

DEVELOPMENT OF THE PCM LASER SOUND DISC AND PLAYER

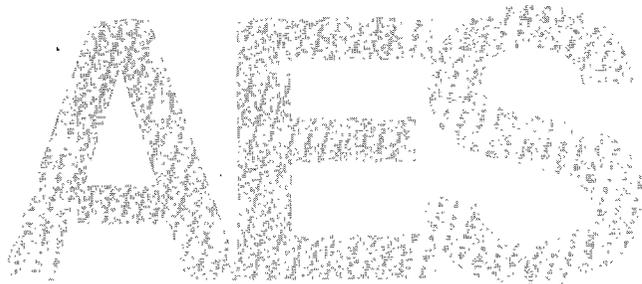
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## DEVELOPMENT OF THE PCM LASER SOUND DISC AND PLAYER

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### Abstract

Recently, under a cooperative research effort, TEAC Corporation, Mitsubishi Electric Company, and Tokyo Denka Company have developed a super high density record/reproduce technique for information such as image and sound, and one application of this technique, a new sound system named "PCM Laser Sound Disc" has been completed.

In the video disc technique whereby an extremely small spot of laser beam is projected into a revolving disc for recording, and using the same laser beam, the recording is read out with no contact with the disc. Many applications have been proposed such as for home video, information file and acquisition, etc.

We have employed this laser disc technique together with pulse code modulation to create a super hifi sound reproducing system for the home.

### Introduction

Presently, the sound recording method in general practice on phono discs and magnetic tape is called the "analogue recording system" by which sound picked up by a microphone is directly recorded as large and small fluctuations into a record groove or as strong or weak magnetism on a tape. Although a high quality sound can be recorded with comparatively simple equipment, on the other hand, not only is noise due to the disc and tape material being reproduced as sound, there is also a limit to improving the dynamic range and distortion resulting from them, and a basic resolution of these problems is needed.

### The PCM recording system (Pulse Code Modulation recording system)

Contrary to the above, in the PCM recording system, the sound signal of one second duration is split into more than 40,000 segments, the level of each segment measured, each measurement (level) converted to binary pulse code signals, FM modulated and then recorded. In the recorded disc, the recording is not amplitude or depth changes of the groove as seen in conventional phono discs but only a continuous chain of holes. Therefore, it is possible to record and reproduce sound signals at high fidelity and therefore be able to obtain an extremely high quality sound since it bears no relation with the peculiarities of the recording medium used in tapes and phono discs.

For the purpose of super high density recording technique development, the three organizations began a cooperative development program using a laser beam and a video disc on February 1974, and realizing the superiority of this system as a super hifi system, each organization solved the many technical problems by assuming responsibility for the technique they were most versed in, which culminated in the results seen today.

In this system, although an approximate 30 minute super hifi record playback is possible on a polyvinyl chloride (PVC) disc similar to the 30 centimeter diameter phono disc on the regular market, we are continuing work on longer recording time and multi-channeling, and in view of the extreme ease in mass producing the discs we believe this technique will have great affect on and provide many possibilities in the audio record field of the future.

## The PCM laser sound disc

### (a) The laser beam allows super high density record and reproduction

There are several proposals on super high density record and reproduce methods for the video disc player but among them the system employing a laser beam has drawn attention by its merit of non-contact with the recording medium during the record and reproduce process. Since it is possible to produce an extremely small spot with a laser beam and that it is a monochromatic wave and a parallel beam, it is most ideal for this type of application. A recording is made on a glass master utilizing equipment, such as shown in Fig. 1, placed in a clean room.

The glass original disc is an extremely flat glass plate upon which is deposited a special thin metal film, and which is rotated at 1800 r.p.m., a small spot of laser beam is projected on it, and this spot is moved at constant speed in a direction parallel to the radius. In doing so, a continuous line of holes called 'pits' are recorded in a spiral form on this glass plate which then becomes the recorded original. Compared to the tracks of conventional discs, the size of this spiral track is approximately 1/100 of it.

The pits of the recorded original are copied in the PCM disc producing step as an accurate replica of their shape, and during reproduce, the existence or not of the pits and their length is read out by a laser beam.

### (b) Super hifi attained by conversion to PCM

Recently, the PCM recording system has drawn attention from many sources as the "Dream in recording and reproducing systems" since a remarkable improvement in performance is possible compared to conventional recording methods. In the conventional record discs and tape decks, the strength of the audio signal is directly converted to changes in the disc grooves or recorded on magnetic tape in the form of changes of magnetism (analogue signal recording) during the sound recording process. In these methods of recording, the physical limitations of the recording medium such as the record disc and the magnetic tape, performance problems of the phono cartridge and magnetic tape heads, and limitations in the reproducing mechanism, all contribute to generating noise, distortion, crosstalk, level fluctuations, wow and flutter, etc., thus becoming the limiting factors of the reproduced sound quality.

In the PCM recording system, the analogue signal waveform is split into samples of about 20 micro-second intervals, as shown in Fig. 2. The moment by moment interval levels (sampled level) of the sample are then partitioned into levels containing more than 1000 steps, coded into corresponding binary codes, and FM recorded in the form of digital signals. As this digital signal, compared to an analogue signal, is very simple even if there are slight fluctuations in rotation or the S/N ratio is inferior, the recorded information will be reproduced accurately by use of a crystal oscillator and a memory. However should there be any error in reproducing the "0" or "1" code, or there is a so-called drop out which results in complete failure of reproduction due to a missing portion of the code, an unusual sound output would result. To prevent this, a special code array is employed in our system which reduces this defect to an unnoticeable level.

### (c) The PCM laser sound disc is excellent for mass production

As shown in Fig. 3, a stamper is made from the master in the same way as conventional phono discs, a transparent polyvinyl chloride (PVC) material used to make stamping (discs), the recorded surface of the stamping plated with a metal reflecting surface, and finally a protective coating deposited over this to complete the PCM laser sound disc. In this production, although specifications regarding the disc material and forming are more critical than conventional phono discs, it is nonetheless excellent for mass production and we are anticipating the possibility of a marketable price.

## Performance of the player

### (a) Operation by four servo systems

The PCM laser sound disc player, as shown in Fig. 4, is comprised of a turntable, laser beam optics and related servo system, and the PCM reproduce amplifier. In the laser optics chain, polarization and coherence characteristics of the laser beam is utilized to read out the PCM signals recorded on the disc, reconverted to the original audio signal and reproduced by the amplifier. The stability of these operations are secured by the following four servo systems,

- 1) Disc servo  
A constant 1800 r.p.m. revolution of the turntable, on which the disc is held, is obtained by a quartz locked direct drive motor.
- 2) Focusing servo  
This is a system for controlling the read out laser beam at a constant size by maintaining a constant distance between the disc surface and the collecting lens which is positioned by the focus adaptor.
- 3) Tracking servo  
The tracking mirror controlled by this system maintains the read out beam directly over the spiral line of pits on the disc.
- 4) Radial feed servo  
This servo feeds the laser beam optics in the radial direction in step with movement of the spiral line of pits.

### (b) Characteristics

- 1) The disc and pickup system can be used almost indefinitely (no need of changing stylus as in a phono disc system) as it is non-contacting.
- 2) Operating modes such as finding the start of the music, random access, or repeat playback, are simple and also quick.
- 3) No affect on sound quality such as by different phono cartridges.
- 4) Wow and flutter is negligible - dependent on the precision of the quartz oscillator.
- 5) Wide dynamic range is possible.
- 6) No crosstalk.
- 7) Extremely good frequency response.
- 8) Free of tracing distortion, pinch effect distortion, tracking error, etc., which exists in normal phono discs.
- 9) No acoustic feedback due to external vibrations.
- 10) Free of scratch noise.
- 11) No complicated operations such as balance adjusting of the phono arm.

(c) Specifications

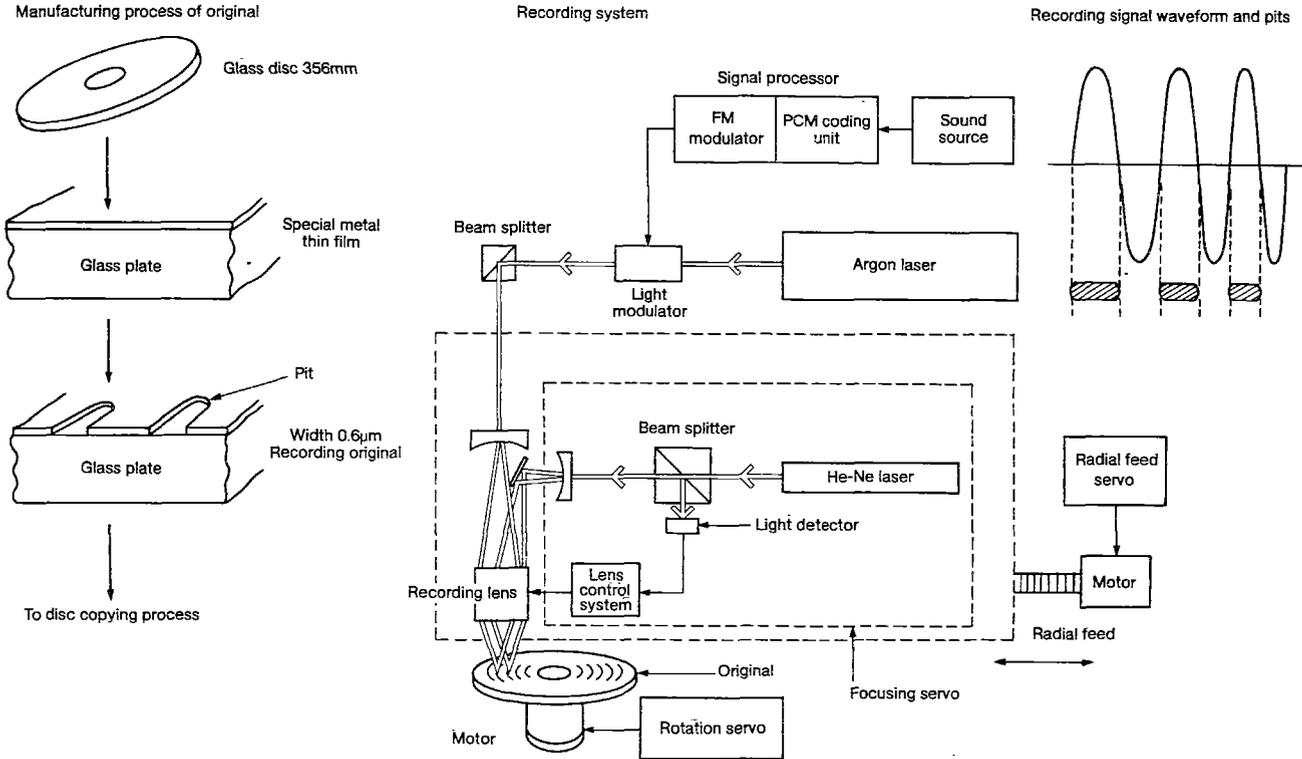
Number of channels	: 2 (stereo)
Output	: Level - 0.3Vrms, load impedance higher than 50K ohms
Dynamic range	: More than 98 dB
Frequency response	: 10Hz - 20KHz, +0.1 dB, -0.5 dB
Noise, harmonic distortion	: Less than 0.1%
Wow and Flutter	: Precision of quartz oscillator
Dimension of disc	: Outer dia. 301mm, thickness 1.1mm
Revolution of disc	: 1,800 r.p.m.
Maximum continuous reproduce time	: 30 minutes
Physical dimensions	: 560mm/22in (W) X 150mm/6in (H) X 399mm/16in (D)
Weight	: About 22kg/50 lbs

Forecast of its future

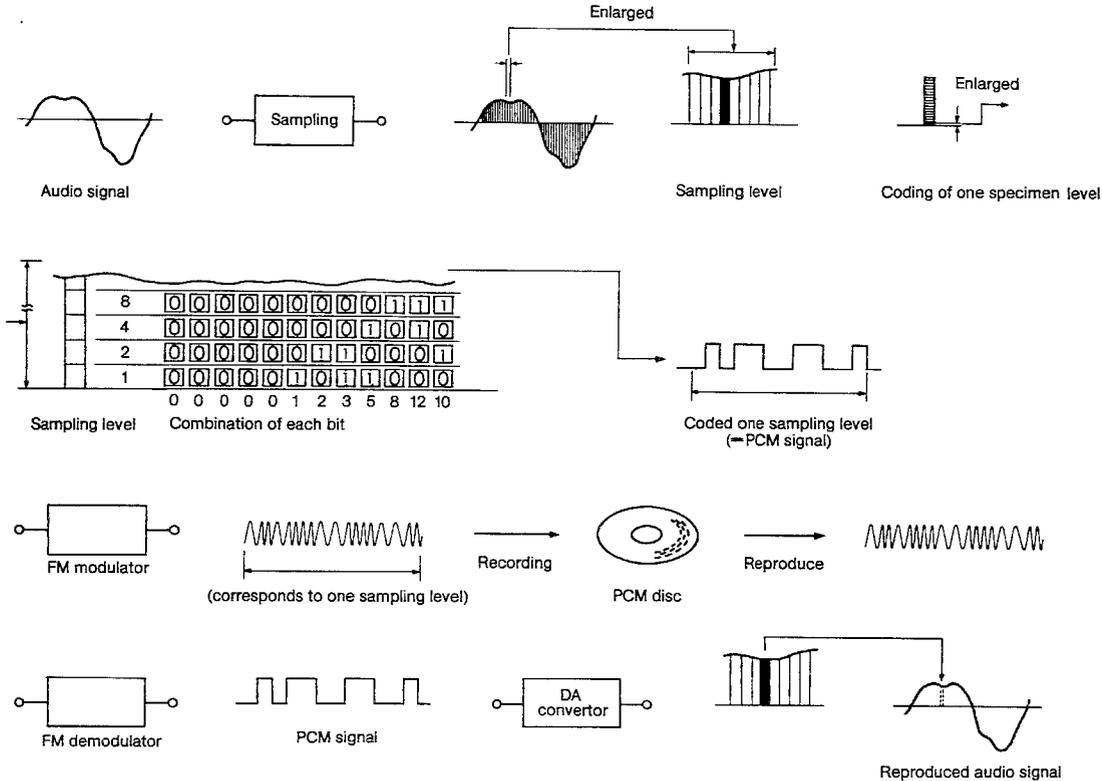
In the area of super high density record and reproduce technique, the PCM laser sound disc and its player will make it possible to provide a super hifi audio system within the price range of home audio systems.

For other application examples of this technique, we may anticipate extended time recording of several symphonies on one disc; a juke-box type application with a single disc recorded with dozens of tunes each addressed for acquisition by utilizing its short access time, or, multi-channeling of music by utilizing separate tracks for each musical instrument, etc., we therefore anticipate the opening of a new field in audio systems not even visualized today.

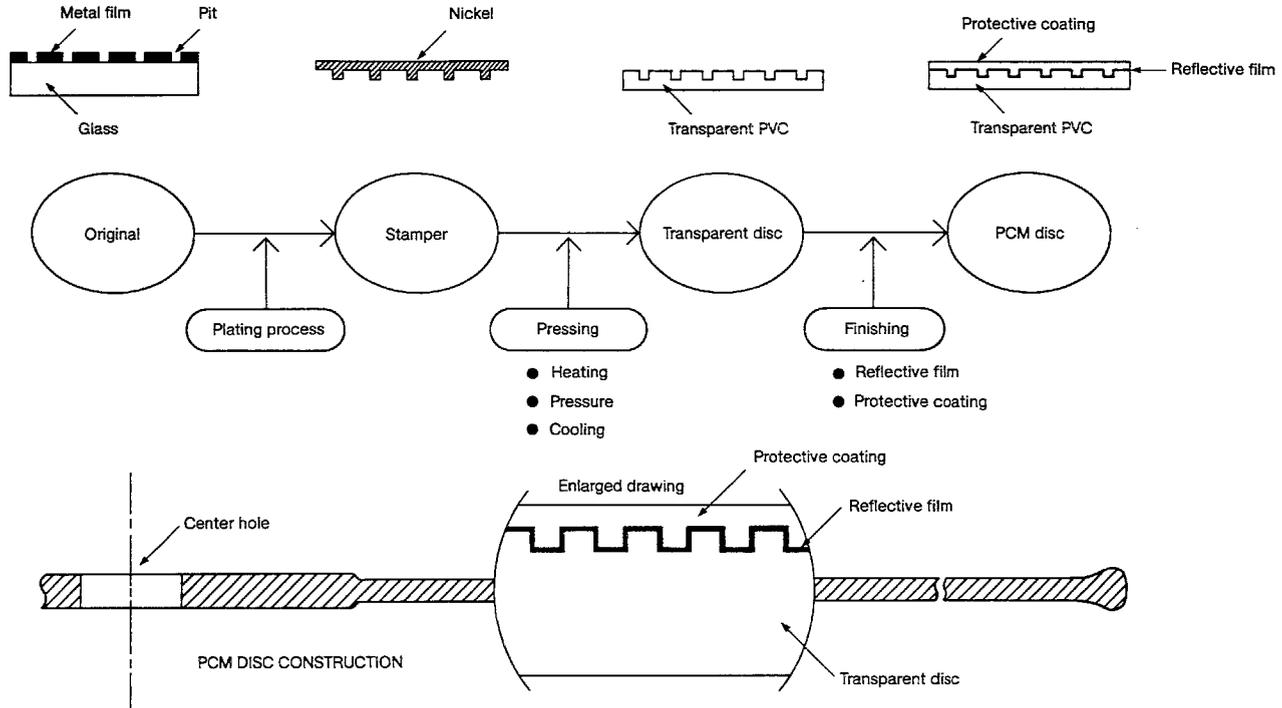
**Fig. 1 SUPER HIGH DENSITY RECORDING BY LASER BEAM**



## Fig. 2 THEORY AND SIGNAL WAVEFORM OF PCM



### Fig. 3 PCM DISC MANUFACTURING PROCESS



# Fig. 4 OPERATION OF THE LASER SOUND DISC PLAYER

