A New PCM Audio Disk Pickup Employing a Laser Diode*

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An improved semiconductor laser pickup for an optical PCM audio disk player is described. In order to raise the servo gain, a reduction in the size and weight of the optical system was tried through the use of a newly designed lens and a revised optical path. A unique simplified two-dimensional servo actuator without any spring for suspension was developed.

0 INTRODUCTION

Simplification and miniaturization are very important factors for the optical system of the laser PCM audio disk player to put the player into mass production and mass utilization. The conventional He–Ne laser pickup uses a rather complex optical system, comprising many optical parts such as mirrors, grating, galvanometer, etc., which are aligned in the optical path.

We have proposed [1] a new semiconductor laser pickup to overcome these disadvantages. The whole optical system, which was assembled in a tube of 38-mm length and 10-g weight, although substantially smaller and lighter than the conventional systems, was not yet quite satisfactory. The semiconductor laser weighing only 0.2 g suggested that an optical system of about 2 g could be developed. Besides, we expected that this lightweight optical system might permit the introduction of a new actuator structure without spring suspension.

Here we introduce an improved optical pickup for the PCM audio disk player.

1 DESIGN OF PICKUP

The targets of the development were as follows:

1) The optical system should be less than 20 mm in length and 2 g in weight.

2) The two-dimensional servo actuator should be simple structured, without any spring suspension.

3) The servo actuator should be separated from the optical system and easily mounted by screws.

Item 3) expects that the optical system and the actuator can be modified separately.

* Presented at the 64th Convention of the Audio Engineering Society, New York, 1979, Nov. 2–5.

2 RESULT

2.1 Optical System

Fig. 1 shows a sectional view of the structure of the developed pickup. Its external appearance is shown in Fig.

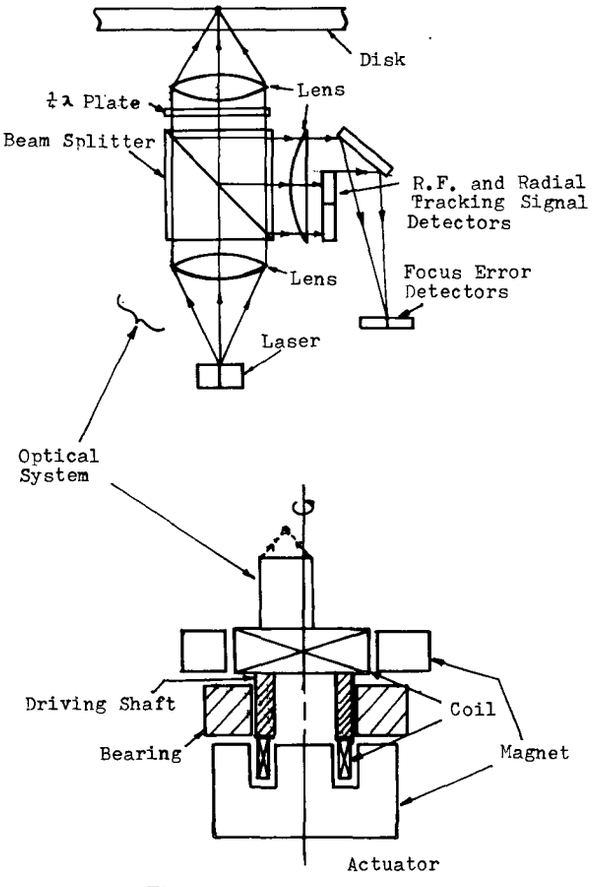

Fig. 1. Illustration of pickup.

2. The radiated beam from the semiconductor laser is collimated by the collimating lens of the numerical aperture (NA = 0.25) and focused on the disk by the objective lens (NA = 0.5). A part of the reflected beam, separated from the incident path by a beam splitter, is passed to the split photodetector placed at the far-field position in the reflected beam path, and generates both a radial tracking-error signal and a radio frequency (RF) signal. The rest of the reflected beam is focused on the other split photodetector to generate the focusing-error signal.

Ultra-lightweight lenses were specially developed for this purpose. Both the collimating and the focusing lenses are 4 mm in diameter, 3 mm in length, and 0.1 g in weight. The astigmatism was not corrected to make the lenses as light as possible.

The dimensions of the developed optical system are 15 by 7.5 by 7.5 mm^3 and 1.5 g in weight. The lightweight lens and the direct mounting of the semiconductor laser have made possible the lightweight optical system.

2.2 Actuator

As shown in Fig. 1, the two-dimensional actuator has its driving shaft, with one end connected to the optical system, held by a bearing with a small friction coefficient, and allowing translation and rotation. The rotation of the driving shaft gives a radial tracking function since, as shown in Fig. 1, the optical system is mounted on the actuator with an offset from the rotational center of the shaft. Both the translational and the rotational movements are generated by respective moving coils, to which the error signals are fed.

We have thus realized a remarkably simplified actuator employing the two-dimensional freedom of the movements. Fig. 3 shows the gain versus frequency characteristics of this actuator.

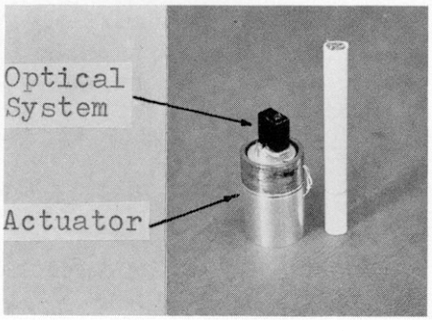

Fig. 2. External appearance of pickup.

2.3 Servo System

It is not difficult for this actuator to attain a servo gain as high as 60 dB. However, the following improvement was needed to increase the radial tracking performance:

1) Improvement of the surface smoothness of the driving shaft,

2) Selection of a less frictional bearing material (Teflon showed the best result).

As a result, a radial tracking accuracy within ± 0.1 μm was attained. A typical reproduced RF signal is shown in Fig. 4.

3 DISK PLAYER

Fig. 5 shows a block diagram of the total PCM audio disk

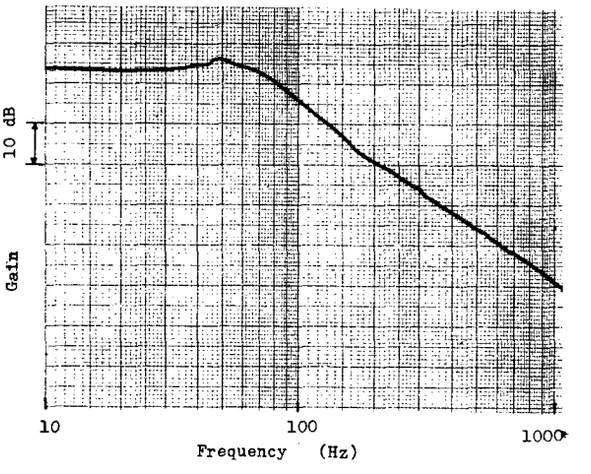

Fig. 3. Gain versus frequency characteristics of the focusing actuator.

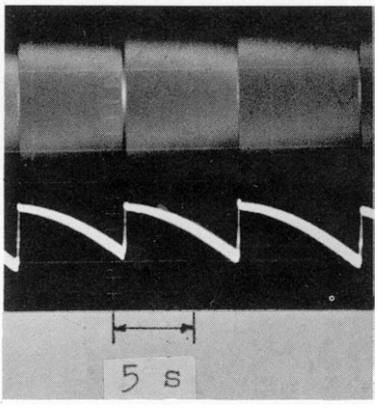

Fig. 4. RF signal (upper trace) and tracking-error signal.

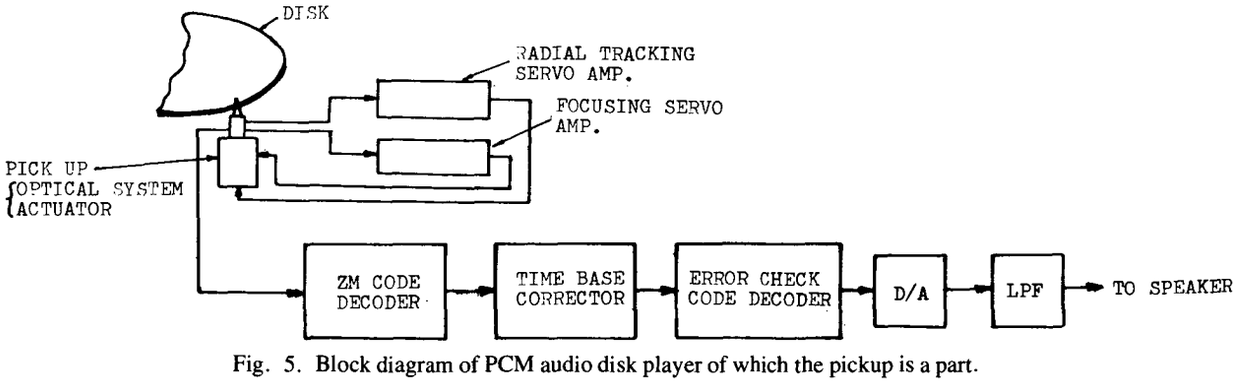

Fig. 5. Block diagram of PCM audio disk player of which the pickup is a part.

player system using the newly developed pickup. The system is composed of player, PCM processor, and retrieval part (Fig. 6). We also tried to design a vertically revolving disk player system which is vertically thinned in contrast to the conventionally horizontally revolving disk player.

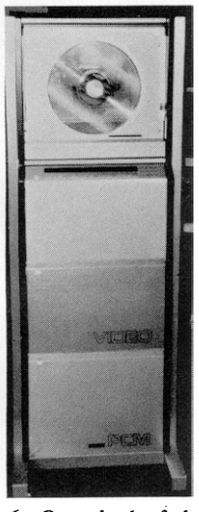

Fig. 6. Outer look of player.

4 CONCLUSION

The newly developed pickup which employs a semiconductor laser satisfies all the requirements for PCM audio disk reproduction. It was designed so that the optical system could be easily detached to facilitate a separate modification. The newly developed two-dimensional servo actuator has produced superior dynamic responses owing to its springless structure, and it has shown a promise for a cost reduction of the pickup for mass production.

5 ACKNOWLEDGMENT

The authors would like to thank all members of the project for their contributions.

6 REFERENCES

[1] K. Okada, W. Susaki, H. Kondo, K. Kime, T. Miyazawa, and T. Sato, "A Compact PCM Audio Disk Pickup Employing Semiconductor Laser," presented at the 61st Convention of the Audio Engineering Society, New York, 1978 November 3–8, preprint no. 1409.

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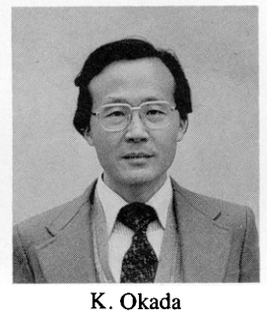

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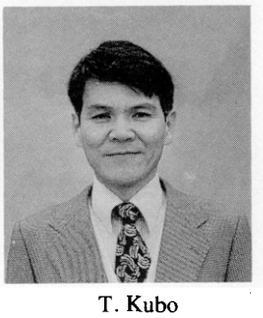

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