6-Disc In-dashboard CD Changer Deck

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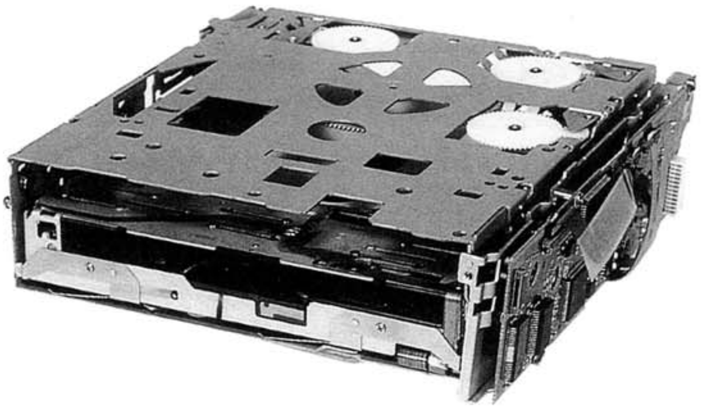

In recent years, sales of disc media equipment for cars have been growing sharply. In this sector, sales of CD players have also been brisk, particularly those with the changer feature which can store, select and play CDs. As popular as CDs have been, they have had their disadvantages: They are too big too fit in any place other than the trunk, and changing CDs has been troublesome for the user.
Accordingly, users of car CD players have voiced their desire for more compact units that can be mounted in the center console of a car.
Fujitsu Ten has worked to fulfill the needs of our customers by developing the DA-26, a 6-disk changer that fits in the console.
This paper outlines the DA-26 CD changer and describes its features.

1. Introduction

Recently, the car audio equipment market has experienced rapid growth in sales of compact disk (CD) players. Sales in this sector have been particularly noticeable for changer-equipped versions that can hold more than one CD. However, changer-equipped CD players tend to be bulky, making it necessary to installed them in the trunk of the car or under the seat. As a result, changing CDs has been troublesome. Users want an changer-equipped CD player that can be installed in the audio space in the center console, as is the case with conventional CD players.

To accommodate this need, Fujitsu TEN has developed an changer-equipped CD player that holds up to six CDs and that be installed in the center console, a first for the car audio industry. This paper is an explanation and an outline of the features of the CD changer deck DA-26 used with this CD player.

2. Purpose of development

The CD changer deck DA-26 was developed as the component of a CD player that can be installed in the audio space in the center console. When we embarked on our product development planning activities, we established three goals: (1) the CD changer deck size must be within 1 DIN; (2) the disk change operation must be easier than that for conventional models ("slot-in" method (a front loading manual insertion method) is used); and (3) the deck must have a capacity of six CDs, as is the case with conventional models (See Figure 1).

To succeed in developing a changer-equipped CD player having a size within 1 DIN, we succeeded in reducing the sizes of components significantly as compared with conventional CD changers. At the same time, we had to give consideration to the space for the deck control PC board, the space for the front operation section (including buttons and PC boards), and space for vibration tolerance (vibration amplitude). As indicated in Table 1, we succeeded in developing a CD changer deck much smaller than conventional models.

Table 1 Development specification

	Conventional model DA23	Developed model DA26
Outside dimensions (W × D × H)	150 × 237 × 58	150 × 165 × 42, compatible with 1 DIN size
CD capacity	6	6
CD loading method	Magazine loading	Slot-in

There are two methods for loading CDs: magazine loading and slot-in. We adopted the slot-in method because operation using this method is easier.

Figure 1. In-dashboard CD changer assembly (without the top cover)

3. Overview

The DA-26 consists of five units as follows (See Figure 2):

(1) Chassis unit
(2) Stacker unit
(3) Shuttle unit
(4) Pickup unit
(5) Control PC board

The chassis unit is the base of the deck. All other units are assembled on the chassis unit. Motors for driving the shuttle and stacker units are also mounted on the chassis unit.

The stacker unit holds CDs. It moves vertically before a CD is loaded, unloaded, played, or exchanged with another CD.

The shuttle unit contains a disk loading/unloading mechanism and a pickup unit for CD playback. Before CD playback, the pickup unit is fed into the stacker unit. The motor for this operation is mounted on the shuttle unit.

The pickup unit works for CD playback. Its components include an optical pickup, a disk clamp, and others.

The control PC board contains all of the circuitry required for deck control, including a microcomputer for controlling deck operation and a signal processor for reading CDs.

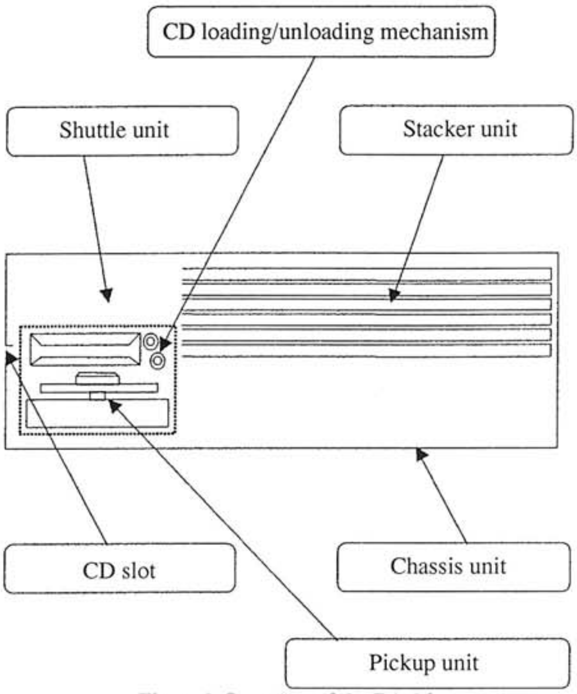

Figure 2 Structure of the DA-26

4. Operation

The DA-26 is designed so that the stacker splits to allow the pickup unit to be inserted between the split parts of the stacker when a CD is to be played. This design has made it possible to achieve the targeted small size.

The rest of this chapter explains the newly developed operation method used in the DA-26.

4.1 CD insertion

The steps for inserting a CD into the stacker are as follows:

(1) The stacker moves until the height of the CD slot matches the height of the desired stacker (See Figure 3).

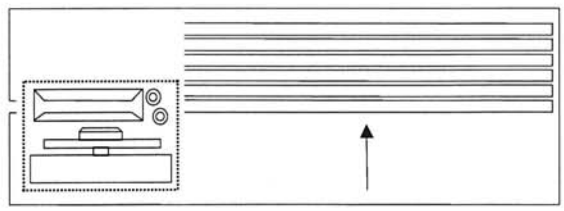

Figure 3. Insertion of a CD (stacker unit move)

(2) When the CD is detected by a sensor, it is adsorbed by rotating rollers (See Figure 4).

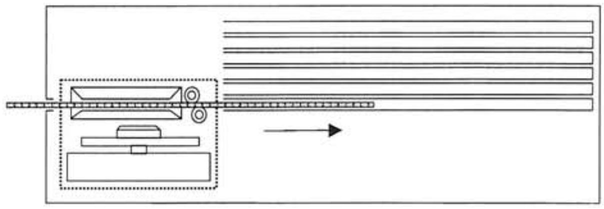

Figure 4. Insertion of a CD (suction)

(3) When the rollers separate from the CD, a push lever pushes the CD into the stacker. When complete insertion of the CD is detected by a sensor, the rollers stop rotating (See Figure 5).

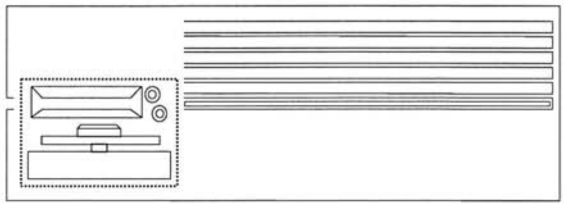

Figure 5. Insertion of a CD (completion of insertion)

4.2 CD ejection

The steps for ejecting a CD are as follows:

(1) The stacker unit moves until the height of the CD slot matches the height of the desired stackerb (See Figure 6).

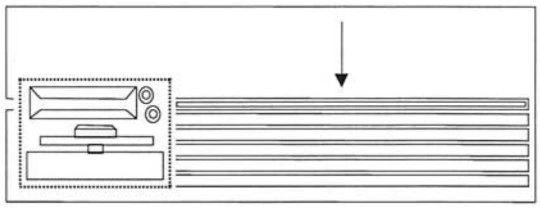

Figure 6. Ejection of a CD (stacker unit move)

(2) A push lever pushes the CD until the CD can be fed with rollers. The rollers then begin to rotate to feed the CD out of the stacker (See Figure 7).

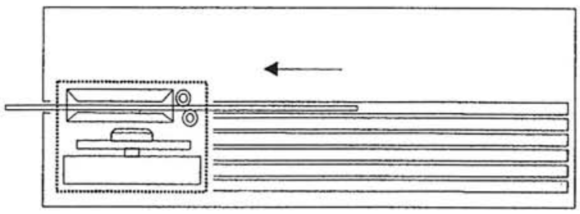

Figure 7. Ejection of a CD (CD feed)

(3) When complete ejection of the CD is detected by a sensor, the rollers stop rotating.

4.3 CD playback

The steps for playing a CD are as follows:

(1) The shuttle unit moves to the height of the desired CD (See Figure 8).

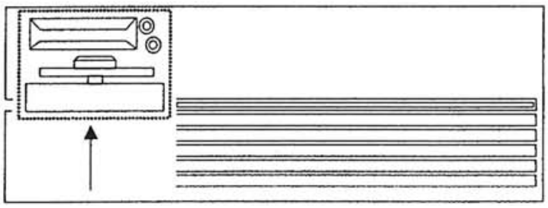

Figure 8. Preparation for playback (shuttle unit move)

(2) The stacker splits (See Figure 9).

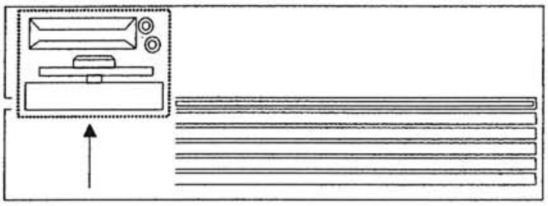

Figure 9. Preparation for playback (stacker unit split)

(3) The pickup unit is inserted between the split parts of the stacker unit (See Figure 10).

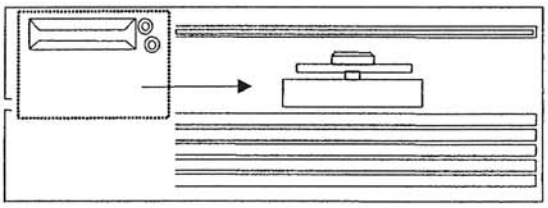

Figure 10. Preparation for playback (pickup unit insertion)

(4) The stacker unit descends and the CD is clamped to the turntable (See Figure 11).

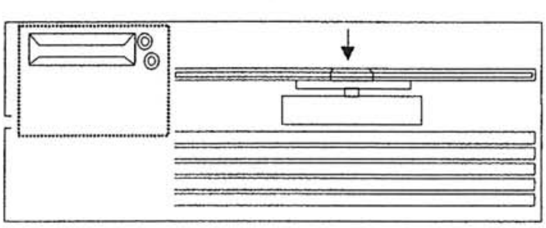

Figure 11. Preparation for playback (CD clamping)

(5) The pickup unit (together with the CD contained in it) is pulled forward (See Figure 12).

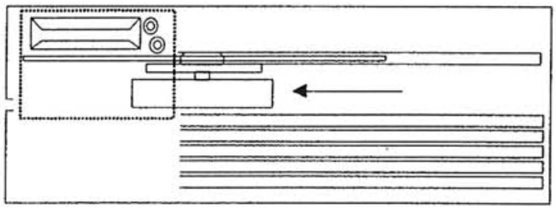

Figure 12. Preparation for playback (CD pulling)

(6) The stacker moves up and the CD begins to turn for playback (See Figure 13).

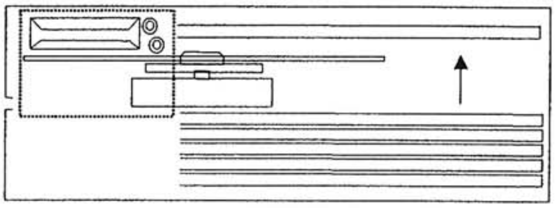

Figure 13. Playback (stacker ascent for playback)

5. Structure

These units are structured and combined to perform the operations explained in the preceding chapter. The individual units are explained in detail below (See Figure 14, 15).

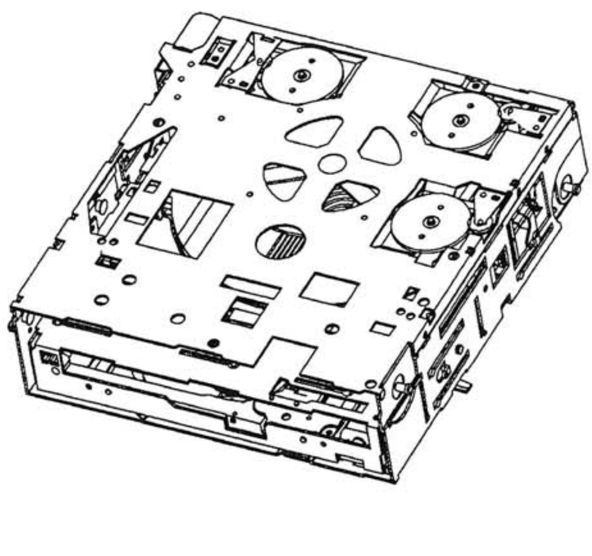

Figure 14. Exterior of the deck assembly

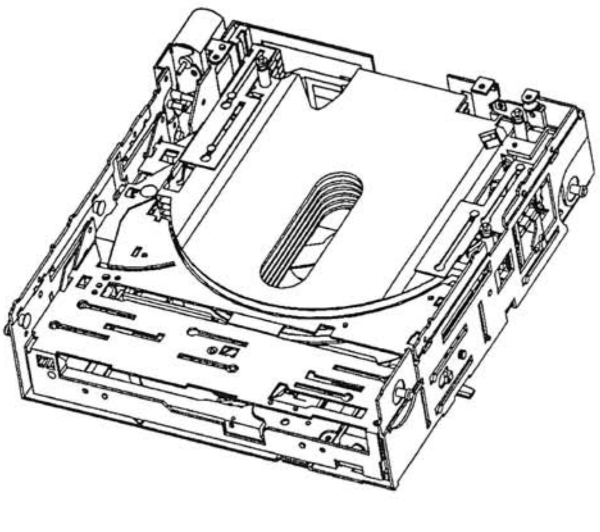

Figure 15. Exterior of the deck assembly without the top chassis

5.1 Chassis unit

The chassis unit has left and right stepped levers on which the shuttle unit is mounted (See Figure 16). The shuttle unit ascends or descends when these levers are moved forward or backward. A stepper motor is used to drive the stepped levers. The motor is also used to move the lever for opening or closing the front door.

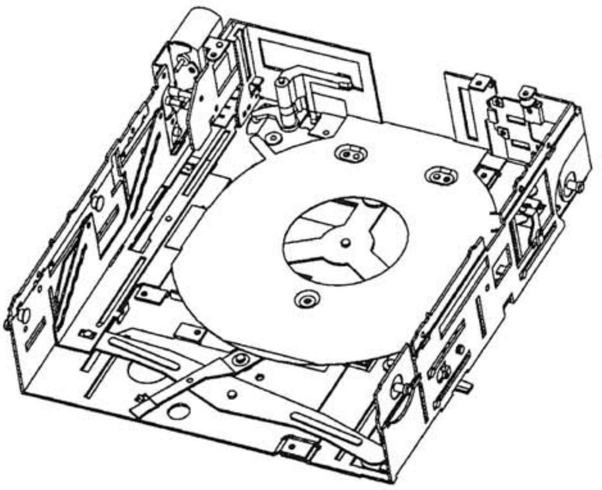

Figure 16. Chassis unit

For disk ejection, the stepper motor drives a push lever which moves the CD from the stacker to the insertion/ ejection mechanism in the shuttle unit.

The ascending/descending motor moves the stacker unit vertically via gearing attached to the top chassis. The vertical level of the stacker unit is sensed by a sliding-contact resistor (potentiometer).

5.2 Stacker unit

The stacker unit holds CDs (See Figure 17). It is fitted with a selector lever which determines the position at which the stacker unit splits. A special coating is applied to the surface of the stackers to protect the CDs contained in the stackers (See Figure 18).

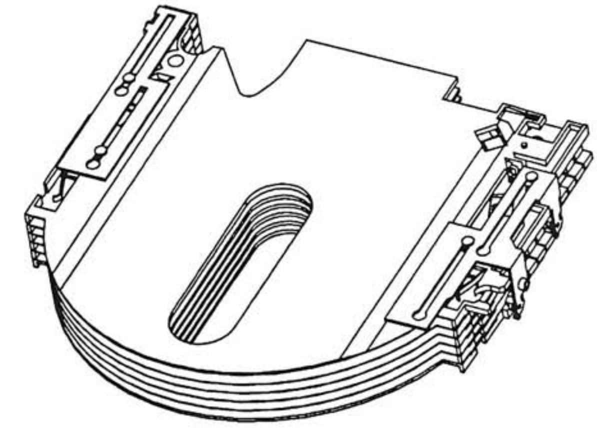

Figure 17. Stacker unit

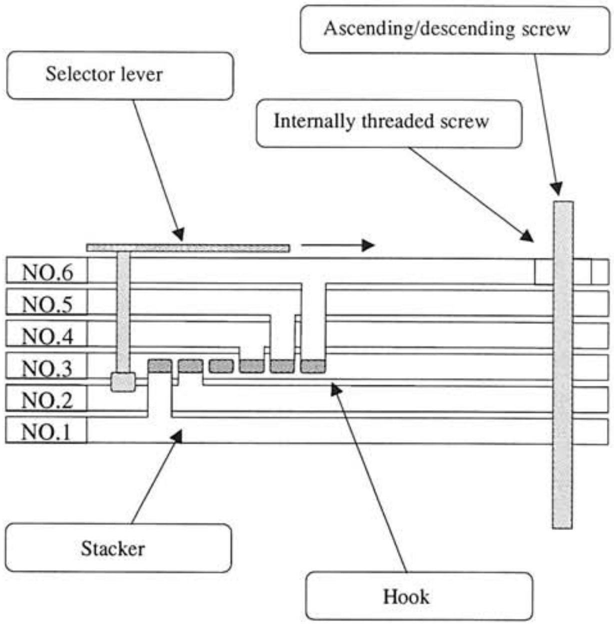

Figure 18. Selector lever

For inserting a CD into, or ejecting it from a stacker, it is necessary to adjust the height of the stacker (having the targeted number of CDs) to that of the CD slot. In this case, the stacker unit moves vertically without being split. Driving the ascending/descending motor while the selector lever is engaged with the hook of the first stacker causes the ascending/descending screw to turn, thereby moving the stacker unit vertically (See Figure 19).

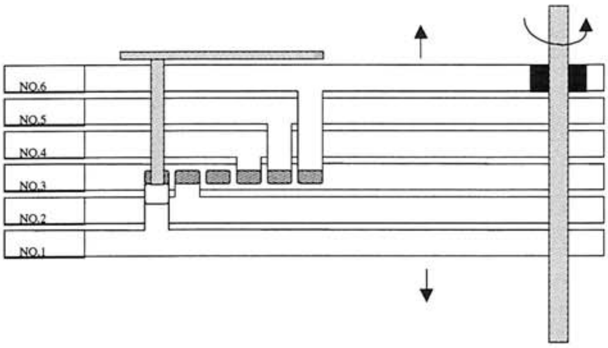

Figure 19. CD insertion/ejection

Before the pickup unit can be inserted into the stacker unit to play a CD, the stacker unit must be split. In this case, the selector lever is moved until it is engaged with the hook of the stacker with the appropriate number, then the ascending/descending screw is turned (See Figure 20). The selector lever is linked with the stepped lever which moves the shuttle unit vertically. Therefore, when the shuttle unit is moved vertically to the desired level, the selector lever moves to the desired stacker hook in synchronization.

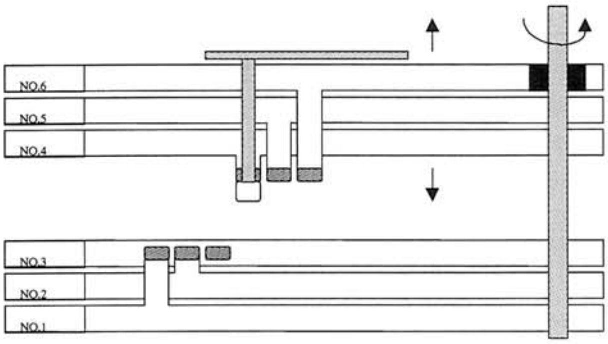

Figure 20. Playback (of the fourth CD)

Information about the height of a stacker can be obtained with a sliding-contact resistor (potentiometer) (See Figure 22). A voltage of 5 V is applied between the terminals of the sliding-contact resistor and the output of the potentiometer is fed to the A/D port on the control microcomputer (See Figure 21).

The sliding-contact resistor used in the DA-26 can detect 25 mm of travel (a full stroke). Since the A/D resolution of the microcomputer is 8 bits, the control accuracy is 0.098 (= 25/28) mm/bit. This means that height control can be achieved with an accuracy of about 0.1 mm.

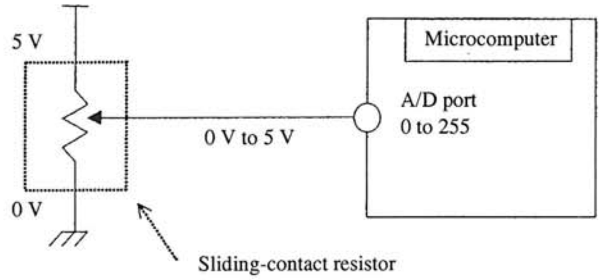

Figure 21. Equivalent circuit

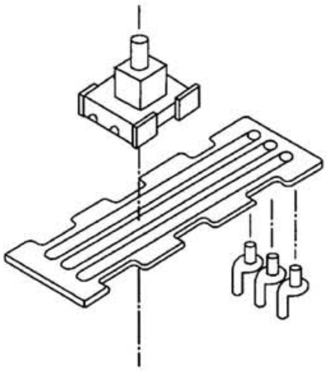

Figure 22. Sliding-contact resistor

5.3 Shuttle unit

The shuttle unit consists of a mechanism for inserting a CD into, or ejecting it from a stacker and a mechanism for inserting the pickup unit into, or removing it from the stacker unit at playback (See Figure 23). For CD insertion/ejection, rollers provided at the front of the shuttle unit are driven by the inserting/ejecting motor. The pickup unit can also be moved forward and backward by running the inserting/ejecting motor after a planetary gear is switched.

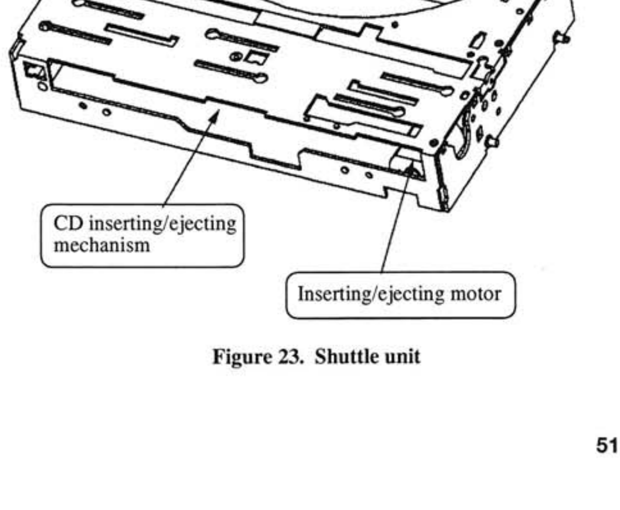

Figure 23. Shuttle unit

5.4 Pickup unit

The pickup unit consists of a pickup for CD playback, a spindle motor (for CD rotation control), and a feed motor which moves the pickup to the playback position on the CD at track search (See Figure 24).

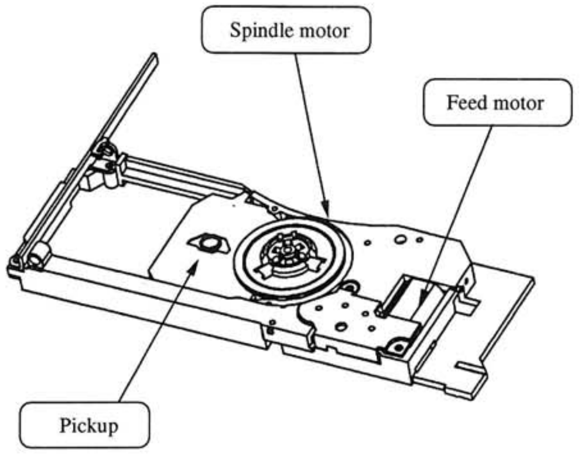

Figure 24. Pickup unit

5.5 Control PC board

The control PC board containing circuit for deck control had to be installed on the side of the deck and had to be very small to achieve the purpose of a 1 DIN size (See Fifuew 25). This means that it was necessary to design the control PC board, including the relief holes for the eight screws (M5) used to install the deck on the vehicle, to be of less than one-third of the area of the control PC board in conventional models.

The desired size was achieved by using a multilayer (four-layer) PC board and selecting small components. Table 2 compares the developed control PC board with a conventional control PC board.

Table 2 Control PC board compared with a previous model

	Conventional model DA-23	Developed model DA-26
Number of PC boards	3 (main, preamplifier, filter PC boards)	1 (integrated PC board)
Size (W × D)	100 × 115 (main), 70 × 75 (preamplifier), 115 × 40 (filter)	150 × 47
Total area	21350 mm^2	7050 mm^2
Number of layers	2	4

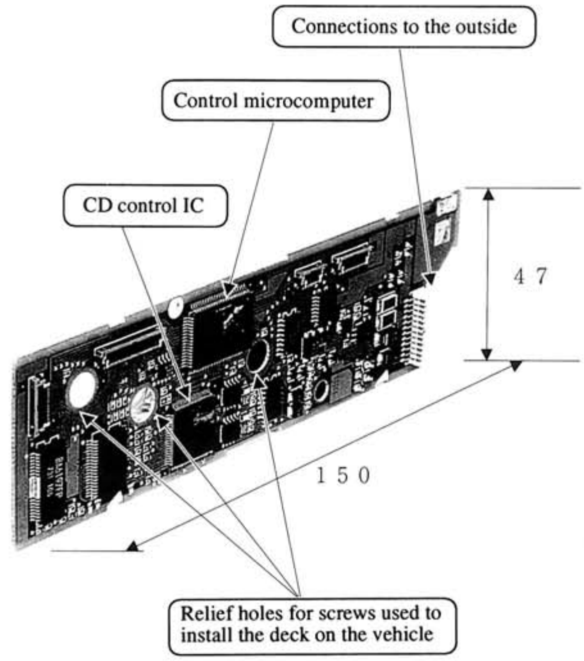

Figure 25. Control PC board

6. Vibration-proof design

Since all car-mounted CD players are always exposed to the effects of vehicle vibration, a vibration-proof design is essential for reliable playback. In general, the entire deck is isolated from the mounts on the vehicle (floating deck) by using springs and dampers so as to reduce vibration transmitted to the pickup. For the DA-26, we developed a small, high-performance damper and installed shock protection buffer. As a result, the vibration resistance of the deck are superior (See Figure 26).

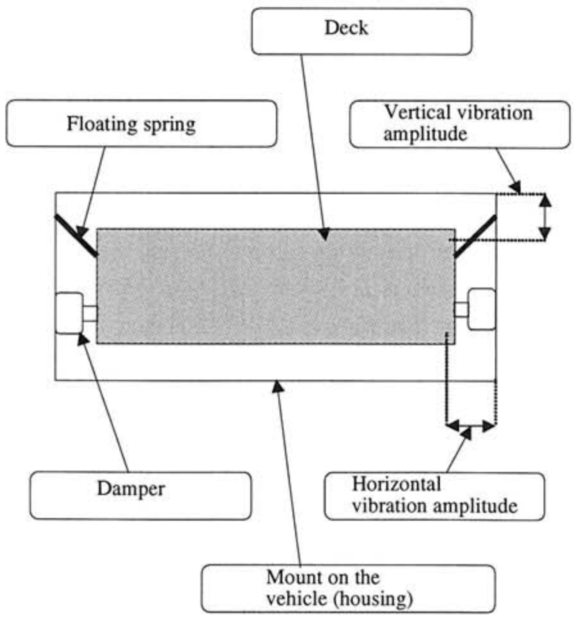

Figure 26. Vibration-proof structure

6.1 Shock protection buffer

The developed high-performance damper assures superior vibration resistance that is sufficient for normal use conditions. However, whenever a vehicle runs on an unpaved road at high speeds, travels over large bumps (such as reflective lane markers) while running at high speeds, or encounters similar unusual conditions, the CD player may skip.

To prevent skipping even under such unusual conditions, the DA-26 is our first CD player to use shock protection buffer incorporating an electrical means of improving vibration resistance.

While sound data from the CD is being played, it is also stored in the shock protection buffer. When a shock occurs and data being read from the pickup is interrupted, data from the buffer continues to be supplied to the sound system. Normal reading is restored before the contents of the buffer are used up. In this way, continuous, skip-free playback is assured (See Figure 27 - 29).

The storage capacity in terms of time is determined by the capacity of the RAM contained in the circuit. Since the DA-26 uses 4 megabytes of DRAM, 2.5 seconds of sound data can be stored in the shock protection buffer (See Table 3).

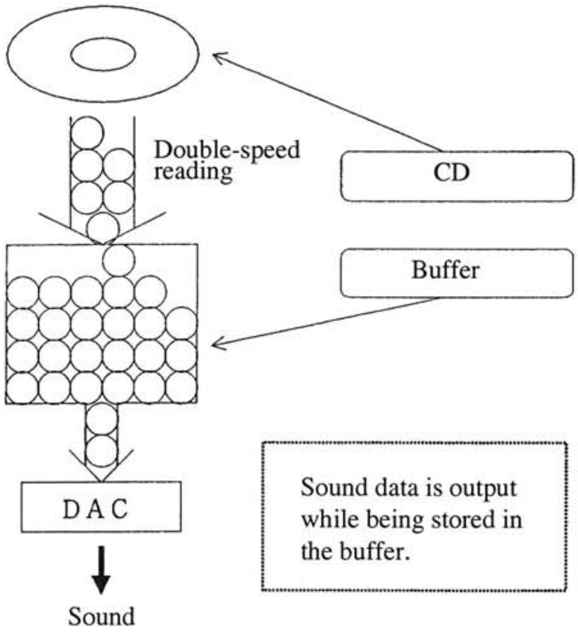

Figure 27. Shock protection buffer (ordinary playback)

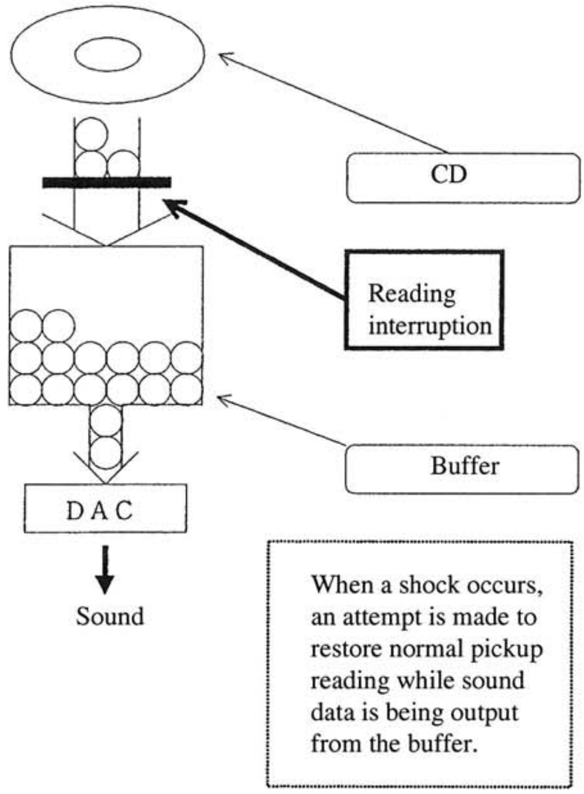

Figure 28. Shock protection buffer (how it works when a shock occurs)

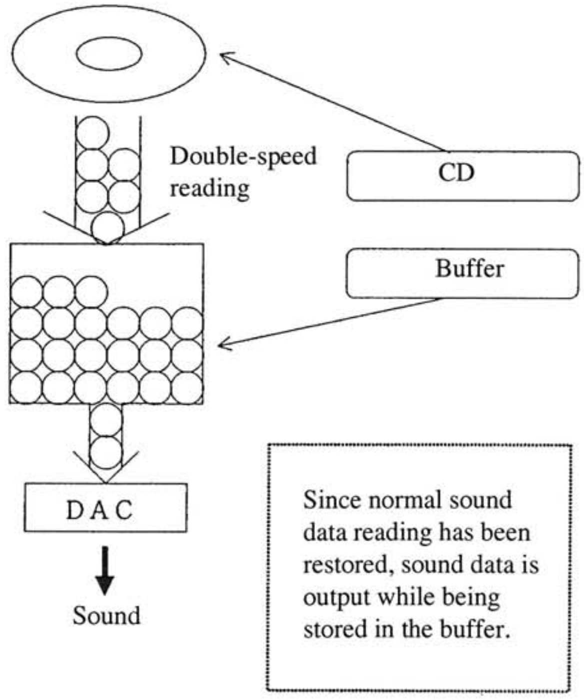

Figure 29. Shock protection buffer (how it works when normal reading is restored)

Table 3 Effect of shock protection buffer

	Number of sound skips	
	Without buffer	With buffer
Unpaved road	3	0
Undulated road	2	0
Passing over reflective lane markers	1	0

Vehicle speed: 40 km/h

7. Conclusion

The CD changer deck DA-26 developed this time has been explained above.

Using a lot of new technology and mechanisms in addition to technology accumulated in the past, we were able to achieve the target size equivalent to 1 DIN.

We plan to develop this product further so that it can support new media and satisfy diversifying user needs.

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