The development of AVN (Audio,Visual and Navigation) Unit incorporating DVD, CD and MD drives

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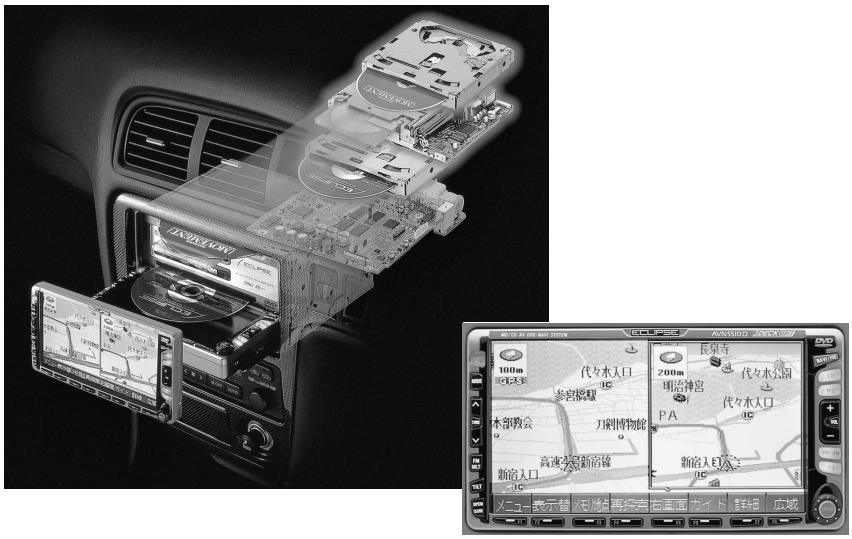

Abstract

The availability of car navigation systems has led to continued and rapid market growth. Fujitsu Ten has cultivated a new navigation market with the integration of audio/visual and navigation functions into one unit. Responding to the strong demands of market , we have developed as pioneer the AVN unit that encompasses DVD,CD and MD into double DIN size with small pakaging technology.

In this paper, we will discuss (or show?) the details of technologies for double DIN size package that are mechanical engineering, Heat control tech, Thin deck engineering, Reducing the digital noise tech.

1. Introduction

Navigation units have become popular in a form that contributes to safe driving. In 1995, our company developed an AV (AudioVisual) unit and made system connectivity with the external navigation unit.

In 1997, we preceded other companies in developing an AVN unit with built-in navigation (incorporating AM, FM, CD, CS, and navigation); and in 1999 we added built-in TV tuner,and MD deck instead at CS.

With the rapid growth of the navigation market recently, market demand has risen for higher performance (DVD support) and improved audio functions (CD playback during navigation). Current AVN units serve also as drives for CD-ROMs and music CDs; consequently, during navigational use, it has not been possible to play CDs and thus meet market demand.

Recently, during the development of a DVD-supporting AVN unit, and with the cooperation of the manufacturer who was in charge of the navigation unit development and automobile manufacturers who are our customers, we were able to manufacture the world's first AVN unit with built-in 6.5-inch wide TFT that incorporates three drives (DVD-ROM, CD, and MD). This achievement satisfies market demand and differentiates the product from that of other companies. This report will explain the product's development.

2. Product overview

2.1 Basic configuration

Fig. 1 shows the overall configuration.

2.2 Functions

- AM/FM/FM multiplex (DARC:Data Radio Channei)
- TV (stereo/bilingual broadcasting, 4-input antenna diversity control function)
- CD player (music with CD-TEXT support)
- MD player (music with title display support)
- VTR external input support
- Infrared remote control support
- Built-in DSP (sound field control, graphic equalizer)
- 35W 4-channel power amp
- Preout output for external amp (4 channels + woofer)
- 6.5-inch wide TFT display
- Power full-tilt function
- Navigation with DVD-ROM support
- FM-VICS/D-GPS
- Voice recognition

The following equipment can also be connected and controlled as part of system expansion:

- CD changer and MD changer
- 3-media VICS
- Hands-free set with MONET (mobile network)

3. Development issues

3.1 Installation for 2DIN size

The greatest issue related to the integration of the three drives is the incorporation of all functions into the 2DIN size (W178 D165 H100).

In contrast to conventional models, an advanced-technology DVD drive has been added. To absorb this addition, it was necessary to resolve the technical issues described below.

3.2 Measures for heat

Even under normal conditions, the AVN consumes 50 watts of power; and in extreme conditions can consume over 100 watts. With DVD support, an additional 13 watts is consumed, making it necessary to implement even greater measures for heat than in the past. Thus, during product development, measures were approached from two aspects: reduction of heat generation and improvement of heat radiation efficiency.

3.3 Measures for noise

To establish the 2DIN size, the gap between each

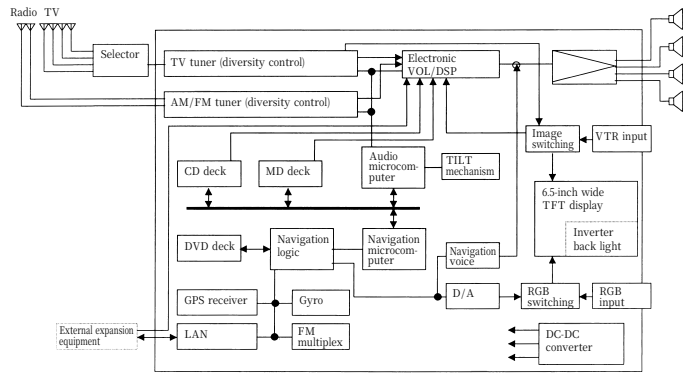

Fig.1 System block diagram for AVN with 3 deck

part has been minimized, producing an extremely high-density layout. As a result, mutual interference between parts and noise were big issues. Noise is thought to be caused by effects on the equipment's internal receiver and by unnecessary noise radiation on the equipment exterior.

This problem was solved by strengthening the shield, reducing device noise, and improving PCB design technology.

4. Compactness

To structurally materialize a three-drive AVN unit with DVD support, the internal components were made thinner.

4.1 Single-deck model

A thin DVD drive was newly developed; and using that as a base, a thin CD drive was simultaneously developed.

Similarly, a thin MD drive was newly developed, using an existing model as a base.

Drive details are explained in Chapter 7.

4.2 PCB assembly

Height limits for components on the audio board were reduced to 5.6 mm from the 8.2 mm for conventional models.

Materialization measures included reducing the height of parts by adopting reflow parts, and increasing the density by adopting two-sided reflow.

For power IC and other parts with lead wire, the spot reflow soldering method was newly developed and adopted as a new work method.

4.3 TV tuner module

The front end of existing-model TV tuners included developing circuit components on the PCB. However, by organizing everything on a single vertical low-height-type module, it has become possible to arrange everything in a limited amount of space even with severe height limits.

And because it was modularized, the dedicated area of the TV tuner unit on the board was reduced from 4,400 m^2 to 1,670 m^2, thus contributing to an improvement in packaging density.

4.4 Display tilt mechanism

4.4.1 Gear unit

The gear unit, which is arranged on the right side of the product, was 47.1 mm in height and 20 mm in thickness in the existing model; thus, its volume was large and the layout of its components was restricted because of interference with the board. As a way to improve this situation, the height was reduced to 39.5 mm and the thickness remained at 20 mm, giving it a more compact size; and its volume decreased from 120,000 mm^3 to 90,000 mm^3, achieving a reduction of about 27%, which contributed to the board having a greater effective area.

(See Figs. 2 and 3.)

① Reexamined the gear layout and structure.

② Changed the shape of connection lever for the display.

③ Changed the operation auxiliary spring from a tension spring to a torsion spring.

④ Reduced the size of the motor by reexamining the worm gear's lead angle and by directly connecting the display connection lever.

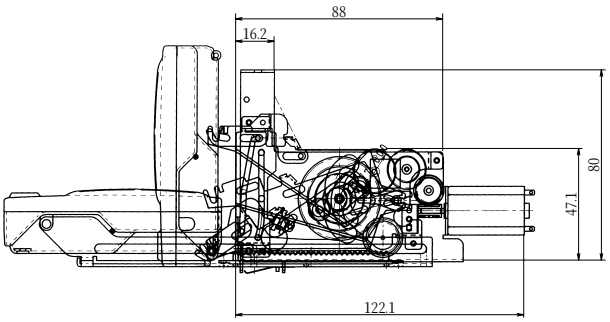

Fig.2 Existing gear unit mechanism

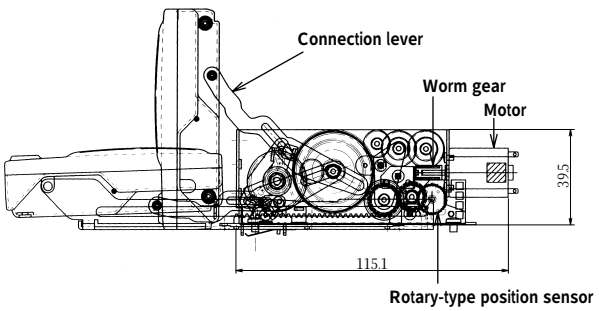

Fig.3 New gear unit mechanism

4.4.2 Position sensor for detecting position of tilt tray

Display tilt angle changes are executed from the tray that is arranged at the base of the product; however, detecting the angle of the display during an operation requires detection of the tray position.

In existing products, a sliding position sensor was positioned at the front of the product in a cut-out section of in the PCB (Fig. 4); but here, a rotary-type position sensor has been incorporated in the aforementioned gear unit (Fig. 3). As a result, there is no need to cut into the board, and the effective area has been expanded.

Further effects include a reduction in sensor cost and simplification of assembly during the manufacturing process.

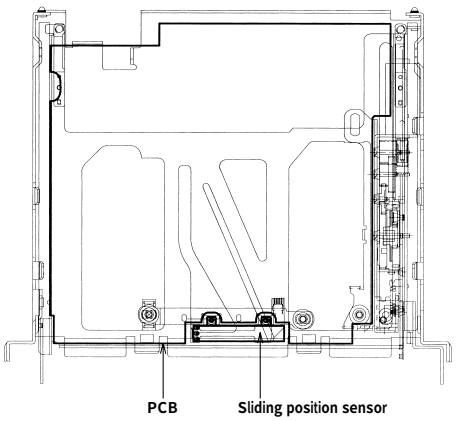

Fig.4 Current sliding position sensor construction

5. Measures for heat

Along with DVD-navigation support, more advanced functions, and higher density, the amount of heat generated inside the product also increases.

By taking measures such as those described hereinafter, we have been able to radiate heat and reduce the amount of heat generated. As a result, the product meets our in-house standards as well as the standards of the automobile manufacturers who are our customers. In other words, it meets the standards for rise in disc surface temperature and continuous operation in a high-temperature environment.

5.1 Reduction in amount of heat generated

5.1.1 DC-DC converter for power supply

A combined output DC-DC converter has been adopted to integrate the power supplies of the navigation unit logic circuit and drive.

With a conventional series regulator system, the lost power of a DVD drive power supply (8V/1A, 5V/0.5A) was 9 watts; but with the use of a DC-DC converter, a loss of 2.7 watts has been achieved, a reduction in lost power of 6.3 watts.

5.1.2 Support with each drive

To reduce the amount of heat generated by the drive, lost-power reduction measures such as those described below were implemented.

① Change in MD-drive motor drive system
A change from a linear system (8V/1A: 5W) to a PWM system (8V/0.5A: 2.5W) achieved a reduction of 2.5 watts.

② Change in DVD drive operation
Logic was added so that if there is no lead command for 30 seconds, deck operation stops and emitted heat is reduced.

5.1.3 Circuit control

① Drive supply power
The power supplies for the CD drive and MD drive were separated.
With this product, the CD drive and MD drive will not play back at the same time, so power can be supplied to each only when needed, unnecessary power consumption is limited, and heat generation is reduced.

② Radiation fan supply power
To reduce radiation fan drive power and minimize noise during fan operation, the use of two stages for the fan drive supply voltage was adopted for the first time.

A thermistor is installed to detect the product's internal temperature. When the power is turned on, the fan is off; but when an internal temperature of 40C is detected, the power supply provides 8.5 volts and the fan starts to operate at low noise.
Later, if the temperature rises, causing the internal temperature to rise to 65C or higher, the supply power will increase to 13.2 volts, increasing the fan output and cooling capacity.

Through these improvements, optimization of heat radiation effects and operating noise has been achieved.

5.2 Heat radiation

5.2.1 Positioning of heating elements

To improve radiation efficiency, PCB heating elements (power ICs, regulators, etc.) have all been positioned in the radiator area at the rear of the product. Fig. 5 shows a rear view of the product.

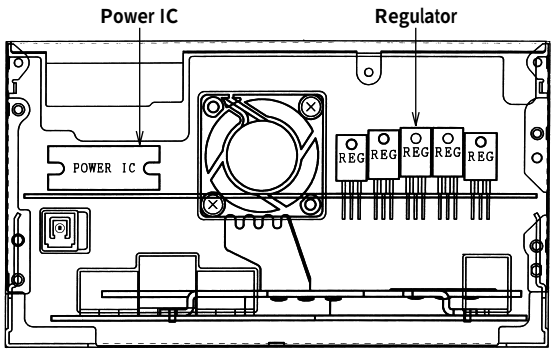

Fig.5 Back side view

5.2.2 Internal heat-conducting plate

Measures such as the following were taken to dissipate heat from PCB heating elements other than lead terminals (such as LSI circuits on a navigation board) that can be arranged in contact with a rear-panel radiator such as that described in the preceding section.

① Heat-conducting plate layout and structure

A 2-mm-thick aluminum board was installed between the DVD drive and navigation board, with the front end being positioned near the radiation fan installed on the product's rear panel.

Heat from the drive and navigation board is absorbed by the aluminum heat-conducting plate, released from the end to the product exterior via wind currents from the radiation fan, and radiated via temperature gradient. Fig. 6 shows the structure of an internal heat-conducting plate.

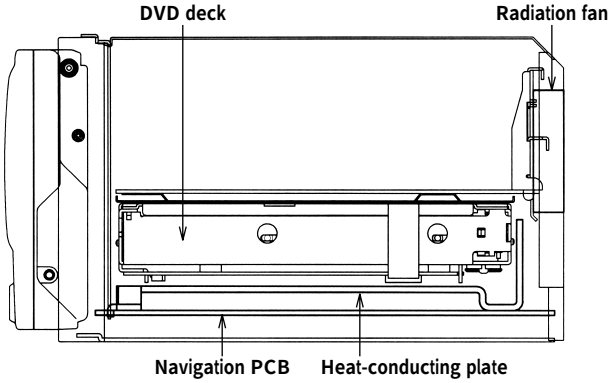

Fig.6 Internal heat sink construction

② Shape of heat-conducting plate

An LSI circuit on a PCB generates a large amount of heat. To prevent the performance of such LSI circuits from deteriorating due to the heat that they themselves generate, the high-efficiency structure shown in Fig. 7 was adopted. With it, the LSI circuit makes direct contact with a heat-conducting plate via a heat conduction seat.

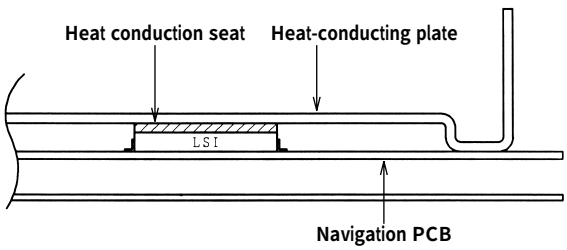

Fig.7 LSI heat control construction

To raise the heat radiation efficiency, the heat-conducting plate can be forced against the LSI circuit. But to reduce creep stress in the terminal area of the LSI circuit, the surface of the heat-conducting plate is dimpled (Fig. 8) to reduce the surface pressure acting on the surface of the LSI circuit. (Patent is pending.)

5.3 Results of rise in temperature

Thanks to the aforementioned measures, the rise in the surface temperature of each disk has been kept within the standard.

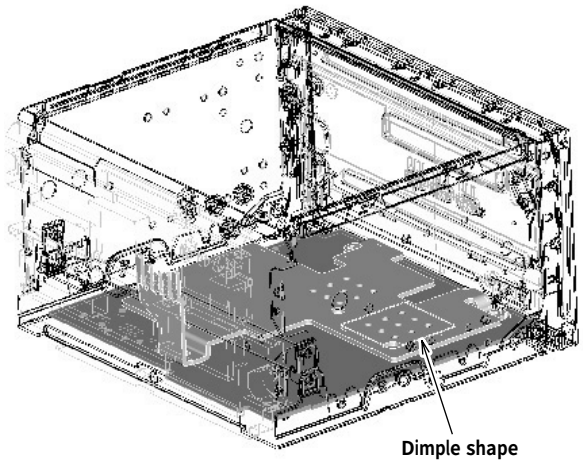

Fig.8 Dimple shape heat sink

• MD disc: 9.6C (meets standard with margin left)
• DVD disc: 4.2C (meets standard with margin left)

6. Measures for noise

An AVN unit contains noise sources as well as high-sensitivity receivers and low-level analog circuits that are affected by such noise sources. With all of these components arranged closely together within the same case, problems of mutual interference occur inside the equipment. Noise sources in digital circuits include navigation CPUs, audio CPUs, drive CPUs, drafting ICs, FM multiple decoders, DVD-ROM decoders, and vehicle-compartment high-speed LANs. Moreover, in power supply units as well, there are DC-DC converters and back light inverters; and with drive oscillations of from several tens of kHz to several hundred kHz, AM bands are affected. In the area of analog voice, there is DSP; and noise is generated during communication with a workpiece RAM. Finding a solution to this issue has been a difficult task.

On the other hand, the receiver was designed with extremely high sensitivity for vehicle installation; and the total gain from antenna input to speaker output is 120 dB.

The antenna input level is approximately 3 V, an extremely weak signal; thus, even very slight noise can cause great interference.

Measures that were adopted for noise include those described below.

① Six-layer audio board

• Utilize the internal-layer GND to create a shield effect (insert communications line between GND layers) and strengthen GND. Fig. 9 shows an image.

• Block the pattern area of the digital unit and power supply unit, and isolate the noise sources. Separate

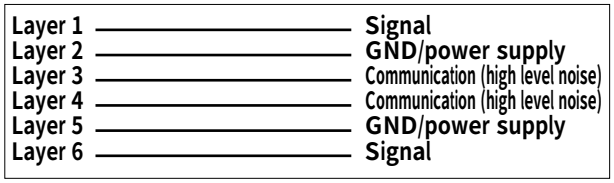

Fig.9 Audio P.C.B. layer construction

the patterns in each block, and mutually connect them in positions of minimum noise.
Fig. 10 shows an image.

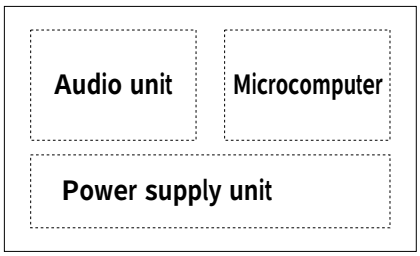

Fig.10 Audio P.C.B. layout

② Addition of shield plate in microcomputer and digital signal processor (DSP)
③ Addition of shield plate on solder side (measure for noise from navigation unit)
④ Strengthening of radio/TV antenna GND
⑤ Addition of communications line (between audio and navigation) EMI filter
⑥ Addition of shield plate (cover) on radio module solder side
⑦ Addition of spring ground plate from top cover to radio/TV module
⑧ Adoption of low-noise microcomputer (internal operation 5V3.3V)
⑨ Navigation board, DC-DC converter unit shield structure
⑩ Making of TV tuner into unit, and addition of box shield

7. Development of DVD drive

DVD-ROMs were first adopted as car navigation systems in 1997. Since that time, there has been a rapid shift from CD-ROM-supporting navigation systems to DVD-ROM-supporting navigation systems. Utilization of DVD's large capacity and high transfer rate has made it possible for navigation systems to achieve high functionality, high performance, higher screen detail, diverse communications, and high response, which is very appealing to users. However, DVD drives that have been adopted for DVD-supporting navigation systems up to now are 35 mm or more in thickness, making it difficult to materialize a three-drive AVN. To materialize a three-drive AVN, our company developed a revolutionary thin DVD drive mechanism, which will be described here.

Specifications of thin DVD drive (Fig. 11)
Size: W 140 mm × D 128 mm × H 23 mm
(Partial board only: H 26 mm)
Applicable disc: DVD-ROM (single layer)
DVD-ROM (dual layer)
CD-DA
CD-ROM
CD-TEXT
CD-R
Playback speed: DVD MAX2 (CAV playback)
CD MAX5 (CAV playback)
Communications system: ATAPI interface

7.1 Standardization of DVD/CD drive mechanism

During the recent development of the three-drive AVN, the allowable thickness of the drives was 23 mm for the DVD drive and 20 mm for the CD drive. As was true during the development of the DVD drive, it became necessary during the development of the CD drive to completely change the structure of the conventional CD drive in order to achieve the objective. When the DVD standards were created, consideration was given to their

Fig.11 Thin DVD deck DV-01

Fig.12 Thin CD deck DA-36

compatibility with CD standards; thus, the exterior dimensions of DVD disks and CD disks are the same.

The DVD drive mechanism and CD drive mechanism were thus given a common structure, and a thin drive mechanism was developed. As a result, the thickness of the mechanism was 23 mm for the DVD and 20 mm for the CD. Fig. 12 shows the appearance of the CD.

With the standardization of the basic structure, at least 90% of the CD drive and DVD drive system parts are commonly shared. The major differences are the pickup and PCB.

① Normally, DVD and CD pickups are different and the drive mechanism is often designed separately. Moreover, to ensure DVD playability, a skew adjustment mechanism is needed to adjust the optical axis so that the laser beam hits the disc perpendicularly. With this unit, a pickup with similar mounting dimensions was adopted and standardization of the pickup drive unit die was achieved by incorporating a skew adjustment mechanism into the motor mount.

② For the electrical circuit, a four-layer PCB of 1-mm thickness is used and low-height components (maximum of 2.5 mm) are installed on both sides, ensuring that the board thickness does not exceed 6 mm. This enables the CD PCB to be installed into a 6-mm-high space under the pickup drive. Since the size of the DVD circuit is about four times that of the CD, and since the DVD PCB does not fit into the same space as the CD, it was installed in the chassis unit under the drive.

③ Standardization produced the following advantages:

• Development period reduction and quality improvements were obtained by centralizing development power as compared to developing completely different mechanisms.

• In-car drive mechanisms are expected to meet severe standards for durability against temperature and vibrational impacts caused by the vehicle environment. Moreover, it is necessary to evaluate customer use under various conceivable conditions, and much effort is needed. Standardization has thus greatly reduced the number of evaluation items.

• The standardization of mechanism structure has greatly reduced costs incurred when mechanism dies are manufactured.

7.2 Structure

Conventional CD mechanisms were 28 mm in thickness. A new mechanism was developed, reducing the thickness to 20 mm.

With the disk tray system adopted for thin drives of notebook PCs, some models experience problems with shift lever interference when the disk tray is withdrawn to the front. For this reason, the CD/DVD disk insert/eject mechanisms installed in vehicles utilize a slot-insertion system by which a disk is inserted as is into a slot. Figs. 13 and 14 show the conventional drive structure and thin drive structure.

① For sound jump control, in-car mechanisms are made such that, during disk playback, the disk and pickup drive float from a fixed part and are supported by damping, which absorbs vibration. Moreover, to accurately center the disk on the turntable during an insertion/ejection operation, the floating unit locks in place. With a conventional unit, only the pickup drive unit floated; with this unit, however, the insertion/ejection unit is integrated into a thickness of 6 mm and installed in the pickup drive. As a result, the damper, which requires thickness, can be arranged in a corner, avoiding the disk and achieving a thinner product.

② In conventional models, slot space was secured by raising the clamper during insertion/ejection. With the new model, as the clamper is raised, the pickup drive mechanism area sinks into the floating range. This allows the lower space to be used effectively and slot-insertion space to be secured without increasing the thickness.

③ The ultra-thin clamper and clamp mechanism have reduced the upper space of the disk by 2.0 mm (patent pending).

7.3 Key device

The items that are most restricted by the thickness of the drive mechanism are the optical pickup and disk motor. The most difficult part of the initial development was the selection of the DVD optical pickup. Only large-size optical pickups for DVDs were available to withstand vehicle environments; there were no optical pickups that could achieve the DVD drive dimensions of 23 mm or less. Thus, with the cooperation of professional manufacturers, an optical PU that can withstand vehicle environments was jointly developed, using as its matrix a DVD optical pickup for notebook PCs. For both CD and DVD disks, a two-laser system that obtains an optimal signal has been adopted. To assure durability under high temperatures and performance under high and low temperatures, a long-life DVD laser was adopted and

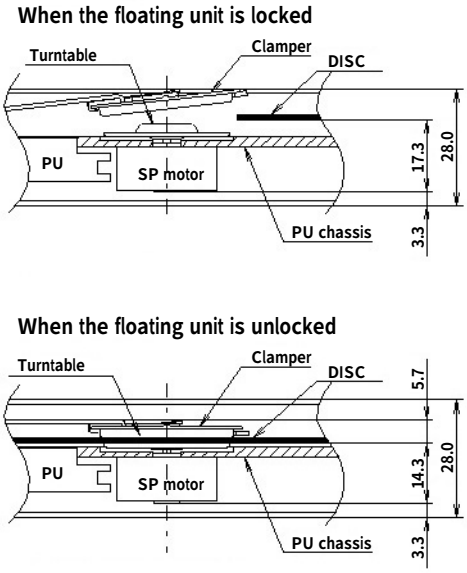

Fig.13 Conventional deck mechanism

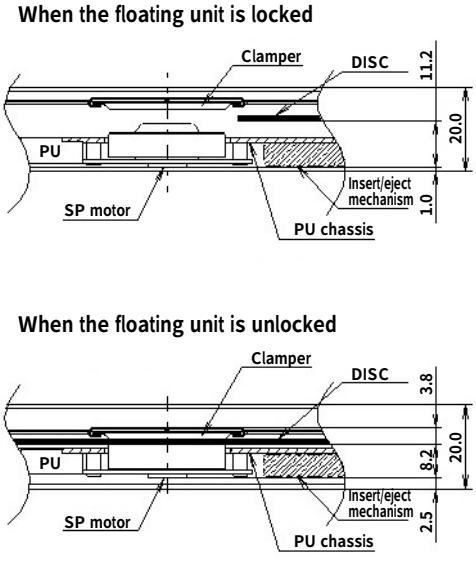

Fig.14 Thin(New) deck mechanism

improvements were made to minimize temperature changes in optical components under both high and low temperatures.

Moreover, the mount used for the CD drive pickup has dimensions that are similar to the DVD drive pickup. This achieves design standardization of the pickup drive mechanism.

Conventional CD pickup	thickness 12.4mm
⇩	
Thin DVD pickup	thickness 6.4mm
Thin CD pickup	thickness 6.0mm

Fig.15 Thin DVD pickup and thin CD pickup

The item that was most restricted by the thickness of the conventional CD drive mechanism was the spindle motor that rotates the disk. Conventionally, the structure was such that the turntable was press-fit into a standard brush motor, and the distance from the turntable surface to the motor bottom surface was 14 mm. With the adoption of a brushless system and integration of the turntable and motor rotor, a thickness of 7 mm have been realized. On top of that, motor durability and surface runout accuracy were improved.

Fig.16 Conventional CD SP motor and thin SP motor

8. Conclusion

The aforementioned newly developed technologies have made it possible to commercialize an AVN unit that incorporates DVD, CD, and MD drives.

Product sales aimed at automobile manufacturers began in the spring of 2000, while sales of our company's Eclipse brand began in July 2000.

Market ratings have been good, and the aim of product development has been achieved. The know-how gained during the development of this product will also be utilized in future models for an even higher level of product development.

Incidentally, this product was developed jointly with a cooperating manufacturer of the navigation unit. We wish to sincerely thank those automobile manufacturers

who provided development-related guidance and others who provided invaluable technical cooperation.

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