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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B62D	A2	(11) International Publication Number: **WO 99/56997** (43) International Publication Date: 11 November 1999 (11.11.99)

(21) International Application Number: PCT/US99/10074

(22) International Filing Date: 6 May 1999 (06.05.99)

(30) Priority Data:
09/073,925 7 May 1998 (07.05.98) US

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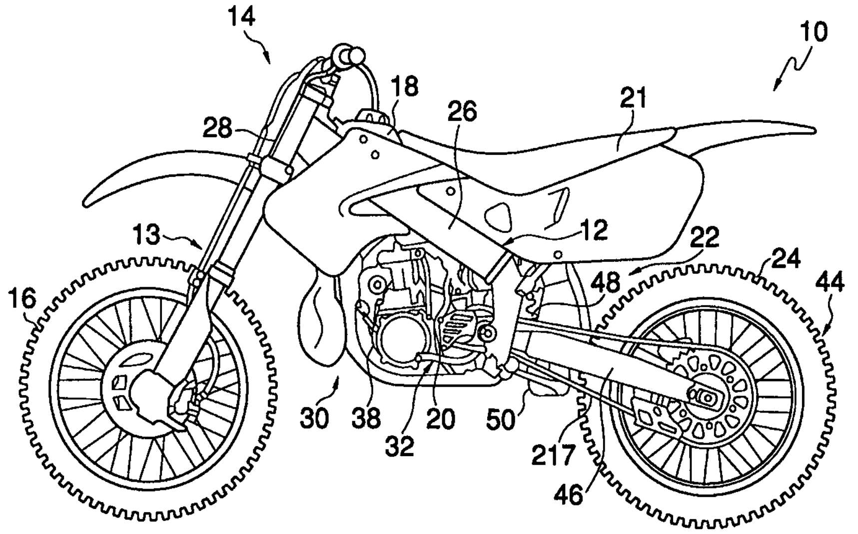
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: MOTORCYCLE



(57) Abstract

The present invention is directed towards a motorcycle for off-road use with an improved engine, frame, and fuel tank. The frame in one embodiment includes a movable engine frame below the main frame which is pivotally attached to the main frame at one end and detachably attached to the main frame at the other end. The engine frame supports the engine thereon and allows access to the engine when the engine frame is detached from the main frame. It also allows the engine frame to support the engine during inspection. In another embodiment, the frame includes a swing arm pivotally attached to the main frame, a shock that is pivotally attached to the main frame and the swing arm. The shock has a angle of less than 45 degrees with respect to a horizontal plane. The fuel tank includes hollow portions that form a tank body having a u-shape with a sidewardly extending cavity. The cavity receives an air filter therein that is coupled to the engine. Thus, the air filter is accessible when the tank is in position on the frame for easy inspection and changing. The engine is an improved four-stroke engine with electronically controlled fuel injectors.

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MOTORCYCLE

FIELD OF THE INVENTION

This invention generally relates to two-wheeled vehicles, and more particularly to motorcycles.

BACKGROUND OF THE INVENTION

Off-road motorcycles are well-known forms of transportation that are built for use on rough terrain and riding them usually includes maneuvering through numerous curves and executing jumps. Thus, the responsiveness of the bike to the rider is critical to the bike having the proper performance. These motorcycles are built to be rugged and maneuverable.

Referring to Figs. 1 and 2, conventional off-road motorcycles 10 generally include a frame 12, a front-suspension 13, steering assembly 14 that includes a front wheel 16, a fuel tank 18, a two-stroke engine 20, a seat 21, and a rear-suspension assembly 22 that includes a rear wheel 24. The motorcycle 10 further includes a brake assembly that includes front and rear brake cylinders 25.

The frame 12 shown is an aluminum frame and includes rearwardly divergent spars 26 that extend from a head tube 28 and an engine support assembly 30. The engine support assembly 30 is formed of tubular members that are fixed to the spars 26 and extend downwardly therefrom to form a space 32 for receiving the engine 20. The engine 20 is bolted to the engine support assembly 30 and spars 26 within the space 32.

Referring to Fig. 1, fuel tank 18 stores fuel to be burned by the engine 20. In general, conventional fuel tanks are positioned on the frame 12 between the head tube 28 and the seat 21. An air filter (not shown) is necessary to prevent dust and dirt from getting sucked into the engine 20 where it can cause harm.

Due to the location of the carburetor and air box 40 behind engine 20, the air filter is typically located below and behind the fuel tank 18. The fuel tank disclosed in U.S. Patent No. 4,577,719 issued to Nomura et al. discloses a main fuel tank disposed above the engine, and a separate auxiliary tank formed below the seat and behind the engine. The auxiliary tank is connected to the main fuel tank by a pipe. The air filter is located beneath the fuel tank.

Inspection and replacement of the air filter is often necessary, because these types of motorcycles are ridden in the dirt and when air filter gets too dirty, it impairs engine performance. Easy access to the air filter is desired.

Several configurations afford improved access to the air filter. For example, U.S. Patent No. 4,648,474 issued to Shinozaki et al. discloses a fuel tank including a forwardly facing U-shaped cavity. An air filter is located within the cavity of the fuel tank. The fuel tank is located above and on the exterior of the sides of the main frame. U.S. Patent No. 4,653,762 issued to Nakamura et al. discloses a main fuel tank of a generally U-shape section straddling the main frame so that it downwardly extends toward an engine. The main fuel tank is formed with an open space in its rear upper portion that extends partially vertically through the tank. An air cleaner is disposed within the space, and covered with a detachable cover. Both of the aforementioned tank configurations are for road motorcycles not off-road motorcycles. Thus, these tanks are configured for larger fuel capacities than that desired for off-road motorcycles, and make off-road motorcycles more difficult to maneuver.

Referring to Figs. 1 and 2, the engine 20 of a typical off-road motorcycle includes a cylinder 38 and a carburetor and air box 40, one of which is shown. The carburetor 40 mixes fuel with air, and this mixture is fed into the engine 20 and burned. The carburetor 40 is located behind the engine cylinder 38. A kick start 42 extends from the rear of one side of the engine 20 for starting the engine.

Most serious off-road motorcycles have two-stroke engines, which provide excellent power output. When installed, the cylinders 38 of two-stroke engines extend vertically and terminate so that they are spaced from the spars 26. As a result, when repair of the engine is necessary, the two-stroke engine is removed sideways from the frame.

Some off-road motorcycles have four-stroke engines, which are typically less powerful than two-stroke engines for the same displacement. However, four-stroke engines are significantly cleaner, more efficient and quieter. In the 1950's most motocross motorcycles had four-stroke engines. An early off-road, four-stroke, motorcycle was Rick Johnson's 1981-1984 Factory Team Bike built by Team Yamaha and Pro-Tec. Other four-stroke motorcycles are the recently introduced Yamaha YZ400 and the ATK 350/605 and 600. All of these four-stroke bikes have steel frames and use carburetors for fuel/air mixture. In order to provide the same power as a two-stroke engine, the cylinder of the four-stroke engine must be significantly larger. Due to the size and weight of the four-stroke engine, the frame is made taller and the bike is heavier, which makes the bike more difficult to ride.

Steel off-road frames typically have a single spar extending from the head tube. The engine support assembly is fixed to the spar, and extends therebelow to form the space 32. In order to make the four-stroke engine fit in this type of frame, the spar is angled upward with respect to the head tube 28 so that the space 32 is large enough to accommodate the entire engine. This allows the engine to be removed sideways from the frame. However, enlarging the space 32 may cause the seat 21 to be higher than in the other configuration. Since a higher seat may make straddling the motorcycle while standing and maneuvering the motorcycle more difficult, this configuration is undesirable.

Due to the performance requirements of off-road motorcycles, they are generally equipped with a rugged rear suspension 44 capable of cushioning the rider from jarring. Typically, the rear suspension 44 of an off-road motorcycle consists of a swing arm 46 that is pivotally attached to the frame 12. The rear wheel 24 is rotatably mounted at the free ends of the swing arm 46. A shock 48 is connected between the swing arm 46 and the frame 12. Since the carburetor and air box 40 are located behind the engine 20, their presence greatly dictates the configuration of the shock 48 connection to the swing arm and main frame.

In order to obtain the desired performance, one arrangement provides a linkage 50 between the lower surface of the swing arm 46 and the shock 48. When the free ends of the swing arm 46 move toward the frame 12, the linkage moves and compresses the shock 48. Consequently, the shock biases the free ends of the swing arm 46 away from the frame 12. The linkage 50 allows the attachment point of the shock 48 to the frame 12 and the shock 48 itself to extend substantially vertically upward, such that it avoids the carburetor and air box 40. Since this arrangement requires the linkage 50, it is more complex than a direct connection of the shock to the swing arm. Therefore, it is undesirable.

Another arrangement directly connects the shock 48 to the swing arm 46. However in order to avoid the carburetors and air box 40, the shock must be off-set from the central plane of the motorcycle. The shock is coupled to either the right of left arm of the swing arm and, thus, loads and stresses that swing arm unevenly. Typically the swing arm must then be built to withstand these conditions. Furthermore, this configuration requires the frame to be configured to compensate for the lack of symmetry of the shock mount and the shock loads. This will not maximize the maneuverability of the motorcycle. Another alternative is to use two shocks connected to each of the arms of the swing arm. However, this tends to make the motorcycle wide through the foot peg area and from a simplicity stand point, fewer parts would be more desirable.

Therefore, in order to overcome the shortcomings of the prior art, the object of the invention herein is to provide an improved off-road motorcycle frame configuration and four-stroke engine.

SUMMARY OF THE INVENTION

These desirous and advantageous features are now provided by the present invention, which relates to a motorcycle comprising an improved frame configuration and four-stroke engine.

The present invention is directed to a motorcycle for use off-road having a longitudinally extending central plane, wherein the motorcycle comprises an engine having a cylinder, a frame, and a fuel tank. The frame comprises a main frame including a head tube, first and second spars extending from the head tube, and first and second swing arm mounts on the spars. The frame further includes an engine frame to which the engine is releasably attached. The engine frame includes a first end pivotally or removably coupled to the swing arm mount free ends and a second end releasably coupled to the spars so that the engine frame is movable between an in or out position. The engine frame further includes first and second bolt rails, each bolt rail is pivotally or removably attached to the respective swing arm mount at the first end and releasably coupled to the main frame at the second end. The engine frame can further include first and second down tubes, each down tube is attached to the lower surface of the respective spar at longitudinally spaced locations. Each bolt rail extends from the associated swing arm mount to the associated down tube. Moreover, the spars include a longitudinally extending center plane that defines an angle with a horizontal plane that is less than 45 degrees.

The frame further includes a swing arm and a shock cross member that includes a shock mount. The swing arm has one end pivotally attached to the swing arm mounts, and the other end rotatably supports a rear wheel. A shock is pivotally connected to the frame shock mount and the swing arm shock mount and is coincident with the motorcycle central plane. The shock in a fully extended position defines an angle with a horizontal plane of less than 45 degrees. The shock in a fully compressed position defines an angle with the horizontal plane of less than 30 degrees. Moreover, the frame shock mount is in front of the swing arm pivot and, preferably, by a horizontal distance of more than 3 inches, and is vertically less than 12 inches above the pivot. In addition, the shock mount is less than two inches vertically from the pivot.

The fuel tank is for use with an air filter in fluid communication with the engine therebelow. The fuel tank comprises an upper wall, a lower wall spaced from the upper wall, and a sidewall that joins the upper wall to the lower wall. The fuel tank forms a first hollow portion with a fuel inlet, a second hollow portion with a fuel outlet and return, and at least one central hollow portion for connecting the first hollow portion to the second hollow portion so that the fuel travels from the first hollow portion to the second hollow portion. The hollow portions define a cavity that extends vertically from the upper wall to the lower wall, and the cavity receives the air filter therein. In one embodiment, the fuel tank includes two central hollow portions spaced from one another so that the cavity is defined therebetween. In another embodiment, the fuel tank includes one central hollow portion and has a u-shape so that the cavity includes a sidewardly facing opening. The fuel tank further includes locating the second hollow portion rearwardly of the engine. Moreover, a volume within the second hollow portion is greater than a volume within the first hollow portion. The fuel tank can further include at least one battery electrically connected to an electronic controller, the battery is mounted on the upper wall of the second hollow portion or to the rear fender. In one embodiment, the fuel tank second hollow portion further includes a fuel pump in fluid communication with the fuel outlet and return. The fuel pump is mounted on the interior or the exterior of the fuel tank.

The present invention is further directed to a motorcycle configuration where a centerline is disposed equidistant between the front and rear wheels. The motorcycle is configured so that less than 50%, more preferably 45% to 49%, of the weight of the motorcycle is forward of the centerline and more than 50%, more preferably 51% to 55%, of the weight is rearward of the centerline.

One advantage of the fuel tank of the present invention is that the air filter can be inspected and changed without removing the tank. A second advantage is that the air filter is up high and out of the elements and dirt and water, so it does not have to work as hard to keep foreign particles out of the engine. With the air filter location and down draft butterfly house, space is provided behind the engine for mounting the shock directly and centrally to the swing arm. Thus a linkage-type suspension is not necessary, since the angle between the shock and a horizontal plane is so low, and a progressive spring rate is achieved without the linkage. Furthermore, since the shock is on the central plane of the motorcycle, loads and stress are minimized.

The present invention is also directed to an improved four-stroke engine that is particularly advantageous for the off-road motorcycle. The engine preferably comprises a single cylinder having an internal volume of between 350 cc and 700 cc and electronically controlled fuel injectors. The four-stroke motor also has an electronic control management system electronically coupled to the fuel injectors to control the amount and timing of the fuel injection with the air intake and ignition. The electronic control management system preferably is programmable and has more than one control map thereon so that different fuel injection/air intake control maps can be selected by the user.

The improved four-stroke engine also has only an electronic starter. Preferably, the starter is coupled to a first end of the engine motor balance shaft and a water pump is mounted on the other end of the balance shaft. By eliminating the standard kick-starter, the frame spars can be significantly improved as stated in more detail below.

In a preferred embodiment, the electronic control management system is located substantially on a plate that is coupled to the cylinder head cam covers and the butterfly house such that the system is removable as a unit and the air filter can be coupled to the plate.

The present invention is further directed to a motorcycle comprising a four-stroke engine and an aluminum frame. The four-stroke engine is preferably angled less than 30° from a vertical position and comprises a single cylinder having an internal volume of between 250 cc and 700 cc, a piston received within the cylinder to substantially transverse within the cylinder, and a cylinder head coupled to the cylinder to form a substantially closed volume with the piston. The cylinder head has two inlets with corresponding inlet valves for introducing fuel into the closed volume and two outlets with corresponding outlet valves for extracting exhaust products from the closed volume. The frame supports the engine and comprises a main frame made of aluminum for supporting the engine and a front wheel, and a swing arm pivotally attached to the main frame for supporting a rear wheel. The engine preferably includes a substantially vertical butterfly house for introducing air into the cylinder head. The frame preferably includes a shock pivotally attached to the main frame at a first end and pivotally attached to the swing arm at a second end, wherein the shock is disposed on a central plane of the motorcycle. The shock preferably has a fully extended position where an angle between the shock and a horizontal plane is less than 45°, and a fully compressed position where the angle is less than 30°.

BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a left side view of a prior art off-road motorcycle.

Fig. 2 is a right side view of the prior art off-road motorcycle.

Fig. 3 is a left side view of a motorcycle of the present invention.

Fig. 4 is a left side view of another embodiment of the off-road motorcycle frame and tank of the present invention.

Fig. 5 is a perspective view of the frame of Fig. 4.

Fig. 6 is a perspective view of a main frame of the present invention.

Fig. 7 is a perspective view of a subframe of the present invention.

Fig. 8 is a perspective view of a swing arm of the present invention.

Fig. 9 is a left side view of a portion of the frame of Fig. 4 illustrating various relationships between the components, wherein the swing arm is in a first position.

Fig. 10 is a left side view of a portion of the frame of Fig. 4 illustrating various relationships between the components, wherein the swing arm is in a second position.

Fig. 11 is an enlarged, left side view of an air intake assembly and a fuel tank of the present invention, wherein a portion of the main frame has been broken away for clarity.

Fig. 12 is a perspective view of an air box of the air intake assembly of Fig. 11.

Fig. 13 is a top view of the fuel tank of the present invention.

Fig. 14 is an enlarged, perspective view of a portion of the fuel tank.

Fig. 15 is a right side view of the fuel tank having a portion broken away for clarity.

Fig. 16 is an enlarged, perspective view of a fuel pump insert of the fuel tank.

Fig. 17 is a perspective view of a four-stroke engine according to the present invention.

Fig. 18 is an assembly drawing of a cylinder, piston and crank assembly of the present invention.

Fig. 19 is a plan view of a preferred embodiment of an electronic control management, butterfly house and cylinder head of the present invention.

Fig. 20 is an assembly drawing of the cylinder head according to the present invention.

Fig. 21 is an assembly drawing of cams and a timing belt of the present invention.

Fig. 22 is an assembly drawing of valves of the present invention.

Fig. 23 is an assembly drawing of a crank case according to the present invention.

Fig. 24 is an assembly drawing of a transmission and clutch cover of the present invention.

Fig. 25 is an assembly drawing of a gear box of the present invention.

Fig. 26 is an assembly drawing of a balance shaft of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to Fig. 3, a motorcycle 100 of the present invention includes a frame 112, an engine 114, an air intake assembly 116 (shown in phantom), a fuel tank 118, a battery 120 (shown in phantom) mounted on the fuel tank or the battery 120′ is located on a rear body panel 124, an engine controller 122 (shown in phantom), a plurality of body panels 124, and a seat 125. The frame 112 supports the other components of the motorcycle 100.

Referring to Figs. 4 and 5, the frame 112 includes a front end 126, a rear end 127 spaced therefrom, and a central plane L that longitudinally extends between the ends 126 and 127. The frame 112 further includes a main frame 128, a subframe 130, a suspension assembly 132, and an engine frame 134. The main frame 128 provides substantial structural support for the components of the motorcycle under static and dynamic loads.

Referring to Fig. 6, the main frame 128 includes a head tube 136, left and right or first and second spars 138a,b, left and right or first and second swing arm mounts 140a,b, and a plurality of spaced cross members 142, 144, 146. The head tube 136 defines a bore 148, therethrough. The head tube 148 is at the center of the main frame 128. The head tube 136 rotatably supports a steering assembly 14 (as shown in Fig. 1), which is conventional and extends through the bore 148.

Referring to Fig. 5, the left and right spars 138a,b have a rectangular cross-section and are mirror-images of one another. They extend rearwardly from the head tube 136 and diverge from one another to define a space 150 therebetween. Each spar 138a,b includes a gusset, the left gusset 152a is shown. The right gusset 152a extends rearwardly from the head tube 136 along a portion of the lower edge of the left spar 138a. The left gusset is similarly located on the right spar 136b. The gussets are open channel pieces of metal that strengthen the main frame 128.

The left gusset 152a includes a gusset mount 154a. The left gusset mount 154a is fixed to and downwardly extending from the left gusset 152a. The left gusset mount 154a is a bracket that defines a transversely extending bore 156a therethrough. The right gusset mount is similarly located on the right gusset.

Referring to Fig. 6, the left and right swing arm mounts 140a,b extend downwardly from the rear ends of the spars 138a,b and are attached thereto. The swing arm mounts 140a,b are curved into a C-shape. The inner surface of each swing arm mount includes a plurality of cavities, the cavities 158b on the right mount 138b are shown. The cavities 158b help minimize the weight of the frame while allowing sufficient strength.

The outer edge of the right swing arm mount 140b includes a lower subframe mount 160b extending upwardly therefrom. The lower subframe mount 160b defines a transversely extending bore 162b. The inner edge of the right swing arm mount 140b defines a bore 164b in the center thereof. The lower end of the right swing arm mount 140b defines two off-set transversely extending bores 166b one of which is shown.

The outer edge of the right swing arm mount 140b further includes a bracket 168 having two transversely extending bores 170, and a bracket 172 having a transversely extending bore 174. The brackets 168 and 172 support a conventional rear brake cylinder 25 (as shown in Fig. 1).

Referring to both Figs. 5 and 6, the outer edge of the left swing arm mount 140a includes a lower subframe mount 160a extending upwardly therefrom. The lower subframe mount 160a defines a transversely extending bore 162a. The bore 162a in the left swing arm mount 140a is aligned with the bore 162b in the right swing arm mount 140b. The inner edge of the left swing arm mount 140a defines a bore 164a in the center thereof. The bore 164a is aligned with the bore 164b to define a pivot axis P for the suspension assembly 132. The bores 164a have a thickened cross-section for reinforcement. The lower end of the left swing arm mount 140a defines two off-set transversely extending bores 166a aligned with the bores 166b.

The cross members 142, 144, and 146 add rigidity to the main frame 128. The head cross member 142 extends between the spars 138a,b closest to the head tube 136. The shock cross member 144 extends between the spars 138a,b spaced from the head cross member 144 near the rear ends of the spars 138a,b. The peg cross member 146 extends between the swing arm mounts 140a,b near the lower curved end. The head and shock cross members 142 and 144 have a triangular cross-section. The peg cross member 146 has a oval cross section.

The shock cross member 144 includes left and right upper subframe mounts 176a,b and left and right shock mounts 178a,b. Each upper subframe mount 176a,b is a tab, which extends upwardly from the shock cross member 144 upper surface adjacent the left or right spars 138a,b, respectively. Each upper subframe mount 176a,b defines a transversely extending bore 180a,b therethrough.

The left and right shock mounts 178a,b are mirror-images of one another and are reinforced tabs for supporting a portion of the suspension assembly 132. The shock mounts 178a,b extend upwardly from the shock cross member 144 upper surface. They are located on either side of the central plane L, and are spaced at an equal distance therefrom. Each shock mount 178a,b defines a transversely extending bore 182a,b therethrough.

Referring to Figs. 3 and 7, the subframe 130 supports the seat 125, and includes left and right upper rails 184a,b, a subframe cross member 186, and left and right lower rails 188a,b. The left and right upper rails 184a,b are spaced apart and parallel to one another. The subframe cross member 186 adds rigidity to the subframe 130, and connects the left and right rails 184a,b to one another near their rear ends. The left and right upper rails 184a,b include left and right upper subframe tabs 190a,b that extend downwardly and perpendicular to the respective rail. Each tab 190a,b includes a transversely extending bore, the bore 192b is shown. The bore 192a in the left tab 190a is aligned with the bore 190b in the right tab 190b.

The lower rails 188a,b are fixed by welding to the upper rails 184a,b, and extend angularly downwardly therefrom. The lower rails 188a,b include lower subframe tabs 194a,b that extend downwardly and perpendicular to the respective rail. Each tab 194a,b includes a transversely extending bore 196a,b therethrough. The left bore 196a in the left tab 194a is aligned with the right bore 197b in the right tab 194b.

The upper and lower subframe tabs 190a,b and 194a,b support conventional mufflers (not shown). Each of the subframe rails 184a,b and 188a,b, have a rectangular cross section and the free ends narrow to terminate in subframe connectors 198a,b. Each subframe connector 198a,b defines a transversely extending bore 200a,b therethrough. The subframe 130 is configured so that the connector bores 200a on the left upper and lower rails 184a, 188a at each end are aligned with the connector bores 200b on the right upper and lower rails 184b, 188b.

Referring to Figs. 5-7, the subframe 130 is connected to the main frame 128 so that the rails 184a,b and 188a,b extend rearwardly from the main frame 128. The front ends of the upper rails 184a,b attach to the main frame 128 when the connectors 198a,b are coupled to the upper subframe mounts 176a,b. The lower rails 188a,b connect to the swing arm mounts 140a,b when the connects 198a,b are attached thereto.

Conventional fasteners are used to connect the subframe 130 to the main frame 128.

In Figs. 3, 5, and 8, the suspension subassembly 132 supports a rear wheel 24, and includes a swing arm 202 and a shock 204 comprising a shock absorber and spring. The swing arm 202 includes a front end 206 and a rear end 208. The swing arm 202 includes left and right stays 210a,b that are spaced apart and substantially parallel to one another, and a swing arm cross member 212 that connects the stays 210a,b to one another near their front ends 206.

The left stay 210a is defined by a front lug portion 214a, a rear lug portion 216a, and a central portion 218a therebetween. The front lug portion 214a is adjacent the engine end 206 of the swing arm. The front lug portion 214a defines a transversely extending bore 220a therethrough. The swing arm preferably has the swing arm cross member 212 integrally formed with the front lug portions 214a, and the stays 210a,b are welded thereto. The rear lug portion 216a is adjacent the wheel end 208 of the swing arm. The left stay 210b is similarly defined. The rear lug portions 216a,b are adapted to receive a conventional tension mechanism for adjusting tension of a chain (not shown).

The rear lug portion 216a defines a transversely extending slot 222a therethrough. The slots 222a,b are aligned with one another, and have an elongated shape. The rear wheel 24 is rotatably mounted to the swing arm 202 through the slots 222a,b. The shape of the slots 222a,b allows longitudinal adjustment of the location of the rear wheel 24 for adjustment of the length of the chain 217.

The front lug portion 214a has a cross-sectional shape that includes a C-shaped upper portion 224a and a straight lower portion 226a. The upper portion 224a is widest at the engine end 206 and narrows toward the wheel end 208 of the swing arm. The rear engine lug portion 216a has a C-shaped cross-section.

The location of the swing arm cross member 212 defines a U-shaped engine cutout 228 at the engine end 206 of the swing arm, and a U-shaped wheel cutout 230 at the wheel end 208 of the swing arm. The wheel cutout 230 receives a portion of the rear wheel 224 therein.

The swing arm cross member 212 includes left and right shock mounts 232a,b extending from the upper surface thereof. The left and right shock mounts 232a,b are mirror-images of one another and are reinforced tabs for supporting the shock 204. They are located on either side of the central plane L, and spaced at the equal distance therefrom. The left swing arm shock mount 232a is aligned with the left frame shock mount 178a. The right swing arm shock mount 232b is aligned with the right frame shock mount 178b. Each shock mount 232a,b defines a transversely extending bore 234a,b (one is shown). Although pairs of frame and swing arm shock mounts are shown, there may be single frame and swing arm shock mounts depending on the shock used.

The engine end 206 of the swing arm 202 is pivotally coupled to the main frame 128. The front lug portions 214a,b are coupled to the swing arm mounts 140a,b.

This pivotal coupling of the front lug portions 214a,b is achieved by using a through shaft spindle. Thus, pivotally coupling the swing arm 202 to opposite sides of the main frame 128 about the pivot axis P.

The rear end 208 of the swing arm 202 moves vertically upwards and downwards as the vehicle hits bumps, as discussed in detail below. The dimensions and configuration of the swing arm should withstand the static and dynamic loads that occur during operation of the vehicle.

The shock 204 includes a shock absorber and spring to bias the wheel end 208 of the swing arm 202, and consequently the rear wheel 24 away from main frame 128. The shock 204 is pivotally connected to the main frame 128 and the swing arm 202. The shock 204 is connected to the frame shock mounts 178a,b and the swing arm shock mounts 232a,b, using conventional pivot pins. The shock 204 lies coincident with the central plane L along the center of the frame 112, and is attached to the middle of the swing arm 202 between the stays 210a,b. The shock 204 has two pivot axes.

Referring to Figs. 5 and 9, the shock 204 first pivot axis designated S_F is at the attachment point of the shock 204 to the main frame 128 about which the shock 204 pivots. The shock 204 second pivot axis designated S_R is at the attachment point of the shock 204 to the swing arm 202 about which the shock 204 pivots.

As shown in the embodiment in Fig. 3, the movable engine frame 134 supports the engine 114 and the air intake assembly 116. The engine frame 134 includes right and left down tubes, the left down tube 235a is shown. The down tube 235a is fixedly attached at spaced longitudinal locations on the spar 138a preferably at spar cross members 237. The engine frame 134 further includes right and left bolt rails, the left bolt rail 236a is shown. The bolt rails are pivotally attached to the main frame 112 and removably connected to the respective down tube 235a.

The embodiment shown in Fig. 4 includes an engine frame 134 modified so that it is one piece and the bolt rails 236a,b are removably attached to the spars 136a,b and swing arm mounts 14a,b. Right and left bolt rails are transversely spaced from one another. Each bolt rail 236a,b is curved so that a space 238 is defined between the rails 236a,b and the main frame spars 138a,b. The engine 114 is receive within the space 238.

Each bolt rail 236a,b includes a mounting tube 244a,b. The mounting tubes 244a,b transversely extend along an upper surface of each rail 236a,b. The tubes 244a,b retain a fastener that extends through the engine 114 to secure the engine 114 to the engine frame 134. The engine is further coupled to the main frame by a single fastener that extends through the swing arm mounts.

When the engine frame 134 is in an in position, the second ends 242a,b (one being shown) are coupled to the spars 152a,b of the main frame 128. The engine 114 extends vertically between the spars 138a,b. In an out position, the second ends 242a,b (one being shown) of the engine frame 134 are spaced from the main frame 128, so that the engine 114 is accessible and removable.

The frame 112 is formed of aluminum. One suitable aluminum is commercially available 6000 series aluminum. The spars, gussets, swing arm mounts, and swing arm lugs are cast, extruded or forged. Preferably, the main frame head tube, cross members, subframe, bolt rails are extruded and machine finished. These components are welded together. The main frame and swing arms may be formed as one piece or two pieces. If these components are two pieces, each piece is a mirror image about the longitudinal axis and are welded together.

Referring to Fig. 9, a number of relationships between the components result from the configuration of the frame 112. A horizontal plane is designated H. The spars 138a,b (one is shown) have a spar center plane M that extends longitudinally along the center of the spars. A spar angle δ is defined between the horizontal plane H and the spar center plane M. The spar angle δ is between about 40° to about 50°, and more preferably less than about 45°, and most particularly 42.7°. The δ angle is possible due to the engine lacking carburetors due to the fuel injection, a kick start due to use of an electric starter, and the use of movable engine frame 134.

When the shock is in the fully extended position, the shock plane is designated S_1, and extends between the front pivot axis S_F and the rear pivot axis S_R. In the fully extended position, a first shock angle α_1 is defined between the shock plane S_1 and the horizontal plane H. The first shock angle α_1 is between about 35° to about 50°, and more preferably less than about 45°, and most preferably about 40°.

Referring to Fig. 10, when the shock 204 is in the fully compressed position, the shock plane is designated S_2, and extends between the front pivot axis S_F and the rear pivot axis S_R. In the fully extended position, a second shock angle

α_2 is defined between the shock plane S_2 and the horizontal plane H. The second shock angle α_2 is between about 25° to about 35°, and more preferably less than about 30°, and most preferably about 29.7°.

The swing arm 202 is in a first position when the shock 204 is in the fully extended position. In the first position, the swing arm has a central plane extending longitudinally therethrough which is designated SA_1. A first swing arm angle θ_1 is defined between the swing arm plane SA_1 and the shock plane S_1. In the first position, the swing arm angle θ_1 is between about 20° to about 30°, and more preferably is about 24.6°.

The swing arm 202 is in a second position when the shock 204 is in the fully compressed position. In the second position, the swing arm has a central plane extending longitudinally therethrough, which is designated SA_2. A second wing arm angle θ_2 is defined between the swing arm plane SA_2 and the shock plane S_2. In the second position, the second swing arm angle θ_2 is between about 45° to about 55° and more preferably is about 50°.

A travel angle β defines the angular offset between the plane SA_1 and SA_2. The motion of the swing arm between the first and second positions is such that the travel angle β is between 15° - 25°, and more preferably less than about 20°, and most particularly about 17.2°.

A horizontal shock mount distance D_H is defined as the distance horizontally between the front pivot axis of the shock S_F and the swing arm pivot axis P. It is preferred that the distance D_H is in front of the swing arm pivot P and, preferably a distance of more than 3 inches. A vertical shock mount distance D_V is defined as the distance vertically between the front pivot axis of the shock S_F and the swing arm pivot axis P. It is preferred that the distance D_V is above the pivot P and less than about 15 inches, and more preferably less than about 12 inches, and most preferably is about 10.8 inches. The vertical distance D from the rear shock mount S_R to the pivot axis P is less than about two inches.

Referring both to Fig. 3 and 4, the engine 114 has a center of gravity designated by the point C_{GE}. Since the engine 114 is a four-stroke engine the engine center of gravity C_{GE} is higher and forward of the center of gravity for a two-stroke engine. In addition, a four-stroke engine has a weight 13-15 pounds greater than a two-stroke engine. The motorcycle 100 has a weight of approximately 240 pounds, and a center of gravity designated by the point C_{BM}. The fuel tank 118 has a volume of 2.5 - 3 gallons and a weight of approximately 10% of the total vehicle weight.

Turning to Fig. 3, the motorcycle has a length from the front wheel axle to the rear wheel axle, and a vertical center plane C that is disposed equidistant between this length. The configuration of the motorcycle and location of the centers of gravity of the components are such that less than 50% of the weight of the motorcycle is forward of the vertical plane C and more than 50% of the weight of the motorcycle is rearward of the vertical plane C. More preferably between about 45° to about 49° of the weight is forward of the centerline and about 51° to about 55° is rearward of the centerline. Most preferably 49% of the weight is forward of the center-line and 51% of the weight is rearward of the center-line. This is advantageous because it allows a rider to more easily raise the front wheel which makes executing jumps easier. This is also advantageous because it allows a rider to steer the motorcycle through a curve along a desired radius with less likelihood of the front wheel slipping. The angle γ is defined between an engine center line E and the vertical center plane C is less than about 30°, and more preferably less than about 15°.

As discussed in more detail below, the engine 114 is four-stroke engine with a cylinder 300 in fluid communication with the air intake assembly 116. The engine 114 has an electronic fuel injector 302 instead of a carburetor. This allows the engine 114 to have a vertical arrangement that extends from the engine frame 134 upward. The portion of the cylinder 300 block shown in phantom extends between the spars 138a,b in the space 150.

Referring to Figs. 11 and 3, the air intake assembly 116 includes a bifurcated housing 304, an air box 306, an air filter 308 and a retaining means 310. The air filter 308 prevents dust and dirt from getting sucked into the engine where it can cause harm. The engine 114 is positioned below the air filter 308. The housing 304 has an air branch 312 and a connected fuel injector 314. The air branch 312 has an open end 316 that is disposed between the right and left spars 138a,b the right spar 138a being shown. The open end 316 is flared upwardly to create a flange 318. The opposite end 320 of the air branch 312 is connected to the engine 114. The air branch 312 introduces an air stream into the housing 304 and transports it toward the engine 114. The fuel injector 314 receives fuel from the fuel tank 118 and injects the fuel into the air stream flowing within the air branch 312. The fuel is injected at a predetermined pressure, angle, and amount to produce a fuel/air mixture that is introduced into the engine 114. The ratio of fuel to air in the fuel/air mixture is controlled by the electronic controller 122. The controller 122 is in electronic communication with the fuel injector as discussed in more detail below.

Referring to Figs. 3, 11 - 12, the air box 306 is an enclosure that supports the air filter 308 and allows air to enter the housing 304 and thus the engine 114. The air box 306 includes a front wall 322 and a base 324. The front wall 322 extends upwardly from the base 324 and surrounds the front perimeter thereof. The front wall protects the air filter 308 from debris leaving the front wheel 16 (as shown in Fig. 1) during operation of the motorcycle.

The base 324 includes a sidewall 325, an outlet manifold 326 and a bore 328. The sidewall 325 extends upwardly from the base 324 and surrounds the perimeter thereof. The front wall 322 is integrally formed therewith. The manifold 326 downwardly extends from the base 324. The manifold 326 further defines holes 329 therethrough for transporting air to the housing 304. The bore 328 is defined in the base 324 between the manifold 326 and the front wall 322.

The retainer assembly 310 couples the air filter 308 to the air box 306. The retainer assembly 310 includes a bolt 330, a support frame 332, an aluminum plate 334, and a nut 335. The bolt 330 is disposed through the bore 328 in the air box so that the head 336 is beneath the base 324 and the threaded stem 337 extends upwardly through the base 324.

The frame 332 is shaped like a truncated cone and surrounds the bolt stem 337. The frame 332 supports the air filter 308 a predetermined distance above the base 324. The frame 332 is formed of a wire mesh so that it does not inhibit air flow through the air box. The plate 334 is disposed between the air filter 308 and the nut 335. The nut 335 is threadably engaged with the bolt stem 337 and secures the air filter 308 to the air box. The plate 334 acts as a bearing surface for the nut 335. The nut can be modified to include a button for holding down the seat. The air filter is a truncated cone shaped piece of filter material that is commercially available.

Referring to Figs. 3 and 13, the fuel tank 118 stores the fuel that is used by the engine 114, and supports the battery 120 and the seat 125. The fuel tank 118 is formed by an upper wall 338, a spaced lower wall 339, and a side wall 340. The walls 338, 339, and 340 are integrally formed so that the fuel tank 118 includes a first or filler portion 341, a second or storage portion 342 spaced from the filler portion 341, and a central or spar portion 344 that connects these portions.

Referring to Figs. 13 - 15, the portions 341, 342 and 344 are hollow and form a U-shaped tank body that defines an interior chamber 346. The interior chamber 346 allows fuel to travel between the portions. The fuel tank 118 further defines a sidewardly facing cavity 348. The cavity 348 extends vertically through the entire tank from the upper wall 338 to the lower wall 339.

Referring to Fig. 11, the installed fuel tank 118 is disposed on the upper surface of the spars 138a,b and the subframe 130. The cavity 348 receives the air box assembly 116 and air filter 308 therein. Thus, the air filter 308 is accessible with the fuel tank 118 in position.

Referring to Fig. 14 as well, the filler portion 341 is disposed on top of the main frame spars 138a,b between the air intake assembly 116 and the head tube 136. The storage portion 342 is disposed on the rear of the main frame 128 and on top of the subframe 130 behind the engine 114. The spar portion 344 is disposed on top of the main frame right spar 138b. The volume within the storage portion 342 is greater than the volume within the filler portion 341. More preferably, the volume within the storage portion 342 is approximately twice the volume within the filler portion 341.

The configuration of the fuel tank can be modified to include two spaced spar portions that are symmetrical and connect the filler portion to the storage portion. The spar portions define the cavity therebetween. Once installed, the spar portions of the fuel tank overlie the frame spars. The air filter is disposed within the cavity, as discussed above.

The filler portion 341 includes a lower portion 350, a fuel inlet 352, and an attachment member 354. The lower portion 350 projects downwardly between the spars 138a,b. The remainder of the filler portion 341 is above the spars 138a,b.

The fuel inlet 352 is disposed through the upper wall 338 of the filler portion 341. The fuel inlet 352 is an opening that introduces the fuel into the interior chamber 346 of the tank. The fuel inlet 352 is closable with a conventional fuel cap.

Referring to Figs. 3 and 14, the attachment member 354 is shaped to fit the contour of the side wall 340 of the filler portion 341 within the cavity 348. The attachment member 354 is secured to the upper wall 338 of the tank 118 with a button head screw 358. The button head screw 358 also secures the seat 125 to the tank. The attachment member 354 is coupled to the head spar 142 with a fastener 360, so that the attachment member 354 secures the tank 118 to the frame 128. The attachment 354 is formed of aluminum. The attachment member can be a rubber band which is permanently attached to the head spar 142 and releasably attached to the button head screw 358. With this type of arrangement the removal and attachment of the tank to the frame is simpler.

Referring to Figs. 11, 13, 15, and 16, the storage portion 342 includes an opening 360, a molded plastic insert 362, a fuel pump insert 364, a fuel pump 366, and a battery recess 370. The storage portion 342 further includes a fuel return for introducing fuel from the fuel injector into the tank. The opening 360 is defined in the upper wall 338 of the tank adjacent the cavity 348. The insert 362 is molded into the tank 118 about the periphery of the opening 360. The opening 360 receives the fuel pump insert 364. The insert 362 reinforces the opening 360 so that it can support the fuel pump insert 364 and provides bores 372 for securing the insert 364 thereto.

Referring to Figs. 13 and 15-16, the fuel pump insert 364 is a one piece member formed of four integral walls, three walls 374, 376, 378 are shown. These walls define a cavity 380. The insert 364 further includes a flange 382 surrounding the walls 374, 376, 378. The flange 382 has a plurality of threaded bores 384 thereabout which are aligned with the bores 372 in the insert 362. The rear wall 378 further includes a chamfered tube 386 for receiving the fuel pump 366 therein. In this embodiment, the fuel pump used is one which requires submersion in the fuel. However, if a non-submergible fuel pump is used the fuel pump can be mounted on the exterior of the fuel tank and a conduit can extend between the fuel tank and the fuel pump. When mounting the fuel pump on the exterior of the fuel tank it is preferred that the fuel pump is below the fuel tank. Use of this type of fuel pump allows an increase in fuel carrying capacity within the fuel tank.

The tube 386 includes an opening 388 near the free end for fluid communication between the fuel tank chamber 346 and the fuel pump 366. A rubber plug 390 is disposed in the free end of the tube 386. The plug 390 is supported by the lower wall 339 of the fuel tank. The plug 390 prevents the weight of the pump from damaging the plastic tank. A rectangular gasket 392 is disposed on the tank 118 prior to disposing the insert 362 therein. The gasket 392 surrounds the opening 360 and seals the opening to prevent leaks of fuel. The gasket 392 includes bores 394 therearound that are aligned with the bores 384 and 372 in the inserts 368 and 362, respectively. Conventional threaded fasteners 396 (one is shown) are disposed in the bores 384, 394, 372 to secure the pump insert 368 to the tank 118.

Referring to Figs. 11 and 15, during operation, the fuel flows from the interior chamber 346 of the tank into the tube 386 through the opening 388. Thus, the insert 368 acts as an outlet for the fuel from the tank. The fuel pump 366 is in fluid communication with the injector 314 through a fuel line. The fuel pump 366 draws the fuel from the tube and forces it toward the injector 314. The pump 366 may include a fuel filter to prevent contaminants and water from entering the fuel injector. The location of the fuel inlet and outlet may be moved, if desired.

Referring to Figs. 3 and 13, the recess 370 is defined rearward of the opening 360. The recess 370 receives the batteries 120. The batteries are releasably coupled to the tank 118 by means such as straps prevent movement of the batteries during operation of the vehicle. In addition to the straps, other means may be used to secure these components to the tank, such as bolts or adhesive tape (not shown) with Velcro® type hook and loop fasteners thereon. One piece of tape with hooks is attached to the component, and the matching piece of tape with loops is attached to the tank or vice versa. Once the hooks are in contact with the loops, the component is secured to the tank.

The batteries 120 are in electrical communication with the electrical controller 122 via a wire harness. In another embodiment, a plugged-in connector may connect the batteries to the controller. The controller 122 is mounted on the interior of the body panel 124 and in electrical communication with the fuel injector via a wire harness beneath the fuel tank. This facilitates easy removal of the tank, because the tank can be removed without disconnecting the wires from the controller to the fuel injector.

The seat 125 is mounted on the upper surface of the fuel tank 118, and extends from the front hollow portion 341 to the rear end of the vehicle. The seat 125 provides a cushioned surface for a rider and encloses the air intake assembly 116, and batteries 120. The air intake assembly 116 is spaced from the upper wall of the fuel tank so that compression of the seat 125 does not affect the filter. The body panels 124 are connected to the frame 12 with conventional fasteners to provide an aesthetically pleasing appearance to the vehicle.

The fuel tank, air box, fuel cap, fuel pump inlet, and body panels are molded from plastic. It is recommended that the fuel tank is rotary molded from cross-linked polyethylene. It is also recommended that the air box, fuel cap, and fuel pump inlet are vacuum formed from polypropylene.

Turning now to the four-stroke engine according to the present invention, reference is now made the engine 400 shown in Fig. 17. The engine 400 is a four-stroke engine having a single cylinder 402 that has an internal volume between 250 cc and 700 cc. Most preferably, the engine has an internal volume of about 400 cc. Basically, the engine comprises a cylinder 402 and a cylinder head 404 coupled to the top of cylinder to form a substantially closed volume. A piston, discussed below, traverses within the closed volume. The cylinder head 404 has two inlets 406 for introducing fuel and air into the cylinder. The cylinder head 404 also has two outlets 408 for allowing exhaust products to be removed from the closed volume. Furthermore, the engine 400 according to the present invention includes an electronic starter 410 and does not include a standard kick-start. As discussed above, the frame spars can be designed in a substantially straight plane extending from the head tube to the swing arm mounts.

Turning now to Fig. 18, the piston 412 is shown as being received within the cylinder 402 along with a cylinder liner 414. The piston and cylinder share the same centerline 401 and have the same radius. Coupled to the bottom of the piston is con rod 416 which is coupled to the crank 418 and crank shaft 420. Piston rings 422 are provided for making sure that the piston 412 substantially fits within the cylinder 402. As is well known in the art, the piston 412 provides the power for the crank shaft through the combustion of the air and fuel mixture within the cylinder 402. Air and fuel are introduced into the cylinder 402 through inlets 406 which are opened and closed with valves. The piston traverses upward inside the cylinder to compress the air-fuel mixture which is then ignited to provide an internal combustion. The internal combustion pushes the piston downward within the cylinder and then the cylinder travels back up and the exhaust valves are opened so that the exhaust can be expelled from the closed cylinder. At the top of the stroke, the inlet valves are then opened again and the exhaust valves closed so that more air and fuel can be introduced into the cylinder.

In order to prevent wear on the con rod 416, it is mounted to the crank via a plurality of bearings 417. Moreover, a first sprocket 419 is provided on the end of the crank shaft 420 for providing power to the timing belt. A gear 421 is provided for power output.

Referring now to Fig. 19, the cylinder head 404 is shown with the inlet 406 for providing fuel and air into the engine. Attached to the cylinder head is a butterfly house

424 which has a first portion 425 that is coupled to the cylinder head 404 and a second portion 427 which extends substantially vertically therefrom and into an air chamber 426, which is encapsulated by an air filter 428. The butterfly house centerline 429 is substantially parallel to the cylinder centerline 401 or at least within 10°. In this embodiment, air flows through the air filter 428 to be cleaned and then the air within the chamber 426 flows through the butterfly house 424 to be mixed with fuel. A butterfly valve 430 regulates the amount of air flow into the engine. Since the butterfly house is substantially vertical it provides an excellent flow path for the air intake. However, as stated above, the fuel tank must be designed for this or the motorcycle becomes too tall.

A pair of fuel injectors 432 are provided to inject fuel from the fuel tank and into the air flow entering the engine. Coupled to the fuel injectors 432 and butterfly valve 430 is an electronic control management system generally depicted as 434 which includes an air temperature sensor 436 and air pressure sensor 438, first and second fuel pressure sensors 440 and 442 and a program board 444. The air temperature sensor 436 is located within the chamber 426 to measure the temperature therein and the air pressure sensor 438 is positioned within the chamber 426 to measure the air pressure entering into the butterfly house. The measurements from these sensors are electronically fed back to the program board 444. The first pressure sensor 442 measures the fuel pressure entering into the fuel injector and the second fuel pressure sensor 440 measures the fuel pressure as it leaves the fuel injector. In other words, a continuous flow of fuel is provided from the tank to the fuel injectors and the control of fuel to the engine is operated by the operation of the fuel injectors. The preferred fuel injectors 432 are Bosch fuel injectors. The electronic control management further includes an RPM sensor for measuring the engine's rotational speed and a water temperature sensor for measuring the cooling water temperature. Based on the power desired, which is provided from a throttle position sensor, and the input signals, the electronic control management system uses a control map to calculate proper control signals for the fuel injection and ignition timing.

In this embodiment, the electronic control management system is primarily provided on a plate 445 which is coupled to the top of the cylinder head and the butterfly house. Moreover, the ignition coil 446 and the spark plug 448 extend down into the cylinder for igniting the air/fuel mixture for combustion. The ignition coil 446 can be coupled to the electronic control management system plate such that the entire device is removable as a unit.

In a most preferred embodiment of the invention, the program board receives the input signals from the throttle position sensor, the RPM sensor, the temperature sensor, the air pressure sensor and the first and second fuel pressure sensors and then provides fuel and ignition control signals to the fuel injectors and ignition coils respectively based on these input signals and the programmed control map. The board is preferably programmed with more than one control map for providing fuel and ignition control signals to the engine such that the user can readily switch between control maps. More particularly, for example, a control map can be provided for dry conditions and a separate control map can be provided for muddy conditions and a switch on the handle bars can be provided for switching between these two control maps. In this manner, when the user shows up to a track early in the morning when the track is in muddy conditions, the user can select a first, muddy control map which would preferably provide less low end torque and then, in the afternoon when the track dries up, can readily switch to a second, dry conditions control map which will provide higher torque at the low end. Still further, an infrared reader 448 can be coupled to the board so that a user can modify or make different control maps on his computer and quickly download them onto the control board for readily changing the control maps of the fuel injection and ignition.

Referring now to Figs. 20 and 21, the cylinder head 404 includes the inlet valve locations 450 and the outlet valve locations 452. Valve cups 451 are positioned over the valve spring assembly and are biased by the cams to open the valves. An inlet plate 454 is provided for coupling the butterfly house 424 to the air inlet 406 and an outlet plate 456 is provided for attaching the exhaust system (not shown) to the cylinder head 404. The cylinder head 404 is coupled to the cylinder 402 with a gasket 458 for proper positioning and sealing therebetween. Valve seats 453 are fitted into the inlets 406 and outlets 408 from underneath the cylinder head 404 to provide a hardened surface for the valves.

On top of the cylinder head 404 is the cam carrier 460 and the cam cover 462. The engine inlet cams 470 and outlet cams 472 are located between the cam carrier and cam cover. Coupled to the front of the cylinder and cylinder head is a front plate 464. The front plate covers the timing chain 466. A center port 463 is substantially along the centerline of the cylinder and receives the spark plug and ignition coil.

The timing chain 466 is coupled to the crank assembly at a first end and to the cam gears 468 at a second end. The cam gears rotate the inlet cams 470 and the outlet cams 472 for opening and closing the valves.

Referring now to Fig. 22, one inlet valve 474 and one outlet valve 476 are shown with a spring assembly 478 and valve retainer assembly 477, which are used to keep the valves biased toward an closed position. The valve lip 479 fits against the valve seat. The cams are used to open the valves by pressing on the valve cup 451. Preferably, the inlet valves are positioned at an angle 480 to the centerline of the cylinder 482 of about 10°. Similarly, the outlet valves are positioned at an angle 484 to the cylinder centerline of approximately 11°. In the preferred embodiment of the invention, these angles are less than 15° to the engine centerline for providing a substantially flat top plate for the closed volume within the cylinder 402.

In Figs. 19 and 22, the fuel injector 432 is positioned so that it injects fuel substantially on the top surface 486 of the inlet valve 474, i.e., each fuel injector has a centerline 433 and the extension of the fuel injector centerline intersects the corresponding top surface 486 and inlet into the closed volume that is closed by the valve. Thus, the air and fuel are provided with a very direct flow path into the engine cylinder 402 for improved performance.

Referring now to Fig. 23, the crank case 490 is shown including a plurality of bearing members 492. Still further, the shifting mechanism 494 is shown having a shifter plate 496 including a stop member 498 for preventing friction with the shifting pins. This provides a much better feel when shifting gears. Also shown is the chain guard 500 for the timing chain 466 shown in Fig. 21. As is readily known by those skilled in the art, the chain will fit through the chamber 502 and extend up to the cams 470 and 472 for providing the engine valve timing.

Referring now to Fig. 24, the transmission 504 and the clutch cover 506 of the engine is shown. Coupled in the transmission is the gear box mechanism which is shown more particularly in Fig. 25. The gear box 508 includes the link roller 510, the shifting forks 512, the shifting pins 514 and the position star 516 which are all coupled to operate the gears 518.

Referring now to Fig. 26, the balance shaft 520 includes a balance 522 coupled thereto for balancing the motor vibration due to the cam. Attached to a first end of the balance shaft is a gear 524 which is coupled to the starter 510 for starting of the engine. Coupled to the other end of the balance shaft is a small turbine 526 which is used for a water pump for cooling the engine. The water pump flows water through the engine and through the radiator in a continuous manner.

While it is apparent that the illustrative embodiments of the invention disclosed herein fulfill the objectives stated above, it is appreciated that numerous modifications and other embodiments may be devised by those skilled in the art. Therefore, it will be understood that the appended claims are intended to cover all such modifications and embodiments which would come within the spirit and scope of the present invention.

CLAIMS

We claim:

1. A frame for a motorcycle having a central longitudinally extending central plane and an engine having a cylinder, wherein the frame comprises:

a) a main frame including

(1) a head tube,

(2) first and second spars, each having a first end coupled to the head tube, each extending downwardly and rearwardly from the head tube and each terminating at second ends that are spaced apart, and

(3) first and second swing arm mounts on the first and second spars respectively, the first swing arm mount extends downwardly from the first spar free end and terminates in a mount free end, the second swing arm mount extends downwardly from the second spar free end and terminates in a mount free end; and

b) an engine frame to which the engine is releasably attached, the engine frame including a first end pivotally attached to the mount free ends, a spaced second end releasably coupled to the first and second spars;

c) wherein the engine frame is movable between an in position and an out position, in the in position the second end of the engine frame is coupled to the first and second spars and the cylinder extends between the first and second spars, and in the open position the second end of the engine frame is spaced from the first and second spars and the cylinder is spaced from the first and second spars.

2. The frame of claim 1, wherein the engine frame further includes first and second bolt rails, the first bolt rail is pivotally attached to first swing arm mount at the first end and releasably coupled to the first spar at the second end, and the second bolt rail is pivotally attached to the second

swing arm mount and releasably coupled to the second spar at the second end.

3. The frame of claim 2, wherein the engine frame further includes first and second down tubes, the first down tube is attached to the lower surface of the first spar at longitudinally spaced locations, the second down tube is attached to the lower surface of the second spar at longitudinally spaced locations, the first bolt rail extends from the first swing arm mount to the first down tube, and the second bolt rail extends from the second swing arm mount to the second down tube.

4. The frame of claim 1, wherein the frame further includes

a) a shock cross member that extends transversely between the first and second spars, the shock cross member includes a first shock mount extending therefrom;

b) a swing arm including two spaced stays, a first end pivotally connected to the swing arm mounts, a spaced second end having a rear wheel rotatably attached thereto, and a swing arm cross member that extends transversely between the stays, the swing arm cross member having a second shock mount extending therefrom; and

c) a shock pivotally connected to the first shock mount and the second shock mount, wherein the shock lies coincident with the central plane.

5. The frame of claim 4, wherein the shock in a fully extended position defines a first shock angle with a horizontal plane of less than 45 degrees, and the shock in a fully compressed position defines a second shock angle with the horizontal plane of less than 30 degrees.

6. A frame for a motorcycle having a longitudinally extending central plane, wherein the frame comprises:

a) a main frame including a head tube, a first spar and a second spar, a first swing arm mount and a second swing arm mount, and a shock cross member, the first and second spars downwardly and rearwardly extend from the head tube and terminate spaced apart at the free ends, the first swing arm mount extends downwardly from the first spar free end and terminates in a mount free end, the second swing arm mount extends downwardly from the second spar free end and terminates in a mount free end; and, the shock cross member extends between the first and second spars and has a first shock mount extending therefrom;

b) a swing arm including two spaced stays, a first end pivotally connected to the first and second swing arm mounts and pivotable about a swing arm pivot axis, a spaced second end having a rear wheel rotatably attached thereto, and a swing arm cross member extending between the stays, said swing arm cross member having a second mount extending therefrom; and

c) a shock pivotally connected to the first mount and the second mount, wherein the shock lies coincident with the central plane.

7. The frame of claim 6, wherein the first and second spars include a longitudinally extending central spar plane, and a spar angle between the central spar plane and a horizontal plane is less than about 45°.

8. The frame of claim 7, wherein a shock mount distance measured from the shock mount to the spring arm pivot axis in a horizontal direction extends forward of the pivot axis.

9. The frame of claim 8, wherein the shock mount distance in the horizontal direction is more than about 3 inches, and in the vertical direction is less than about 12 inches.

10. The frame of claim 6, wherein a swing arm plane extends longitudinally along the center of the stays, and a travel angle is defined between the swing arm plane in a first position when the shock is in a fully extended position and

the swing plane in a second position when the shock is in the fully compressed position, and the travel angle is more than about 15 degrees.

11. The frame of claim 10, wherein the shock in a fully extended position defines a first shock angle with a horizontal plane of less than about 45 degrees, and the shock in a fully compressed position defines a second shock angle with the horizontal plane of less than about 30 degrees.

12. The frame of claim 11, wherein a first swing arm angle between the shock and the swing arm plane in the first position is about 25 degrees, and a second swing arm angle between the shock and the swing arm plane in the second position is about 50 degrees.

13. A fuel tank for use with a motorcycle having an air filter in fluid communication with an engine therebelow, the fuel tank comprising:

a) an upper wall;

b) a lower wall spaced from the upper wall;

c) a sidewall joining the upper wall to the lower wall to form

(1) a first hollow portion defining a fuel inlet for introducing a fuel therethrough;

(2) a second hollow portion including a fuel outlet disposed therein for egress of the fuel therefrom; and

(3) at least one central hollow portion for connecting the first hollow portion to the second hollow portion so that the fuel travels from the first hollow portion to the second hollow portion;

wherein the first hollow portion, the second hollow portion and the central portion define a cavity that extends vertically from the upper wall to the lower wall, and the cavity receives the air filter therein.

14. The fuel tank of claim 13, wherein the fuel tank includes two central hollow portions spaced from one another so that the cavity is defined therebetween.

15. The fuel tank of claim 13, wherein the first hollow portion, the second hollow portion, and one central hollow portion form a u-shape so the cavity includes a sidewardly facing opening.

16. The fuel tank of claim 15, wherein the second hollow portion is located rearwardly of the engine.

17. The fuel tank of claim 16, wherein a volume within the second hollow portion is greater than a volume within the first hollow portion.

18. The fuel tank of claim 17 wherein a volume within the second hollow portion is approximately twice a volume within the first hollow portion.

19. The fuel tank of claim 13 further including at least one battery electrically connected to an electronic controller, the battery is mounted on the upper wall of the second hollow portion.

20. The fuel tank of claim 19 wherein the battery is electrically connected to the controller through a plug-in connector.

21. The fuel tank of claim 13, wherein the second hollow portion further includes a fuel pump in fluid communication with the fuel outlet.

22. The fuel tank of claim 21, wherein the upper wall of the second hollow portion defines an opening and a fuel pump insert is disposed within the opening and coupled to the upper wall of the second hollow portion, the fuel pump insert

includes a tube that extends into the interior of the fuel tank, the tube defines an opening therein for receiving fuel, and the fuel pump is secured within the tube.

23. A motorcycle having a central longitudinally extending plane, wherein the motorcycle comprises:

a) an engine having a cylinder;

b) a frame including:

(1) a main frame including a head tube for receiving a steering assembly including a front wheel, a first spar and a second spar, and a first swing arm mount and a second swing arm mount, the first and second spars downwardly and rearwardly extend from the head tube and terminate spaced apart at the free ends, the first swing arm mount extends downwardly from the first spar free end and terminates in a mount free end, the second swing arm mount extends downwardly from the second spar free end and terminates in a mount free end;

(2) a movable engine frame including a first end releasably attached to the mount free ends, a spaced second end releasably coupled to the first and second spars, the engine is releasably coupled to the engine frame;

(3) swing arm having a first end pivotally connected to the swing arm mounts, a spaced second end having a rear wheel rotatably attached thereto;

c) a shock pivotally connected to the swing arm and the main frame and extending along the center plane; and

d) a fuel tank supported on top of the frame so that a largest volume of the tank is disposed rearward of the engine.

24. The motorcycle of claim 23, wherein a vertical center plane is disposed equidistant between the front wheel axle and the rear wheel axle, and the motorcycle has a weight, and

less than 50% of the weight is forward of the centerline and greater than 50% of the weight is rearward of the centerline.

25. The motorcycle of claim 24, wherein about 45% to about 49% of the weight is forward of the vertical center plane and about 51% to about 55% of the weight is rearward of the vertical center plane.

26. The motorcycle of claim 22, further including an air filter in fluid communication with the engine, and the fuel tank further includes:

a) an upper wall;

b) a lower wall spaced from the upper wall;

c) a sidewall joining the upper wall to the lower wall to form

(1) a first hollow portion defining a fuel inlet for introducing a fuel therethrough;

(2) a second hollow portion including a fuel outlet disposed therein for egress of the fuel therefrom; and

(3) at least one central hollow portion for connecting the first hollow portion to the second hollow portion so that the fuel travels from the first hollow portion to the second hollow portion;

wherein the first hollow portion, the second hollow portion and the central portion define a cavity that extends vertically from the upper wall to the lower wall, and the cavity receives the air filter therein.

27. The motorcycle of claim 26, wherein the second hollow portion is located rearwardly of the engine.

28. A four-stroke engine comprising:

a) a single cylinder having a predetermined radius, centerline, a fist end and a second end and an internal volume of between 250 cc and 700 cc;

b) a piston received within the cylinder having substantially the same radius and being able to substantially transverse within the cylinder from the first end to the second end;

c) a cylinder head coupled to the cylinder at the first end to form a substantially closed volume with the piston, the cylinder head having two inlets with corresponding inlet valves for introducing fuel into the closed volume and two outlets with corresponding outlet valves for exhaust products from the closed volume;

d) a butterfly house for introducing air into the cylinder head; and

e) two electronically controlled fuel injectors coupled to the butterfly house and positioned to inject fuel at the inlet valves.

29. The four-stroke engine of claim 28, further comprising:

a) an electronic control management system electronically coupled to the fuel injectors to control the amount and timing of the fuel injection, the electronic control management system comprising:

(1) an air temperature sensor positioned for measuring air temperature flowing into the butterfly housing;

(2) an air pressure sensor positioned for measuring air pressure entering into the butterfly housing;

(3) first and second fuel pressure sensors, the first fuel pressure sensors positioned for measuring fuel pressure entering the fuel injectors and the second fuel pressure sensors positioned for measuring fuel leaving the fuel injectors; and

(4) a programmed board for receiving input signals from the air temperature sensor, the air pressure sensor and the first and second fuel pressure sensors and providing control signals to the fuel injectors based on the input signals.

30. The four-stroke engine of claim 29 wherein the programmed board contains at least two different fuel injector control maps for providing control signals, the fuel injector control maps being selectable by a user.

31. The four-stroke engine of claim 30 wherein the electronic control management system further includes means for electronically coupling the programmed board to a computer such that the fuel injector control maps can be changed with the computer.

32. The four-stroke engine of claim 28 further comprising:

a) a crank and crank shaft for providing engine power;

b) a con rod coupled between the piston and the crank; and

c) a balance shaft and balance coupled to the crank shaft by a gear for balancing the engine.

33. The four-stroke engine of claim 32 further comprising an electronic starter mounted on an end of the balance shaft.

34. The four-stroke engine of claim 33 further comprising a water pump mounted on an end of the balance shaft.

35. The four-stroke engine of claim 28 wherein the inlet valves are angled less than about 15° from the centerline.

36. The four-stroke engine of claim 35 wherein the outlet valves are angled less than about 15° from the centerline.

37. The four-stroke engine of claim 29 wherein the air temperature sensor, the air pressure sensor and the programmed board are coupled to a plate and the plate is coupled to the cam cover so that the electronic control management system can be removed as a unit.

38. The four-stroke engine of claim 35 wherein the engine further comprises an ignition coil and the ignition coil is coupled to the plate.

39. The four-stroke engine of claim 35 wherein the air filter is releasably coupled to the plate.

40. The four-stroke engine of claim 28 further comprising a starter consisting only of an electronic starter.

41. A motorcycle comprising:

a) four-stroke engine comprising:

(1) a single cylinder having an internal volume of between 250 cc and 700 cc;

(2) a piston received within the cylinder to substantially transverse therein;

(3) a cylinder head coupled to the cylinder to form a substantially closed volume with the piston and the cylinder, the cylinder head having two inlets with corresponding inlet valves for introducing fuel into the closed volume and two outlets with corresponding outlet valves for extracting exhaust products from the closed volume; and

b) an aluminum frame for supporting the engine comprising:

(1) a main frame for supporting the engine and a front wheel; and

(2) a swing arm pivotally attached to the main frame for supporting a rear wheel.

42. The motorcycle of claim 41, wherein the engine further includes a cylinder centerline that is angled less than 15° from a vertical plane.

43. The motorcycle of claim 42 wherein the engine further includes a substantially vertical butterfly house for introducing air into the cylinder head.

44. The motorcycle of claim 41, wherein the frame further includes a shock pivotally attached to the main frame at a first end and pivotally attached to the swing arm at a second end that has a vertical distance from the swing arm attachment to the main frame of less than two inches, wherein the shock is disposed on a central plane of the motorcycle.

45. The motorcycle of claim 44, wherein the shock has a fully extended position where an angle between the shock and a horizontal plane is less than about 45°, and a fully compressed position where the angle is less than about 30°.

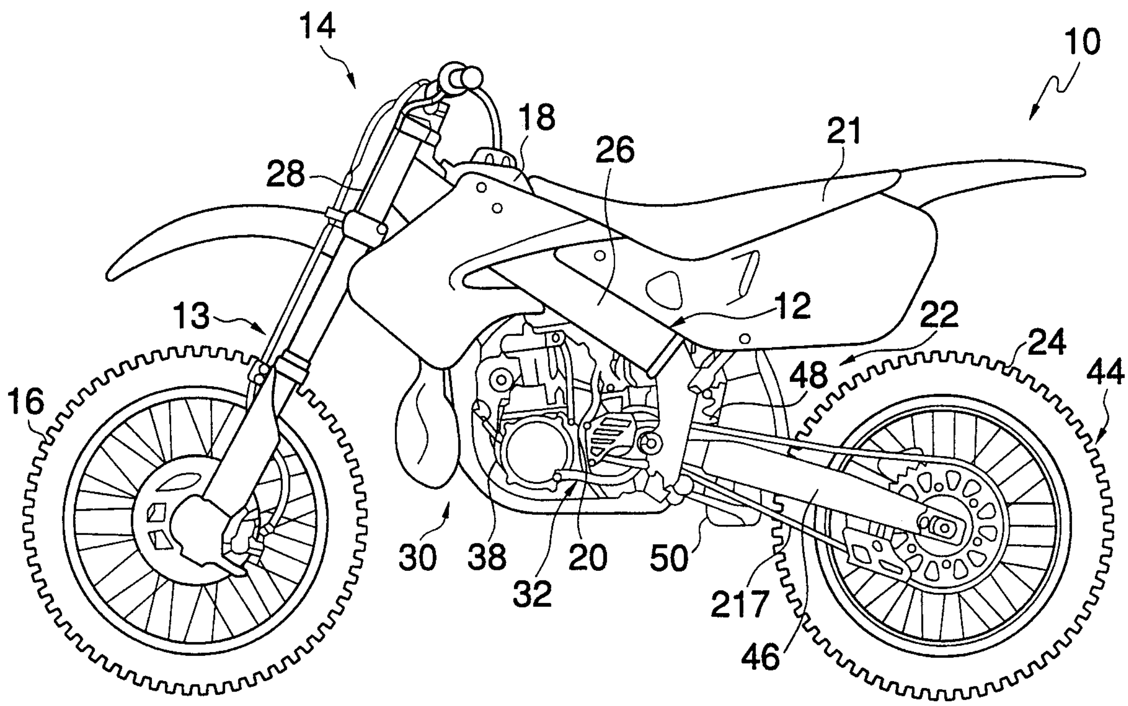

FIG. 1
PRIOR ART

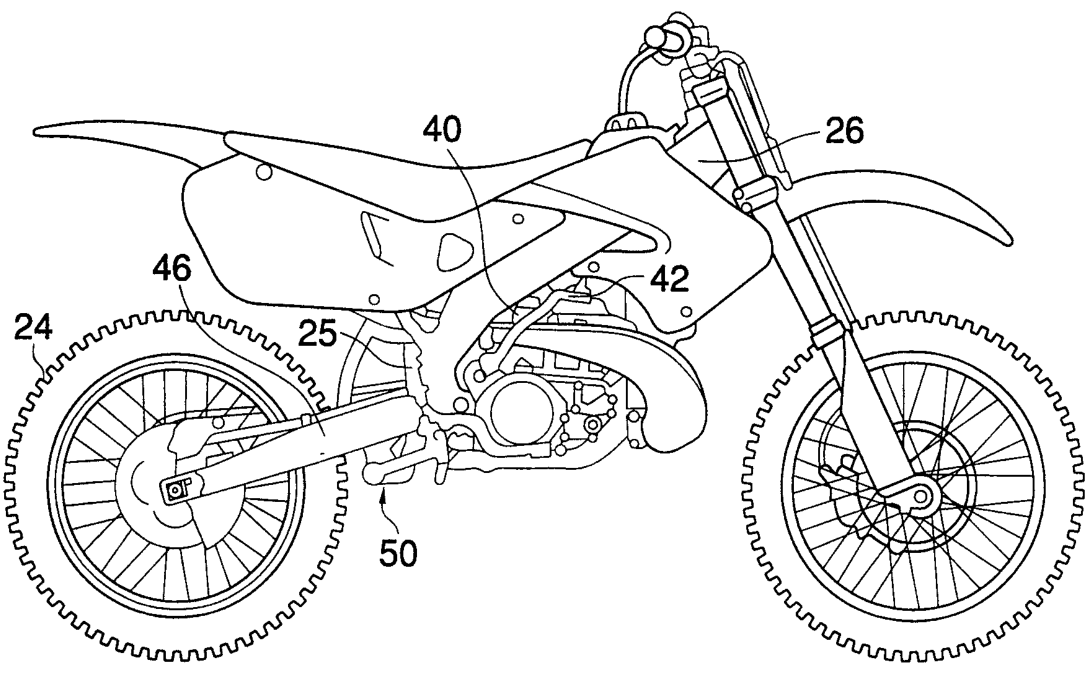

FIG. 2
PRIOR ART

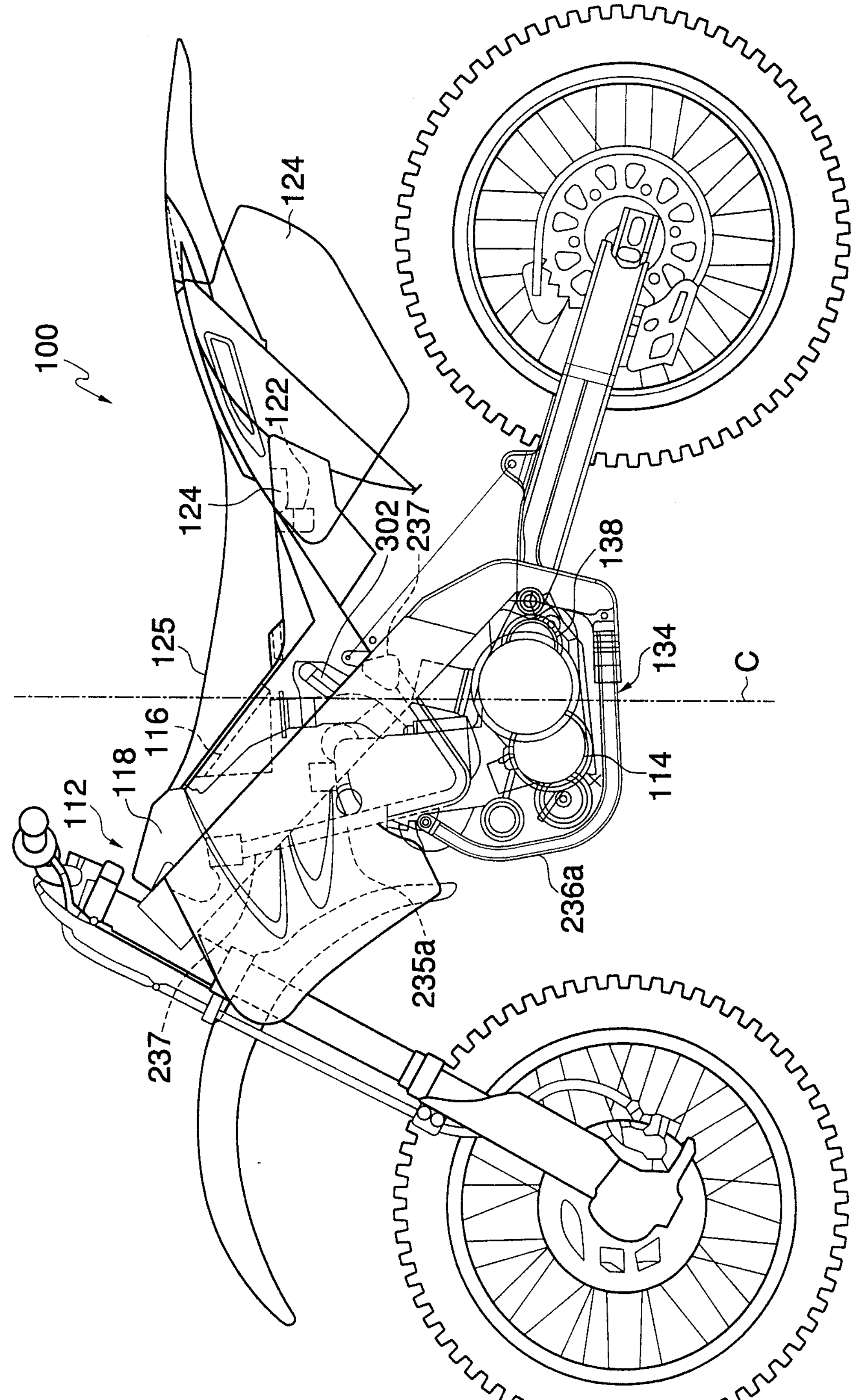
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FIG. 3

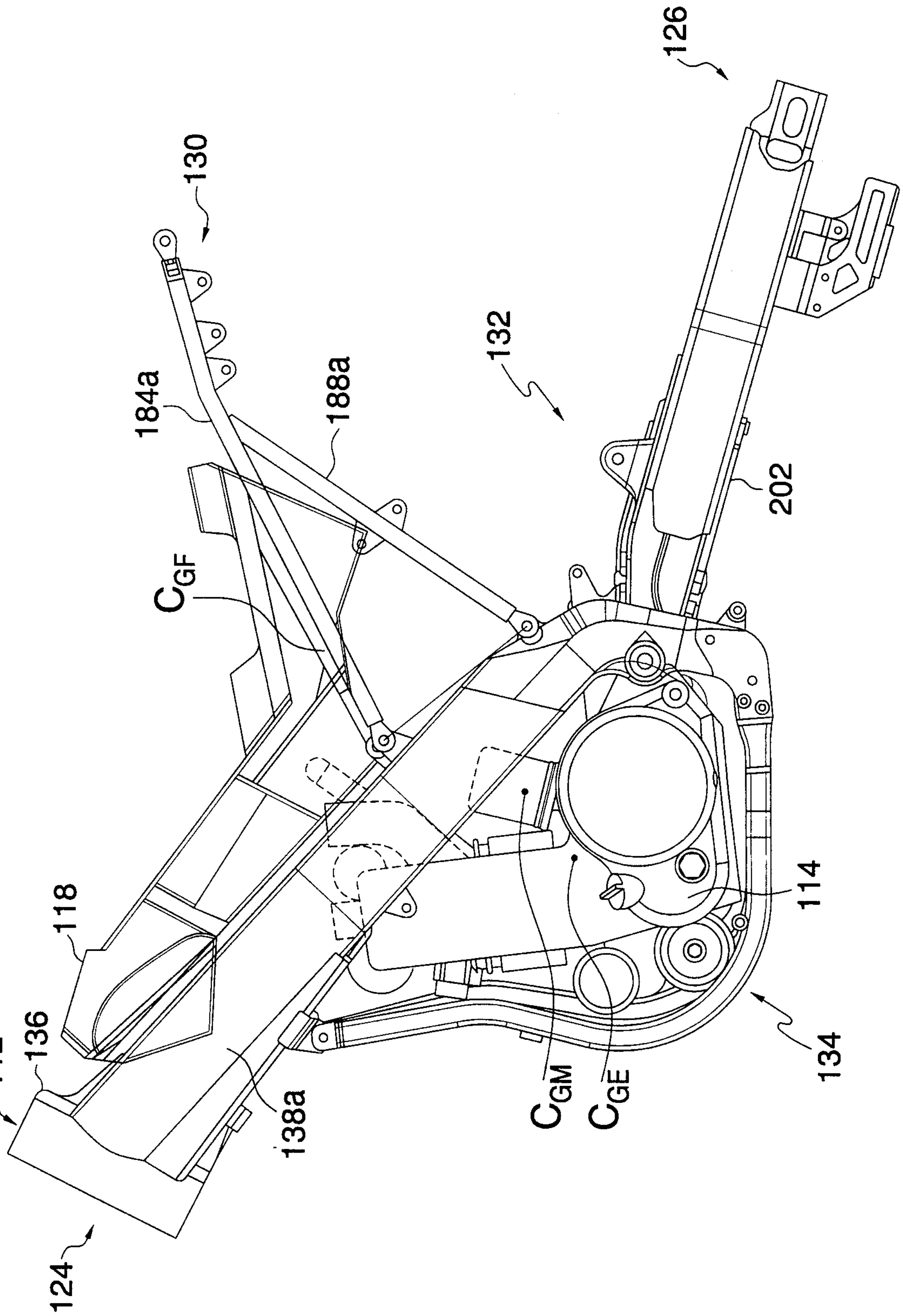
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FIG. 4

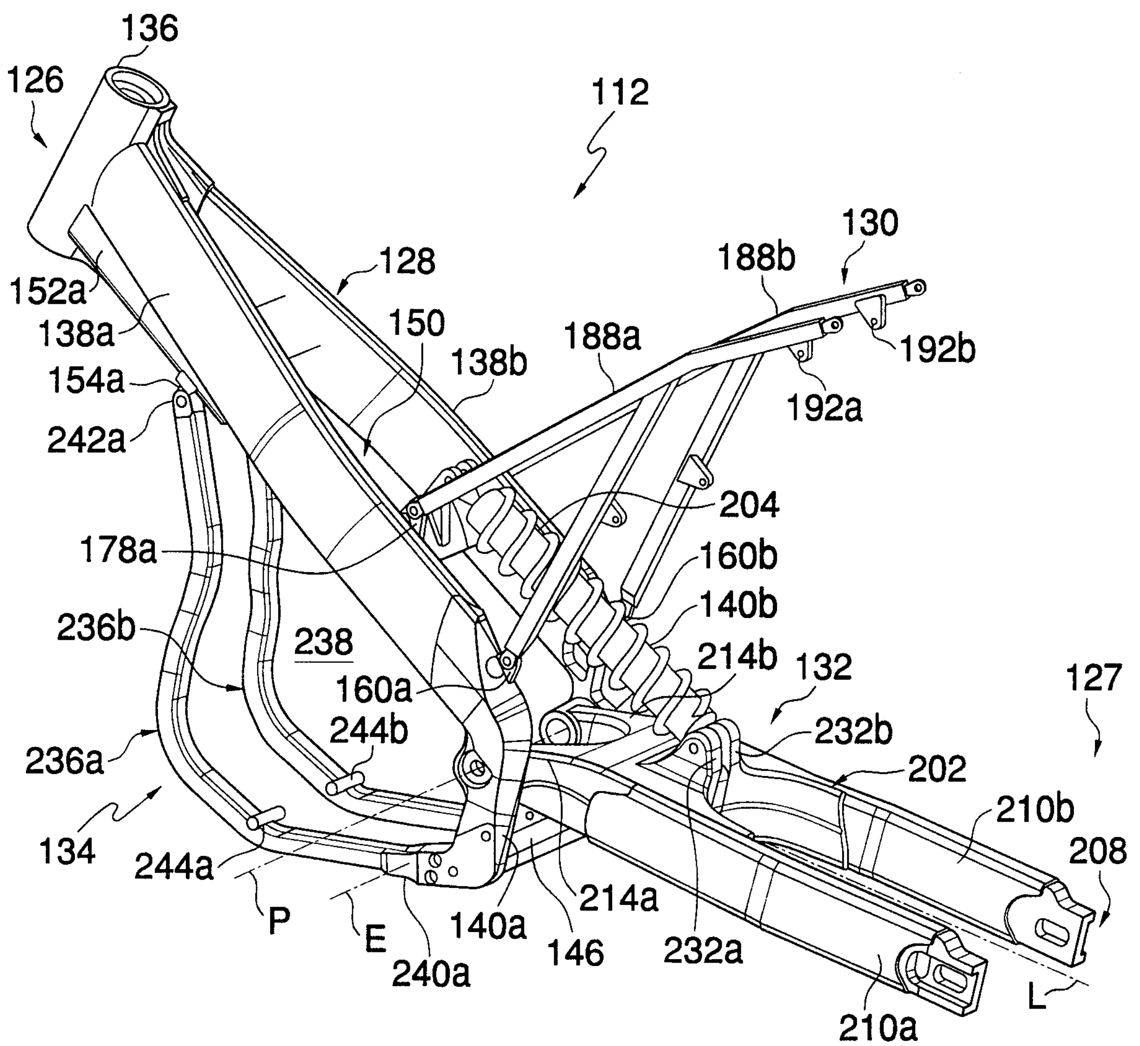
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FIG. 5

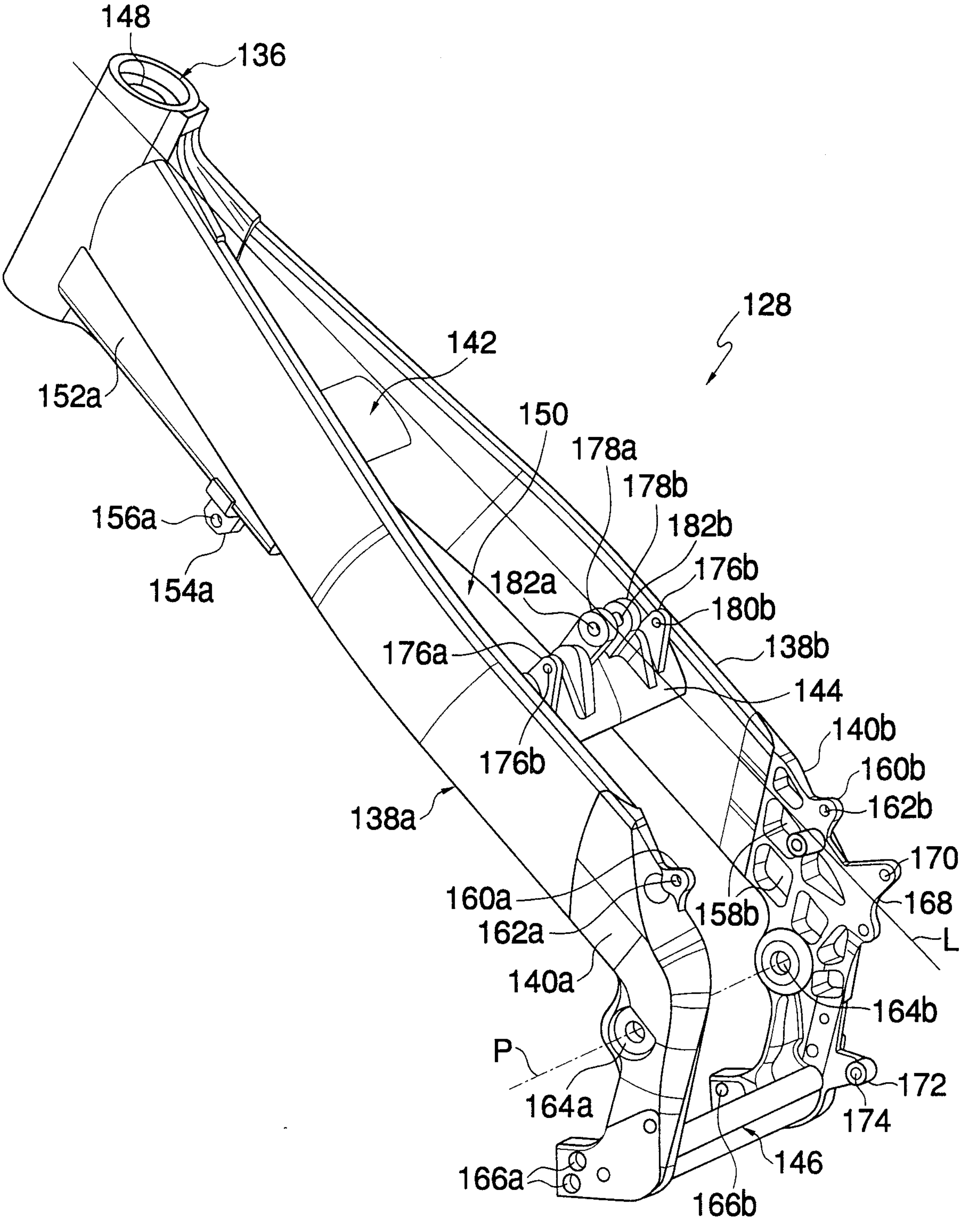
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FIG. 6

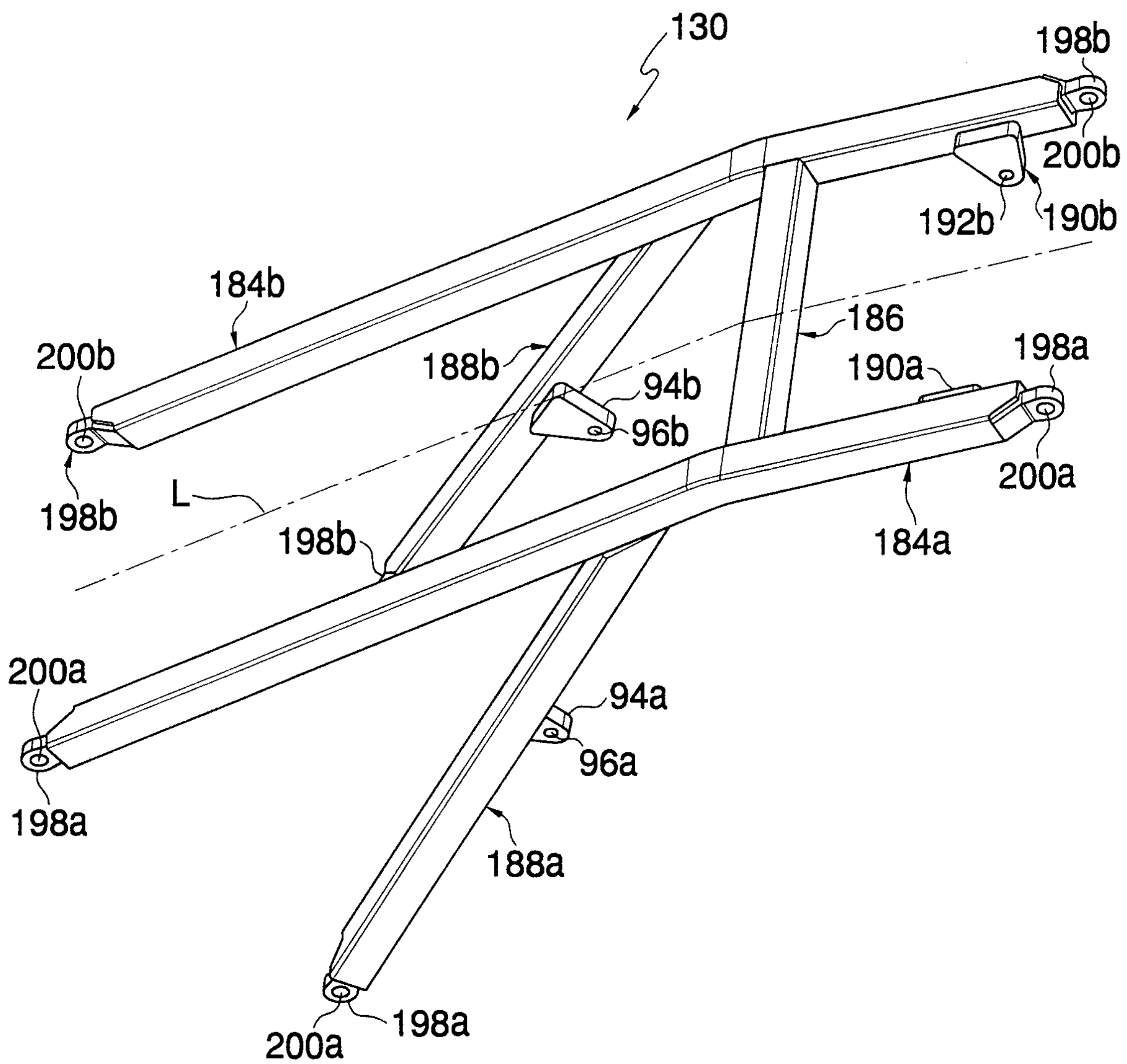
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FIG. 7

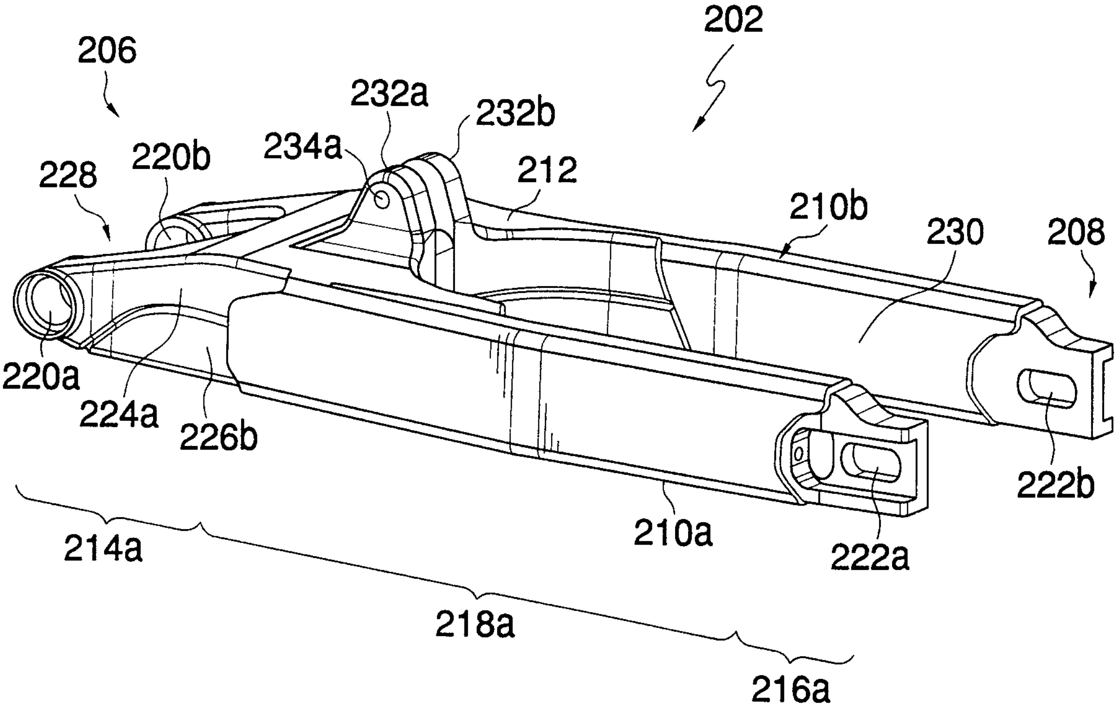
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FIG. 8

8/23

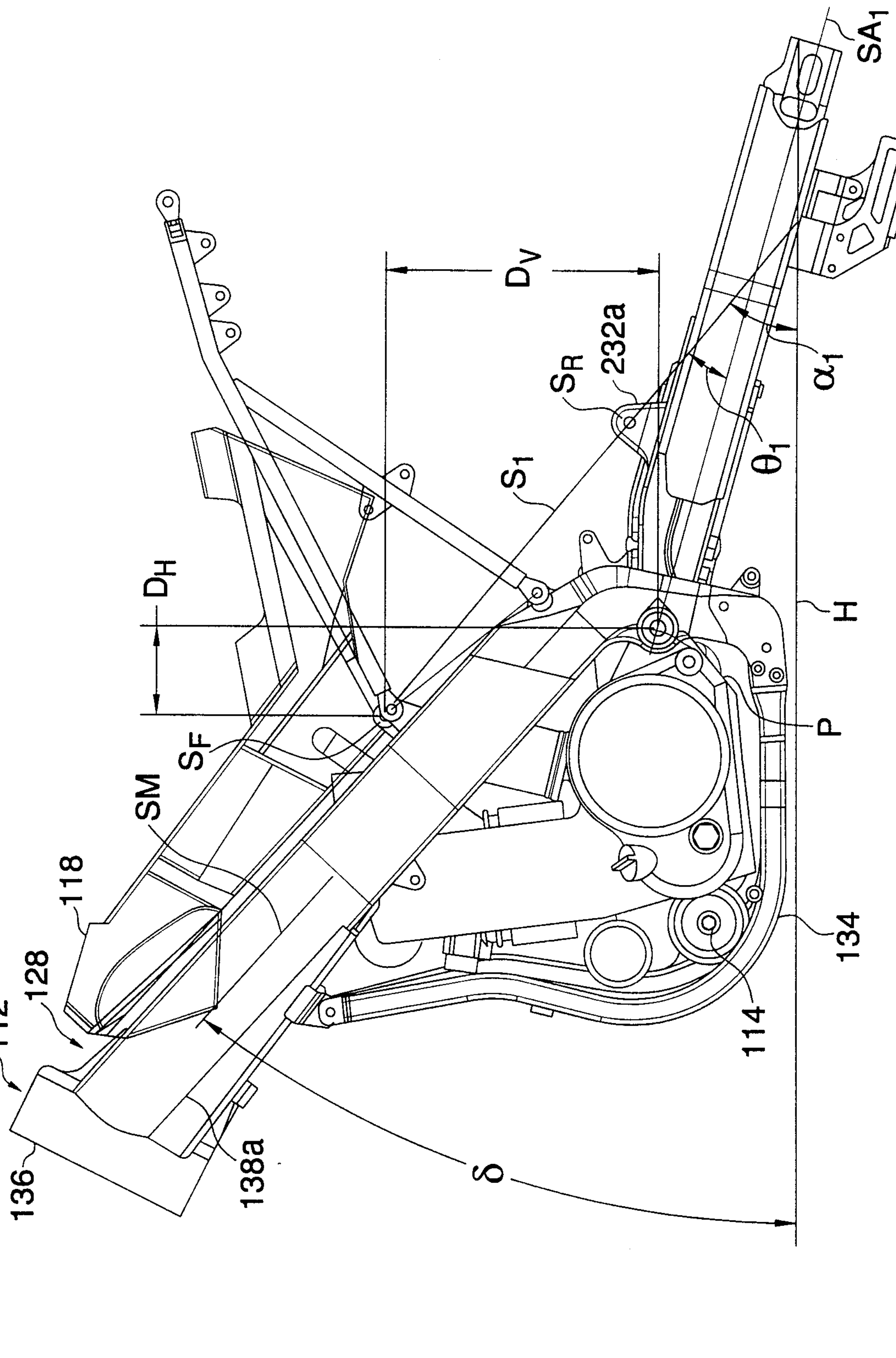

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FIG. 9

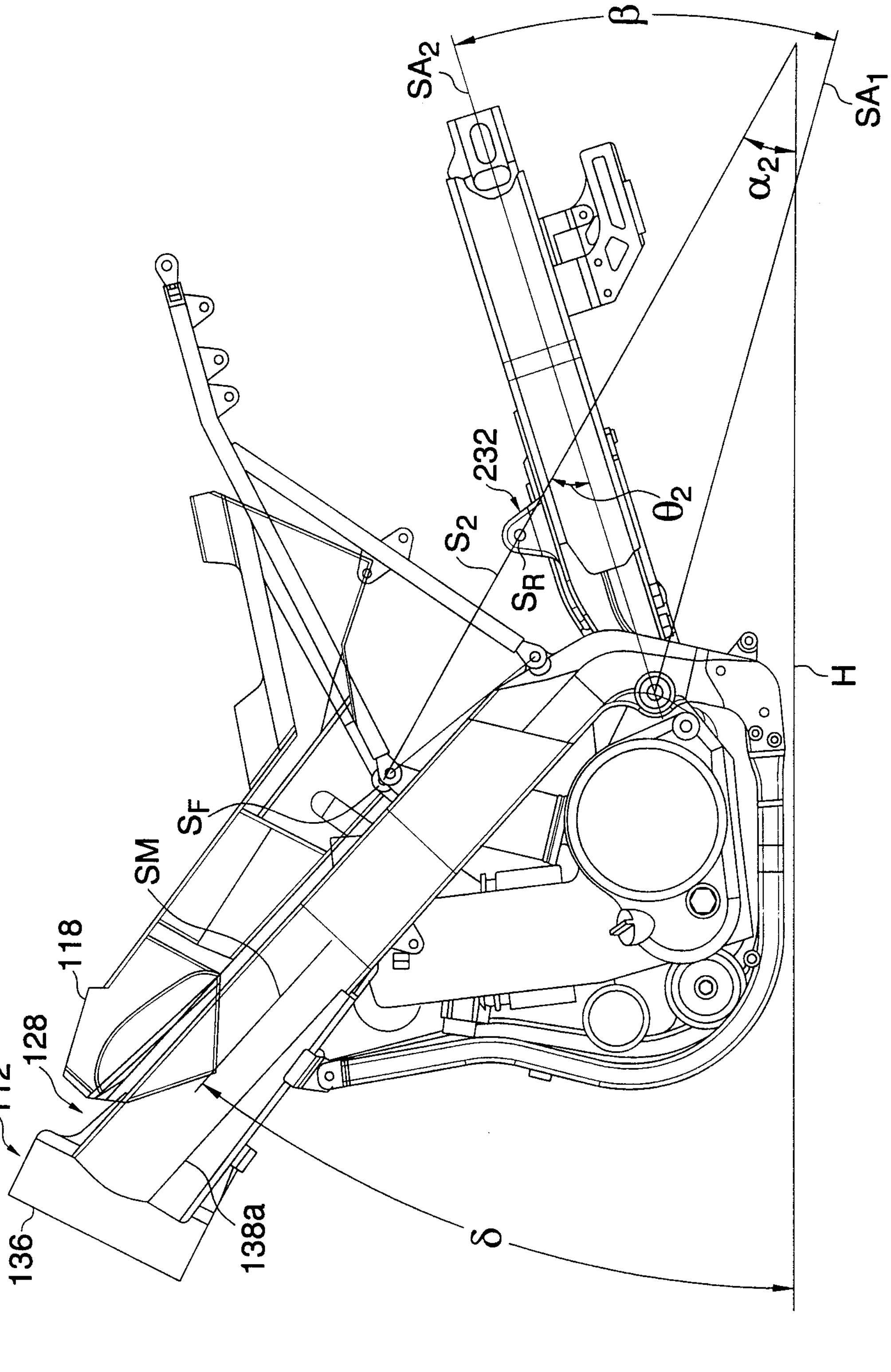

FIG. 10

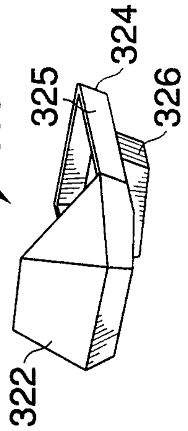
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FIG. 12

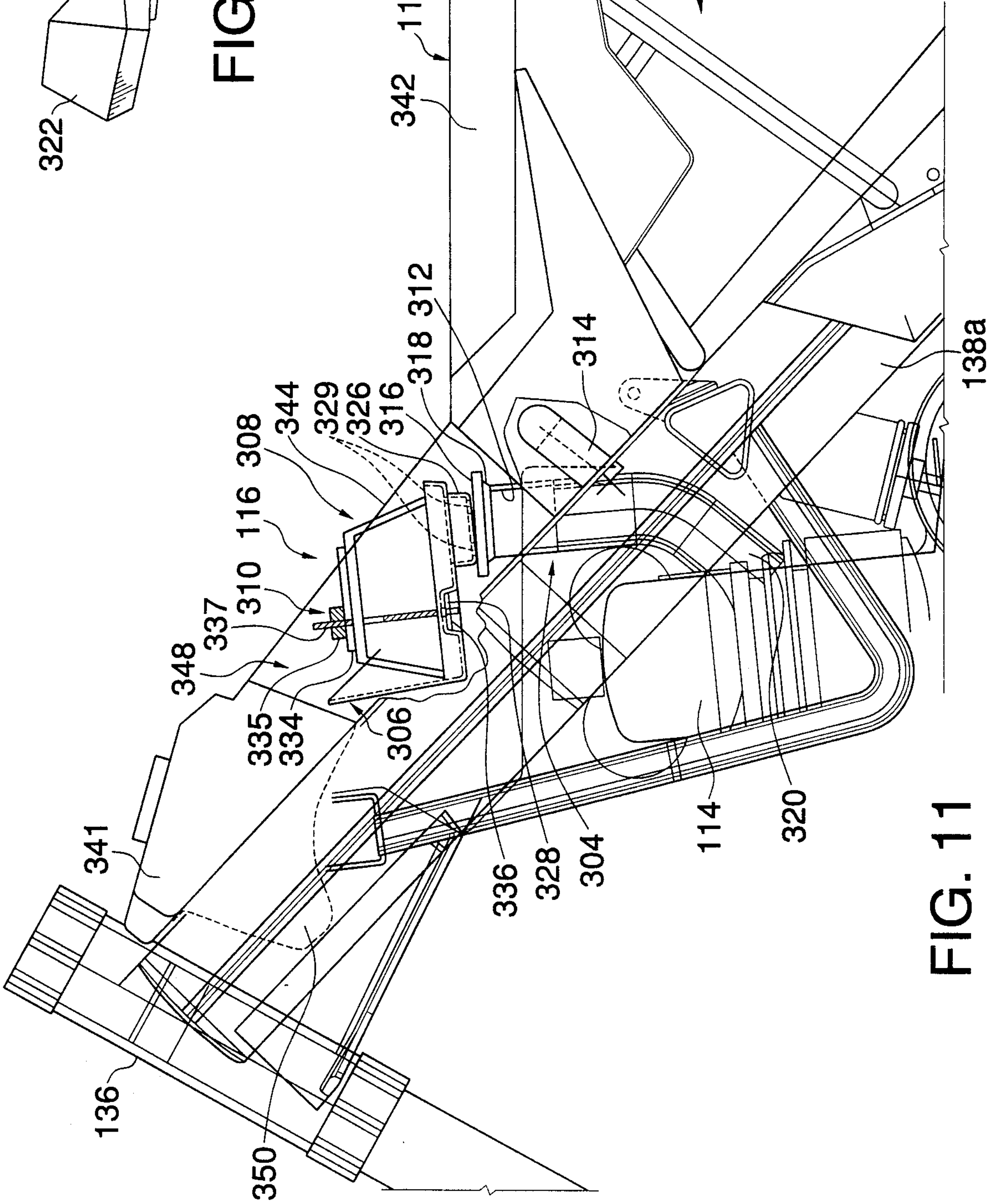
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FIG. 11

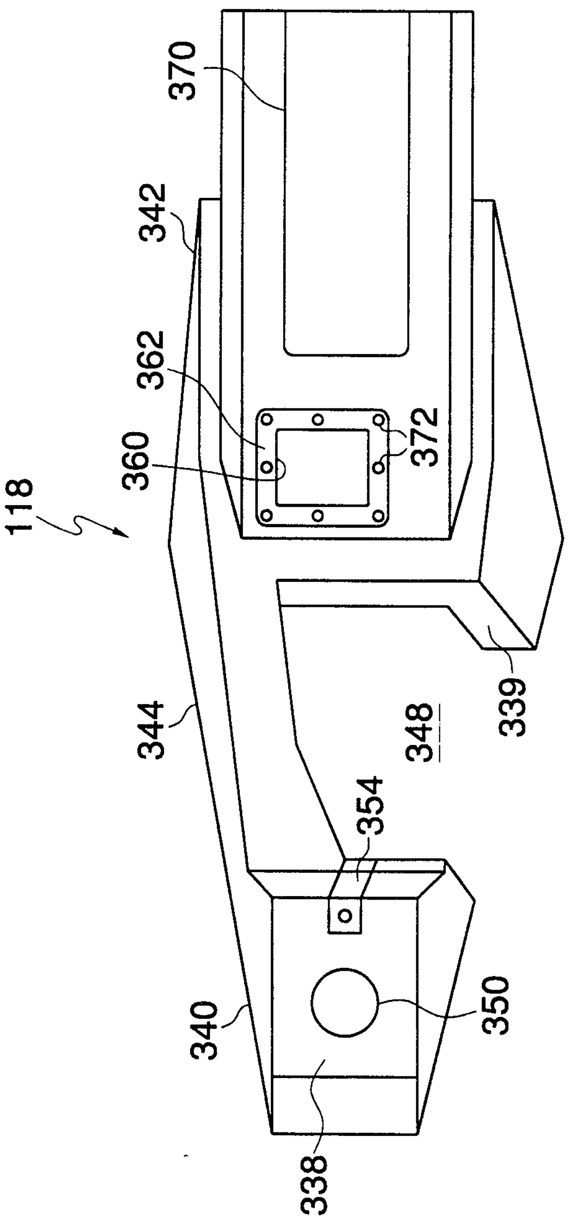

FIG. 13

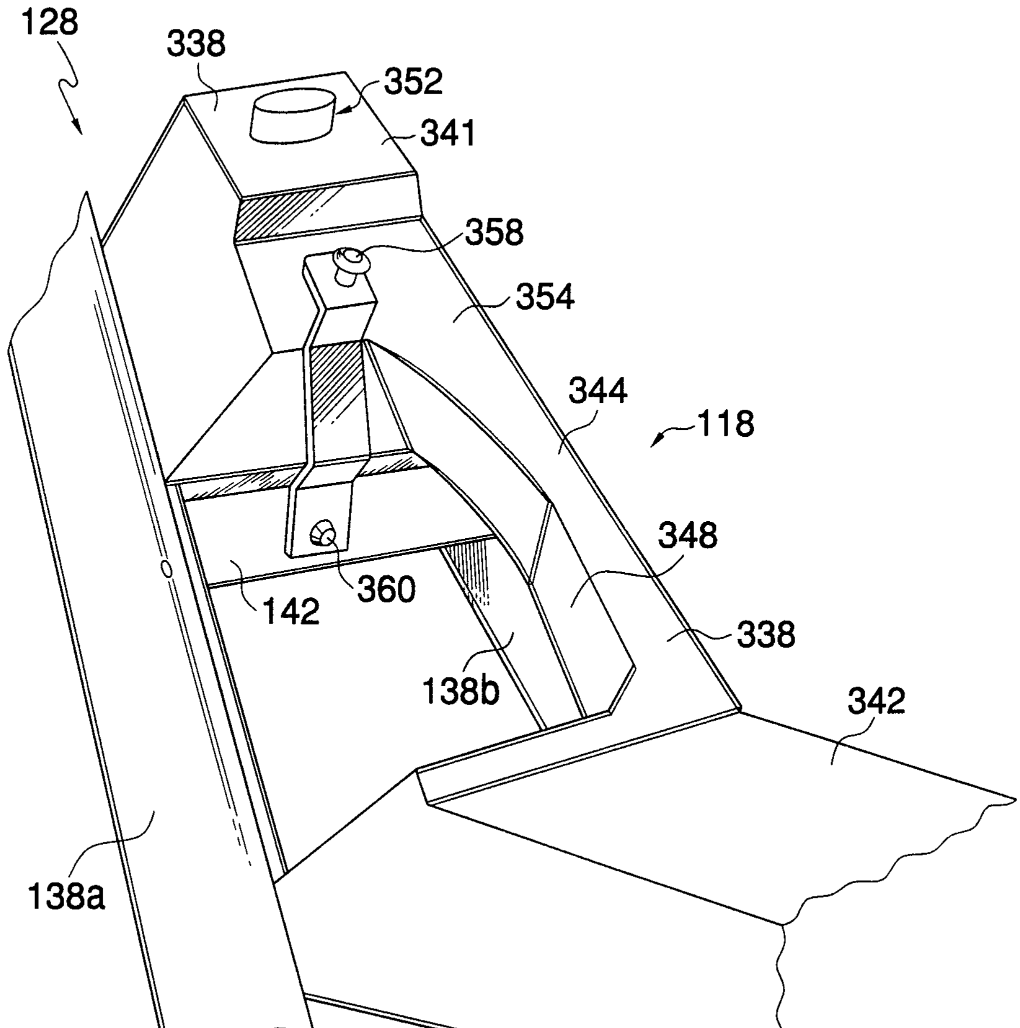
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FIG. 14

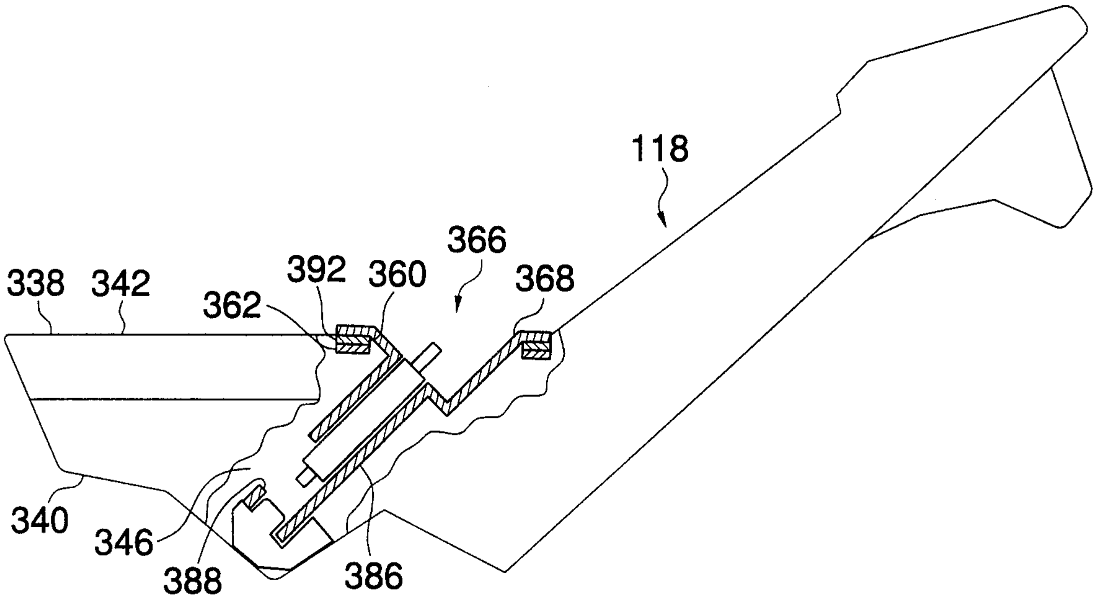
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FIG. 15

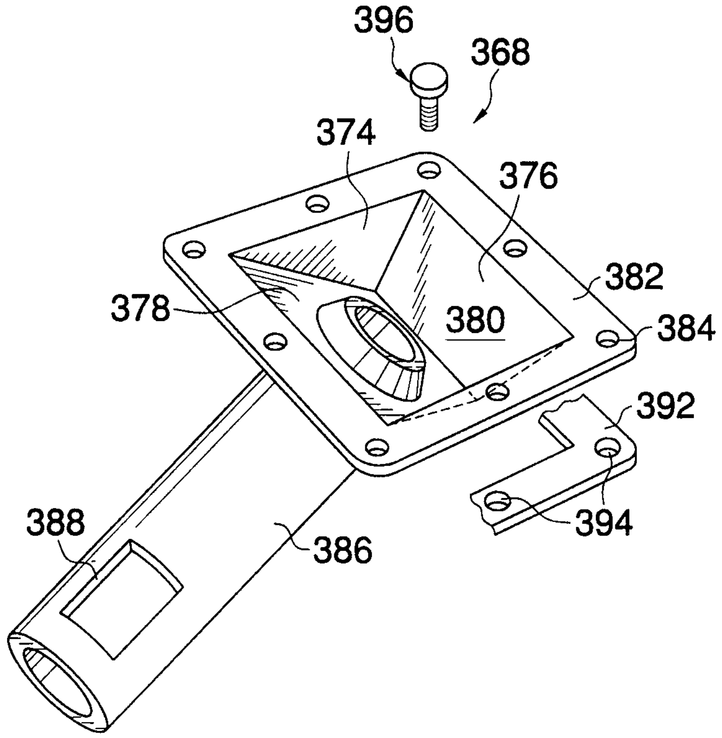
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FIG. 16

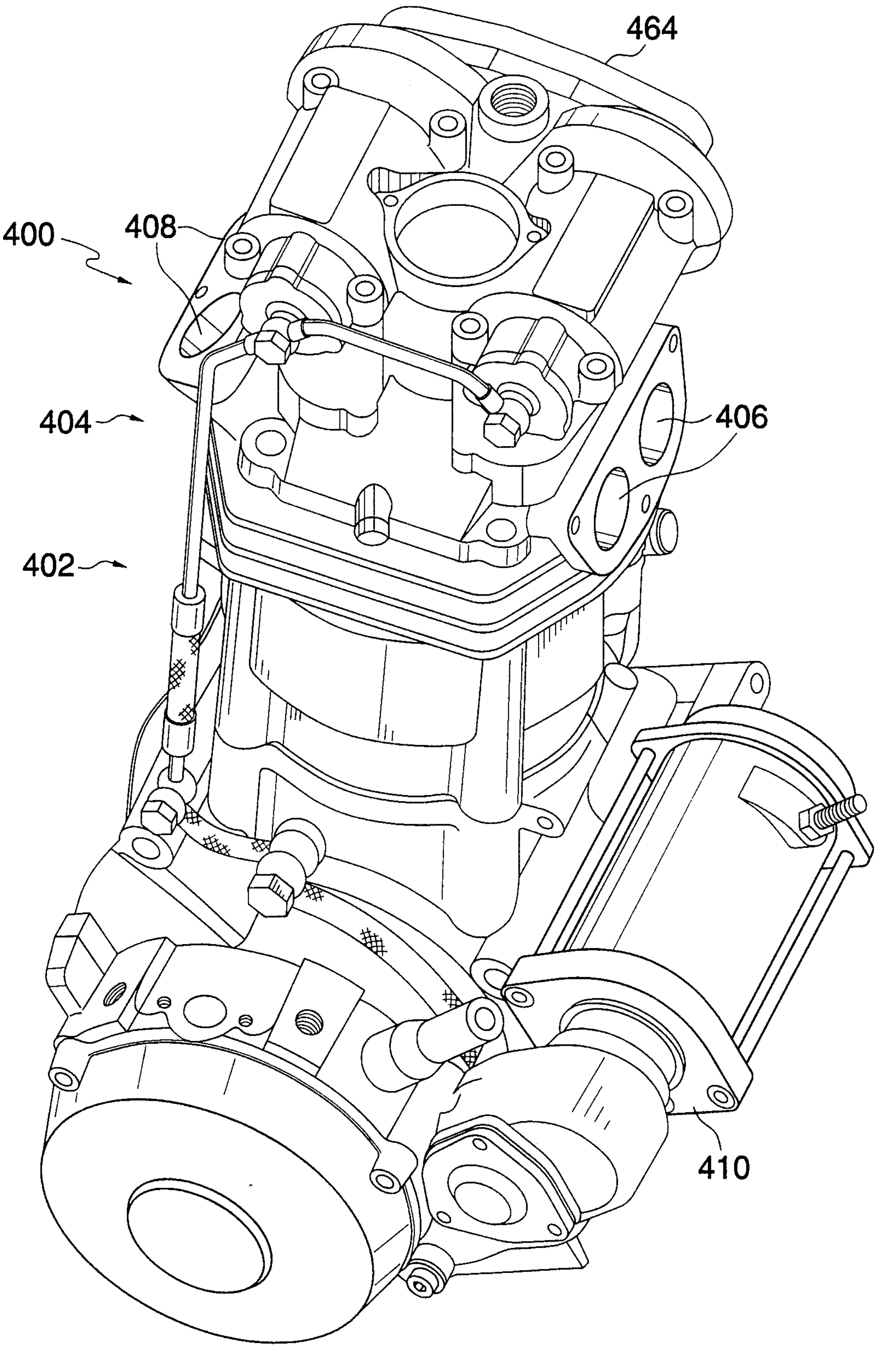

FIG. 17

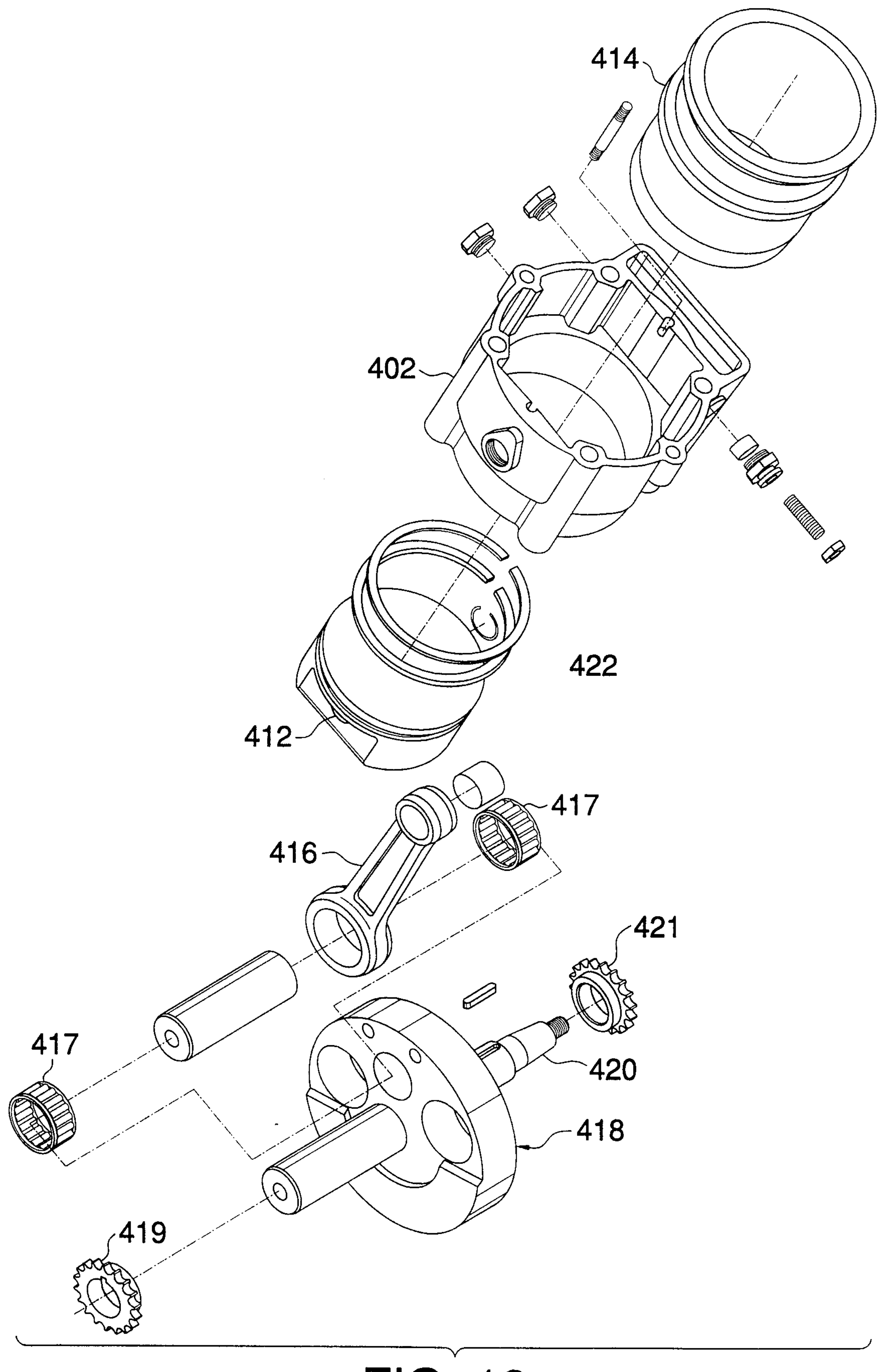

FIG. 18

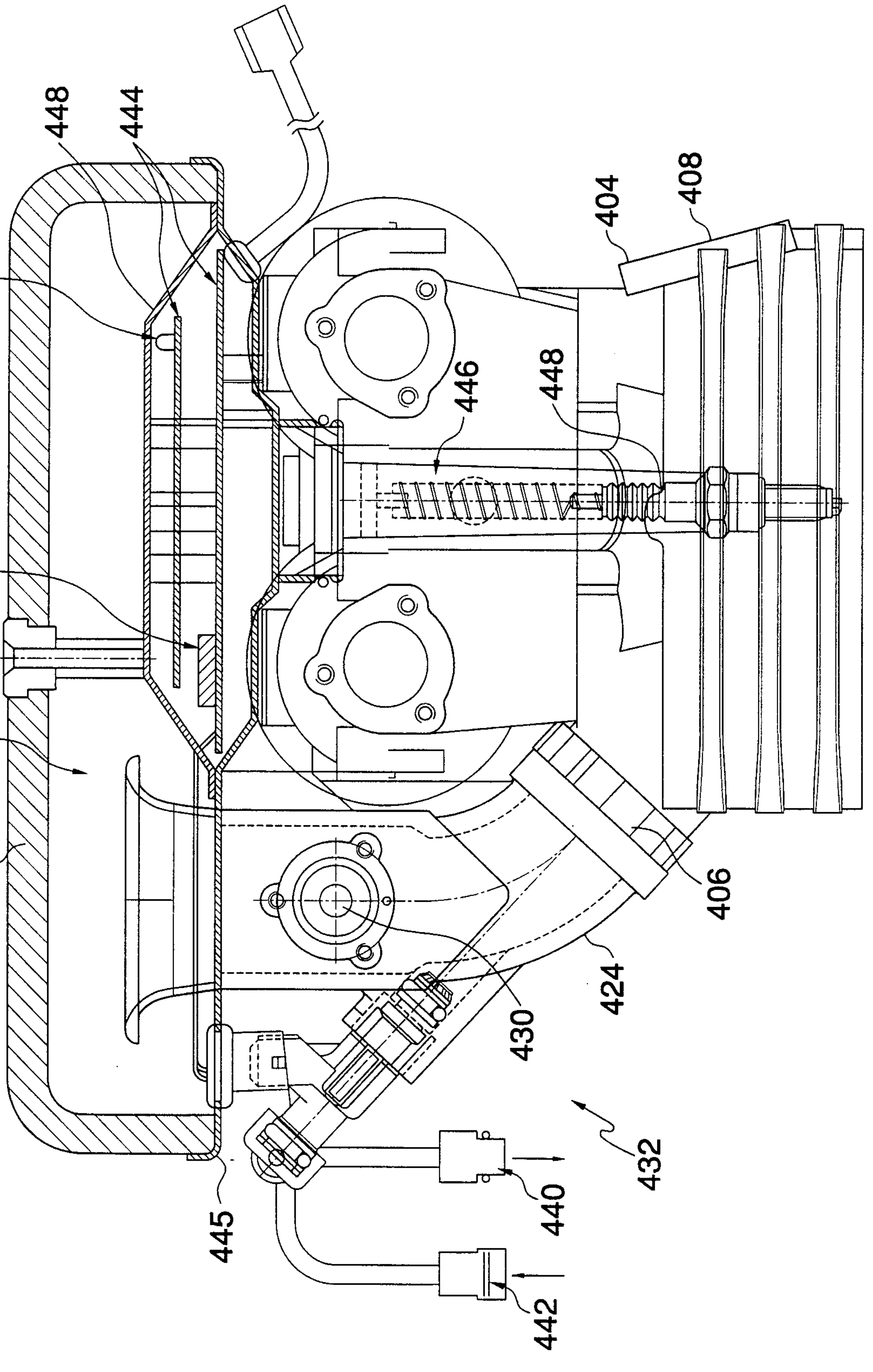
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FIG. 19

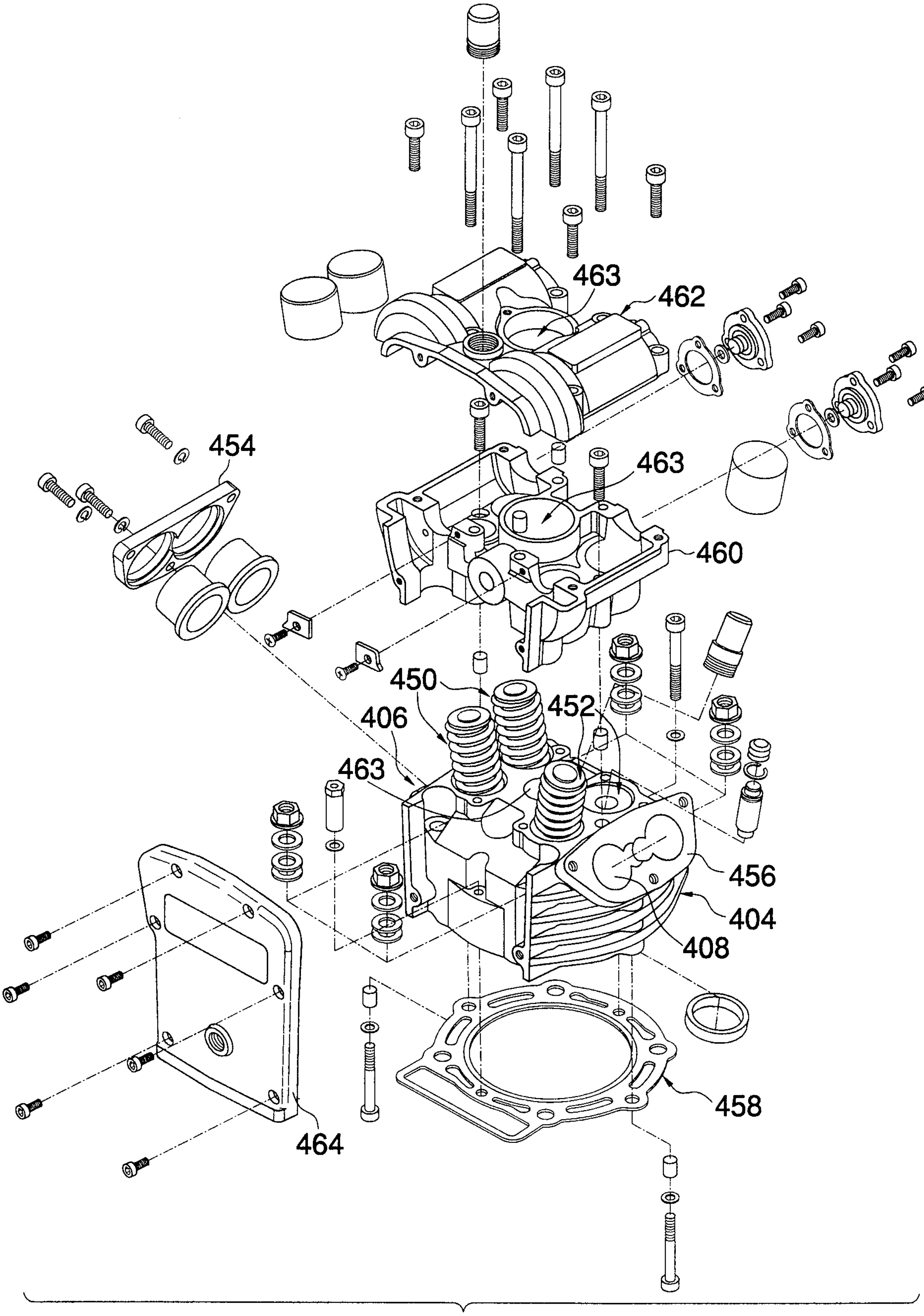

FIG. 20

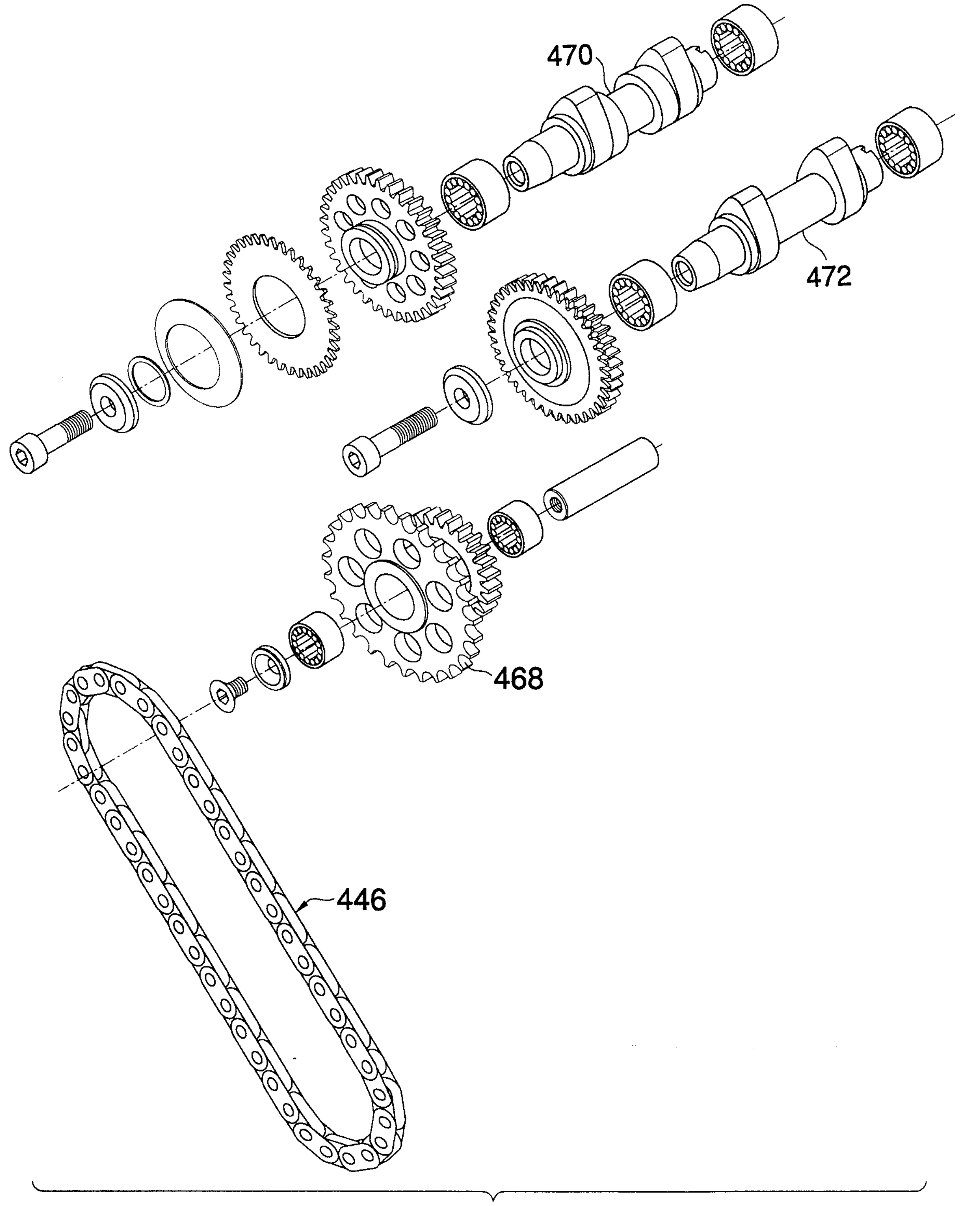

FIG. 21

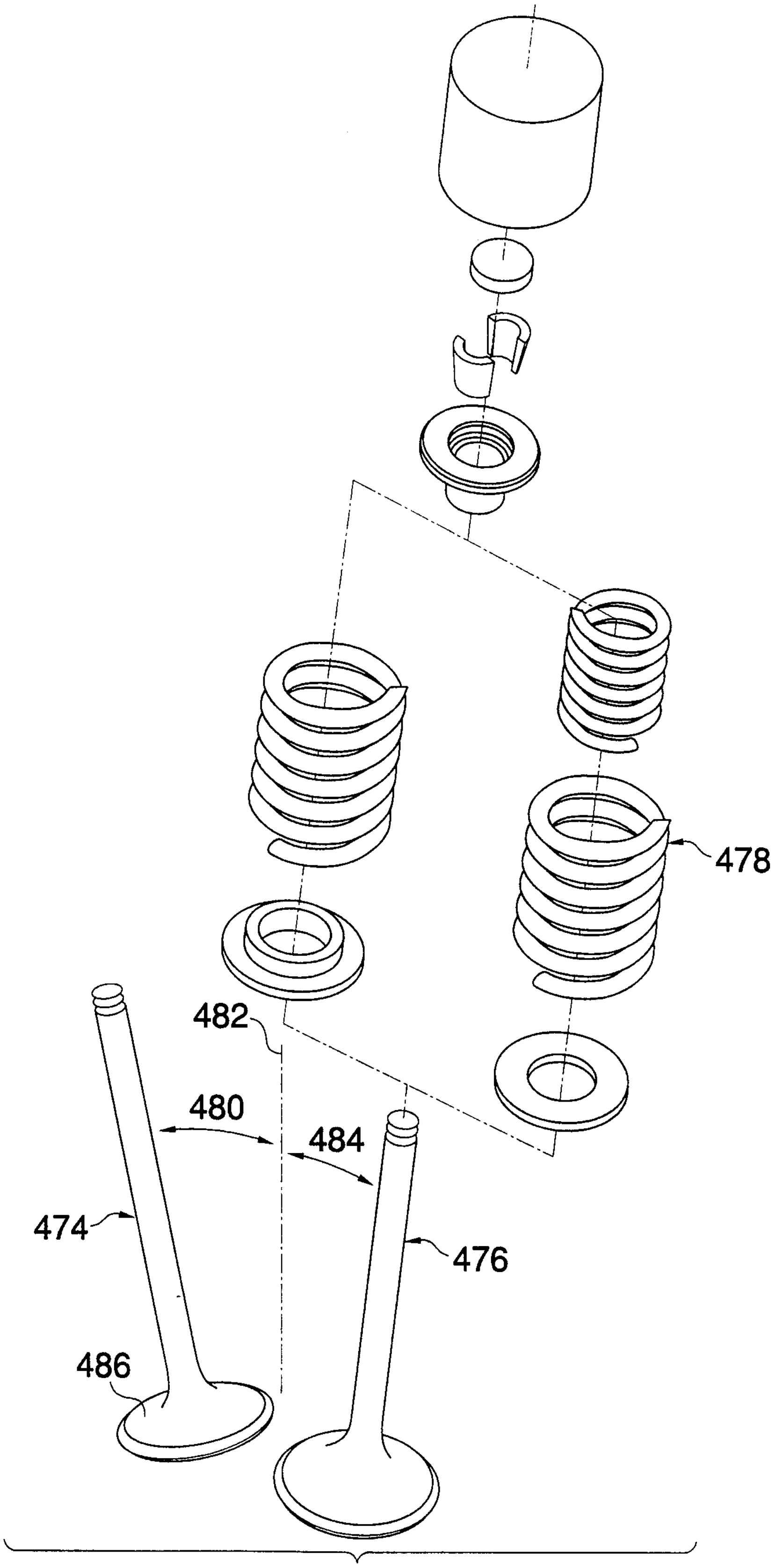

FIG. 22

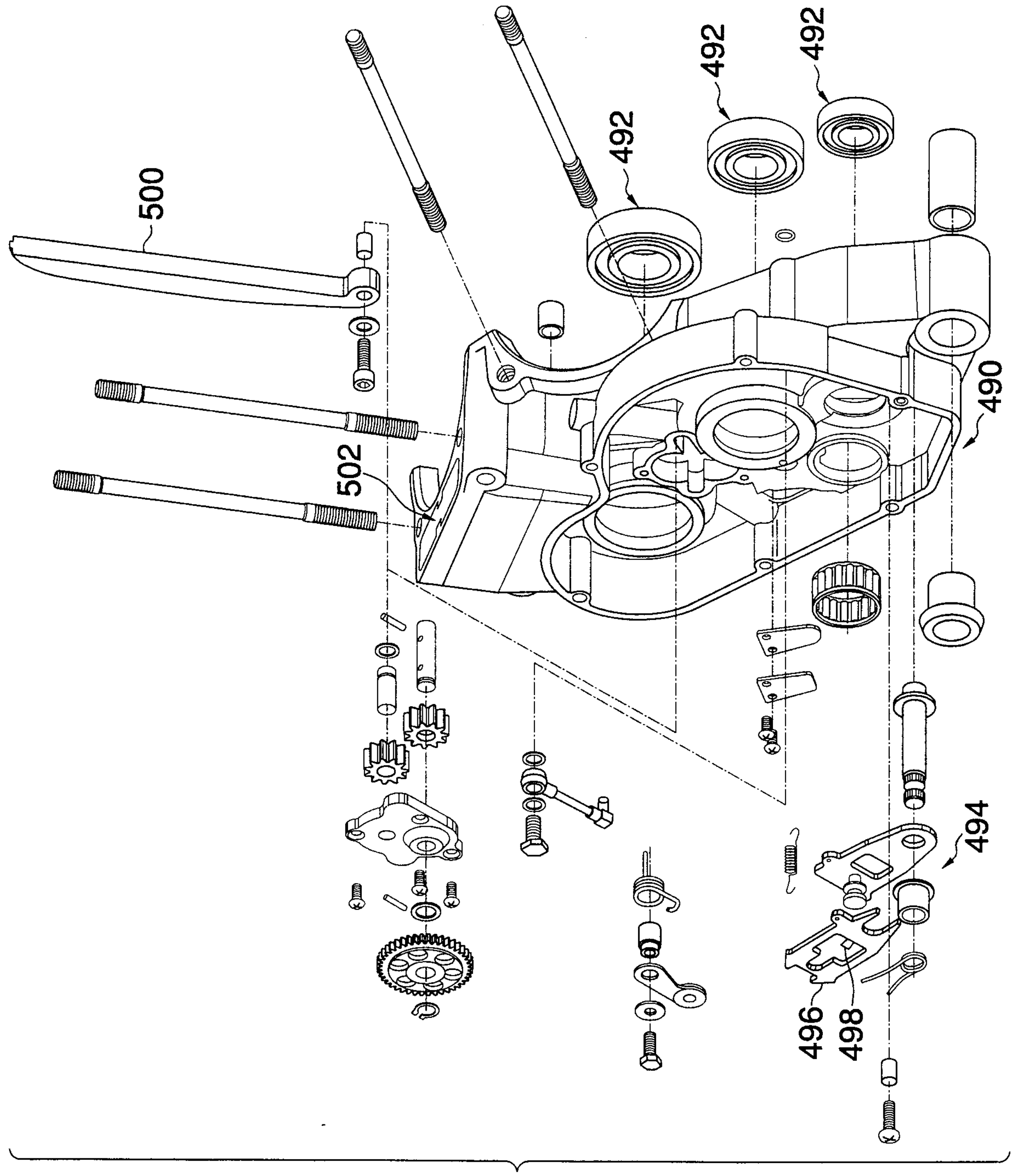

FIG. 23

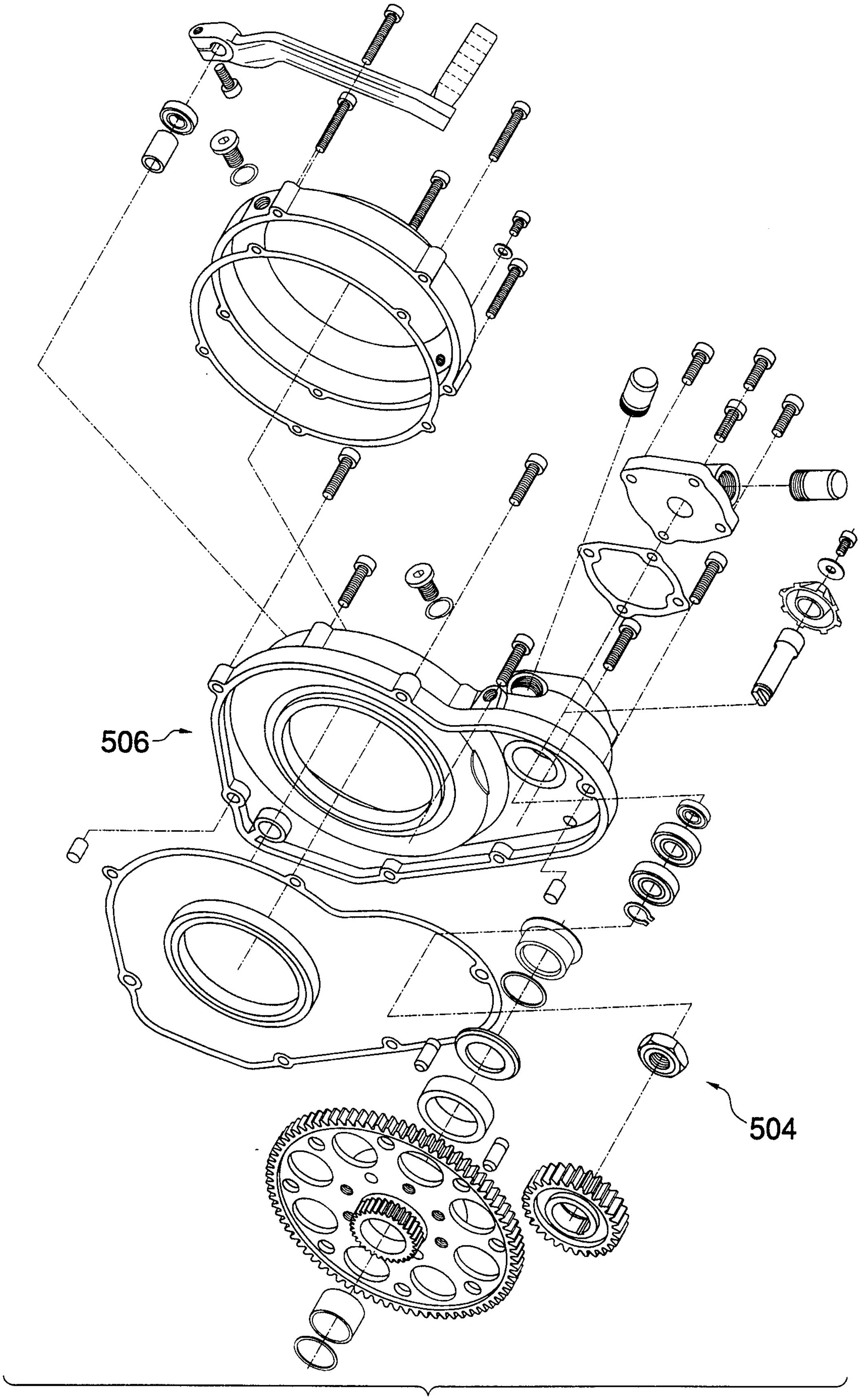

FIG. 24

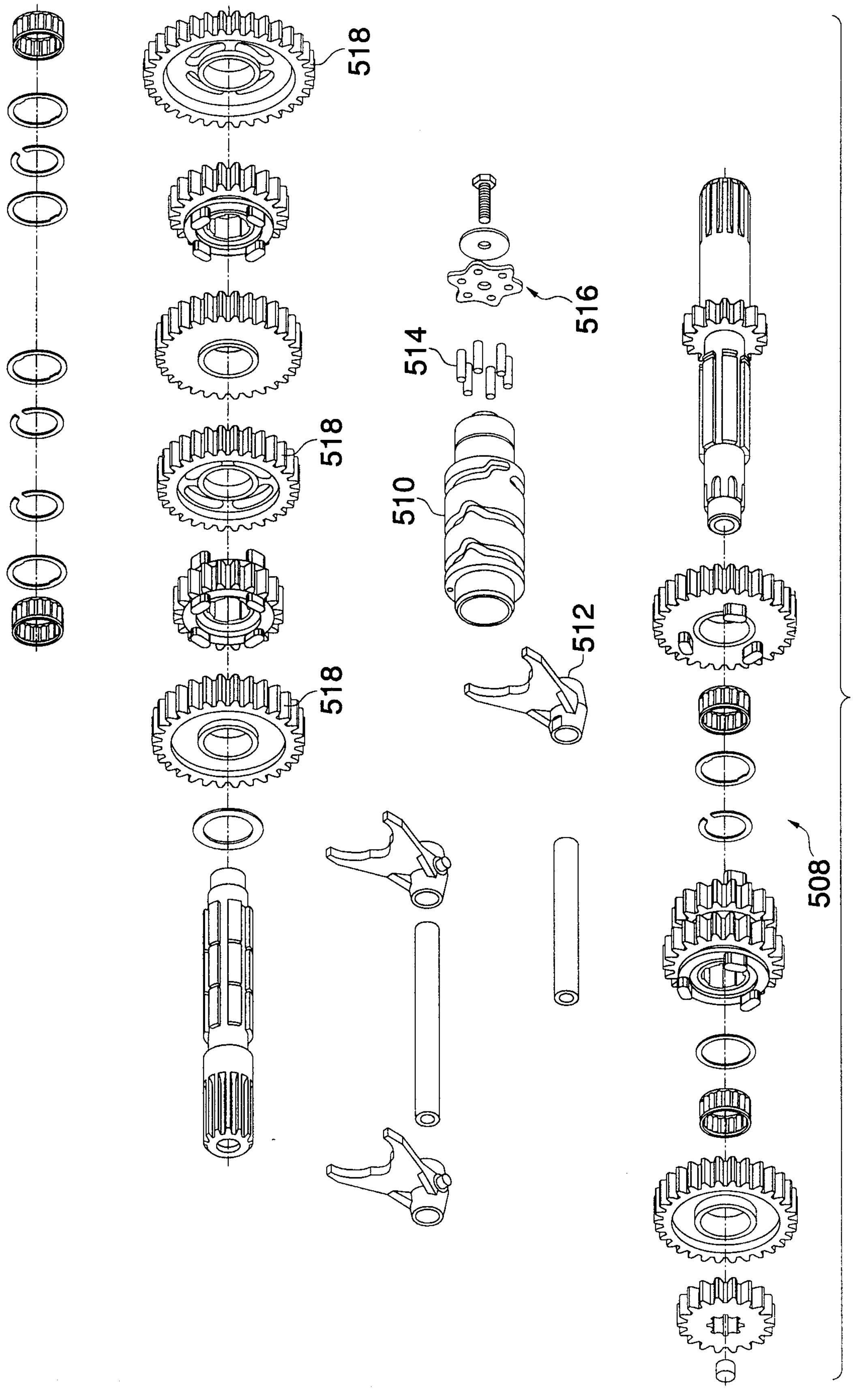

FIG. 25

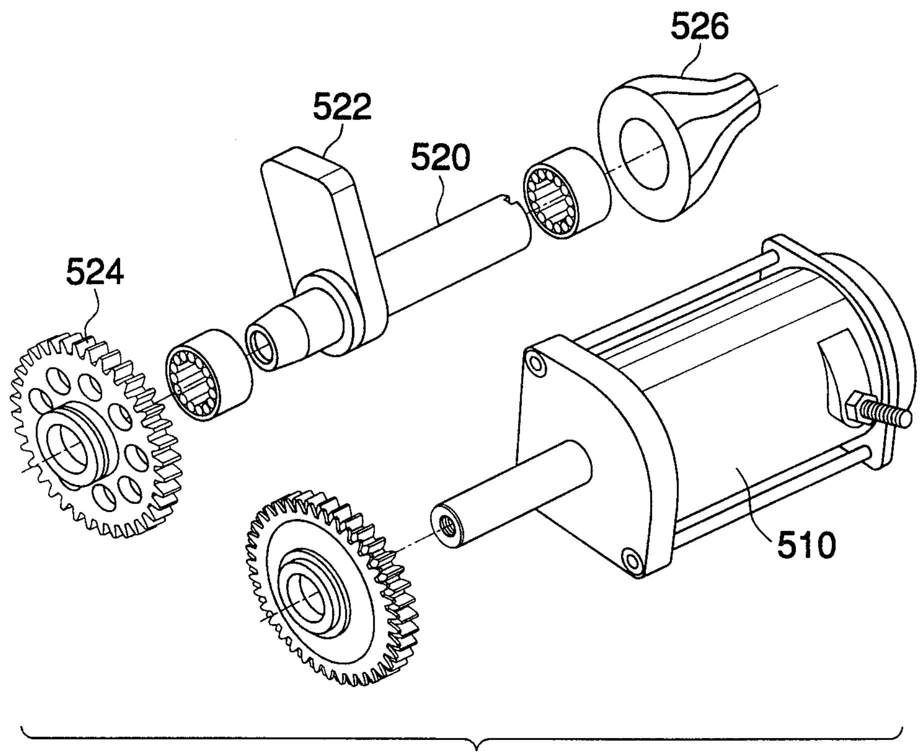

FIG. 26