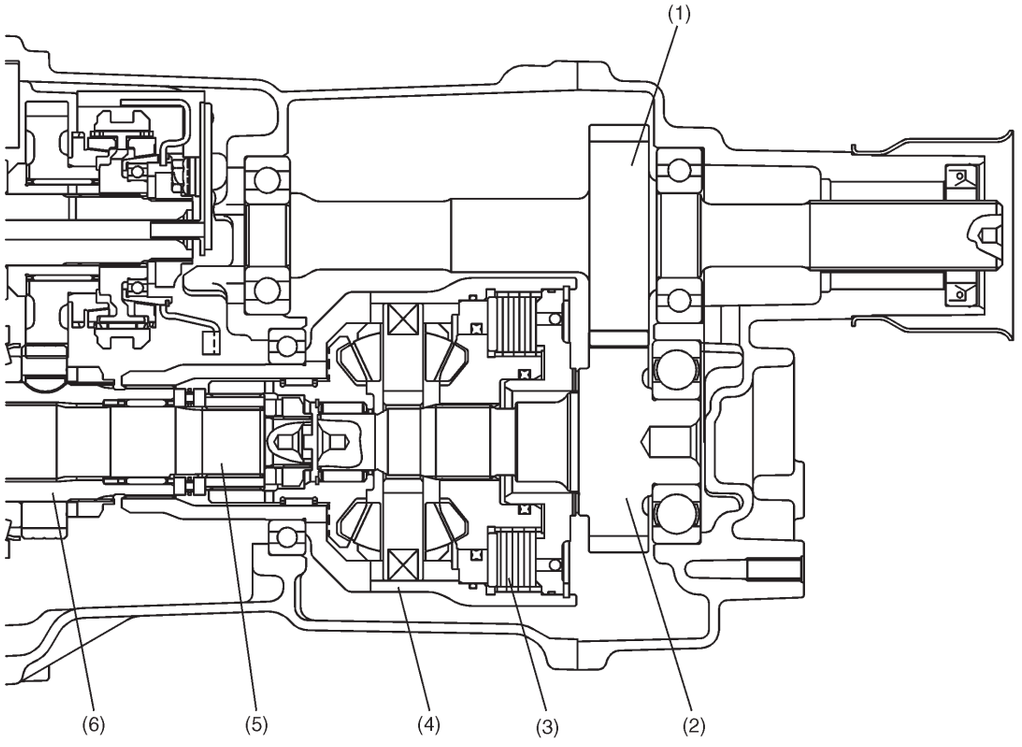
3. Center Differential

A: CONSTRUCTION

The center differential is composed of a mechanical differential and a viscous coupling and transmits the power from the transfer drive gear to the drive pinion shaft and the driven shaft.

The center differential has in general two functions; distributing engine torque to the front and rear wheel drive shafts equally, and absorbing the difference in rotating speed between the front and rear wheels during turns.
The differential with a viscous coupling, however, has the following function in addition to the above-mentioned functions. It generates viscous torque when spinning front or rear wheels have caused a rotating speed difference between the front and rear axles, limiting the differential action so that the optimum drive torque distribution may be attained.



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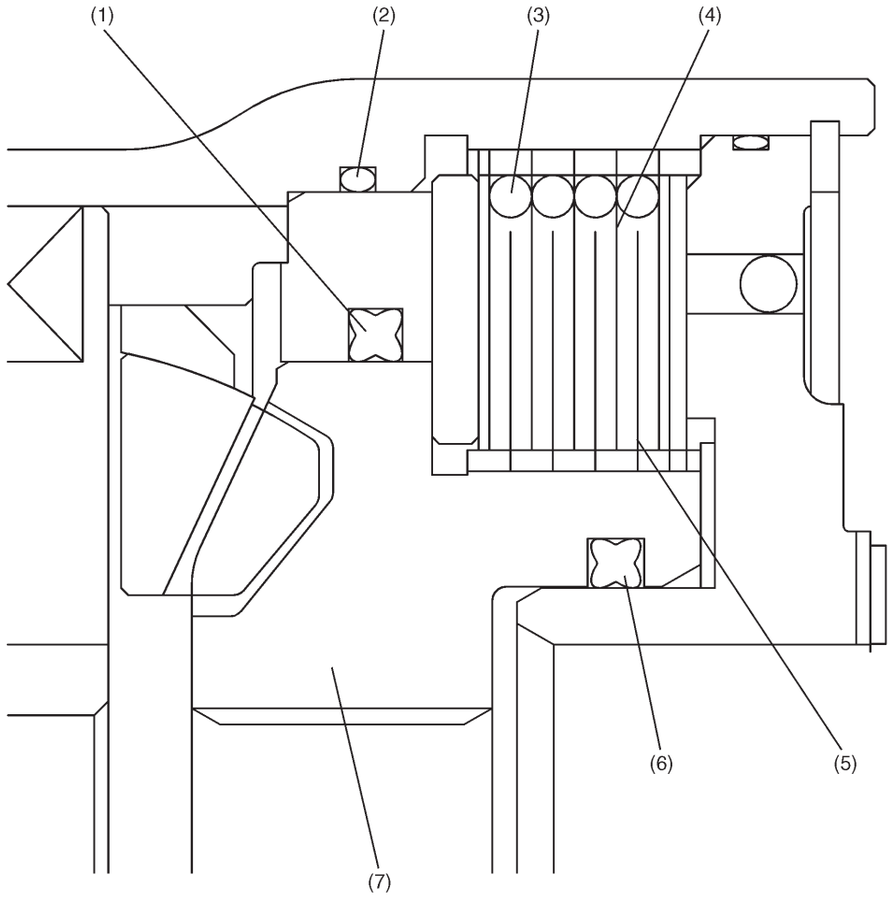
(1) Transfer driven gear
(2) Transfer drive gear
(3) Viscous coupling
(4) Center differential with viscous coupling
(5) Drive pinion shaft
(6) Driven shaft

B: MECHANISM OF VISCOUS COUPLING

The viscous coupling housing contains a number of inner and outer plates which are arranged alternately. The inner plate has its internal perimeter fitted to the external side gear (rear) splines while the outer plate has its external perimeter fitted to the internal center differential case splines. A spacer ring is provided to position the perimeter of the outer plate. The inner plate has no spacer ring and moves slightly between the adjacent outer plates, along the side gear (rear) splined in the axial direction.

A mixture of silicone oil and air is sealed in the space inside the center differential case. An “X” seal ring prevents silicone oil from entering the transmission. This could occur when silicone oil is highly pressurized due to an increase in rotating speed difference between the front and rear wheels.



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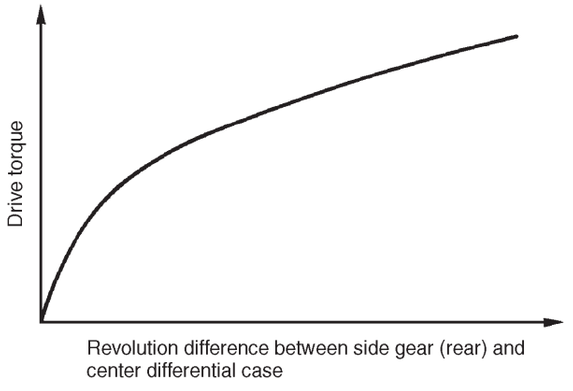
(1) X-ring
(2) O-ring
(3) Spacer ring
(4) Outer plate
(5) Inner plate
(6) X-ring
(7) Side gear (rear)

1. TORQUE CHARACTERISTICS

When a difference in rotating speed between the center differential case and the side gear (rear) occurs, a viscous shearing force is generated in the silicone oil placed between the outer and inner plates. The torque is then transmitted by the silicone oil between the center differential case and the side gear (rear).

The greater the difference in rotating speed between the center differential case and the side gear (rear), the greater the shearing force of the silicone oil. The relationship between the torque transmission and rotation speed difference is shown in the figure. As can be seen from the figure, the smaller the rotating speed difference, the lesser the torque transmission and the differential-action.



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2. “HUMP” PHENOMENON

Silicone oil is heated and expands as differential action continues. This crushes air inside the viscous coupling so that the silicone oil “charging rate” will increase. As differential action continues, internal pressure will abruptly increase so that inner and outer plates (alternately arranged) come in contact. This causes quick torque transmission to occur, which is called a “hump” phenomenon.

The “hump” phenomenon eliminates the rotating speed difference between the center differential case and side gear (rear) (which results in a state similar to “direct coupling”). This in turn decrease internal pressure and temperature. The viscous coupling returns to the normal operation. (The “hump” phenomenon does not occur under normal operating conditions.)

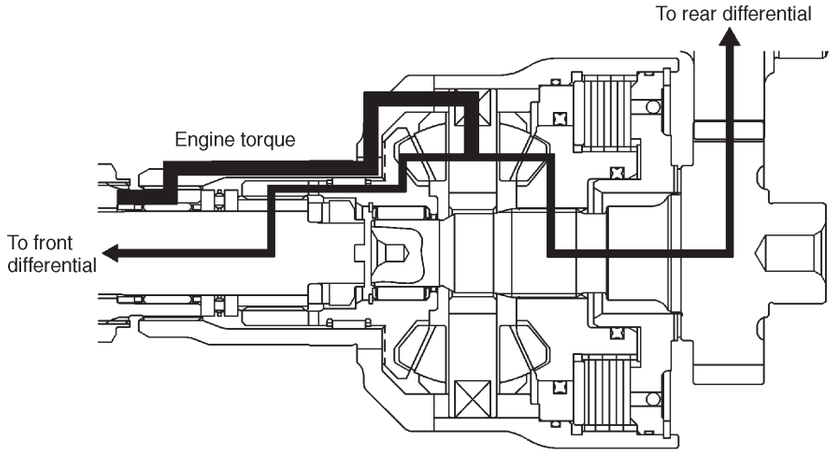
C: FUNCTION

During normal driving (when there is no speed difference between the front and rear wheels), the center differential delivers drive power to the front and rear wheels at a torque ratio of 50:50.

When a rotating speed difference occurs between the front and rear wheels, the center differential action is controlled by viscous coupling so that optimum drive forces are automatically distributed to the two.

1. DURING NORMAL DRIVING

During normal straight driving (on flat roads at constant speed), all four wheels rotate at the same speed. The center differential delivers engine torque to the front and rear drive axles. The viscous coupling does not perform the differential-action control because there is no rotating speed difference between the front and rear drive shafts.



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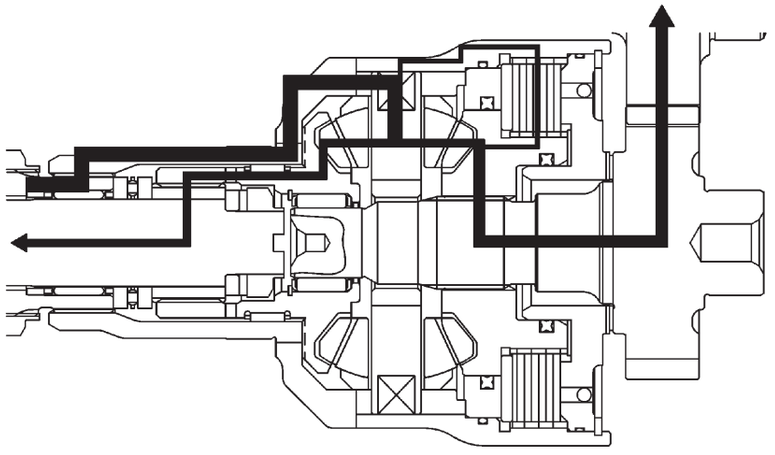
2. DURING TURNS AT LOW SPEEDS

During turns at low speeds, a rotating speed difference occurs between the front and rear wheels, as well as the left and right wheels. In other words, the front wheels rotate faster than the rear wheels. When there is a small rotating speed difference (when vehicle speed is low), the center differential acts to absorb the rotating speed difference, making it possible to drive smoothly.

Although a slight rotating speed difference is transmitted to the viscous coupling, less torque transmission occurs because of the small rotating speed difference.



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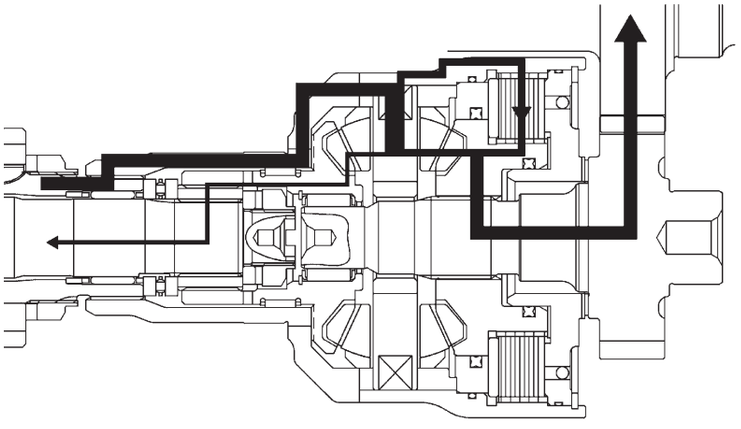
3. DRIVING ON ROUGH ROAD AND LOW "μ" ROAD

● When front wheel is on slippery surface

When the front wheels begins to spin during rough-road driving, the rotating speed difference between the shafts is increased by the differential's action. At this point, the viscous coupling delivers large torque to the differential on the side which is not spinning. In this way, driving stability on rough roads is increased.



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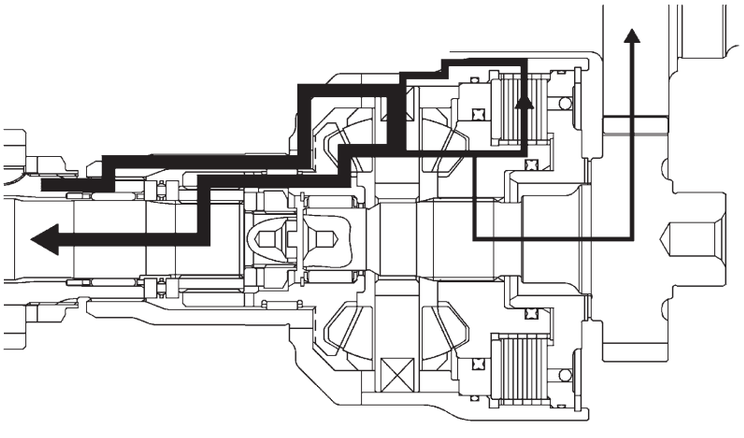
● When rear wheel is on slippery surface

During rapid acceleration from standing starts on a slippery (low "μ") road, front and rear wheel weight distribution changes. When the rear wheels begin to spin, the rotating speed difference between the two shafts increase simultaneously. This causes the viscous coupling to activate to that more torque is transmitted to the front wheels than to the rear. In addition, the center-differential's action is also restricted. In this way, acceleration performance during standing starts on low "μ" roads is greatly enhanced.



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