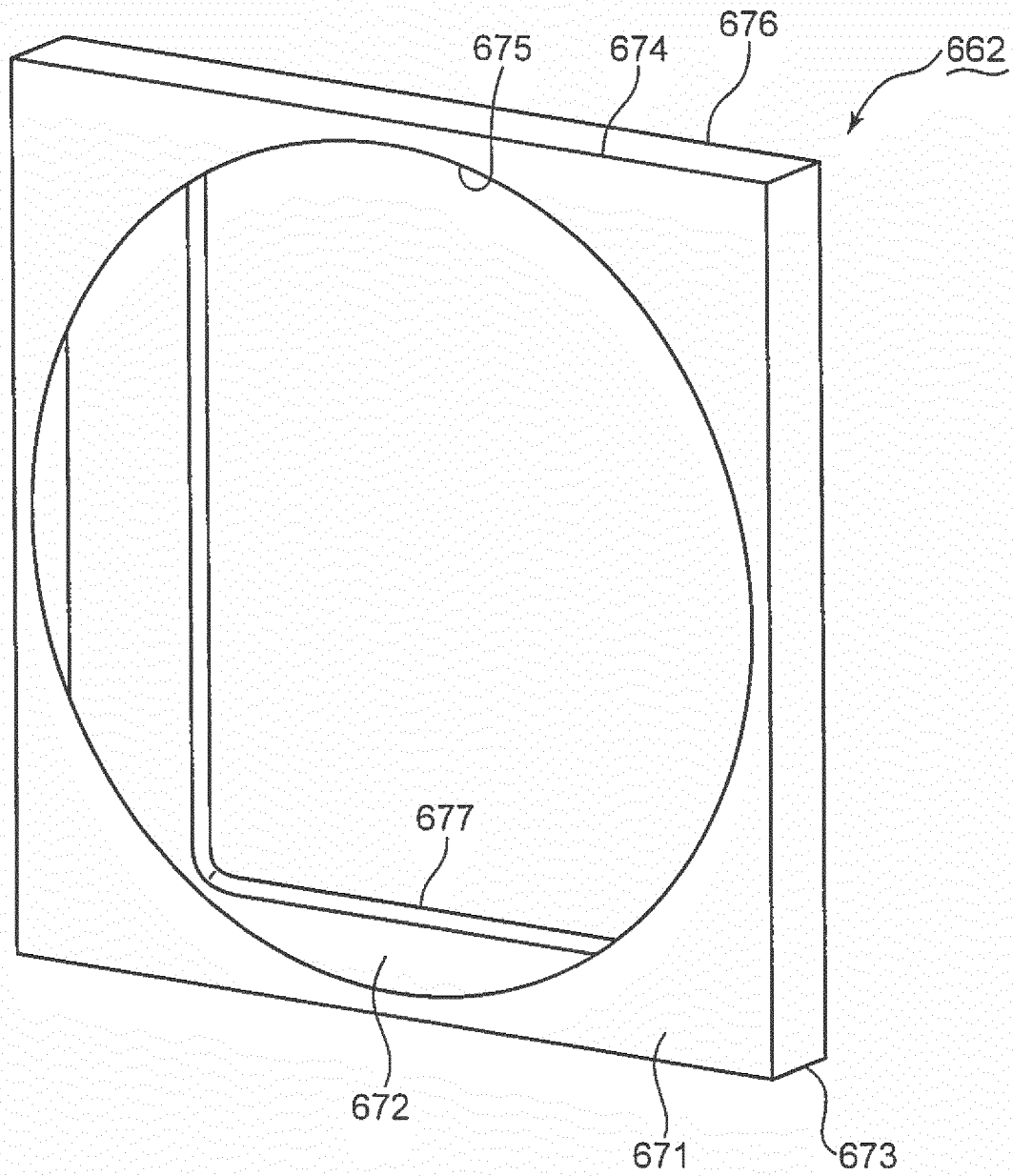


FIG. 13B

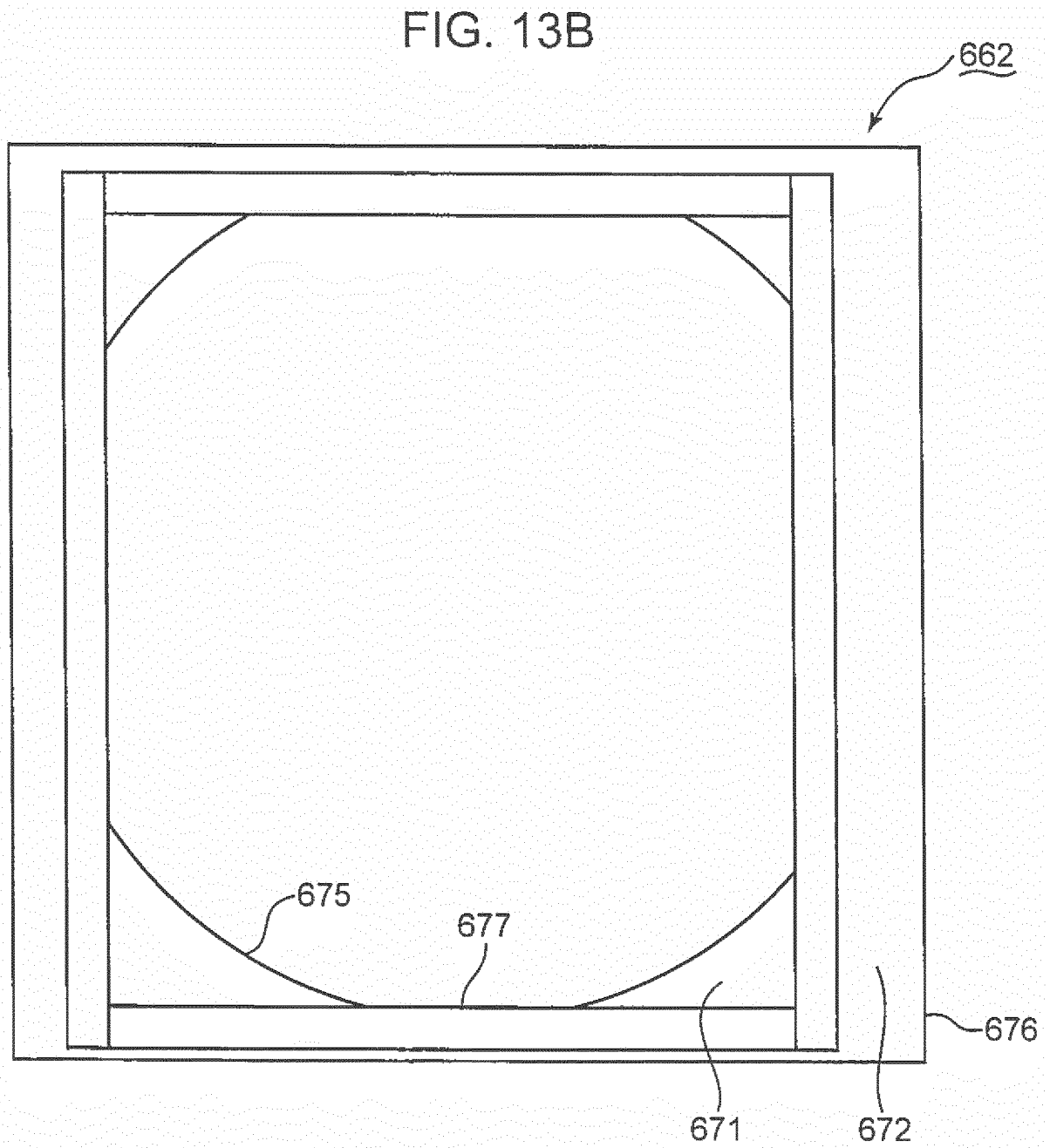


FIG. 14A

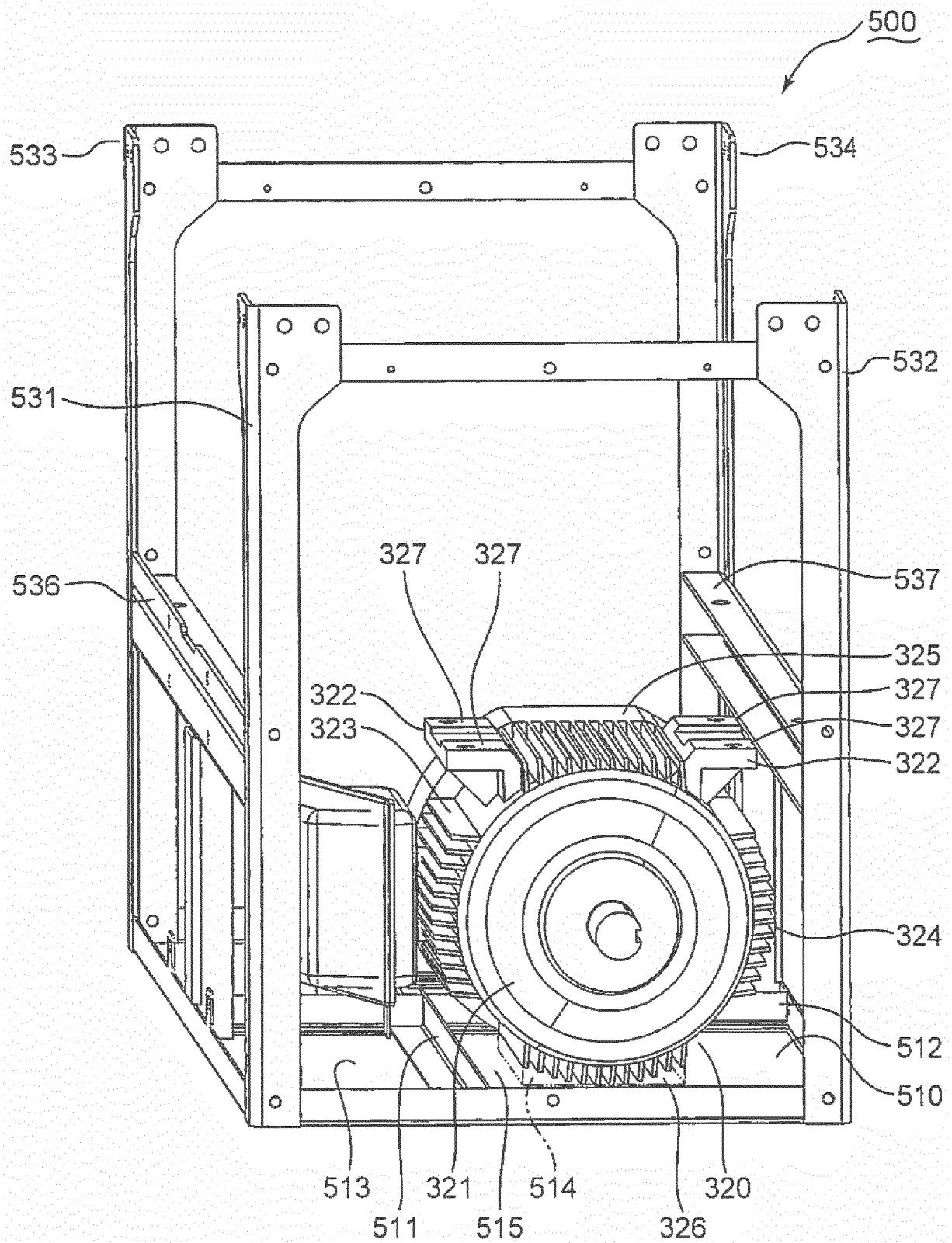


FIG. 14B

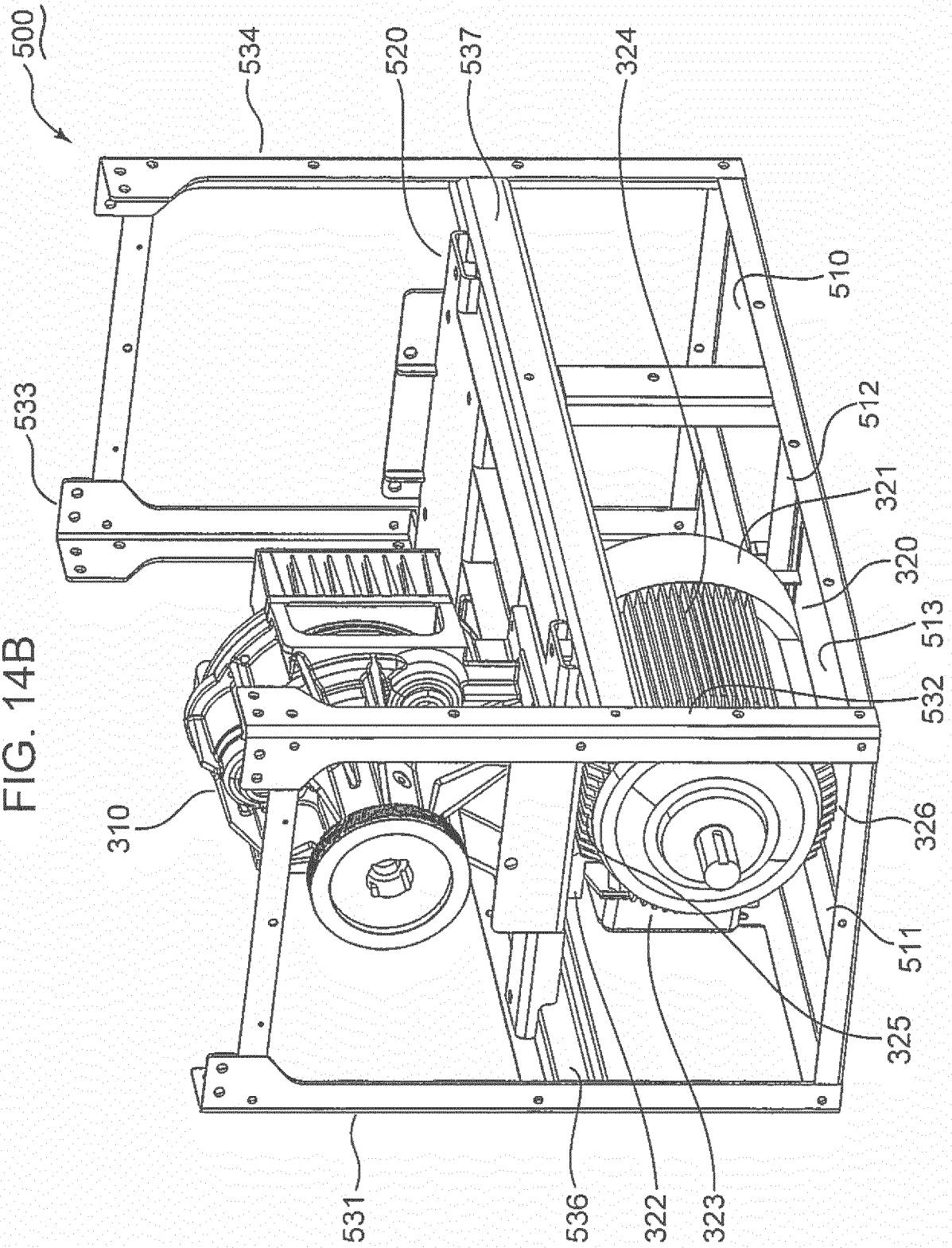


FIG. 15

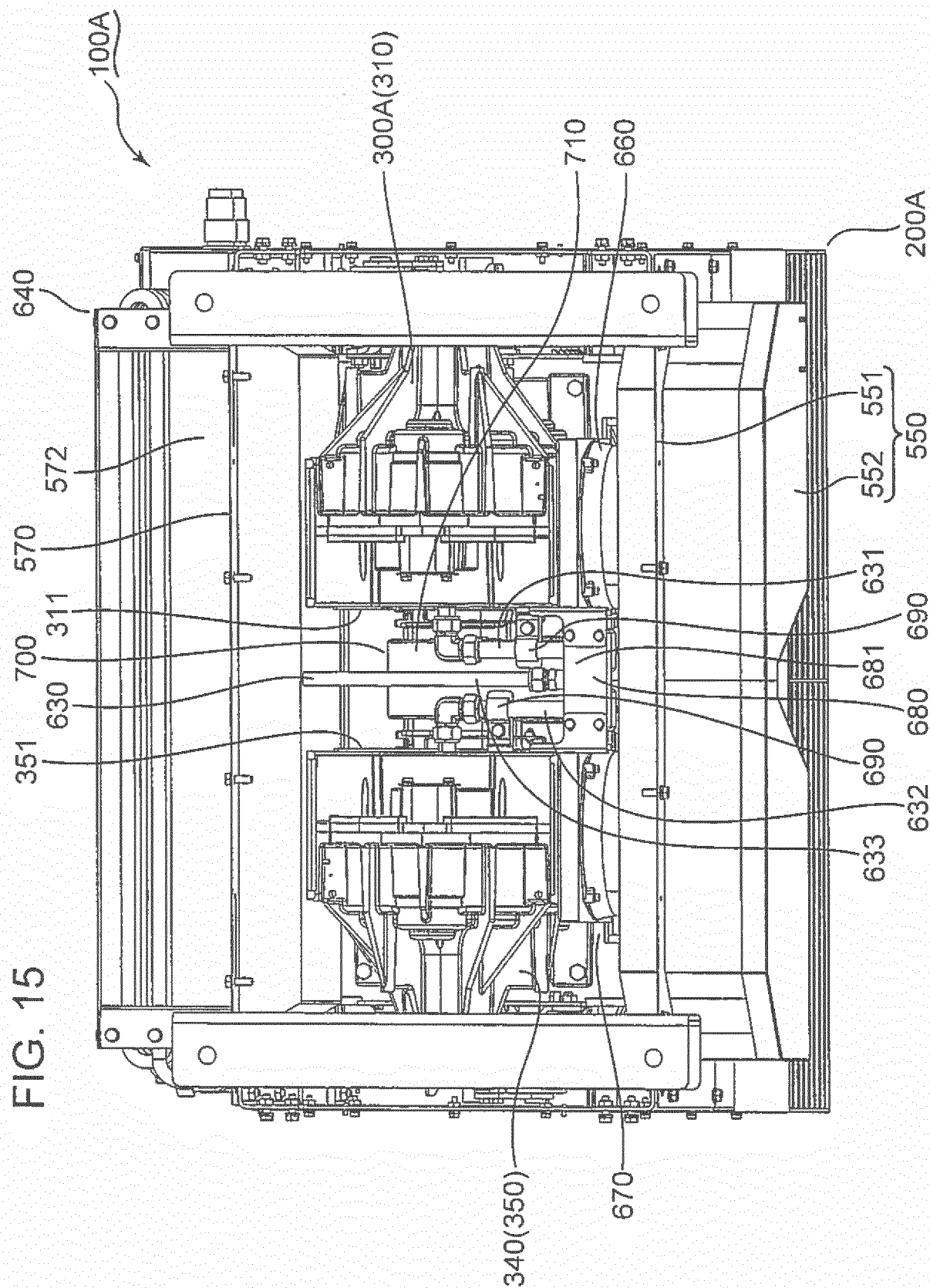


FIG. 16

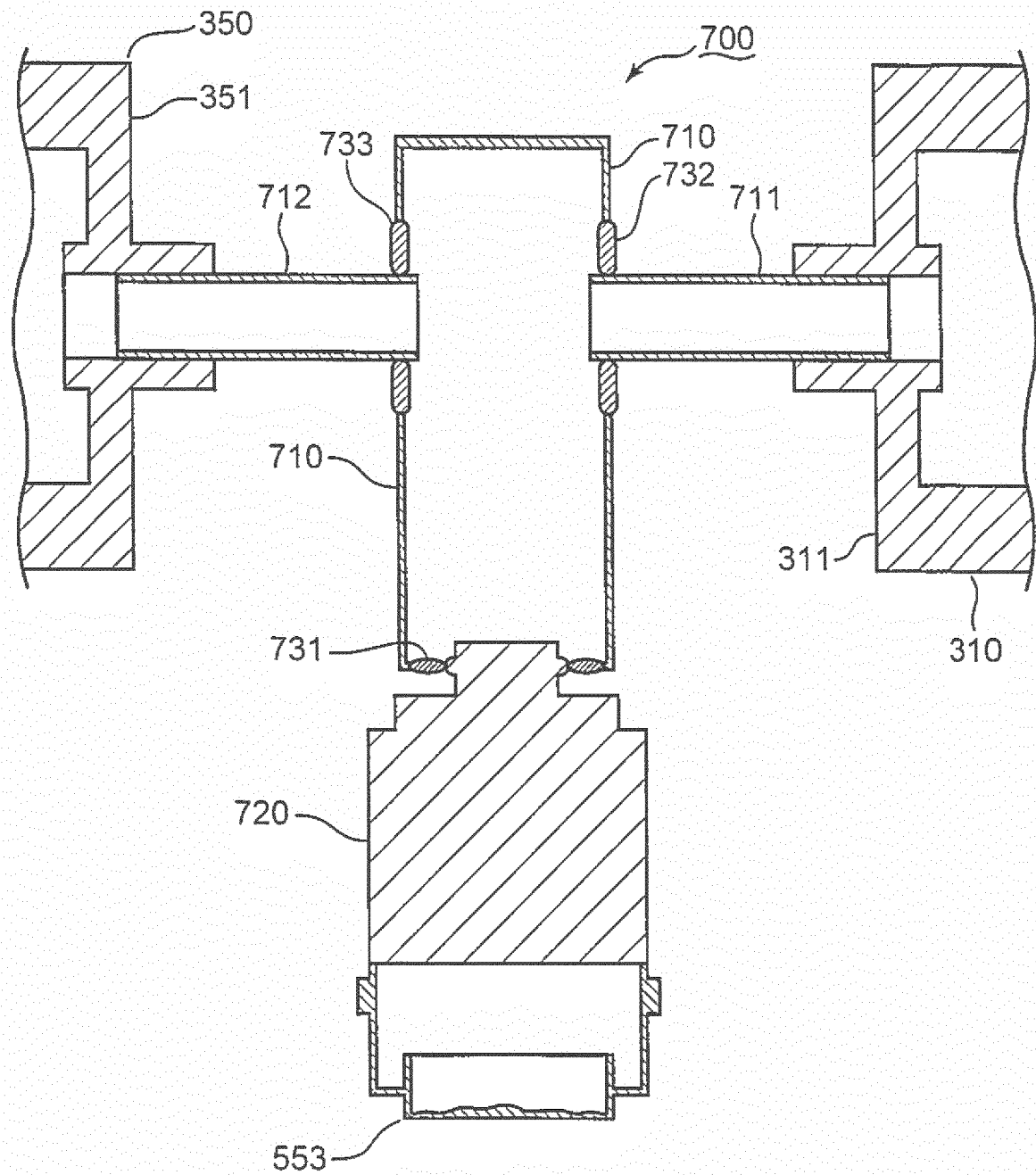
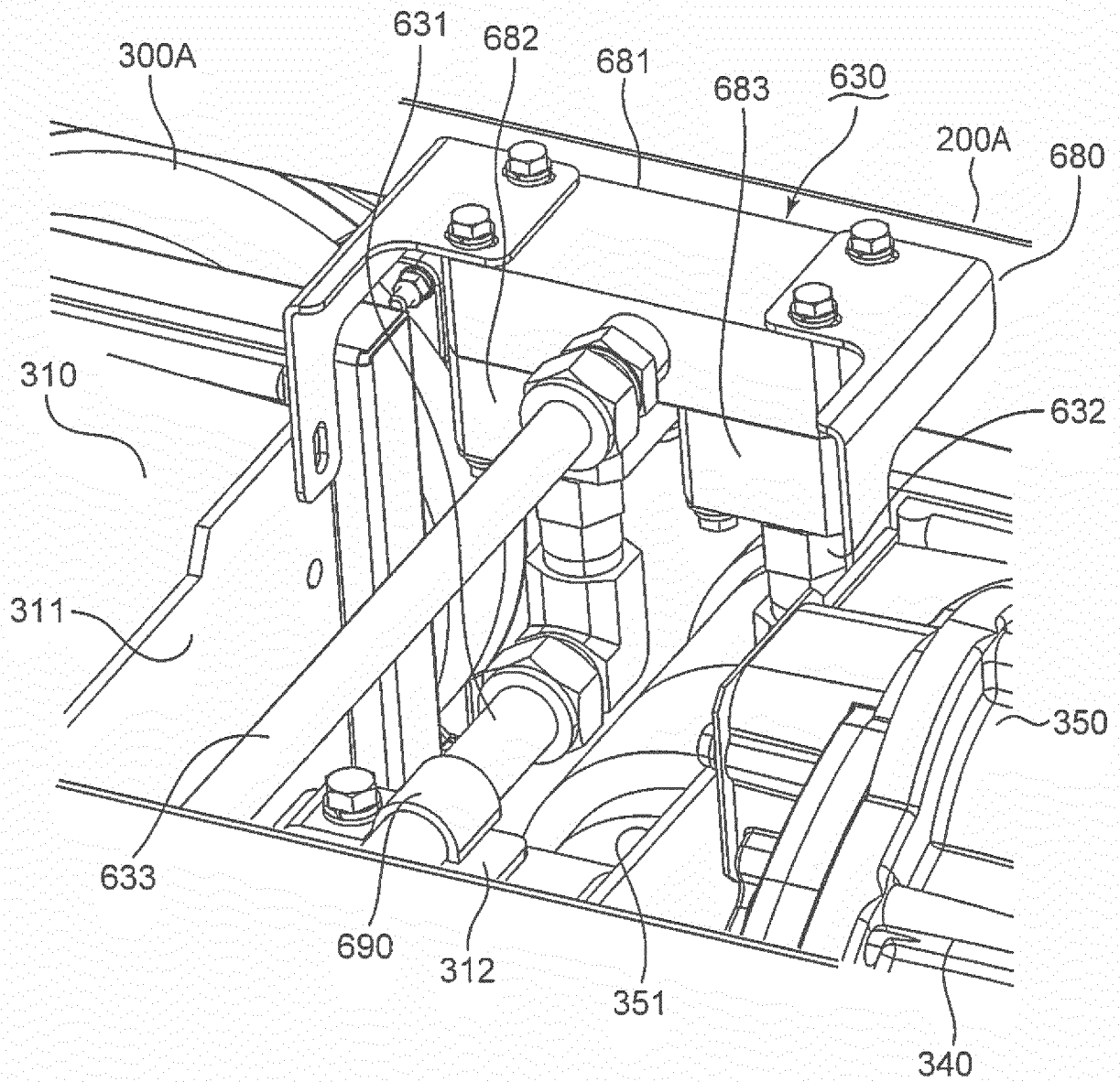


FIG. 17



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/065534

A. CLASSIFICATION OF SUBJECT MATTER

F04C29/00(2006.01)i, F04B39/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04C29/00, F04B39/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
 Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	JP 10-176668 A (Kobe Steel, Ltd.), 30 June 1998 (30.06.1998), paragraphs [0006] to [0010]; fig. 1 to 4 (Family: none)	1 2-8
X Y A	US 2004/0191085 A1 (STUTTS, Larry Rodney), 30 September 2004 (30.09.2004), paragraphs [0002], [0015] to [0028]; fig. 1 to 3 (Family: none)	1 2-3 4-8
Y A	JP 2003-200826 A (Nabco Ltd.), 15 July 2003 (15.07.2003), paragraphs [0015] to [0031]; fig. 1 to 6 (Family: none)	1-3 4-8

☒ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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Date of the actual completion of the international search
04 August 2016 (04.08.16)Date of mailing of the international search report
16 August 2016 (16.08.16)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2016/065534

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 17472/1985 (Laid-open No. 134585/1986) (Nippon Air Brake Co., Ltd.), 22 August 1986 (22.08.1986), entire text; all drawings (Family: none)	1-8

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

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Patent documents cited in the description

- JP 3150077 B [0005]