

Introduction of the Gold Wing GL 1800

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ABSTRACT

The Gold Wing GL 1800 was developed focusing on compatibility with the needs of riders and passengers. As a result, Honda succeeded in revolutionizing the luxury-touring category for motorcycles by combining the superior characteristics of long touring motorcycles with those of the sports type. This was made possible by making the engine more compact and moving it forward. In spite of heightened performance through increasing the engine displacement by 312 cm³, the GL 1800 achieved both reduced weight and improvement of fuel economy. Through adopting numerous new technologies the GL 1800 was able to achieve superior environmental protection in exhaust emissions and was the first U.S.A. production model to apply an aluminum alloy frame.

1. Introduction

In 1975, Honda released the Gold Wing GL 1000, equipped with a horizontally opposed four-cylinder engine, as a super sports motorcycle. In the U.S., however, most customers used the GL 1000 as a touring motorcycle, not as a sports motorcycle. Equipping the motorcycle with a fairing, trunk, or saddlebags, couples would ride cross-country on the GL 1000. With the release of the 1980 Gold Wing model, the GL 1100, a fairing was made standard equipment, transforming the motorcycle into a true touring motorcycle. In 1984, the Gold Wing GL 1200 was even more fully equipped, and the 1988 model, the GL 1500, was upgraded to a horizontally opposed six-cylinder engine to again transform the motorcycle into a long touring motorcycle. These earlier versions of the Gold Wing are shown in Fig. 1.

The 2001 model, the Gold Wing GL 1800, is designed to provide not only the comfort that is expected in a long

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Fig. 1 Appearances of GL1000, GL1100, GL1200 and GL1500

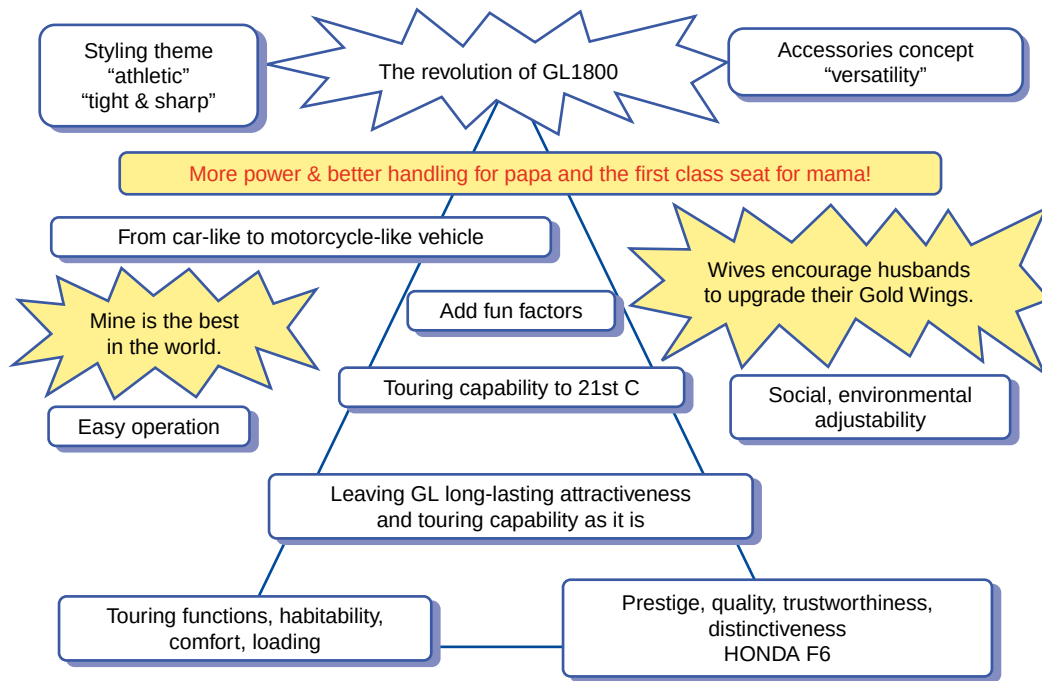


Fig. 2 Development concept

touring motorcycle, but also a sporty feel with well balanced driving, cornering and stopping performance. This maximum displacement motorcycle was also designed to be more environmentally friendly. Although this model was developed for the U.S., Japan, and Europe, this paper will describe the U.S. version which is the primary market, and also the version for Japan.

2. Development Concept

As shown in Fig. 2, the development team established "More power and better handling for the rider and first-class comfort for the passenger" as the development concept for the Gold Wing GL 1800, and commenced to study the technical elements that would be necessary in order to achieve this development concept.

If the riding position could be moved forward, it would be possible to provide the rider with the sporty handling expected of a motorcycle while also providing the passenger with more space. However, while the horizontally opposed six-cylinder engine does offer some benefits in terms of a low center of gravity and low vibration, it does restrict the foot space available to the rider. Therefore, it became important to be able to make the engine more compact and to move the engine forward; if these two aims could be met, it was felt that it would help improve fuel economy by reducing the frontal area. Fig. 3 shows a preliminary illustration of the concept, while Fig. 4 shows the final sketch.

3. Overview of the Gold Wing GL 1800

Table 1 lists the major specifications of the GL 1800, and Fig. 5 shows its appearance. Manufactured in the U.S.A., the GL 1800 features a 4-cycle OHC horizontally opposed 6-cylinder engine in a vertical configuration, and

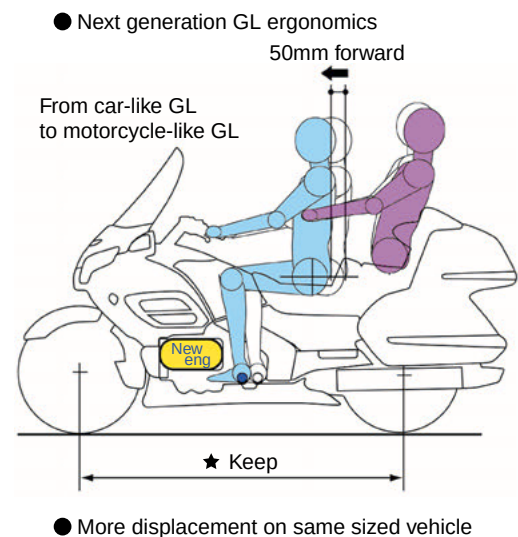


Fig. 3 Image diagram of the product concept



Fig. 4 Final styling design

Table 1 Specifications of GL 1800 and GL 1500 (for U.S.A.)

Item		Specifications	
Model		GL 1800	GL 1500
Cylinder arrangement		6-horizontally opposed	6-horizontally opposed
Cooling system		Liquid cooled	Liquid cooled
Valve train		OHC	OHC
Number of valves		IN: 1 EX: 1 per cylinder	IN: 1 EX: 1 per cylinder
Bore × Stroke (mm)		74 × 71	71 × 64
Engine displacement (cm ³)		1832	1520
Compression ratio		9.8 : 1	9.8 : 1
Fuel supply system		PGM-fuel injection	Carburetor
Max. power (kW/rpm)		88/5500	71.6/5000
Max. torque (N·m/rpm)		170.6/4000	145/4000
Transmission		5 speed constant mesh	5 speed constant mesh
Engine dimensions (L × W × H) (mm)		678 × 706 × 513	690 × 705 × 755
Engine mass (kg)		118.3	119.4
Vehicle dimensions (L × W × H) (mm)		2635 × 945 × 1455	2615 × 955 × 1495
Wheelbase (mm)		1690	1690
Vehicle dry mass (kg)		359 (Type-1), 362 (Type-2)	370 (SE), 364 (ASP)
Fuel capacity (L)		25 (6.6gallon)	23.8 (6.3gallon)
Tire size	Front	130/70R18 63H	130/70-18 63H
	Rear	180/60R16 74H	160/80-18 75H
Suspension	Front	Telescopic	Telescopic
	Rear	Single supported swing-arm (with PRO-LINK)	Conventional swing-arm
Brake system	Type-1	LBS (Linked Brake System) (both hand and foot operated)	Foot operated combined brake system Hand operated conventional brake system
	Type-2	LBS with ABS (both hand and foot operated)	_____
Brake disk	Front	φ 296 floating double disc	φ 296 solid type double disc
	Rear	φ 316 ventilated single disc	φ 316 solid type single disc

an aluminum alloy dual-spar diamond type frame. Despite the fact that the engine displacement has been increased from 1520 cm³ in the GL 1500 to 1832 cm³ in the GL 1800, the engine weight has been decreased by approximately 1.1 kg and the vehicle dry weight has been decreased by approximately 11 kg. By optimizing the shape of the combustion chambers, reducing friction, optimizing the fuel injection timing, going to higher ratios in the transmission, various other engine improvements, and by reducing the frontal area in order to achieve approximately a 10% reduction in the drag coefficient (μ_a), fuel economy at 75 mph (120 km/h) has been improved by 27% compared to the GL 1500. Furthermore, the improvement in fuel economy combined with a larger fuel tank capacity has increased the cruising range of the GL 1800 to 400 km compared with approximately 300 km for the GL 1500. Fig.



Fig. 5 Appearance of GL1800

6 shows a comparison of the frontal area of the GL 1800 with that of the GL 1500.

Fig. 7 shows the engine performance curve. Due to the increase in engine displacement, the engine exhibits a 23% increase in maximum output, an 18% increase in maximum torque, and easy-to-handle output characteristics. Emission control devices include a three-way catalyst and an air-fuel mixture feedback control mechanism in the secondary air supplier as well as an electronic fuel injection system in the air intake system.

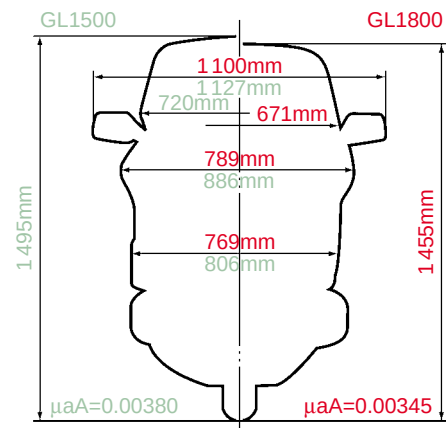


Fig. 6 Front view profile diagram

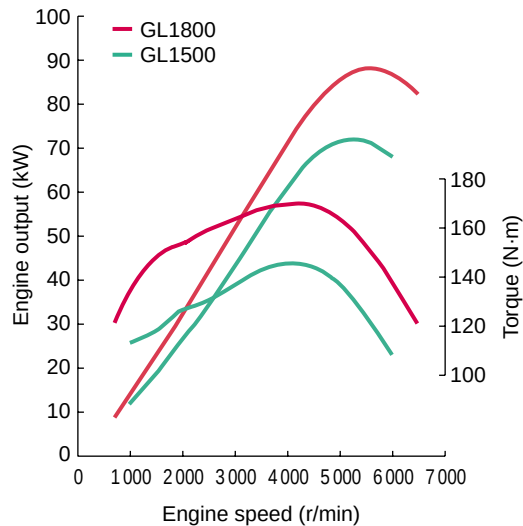


Fig. 7 Engine performance curve



Fig. 9 Parallel two-valve train system

4. Engine

4.1 Compact and Lightweight

Fig. 8 shows a perspective drawing of the engine. The valve mechanism was changed from the rocker arm type with HLA (Hydro Lash Adjuster) that was used in the GL 1500 to the direct acting parallel type using shim-under-bucket that is shown in Fig. 9. This change made it possible to reduce the number of parts and to save space and weight in the vicinity of the cylinder heads. Fig. 10 shows the components of the valve systems used in the GL 1500 and the GL 1800. The cam driving system was changed from belt drive to a silent camshaft chain driving system that uses an auto tensioner lifter. In addition to helping to make the engine more compact, this system is also maintenance free. In order to make it possible to mount the engine forward, the side-mounted radiators shown in Fig. 11 were adopted for the cooling system. In order to handle the heat load and improve the warm-up characteristics, the parallel coolant flow used in the GL 1500 was changed to series flow in

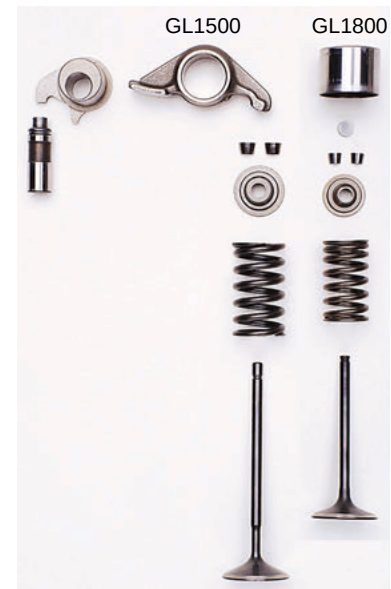


Fig. 10 Valve systems for GL1800 and GL1500

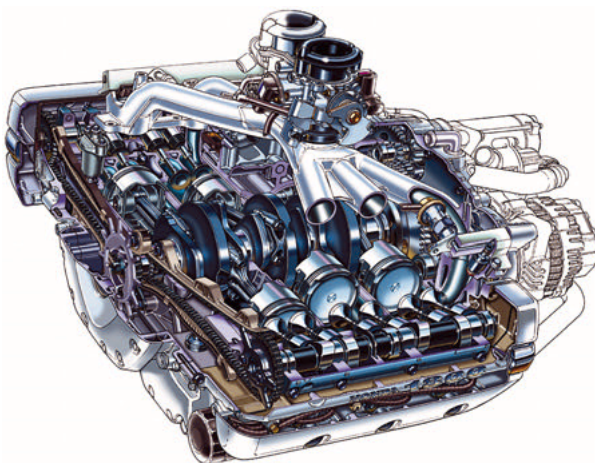


Fig. 8 Perspective drawing of engine

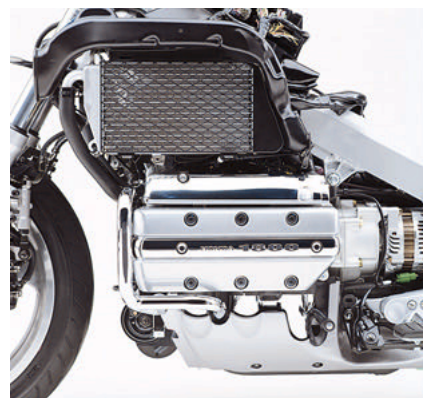


Fig. 11 Side-mounted radiators

the GL 1800.

As shown in Fig. 12, these changes made it possible to move the engine forward 25 mm in comparison to the GL 1500, and reducing the size of the components around the cylinder heads made it possible to secure even more

foot space for the rider.

The transmission was changed from a separate shifter type to a newly designed unibody shifter type in order to minimize the increase in weight. In order to minimize the increase in clearance while hot, a sintered bearing cap was adopted for the crank journal.

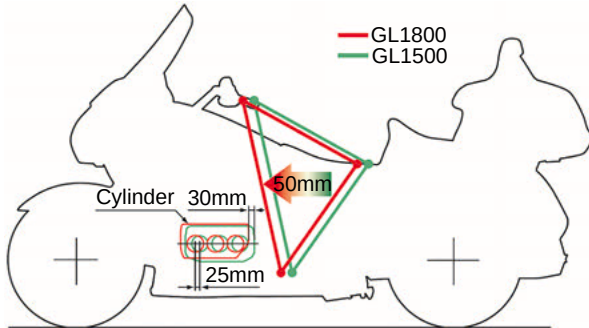


Fig. 12 Engine location and riding position

4.2 ACG Drive Damper System

In order to eliminate the reaction torque that is generated by the inertial force fluctuations of the crankshaft in a longitudinal mounted engine, speed increase and reverse drive is implemented in the ACG by means of gears. Furthermore, in order to handle the increased capacity of the ACG, two spring dampers are arranged in series as shown in Fig. 13, and a scissors gear is placed on the drive gear side.

4.3 Hydraulic-assist Clutch

The hydraulic-assist clutch uses hydraulic pressure in addition to the mechanical load to increase the clutch's

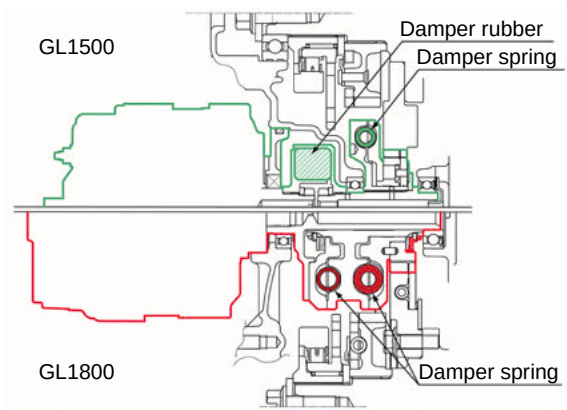


Fig. 13 ACG spring damper

engagement force, which made it possible to reduce the size and weight of the clutch and decrease the operating load of the clutch lever despite the increase in the engine displacement. Fig. 14 shows the clutch in the engaged and disengaged states.

When the clutch is engaged while the engine is running, the engine oil is controlled by the regulator valve through the hydraulic path. The high-pressure oil that is supplied to the clutch flows through the joint and main shaft oil path into the oil pressure chamber, moving the pressure plate towards the clutch center. Because the diaphragm spring is pressed against the pressure plate, the clutch plate and the friction disk are pressed together by the hydraulic pressure and the spring force. On the other hand, if the lifter plate is pressed by the clutch release rod, the spring pressure is released, the oil outlet that had been sealed opens, reducing the pressure in the oil pressure chamber and releasing the friction between the clutch plate and the friction disk.

5. Emissions Technologies

To address emissions requirements in the GL 1800, an

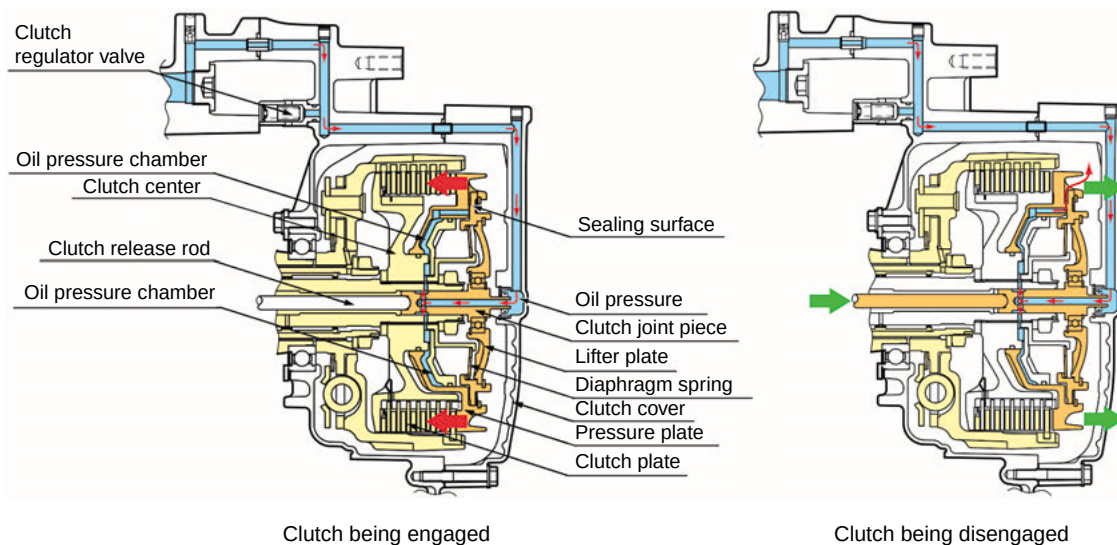


Fig. 14 Hydraulic-assist clutch

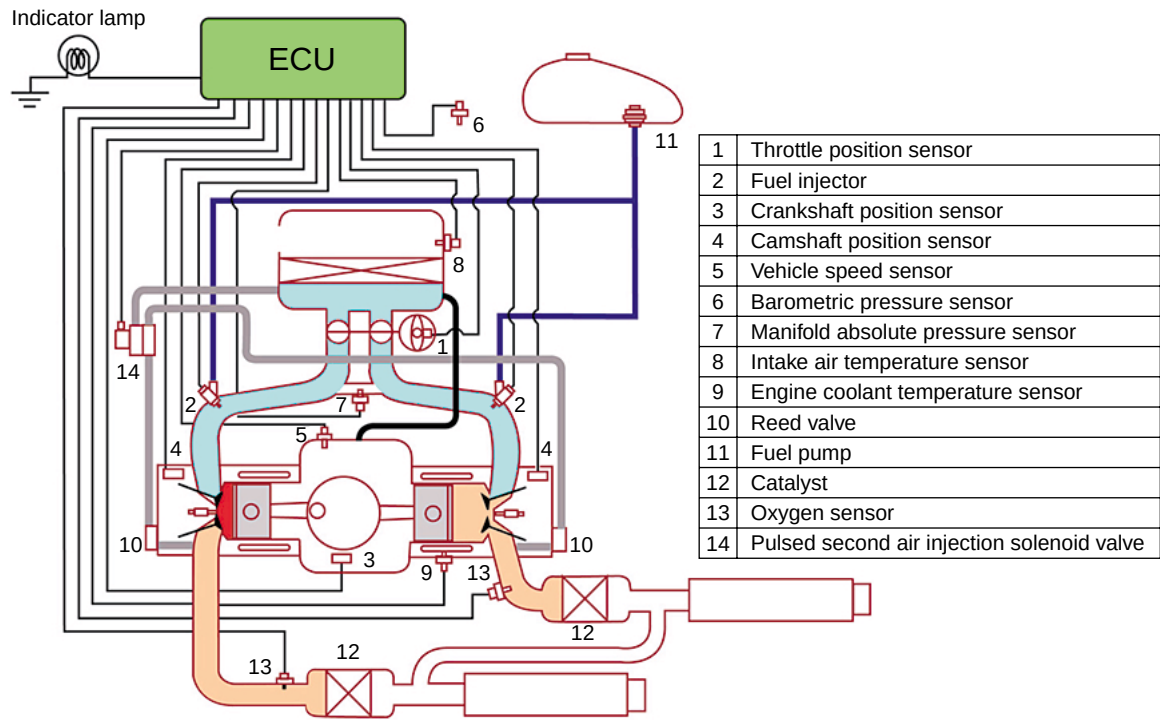


Fig. 15 Emissions control system

electronic fuel injection system was included in the intake system; a system consisting of a secondary air supplier, a three-way catalyst, and an air-fuel ratio feedback control system was implemented; and the shield method was adopted for the crankcase emission control system. Fig. 15 shows the emissions control system.

In the electronic fuel injection system, the ECU (Electric Control Unit) calculates the fuel injection timing and amount on the basis of data such as the engine speed, throttle position, intake air pressure, intake temperature, barometric pressure and water temperature, and determines

engine speed, gear position, water temperature and the knock sensor.

Depending on the operating status, the secondary air supplier supplies secondary air from the air cleaner to the exhaust port through the reed valve. In addition to promoting oxidation of unburned gas, this also promotes reactions in the oxidation catalyst that is installed in the exhaust manifold.

Catalytic devices include a monolithic type three-way catalyst in the exhaust pipe and an air-fuel ratio feedback control system. These devices oxidize CO and HC in the emissions, and lower NO_x emissions through a reducing process.

The air-fuel ratio feedback control system uses an O₂ sensor to detect oxygen levels in the emissions. The O₂ level signal is processed by the ECU, which then adjusts the fuel injection amount to roughly the stoichiometric air-fuel ratio in order to maximize the functioning of the three-way catalyst.

For the crankcase emission control system the shield system was adopted, in which blow-by gas is returned to the air cleaner from the top of the crankcase, and is then returned to the combustion chamber.



Fig. 16 Fuel injector

the target air-fuel ratio according to the load. Fig. 16 shows the installation of the fuel injector.

In the spark timing control system, the ECU determines the optimal spark timing for the current operating status of the engine on the basis of data such as throttle position,

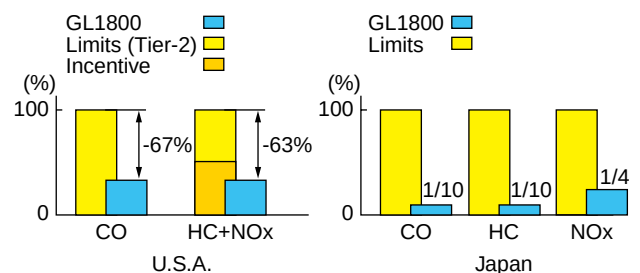


Fig. 17 Exhaust emission values

As shown in Fig. 17, the adoption of these emissions control technologies has resulted in a reduction of CO and HC emissions to 1/10 of Japanese requirements and a reduction of NOx to 1/4 of Japanese requirements. The GL 1800 also has reached the incentive level of 1/2 or lower of California's Tier-2 requirements for 2008 for HC + NOx emissions; these technologies will be used in motorcycles sold in all markets throughout the U.S.

6. Frame

The steel double-cradle frame used in the GL 1500 is being replaced with an aluminum alloy dual-spar diamond type frame, the first of its kind to be produced in the U.S. In addition, by using aluminum alloy for the trunk and saddlebag stays, the weight of this lightweight frame has been reduced by 35% to approximately 21 kg⁽¹⁾. As shown in Fig. 18 and Fig. 19, the front frame consists of dual spars with a four-compartment section that offers high specific rigidity, a core box section type gravity casting head pipe, a pivot plate, stiffeners, and engine hangers. The rear frame consists of a circular section extrusion aluminum alloy seat rail pipe and an open section rear plate. The front and rear sections are welded together.

The engine is mounted with a fully rigid mount in order to use the engine crank case and the rear case as frame rigidity members. As a result, even though the frame is lighter than that used in the GL 1500, it offers 1.75 times

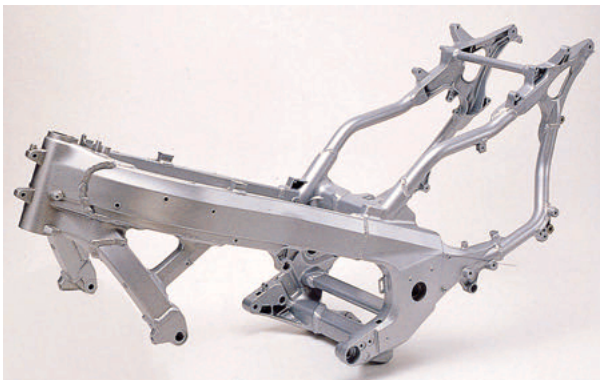


Fig. 18 Aluminum-alloy frame



Fig. 19 Spar section of frame

greater torsional rigidity and 2.1 times greater lateral rigidity.

7. Riding Position and Seats

As shown in Fig. 12, making the engine more compact and positioning it farther forward made it possible to move the riding position 50 mm forward. This allows the rider to find a riding position that facilitates sporty handling. Although the wheelbase of the GL 1800 is the same as that of the GL 1500, passenger comfort has been enhanced by lengthening the passenger seat by 50 mm and widening it

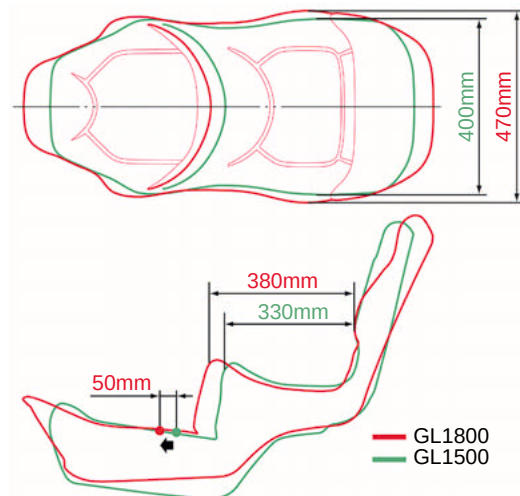


Fig. 20 Seat

by 70 mm.

8. Chassis

8.1 Electric Suspension Preload Adjustment System Equipped with Memory

Although the GL 1500 had a conventional suspension system equipped with twin rear shock absorbers, in order to achieve superior ride performance and driving performance, the Pro-Link construction was adopted for the rear suspension, and a motor-powered hydraulic jack type preload adjustment system suited for this suspension construction was also adopted. This system provided a comfortable ride, regardless of the weight of passengers and luggage. This system consists of an actuator that converts the rotational torque of the motor through a worm gear and trapezoidal screw into forward force on the leveling piston, and a piston mechanism on the reaction side that moves in proportion to the leveling piston of the actuator, pushing the shock absorber spring up. The actuator is also equipped with an adjustment position sensor that displays the adjustment status on the multi-display. Operability is also improved through the addition of a two-position memory.

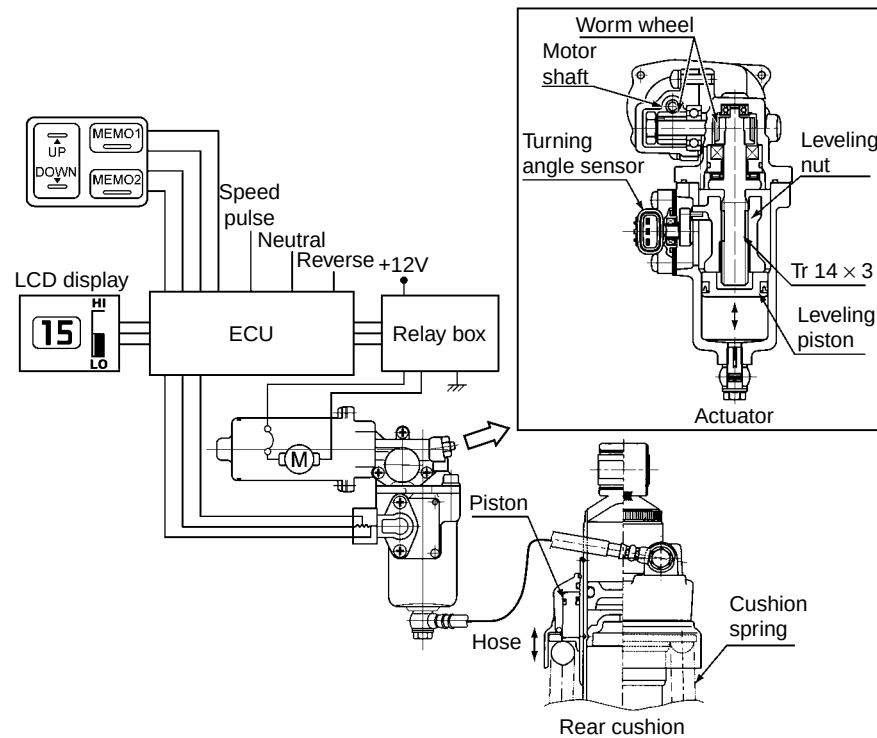


Fig. 21 Computer-controlled adjustable hydraulic rear suspension system

Fig. 21 shows the hydraulic jack type preload adjustment system.

8.2 Pro-Arm

The rear swing arm (Pro-Arm) construction has a simple torsion damper formed from two tubes joined by rubber built into the propeller shaft, and the wheel is fixed in place with the final gear on one side. Not only does the Pro-Arm enhance shift shock convergence characteristics due to differences in the hysteresis characteristics of the damper; it also makes serviceability easier when changing the tires, etc. Fig. 22 shows the drive shaft damper, while Fig. 23 shows the aluminum alloy swing arm.

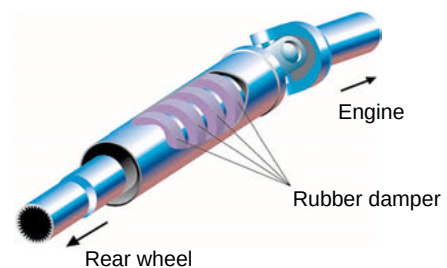


Fig. 22 Driveshaft-damper

8.3 Torque-reactive Combined Braking System with ABS

The Anti-lock Braking System (ABS)⁽²⁾ for motorcycles prevents the wheels from locking up when the brakes are applied too hard in straight ahead braking, reducing rider concerns. On the other hand, the Linked Brake system (LBS, also known as "Dual CBS")^{(3) (4)} makes high deceleration simpler by applying appropriate braking force distribution on the front and rear wheel. The basic system that combines these two functions simply, the torque-reactive combined braking system with ABS⁽⁵⁾, is the same as that found in the ST 1100, but in the GL 1800, in which the foot brake is used frequently, the two pistons at both ends of the front three piston calipers on the left side function when the pedal brake is pressed, unlike the ST 1100, resulting in an increase in braking force when the pedal brake is applied. Fig. 24 shows the brake system.

8.4 Anti-dive Control System

The anti-dive control system controls any sudden dives forward by the vehicle while braking; this capability makes it possible to implement a shock absorber setting that emphasizes a suitable level of comfort during normal



Fig. 23 Single-supported swing-arm (Pro-arm)

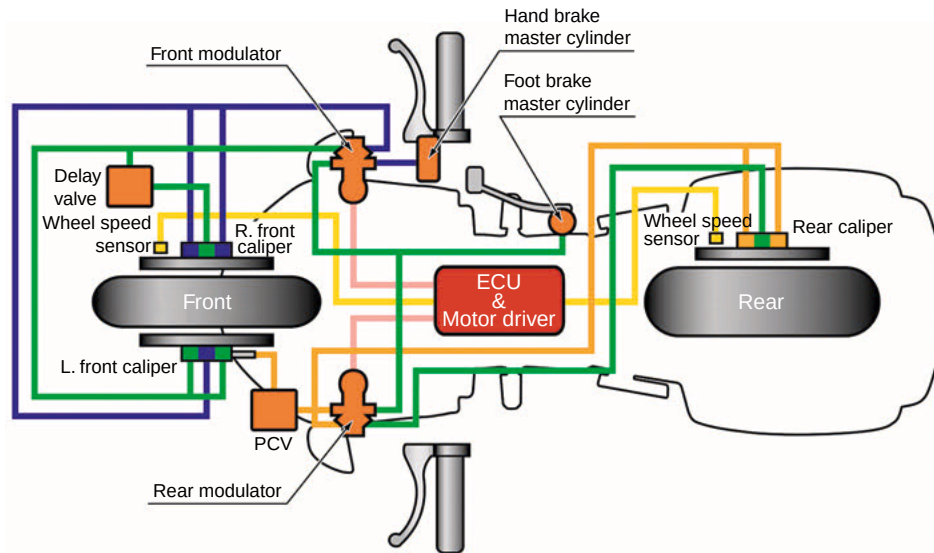


Fig. 24 LBS with ABS

driving. In the GL 1800, whether the hand brake is applied or the foot brake is applied, the hydraulic pressure in the LBS secondary master cylinder that is generated by the reverse torque of the left caliper on the front wheel is used to close off the hydraulic path to the front fork. Fig. 25 shows the anti-dive control systems for the GL 1500 and for the GL 1800. Ensuring an adequate anti-dive effect, the H.M.A.S. (Honda Multi-Action Suspension)⁽⁶⁾, which used a cartridge valve, could be adopted on the right side of the front fork by installing the anti-dive control system on the left side of the front fork. Fig. 26 shows the damping characteristics of the front suspension.

9. Electronics

9.1 Motor Actuated Reverse System

In consideration of handling of the Gold Wing while parking, a motor actuated reverse system was adopted, starting with the GL 1500⁽⁷⁾. In the GL 1800, the positions

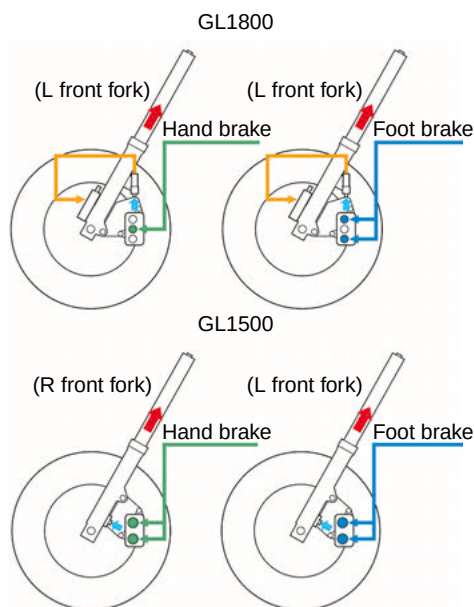


Fig. 25 Anti-dive systems for GL1800 and GL1500

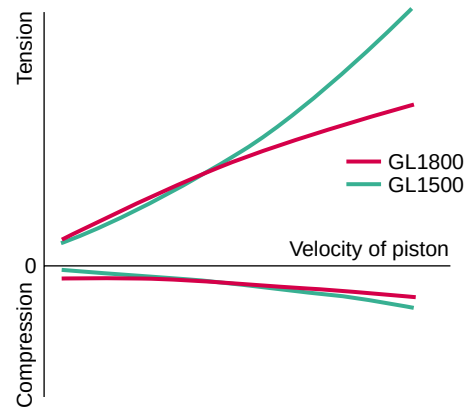


Fig. 26 Characteristics of damping force of front suspension

of the operation switches has been changed so that they can be operated by the thumb of the right hand without releasing the handlebar.

Fig. 27 shows the motor actuated reverse system. The system consists of a reverse shift switch, a reverse switch that is also used as the starter button, a reverse drive motor that is also used as the starter motor, a reverse shift actuator and an integrated ECU for cruise control.

When the reverse switch is turned on, the reverse shift actuator operates under ECU control so that the reverse gear on the engine side engages the driven gear on the final shaft side. The reverse drive motor operates under the control of the ECU powering the rear wheel through the final drive shaft. The ECU also handles speed control to ensure that a constant reverse speed is maintained. Note that shifting into reverse is possible when the engine is in neutral and the side stand is in the raised position; the motorcycle will then move backwards, if the engine is running.

9.2 Cruise Control System

A cruise control system is essential for a long-distance

touring motorcycle. While a negative pressure actuated type cruise control was used in the GL 1500, a motor actuated type was adopted in the GL 1800 in order to improve vehicle speed stability, to make the system lighter, and to save space.

Fig. 28 shows the cruise control system. This system controls the vehicle speed by trying to maintain a zero difference between the current vehicle speed and the vehicle speed at which the cruise control was set. The ECU controls the electromagnetic clutch and the control motor inside the actuator to adjust the opening of the throttle. Acceleration by manual means is still possible even while cruise control is on. Cruise control can be cancelled either by turning off the cruise control switch, using the front or rear wheel brakes, using the clutch, or closing the throttle.

9.3 Headlight

9.3.1 HID Headlight

Nighttime visibility has been enhanced by adopting, for

the dipped-beam headlight used in Japan, the first HID (High Intensity Discharge) headlight to be mass-produced for motorcycles. In an HID headlight, high AC voltage is applied to electrodes at both ends of a sealed discharge tube (burner) containing xenon gas, mercury, and metal halide, which causes the lamp to shine as a result of sequential arc discharges. As a light source, the HID lamp is more efficient than a halogen lamp, producing 3,000 lm, or twice the approximately 1,500 lm that a halogen lamp produces. As shown in Fig. 29, the road surface illumination characteristics of the GL 1800 are superior to those of the GL 1500, illuminating a much larger area. Note that in conjunction with the adoption of the HID headlight, consideration is being given to the maximum luminosity and distribution of light so as to not create glare for oncoming vehicles.

9.3.2 Motorized Headlight Aiming System

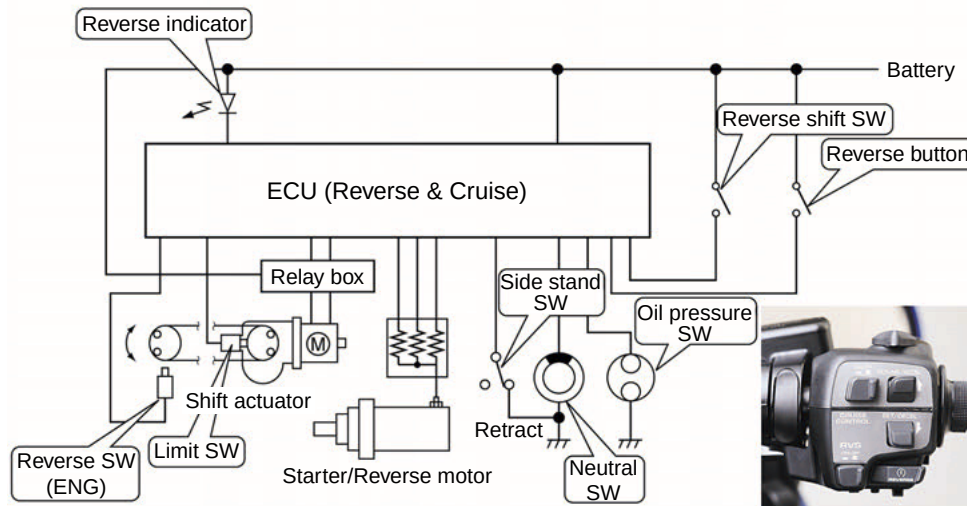


Fig. 27 Electric reverse system

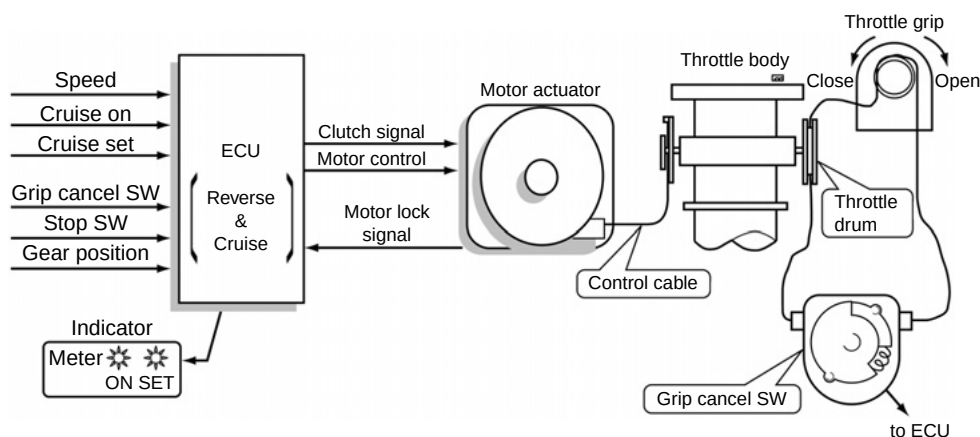


Fig. 28 Electronic cruise control system

Motorized control is used to adjust the axis of the headlight beam in the vertical direction so that the headlight can be aimed while sitting on the motorcycle. The aim can be easily adjusted to one of 11 positions simply by turning the dial on the left side panel. Fig. 30 shows the headlight

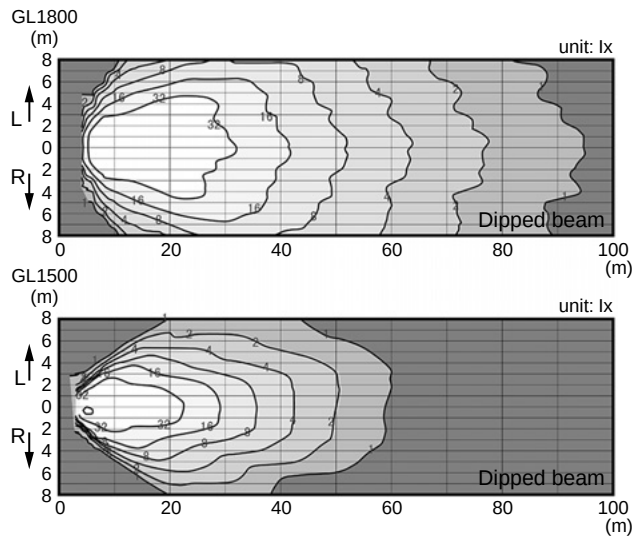


Fig. 29 Light distributions of GL1800 and GL1500

aiming system.

9.4 Audio System

The volume and sound quality of the GL 1800's audio system has been improved by increasing the amplifier output ($25W \times 4$) and by changing the speaker specifications (with a new, specially designed speaker box), so that now the GL 1800 has one of the best audio systems found on a motorcycle. Furthermore, by placing the controls not only on the audio system itself but also on the left

handle bar, the rider can now control the radio, CB, and CD without releasing the handle grip. The LCD multi-display in the meter has been designed so that the operating status of the audio system can be understood easily. In order to simplify the collection of useful information while touring, a weather band select button has been added in the design for the U.S., and a traffic information select button has been added in the design for Japan. Fig. 31 shows the audio system.

9.5 Trunk Lock Control System

A trunk lock control system has been adopted for the trunk and saddlebags in the GL 1800, with improved open/close and locking operability. Fig. 32 shows the trunk lock control system. By combining a transmitter, a receiver, a trunk open/close detection switch and an actuator, the system can lock and unlock the trunk and saddlebags, can detect whether they are open, and can pop open the trunk. When the remote control is used to lock or unlock the trunk, the turn signals flash to indicate that the action occurred. In addition, if any of the lids are open, the corresponding LCD indicator in the meter flashes as a warning. The system also includes other functions, such as a function in which the remote control can be used to make the horn sound in order to confirm the location of the vehicle (in the U.S. version), and a function that automatically locks the trunk and saddlebags after a certain period of time elapses in case the owner forgets to lock them.

10. Plastic Fuel Tank

Instead of the conventional steel fuel tank with welded seams, a fuel tank produced by high-density polyethylene blow molding was adopted for the GL 1800. Taking advantage of the high degree of design freedom that is made possible by blow molding, the battery, auxiliary parts, etc., are located under the seat while the capacity of the fuel tank

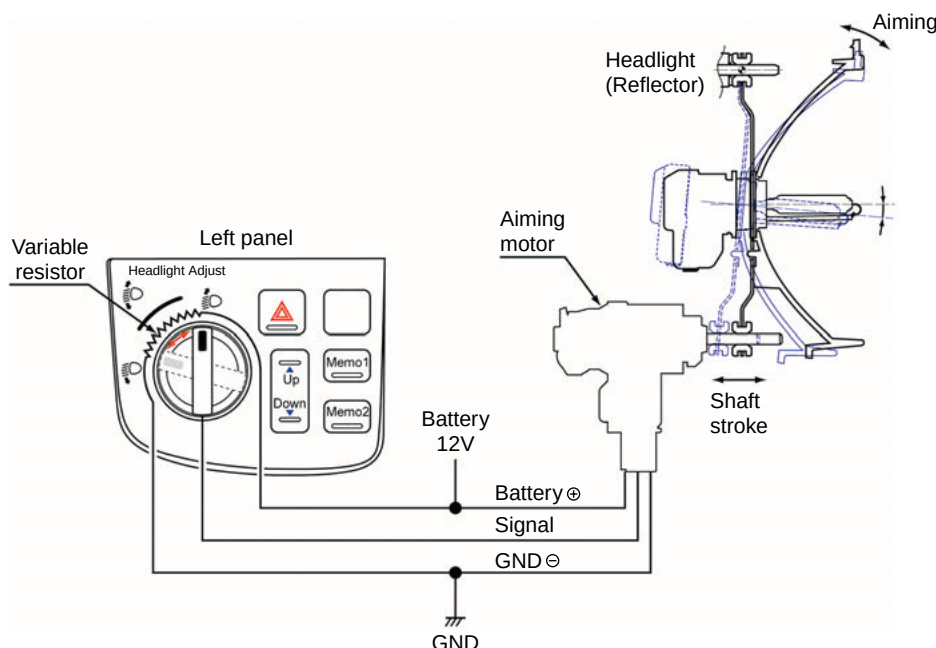


Fig. 30 Headlight aiming system

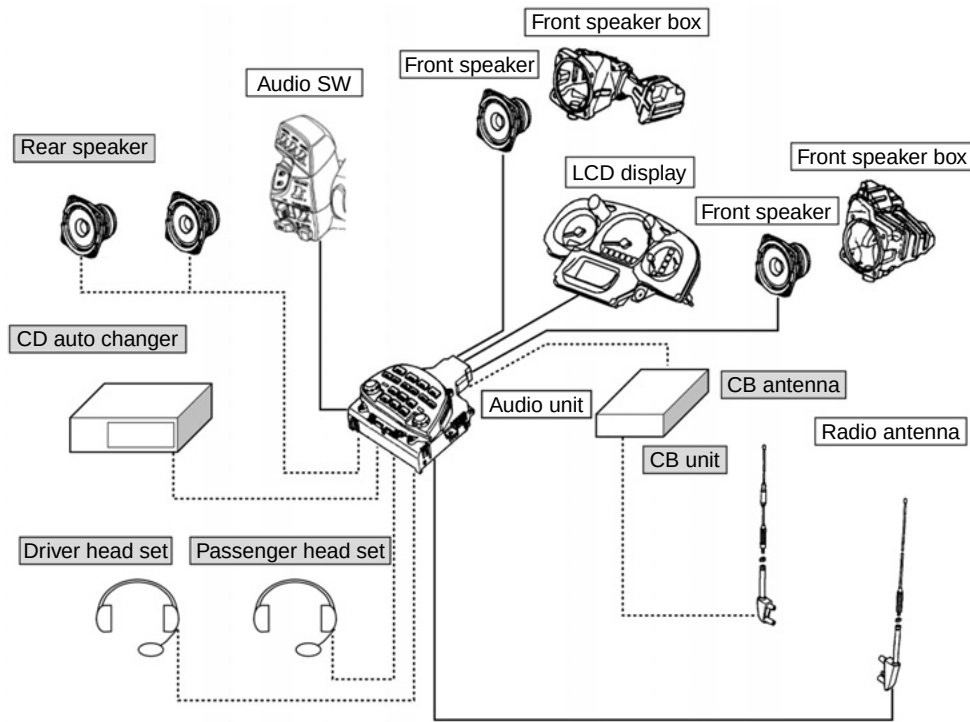


Fig. 31 Audio system

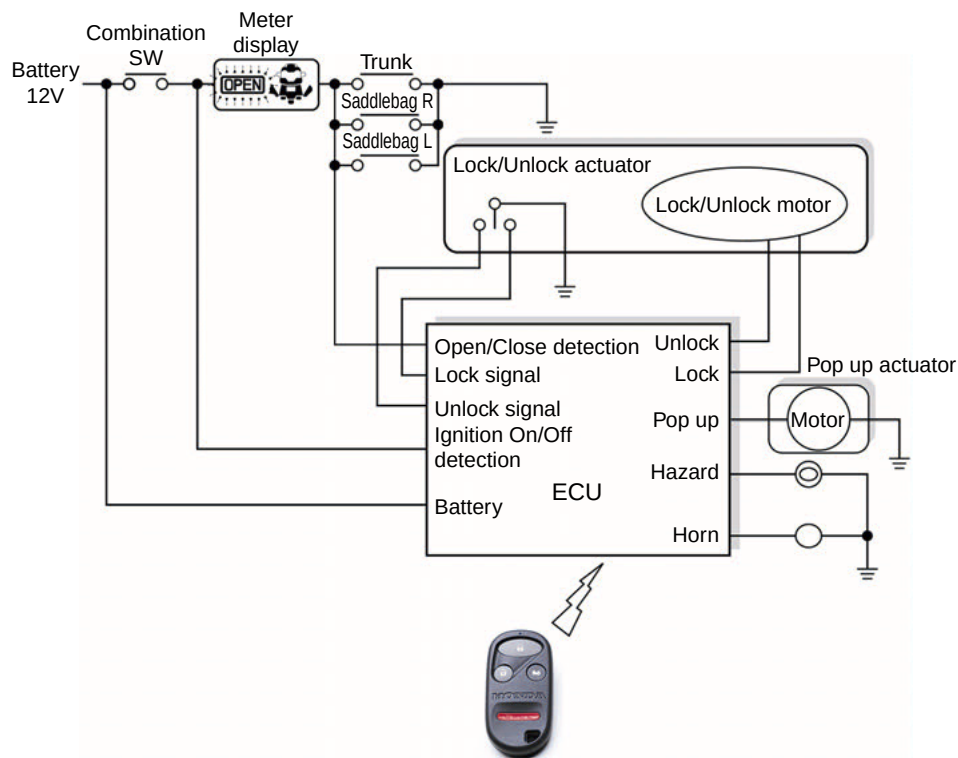


Fig. 32 Remote-control key-lock system

has been increased by 1.2 liters to 25 liters. Fig. 33 shows the external appearance of the fuel tank. As shown in Fig. 34, the fuel tank is formed of six layers of four different materials, with an EVOH barrier layer in the middle to prevent gasoline from penetrating. The fuel cap is air tight,

and the evaporative emission canister system that is needed in order to comply with California Air Resources Board (CARB) evaporative emission requirements is provided in all markets throughout the U.S. Fig. 34 shows the evaporative emission canister system.

With the implementation of fuel injection, the pump unit is made of plastic and consists of a high-pressure pump and filter, and is built into the fuel tank as shown in Fig. 35. Gasoline is supplied to the injector through the fuel hose, and the gasoline that is returned through the return hose is returned at a higher flow rate through the orifice section of the pump unit intake. Since gasoline in the fuel tank is forcibly taken into the pump unit, the result is a stable fuel supply system that is not affected by changes in the fuel level.

11. Conclusion

The Gold Wing GL 1800 was developed with a twin focus on both the rider and the passenger. While offering further enhancements in the touring performance that has been developed over many years, the GL 1800 also provides excellent balance in terms of basic driving, cornering and stopping performance for a sporty feel that sets a new standard for the luxury touring category.



Fig. 33 External view of fuel tank

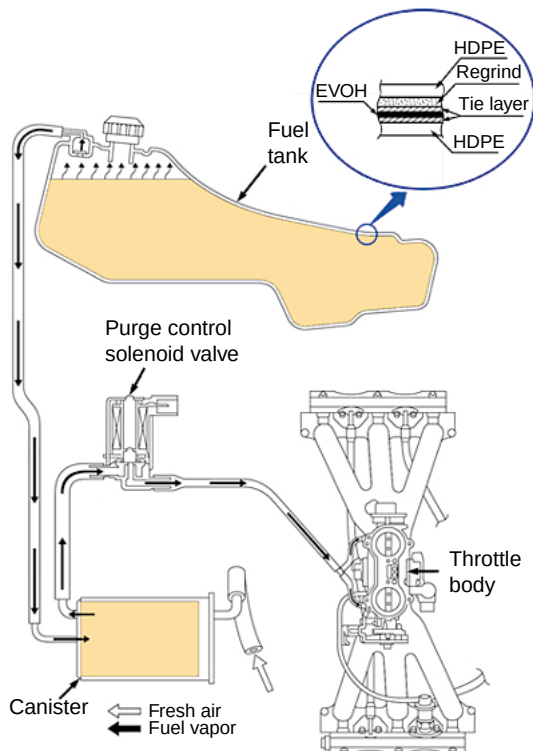


Fig. 34 Canister system for evaporative gas emission and plastic layer structure of fuel tank

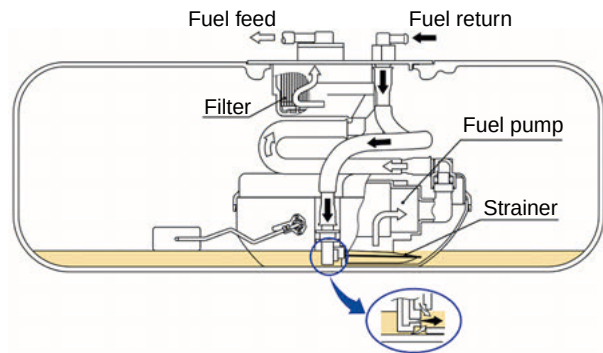


Fig. 35 Fuel pump system

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