SONY®
Video Communications

LDP-1000

INTERFACE MANUAL

SECTION 1
INTERFACE INFORMATION

1-1. COMPUTER INTERFACING 4
1-2. THE LDP-1000 INTERFACE 5
1-3. LDP-1000 INTERFACE CONNECTIONS 5
1-4. SETTING THE INTERFACE 6
1-5. PROM IDENTIFICATION 6
1-6. INTERFACE COMMANDS 6
1-7. STATUS INQUIRY FORMAT
1-8. DISC I.D. INQUIRY FORMAT 8
1-9. COMMAND EXECUTION TIME 9

SECTION 2
TECHNICAL INFORMATION

2-1. GENERAL 10
2-2. DISC: 10
2-2-1. MASTERING 10
2-2-2. REPLICATION 12
2-2-3. DISC SPECIFICATIONS 12
2-3. PLAYER: 13
2-3-1. OPTICAL PICK-UP 13
2-3-2. FOCUS SERVO 16
2-3-3. TRACKING SERVO 16
2-3-4. SPINDLE SERVO AND TANGENTIAL SERVO 17
2-3-5. TRACK PLAY 17
2-3-6. RANDOM ACCESS 19

SECTION 1
INTERFACE MANUAL
INTRODUCTION

The Sony LDP-1000 VideoDisc Player is a well equipped and versatile industrial grade disc player especially designed with the needs of computer/videodisc system designers in mind. The standard Z-80 internal microcomputer and RS-232C communication interface provide easy and flexible connection to external computers without the need for additional interface equipment.

Close cooperation with LDP-1000 users has resulted in the development of enhanced interface capabilities, which are covered in this manual. Players so equipped are identified by a "V1.6" sticker on the back panel. In addition, a PROM Upgrade Kit is available from Sony Communications for retrofit of existing players. Contact your Sony Communications representative for information.

As we said, the LDP-1000 interface conforms to industry standard RS-232C, which is available on virtually all commercial grade computers, from the smallest to the largest. When used with this equipment, no additional interface of any kind is required. However, users of some popular home computers may be required to obtain appropriate equipment from a source other than the manufacturer. Some of these interfaces may also have capabilities in addition to RS-232C protocol. For your convenience we have included a list of some of these suppliers.

1-1. COMPUTER INTERFACING

Computer interfacing is a set of techniques which allows your computer to "talk" to many computer peripherals, such as a keyboard, light pen, tough panel, or even another computer.

The Sony VideoDisc Player can be treated as a kind of computer which does not accept Basic or Fortran, but a special command language to control all mechanical and electric functions of the player.

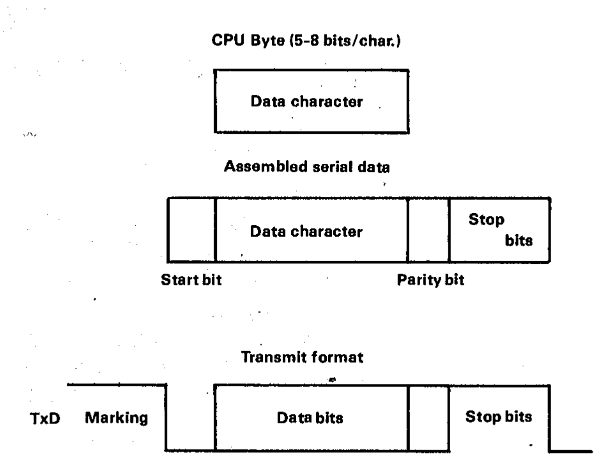
If the Disc Player is interfaced with an external computer, the Disc Player also can "talk" to the computer. This will expand your disc player capability tremendously, especially in interactive usage.

Sometimes the computer expects eight bits of data (one byte) to be transferred at once through its peripheral connectors—this is called a parallel interface. In this case, the computer and the peripheral must be perfectly matched to each other, and all data bits must be available at the same time. The first requirement gives a limitation in combinations, and the second requirement limits the length of cables connecting the computer to the peripheral or another computer.

To solve those problems, the sender can use a method to convert the parallel data into serial data, while the receiver must be able to reconvert the serial data to parallel. We call this a serial interface. This presents a problem for the receiver because the serial data is nothing more than a continuous stream of ones and zeroes.

How can the receiver tell which eight bit group is the correct group of data? To solve this problem, two schemes have been devised—Synchronous and Asynchronous modes of transmission. In the Synchronous transmission mode, a predefined pattern of synchronization bits are sent out first. When the receiver finds this pattern, it locks onto it. Then it automatically divides up all subsequent bits into eight bit groups for the rest of the transmission.

Asynchronous interface will handle this differently. A start bit is added to the front of the bit groups, plus one or two stop bits at the tail.



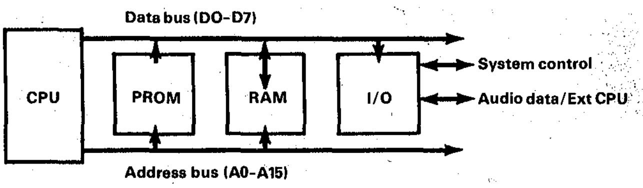
This total group of bits is then transmitted over the interface one bit at a time. Now, how fast can the computer transmit this data?

This can be defined as the baud rate. Usually, the rate is given as an even multiple of 75 baud (bits per second including all "overhead" bits, such as start and stop bit). A few other baud rates, such as 50, 110, and 134, are used in major industry products.

It is necessary to exchange signals that can tell the sender "yes I got it" or "wait, I'm busy now." This is called "handshaking." The EIA created signal specifications for interface to allow manufacturers of various types of equipment to standardize. For serial interface, this is called the RS-232C communication bus standard.

1-2. THE SONY LDP-1000 INTERFACE

As mentioned before, the LDP-1000 has a microprocessor system control in which the circuits are almost the same as in regular computers.



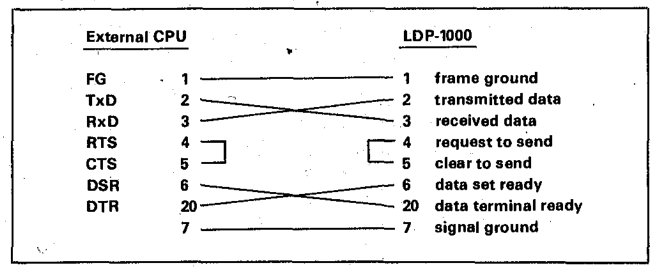
The major interface component of the LDP-1000 is an I.C. chip, designated as an 8251 by Intel, and called a universal synchronous/asynchronous receiver transmitter, or USART for short. This integrated circuit can be programmed to handle either synchronous or asynchronous serial I/O with variable word length, clock division, ratios, number of stop bits, status of parity check, transmit control, and receive control. In LDP-1000, the 8251 is progammed as listed below.

Mode	Asynchronous
Word Length	8 Bit
Transmit Clock	16 times of baud rate
Parity Check	None
Stop Bit	1, 1½, 2 (selectable)

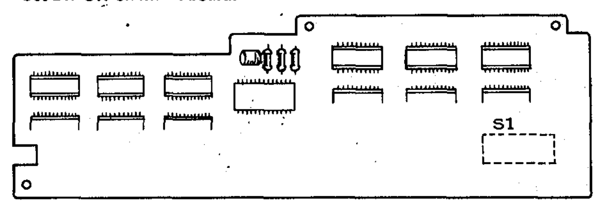
LDP-1000 initialize format.

When the 8251 is first powered up, or after it is reset, 8251 logic assumes a mode select command mode. If the mode select command specifies asynchronous mode, then logic switches to expecting control select modes (command). This persists until the 8251 is reset, or a special control select is output forcing the choice back to mode select.

1-3. LDP-1000 EXTERNAL COMPUTER INTERFACE CONNECTIONS

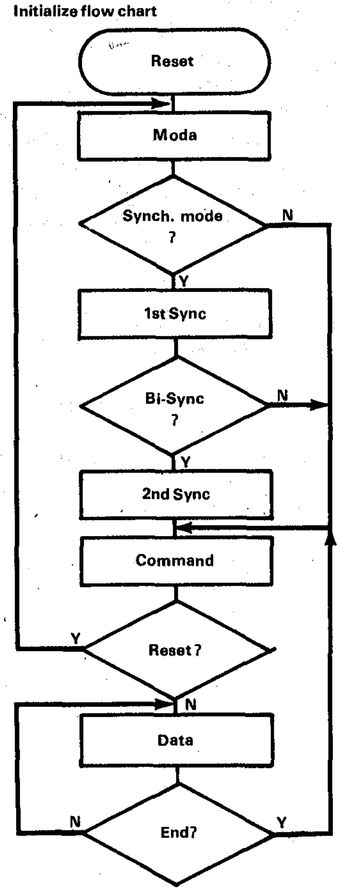


Set DIP SW on MP-11 board.

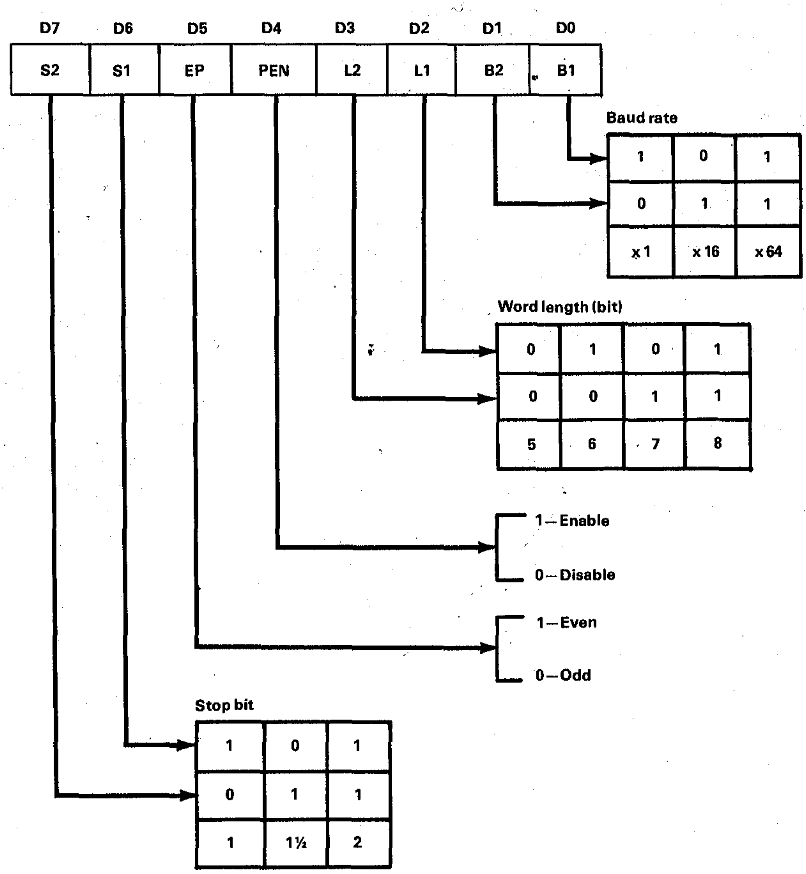


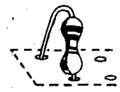
Note: SW's 6 and 7 are not used.

Initialize flow chart



Mode instruction





@ Latest players are using resistors (2.2 ohm) instead of the Dip switch.

STOP BIT	1 (ON)	2 (OFF)	3 (S1)	4	5	BAUD RATE
1	OFF	ON	ON	ON	ON	300 Baud
1½	ON	OFF	OFF	ON	ON	600 Baud
2	ON	ON	ON	OFF	ON	1200 Baud
	X	X	OFF	OFF	ON	2400 Baud
	X	X	ON	ON	OFF	4800 Baud
	X	X	OFF	ON	OFF	9600 Baud

Those selections are read only during power-on reset. If the selections need to be changed, the player power must be turned off then on to reset the 8251.

1-4. SETTING THE LDP-1000 INTERFACE

The communication mode of the LDP-1000 is preset at the factory as follows:

Baud rate: 1200
Stop bit: 1
Word Length: 8

If it is necessary to check the baud rate, or to change the PROM set, we strongly recommend that you refer this service to an authorized Sony Communications dealer. However, if you are confident of your ability to perform these operations, proceed as follows:

1) Remove the front panel of the player by removing two screws at the front edge of the cover, one in the commander recess, two on the bottom of the front panel and the antenna selector knob. The panel will pull straight out.

2) Remove the five screws holding the circuit block. The screw in the upper right has a ground collar attached to it. The entire circuit block, including the metal frame, can now be carefully pulled out and laid flat, leaving all connectors in place.

3) The baud rate switch will now be visible in the lower right hand corner of the circuit block which is now accessible. In newer machines the switch has been replaced by a resistor network. The circuit board is marked "S1" at the switch position. Refer to the S1 chart for setting of the baud rate.

1-5. PROM IDENTIFICATION

As a result of continued development of the LDP-1000 operating capabilities, a PROM set with an enhanced command set has been made available as an upgrade kit for existing LDP-1000's. All models subsequent to the LDP-1000, or models otherwise designated (such as LDP-1000A), contain the revised PROM set. In addition, current LDP-1000 players which have received the upgrade will have an identification sticker on the back of the unit.

All operations through the Remote Commander or through programs stored on the disc are identical for both PROM sets. If you are in doubt about which set is in a particular unit, connect the player to an external computer and attempt to execute any command from 61 to 68hex. The result will be an error or invalid command message. Also, the upgraded PROM returns ACK's in response to commands, while the original PROM does not.

Details of the procedure for exchanging PROM's are covered in the PROM Upgrade Kit documentation, and whenever possible should be referred to an authorized Sony Service station.

To understand the difference in PROM capabilities, look at the RS-232 command chart. The original PROM supported the error messages 01, 02, 05 and all commands from 30 to 61hex. No ACK is given, so the external computer must allow adequate execution time between sent commands. The execution time chart in this manual will help in understanding the timing requirements.

The capabilities of the upgraded PROM are as covered in the remainder of this manual.

1-6. LDP-1000 INTERFACE COMMANDS

Setup

To intialize communication between an external computer and the LDP-1000:

1) Set the external computer RS-232C port to "ready" (DTR high)
2) Set the LDP-1000 External CPU switch to "on"
3) LDP-1000 power "on", open cover, insert disc
4) If the disc has a program on audio channel 2, it will load and begin executing automatically. To exit this mode, send CLEAR from the external computer. If there is no program, the disc player will stop on frame #00001 in PROGRAM mode.
5) LDP-1000 is now ready for communication
6) As an option, when using the remote commander, you can switch to external mode by setting the external switch to "on" and sending a CLEAR from the commander. This will initialize the CPU and set it in the external mode. You can switch from external to internal without power off by setting the external mode switch to "off" and sending a CLEAR from the external computer.

Communication

RS-232 commands are reserved at 30 to 68hex
Feedback codes are reserved at 00 to 0Fhex

The following commands apply specifically to external control:

F/R STEP
Puts the player in auto-step mode (1/7 speed). To make the player step-frame, send STEP followed at least 33ms later by STILL. Maximum delay is 200ms.

F/R SCAN
Causes the player to scan until a new command is received

RS-232C COMMANDS

L \ H	Ø	1	2	3	4	5	6	7
Ø				Ø	ENTER	INDEX ON	ADDR INQ	
1	COMPLETION			1	C.E.	INDEX OFF	CONTINUE	
2	ERROR			2	MENU	DUMP IN LDP◄CPU	MOTOR ON	
3				3	SEARCH	DUMP OUT LDP►CPU	MOTOR OFF	
4	PGM END			4	REPEAT	SEG MODE	CH-1	
5	NOT TARGET			5	SEGMENT	FRAME # MODE	CH-2	
6				6	CH-1 ON	C.L.	INDEX	
7				7	CH-1 OFF	PGM	STATUS INQ.	
8				8	CH-2 ON	RUN	DISC ID INQ.	
9				9	CH-2 OFF	END		
A	ACK			F-PLAY	R-PLAY	MEMORY		
B	NAK			F-FAST	R-FAST	M-SEARCH		
C				F-SLOW	R-SLOW	SKIP		
D				F-STEP	R-STEP	INT		
E				F-SCAN	R-SCAN	REVIEW		
F				STOP	STILL	MODE		

CH-1 ON, CH-1 OFF, CH-2 ON, CH-2 OFF
These commands set the audio channels as indicated. They do not toggle, since toggle commands require that the external computer know the previous state of control, which is not always possible.

INDEX ON, INDEX OFF
As above, these commands set the index regardless of the previous state.

SEGMENT MODE, FRAME # MODE
As above, sets the mode in SEARCH and REPEAT operations

STILL
Stops the player on the present frame

CONTINUE
Use after STILL command. Returns to the previous mode.

MOTOR OFF
Sled returns to home position, stops motor, shuts off laser, returns ACK when motor has stopped. Lid can be opened.

MOTOR ON
Starts motor. ACK returned when player is ready to receive more commands.

ADDRESS INQUIRY
Player sends ASCII codes for five digit frame number.

STATUS INQUIRY
Same communication as above. Player returns 5 bytes (see 1-7).

DUMP IN/OUT
Maximum data is 1024 bytes. For DUMP IN no ACK is sent for each byte, but you must send 1025 bytes and receive an error code as confirmation. Send CE to restart normal communication. Since the player interprets all input as data, you must reset the system to break a DUMP IN. DUMP OUT requires an ACK from the external CPU for each byte and can be interrupted.

I.D. INQUIRY (see 1-8)
Player sends 40 ASCII characters. 3Bhex is the end signal. If no I.D. is present, player will NACK command.

Codes returned from the LDP-1000:

COMPLETION
Returned on completion of SEARCH or REPEAT operations.

NOT TARGET
Returned if frame number is not found or if end frame of a repeat is not readable. Player stops on next readable frame, which can be checked with ADDRESS INQUIRY.

PROGRAM END
Returned if execution of an internal program ends.

ERROR
Returned if command is invalid or too large. If index is on, error will be displayed. Send CL or CE to restart communication.

ACK
Returned when player receives command and is ready for next command.

NACK
Command not in valid range.

1-7. LDP-1000 STATUS INQUIRY FORMAT

STATUS INQUIRY (67hex) returns 5 bytes:
1st byte (1 = flag set)
7: X (not used)
6: SEARCH/REPEAT mode
5: MOTOR OFF mode
4: Player initialized flag
3: Lid open
2: X
1: X
0: ERROR (reset by CE or CL)

2nd byte (program status byte)
7: X
6: MEMORY SEARCH mode (reset when memory address is located)
5: STOP mode
4: DECIMAL mode
3: PROGRAM mode (57hex—ready for start-line input)
2: PROGRAM display mode (see player operating instructions)
1: PROGRAM execution mode (internal program running)
0: PROGRAM input mode (ready for internal program loading)

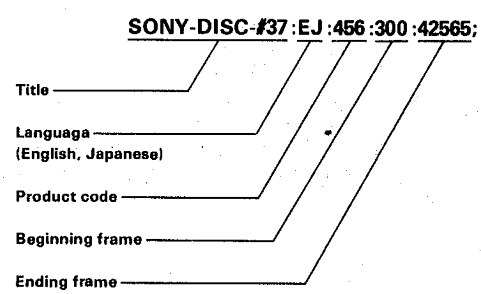
3rd byte (key mask status byte)
7: PROGRAM mode (set for any of the above PROGRAM conditions)
6: NATIVE mode (any mode other than PROGRAM)
5: X *These flags are reset by SEARCH/REPEAT modes
4: X
3: X
2: X
1: X
0: X

4th byte (key mode status byte)
7: Step number in (to reset, NUMBER INPUT + ENTER is required)
6: NUMBER INPUT mode
5: X
4: SEGMENT mode (ready for segment number input)
3: Picture stop code (set by auto stop code on disc)
2: REPEAT mode
1: SEARCH mode
0: NUMBER INPUT (holding for N.I. in any mode)

5th byte (command status byte)
7: 0 = forward, 1 = reverse
6: X
5: STOP
4: SCAN
3: STEP
2: SLOW
1: FAST
0: PLAY

1-8. LDP-1000 DISC I.D. INQUIRY FORMAT

The disc I.D. code is provided by the producer at the time of disc mastering. It provides a convenient way for an external computer to tell which disc is in which player, and can be used to convey other information, such as first and last frame numbers or any other parameters. The I.D. code is limited to a maximum of 40 ASCII characters including punctuation. The end code is always a ";".
An example of an I.D. code:



*Note that players with I.D. code capability have a maximum of 58 segments available.

1-9. LDP-1000
EXECUTION TIME OF EACH COMMAND

COMMANDS	EXEC TIME	COMMANDS	EXEC TIME
0-9	4.3 ms	INT	60 ms
PLAY	5.5 ms	REVIEW	9.6 ms
FAST	5.5 ms	MODE	3.7 ms
SLOW	5.5 ms	CH-1	0.53 ms
STEP	5.5 ms	CH-2	0.53 ms
STOP	5.5 ms	INDEX	0.53 ms
C.E. (From ERROR)	8.0 ms		
ENTER	1.3 ms		
MENU	11.5 ms		
SEARCH	9.0 ms		
REPEAT	8.0 ms		
SEG	10.0 ms		
CH-1 ON/OFF	0.4 ms		
CH-2 ON/OFF	0.4 ms		
INDEX ON/OFF	0.4 ms		
MODE (SEG)	0.4 ms		
MODE (FRAME)	0.4 ms		
STILL	0.4 ms		
C.L.	5.5 ms		
PGM	7.9 ms		
RUN	7.0 ms		
END (From PGM)	10.5 ms		
MEMORY	0.76 ms		
M-SEARCH	11.1 ms		
SKIP	5.8 ms		

SECTION 2
TECHNICAL INFORMATION

2-1. GENERAL

A videodisc is a prerecorded disc from which a color picture and sound come out. The disc similar to familiar "audio record", plays a color picture and sound through any monitor television or standard color television receiver.

You can watch the slow motion of a fine play in a telecasted sport program just immediately after that fine play. A disc for a broadcast station can playback such a slow motion picture. The broadcast use disc is the magnetic record and playback system that is same as VTRs where magnetic material is coated on the disc, and the recording and playback are done with a magnetic head. The videodisc mentioned above is different from the disc being used now in broadcasting. The videodisc playback systems we are discussing now are such an optical system and a stylus system which are non-magnetic systems. The optical system is that a laser beam is projected on the videodisc where its reflected beam is picked up, and an light signal is converted into an electric signal. The stylus system is that a stylus traces the track on the disc in order to pick up a mechanical signal.

From the various videodisc systems employed by several companies, the optical system will be described here.

This system is called "VLP (Video Long Playing) system". The disc is an acrylic disc having a diameter of 30 cm (12 inches) same as familiar audio LP records. The revolution of the disc is 1800 rpm at CAV (Constant Angular Velocity) in NTSC color disc. The video and audio information are recorded onto the high density tracks which is 600 lines per 1 mm. The tracks are not grooves like the ones in an ordinary audio record, but are made of continuous oval hollows called "pits". The depth of the pit is approximately 0.1μ and its width approximately 0.4μ. The length of a pit and the spacing between pits are continuously varied by the video and audio signals. The pits form continuous spiral from the inside of the videodisc to the outside.

He-Ne laser beam is used for the playback of the videodisc. This beam traces the pits automatically from the inside of the disc to the outside, according to the rotation of disc. An optics control system by electronic means is employed so that the laser beam always traces onto the center of the track and is focused upon the reflecting plane of videodisc.

The projected laser beam is reflected back from the surface of the videodisc. Thus reflected beam is modulated by the variation of the pits. A photodiodes catches the reflected laser beam and create the electric signal. This system features that a pickup does not contact the videodisc and there-fore wear of the disc and the pickup are not caused. "Special playback features" such as the slow motion, high speed playback, still, reverse, and random access can be realized smoothly by making the track jump.

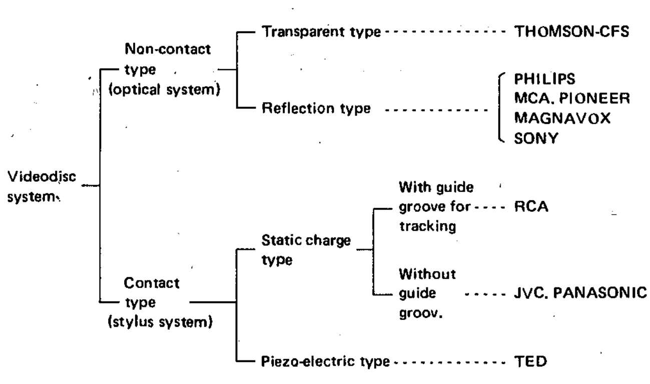


Fig. 2-1. Classification of videodisc system

2-2. DISC

2-2-1. Mastering

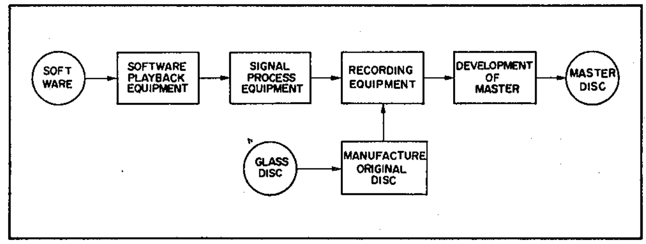


Fig. 2-2. Process for making master

Signal Processing Equipment:

Signal processing equipment converts a signal from a software into an FM signal suitable for recording. The video signal is converted into the FM signal whose center frequency is 8.1 MHz (frequency deviation is 1.7 MHz). The two channel sound signals are converted into the FM signals whose center frequencies are 2.3 MHz and 2.8 MHz (frequency deviations are 100 KHz). The video FM signal and the sound FM signals are added. The amplitude of the added signal is limited by a limiter so that the signal is shaped into a rectangular waveform. The resultant signal is a multiplex signal. The frequency variation of the multiplex signal represents the video information and its duty variation does the sound information.

The addition ratio of the video carrier and the sound carrier has been set to 10:1 in consideration of the linearity of the modulation, mixed modulation, and S/N ratio. (See Fig.s 2-3 and 2-4.)

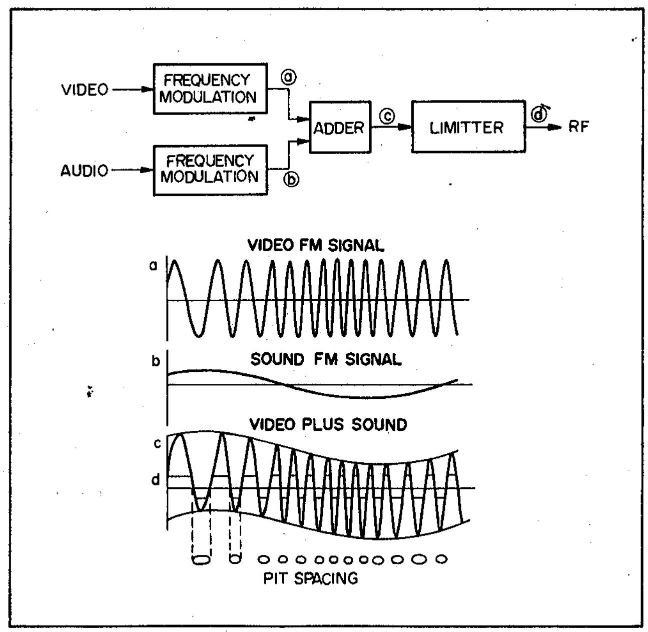


Fig. 2-3. Encoding of information onto DISC

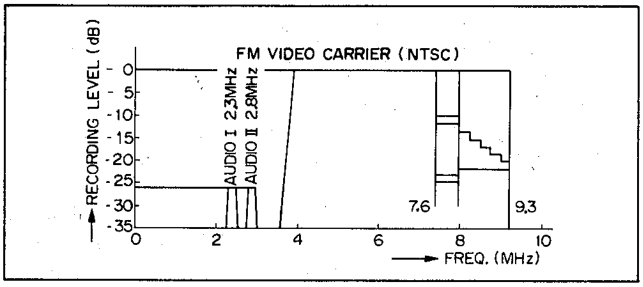


Fig. 2-4. Frequency spectrum of videodisc

Recording Equipment:

The rectangular wave is fed to a laser beam modulator for turning ON/OFF of the laser beam. A record lens is a high efficiency objective lens focusing the laser beam on the track so that the beam becomes a tiny spot of about 0.4μ diameter on the photo-resist face of the glass disc. The converged tiny laser spot exposes an unprocessed disc while the disc is rotated. The exposed disc is developed and the master disc is obtained.

The uniformity of the shape of the oval hollows on the disc called "Pits" affects much the picture quality in playback and the convergence error of the laser beam must be suppressed without regarding the up and down movements of the photo-resist face. The movements are caused by the disc rotation during the master disc processing.

A focus servo device is used so that the record lens is driven by an electromagnetic means in order to follow the up and down movements of the photo-resist face correctly.

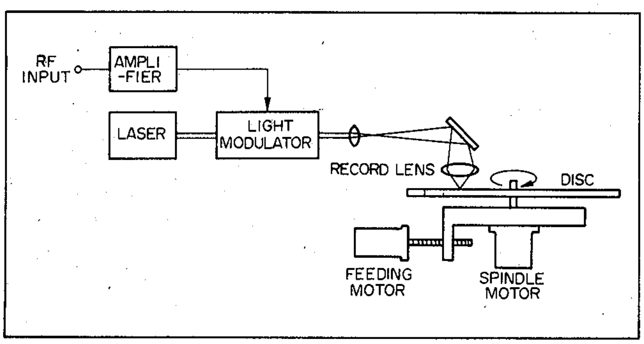
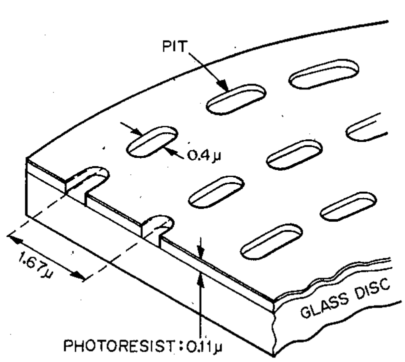


Fig. 2-5. Recording equipment



Thickness of this photoresist is correspond to 1/4 wavelength of He-Ne laser into the plastic disc.

Fig. 2-6. Structure of master disc

Record System:

- CAV (Constant Angular Velocity) System
  Each revolution of the videodisc exactly corresponds to the video signal of one frame. It is arranged at the same time so that sync signals are aligned in the radius direction. The CAV system is suitable for producing a disc with special mode of operation such as still picture playback and others. The playback time is 30 minutes per side.
- CLV (Constant Linear Velocity) System
  Recording is made at a constant linear velocity of about 11 m/sec. One frame video signal is recorded on an inner circumference and three frame video signal on outer circumferences. The maximum playback time is 60 minutes per side.
- The spiral track that is composed of the pits is arranged to have a constant space of 1.67μ between the adjacent tracks from the inner circumference toward the outer circumference.

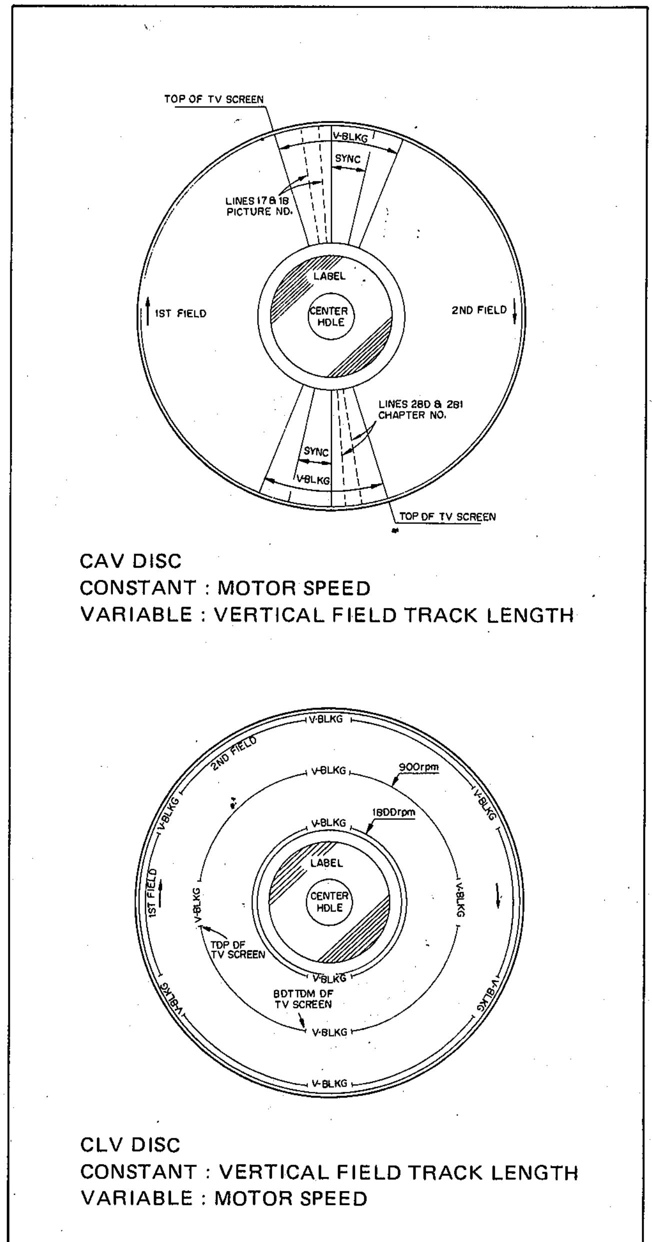


Fig. 2-7. CAV. CLV disc comparison

2-2-2. Replication

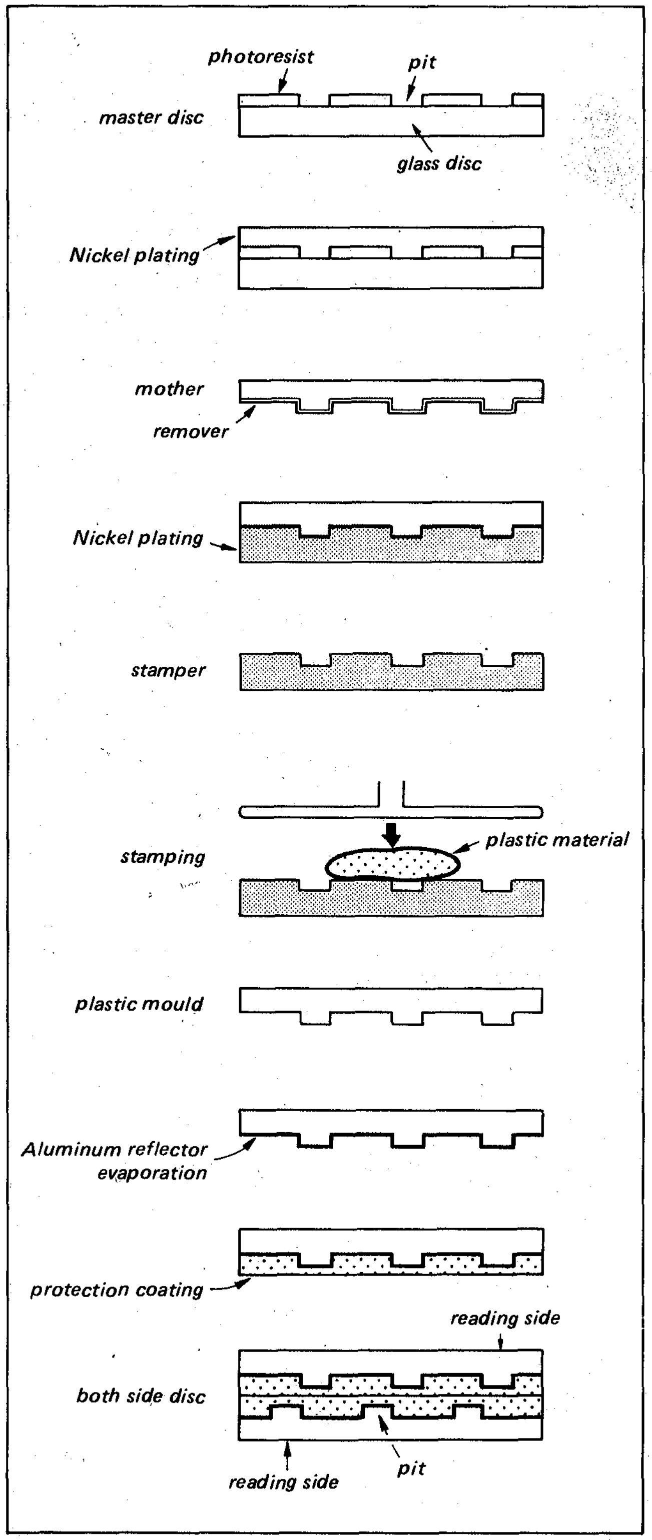


Fig. 2-8. Replication

Conductivity is given to the photo-resist surface of the master disc by evaporation or plating. The disc is covered by Nickel plating so that a mother disc is obtained.

Remover is coated on the mother and then the mother is Nickel plated again, so that the resultant is a stamper. Flatness of the stamper must be as flat as possible for reducing a warp and a distortion of a disc.

An injection molding, a compression molding, or 2P molding can be employed as the disc molding methods. The compression molding is that vinyl chloride polymer is placed on the stamper, heated, pressed, and cooled for transcription of pits. The 2P molding is that a plastic solvent which can be stiffened by ultraviolet rays is poured onto an acrylic cast plate and stiffened by ultraviolet rays for forming the pits.

Aluminum reflective layer of about 400Å is evaporated on the face where the pits were transcribed. A plastic protective coating is placed over on the aluminum layer.

Two discs are put together to form a both side disc with the protective coating sides facing each other. This disc has the pits on its two sides.

2-2-3. Disc Specifications

Diameter:	ϕ300 mm (12 inches)
Spindle hole diameter:	ϕ35 mm (installation hole)
Thickness:	1.25 mm x 2.5 mm (incl. adhesive & label)
Recording range:	ϕ110 mm to ϕ295 mm
Track pitch:	1.67μm
Playing time:	CAV 30 min. (one side) (5,400 frames) CLV 60 min. (one side) (10,800 frames)
Rotation:	CAV 1800 rpm CLV 1800 rpm to 680 rpm (line velocity: about 11 m/sec.)
Laser:	He-Ne laser (λ=0.6328μm)
Signal coding:	Direct NTSC Video . . . Sync tip; 7.6 MHz White peak; 9.3 MHz Sound . . . 2.3 MHz ± 100 KHz (CH-1/L) 2.8 MHz ± 100 KHz (CH-2/R)

2-3. PLAYER

Disc player is composed of an optical system to readout pits of the disc, rotation mechanisms to rotate the disc and move the optical system, a video demodulator circuit, a sound demodulator circuit, servo circuits to controll electromagnetic actuator of the optical pickup, the disc rotation motor, and a control circuit for the overall operation in accordance with operation commands.

The optical system and its servo system which are not found in the conventional VTRs will be described here.

2-3-1. Optical Pick-up

Optical system of the videodisc player is the most important section to readout information from the disc. The optical system is the heart of the player, nucleus of the optical videodisc system.

The characteristics of light and its polarization will be described here simply to understand the principle of the optical system. It is considered that light is a kind of the electromagnetic waves and its wavelength is visible to the human eye. The ordinary light includes various lights having different wavelengthes and phases. It is continually changing its direction of polarization at random.

Since laser (Light Amplification by Stimulated Emission of Radiation) is composed of extremely narrow bandwidth of wavelength, aligned phases, and having a signal color. The laser goes straight, it can be converged into an extremely fine beam.

Light whose direction of polarization changes at random like the ordinary light is called non-polarized light. The light shown in (a) and (b) of Fig. 2-9 are called linearly polarized lights; (a) is called vertically polarized light while (b) is horizontally polarized light. When the lightwave rotates in only one direction, clockwise or counterclockwise, it is called circularly polarized light.

Perhaps the most well known application of this phenomenon is in polarized sunglass. The special lenses will not pass the horizontally polarized light. Since most light from glare and reflections is horizontally polarized, it can not pass through the lenses. The videodisc player also uses optical system which are affected by the polarity of light.

The laser beam travels the optical path shown in Fig. 2-10 on the optical sled. Fixed angle mirror merely changes the beam angle so that player can be housed in a compact space. The reflection index of the mirror is 99% to make the light loss minimum.

The red light beam from the laser is vertically polarized. It is diffracted by a grating that is the first optical component. This optical device is a piece of glass with several fine horizontal lines etched in it. Its effect is to divide the beam into three beams. The three beams are the center bright beam, a secondary beam above and below the main beam. The secondary beams are less bright than the main beam. Actually, the raster grate creates more than three beams, but the others are of such reduced brightness that they are ignored. The center beam is used for detecting the FM signal on the disc and a focus error detection. The two adjacent beams are used for detecting a radial tracking error. The three beams are collectively referred to as a light bundle. For purposes of discussion, the light bundle is treated as a signal beam.

The beam reaches a spot lens next. This lens focuses the beam to the correct size so that the beam spot completely fills the aperture of the objective lens.

The beam after the spot lens reaches a PBS (Polarizing Beam Splitter) and a ¼ wavelength retardation plate. These two optical components are used to separate the projected beam from the reflected beams. The vertically polarized beam can pass through the PBS but the horizontally polarized beam is bent 90° as passing through the PBS.

Since the laser beam is vertically polarized, it can pass through the PBS and reaches the ¼λ retardation plate. This ¼λ retardation plate is also called as polarity converter. This component provides a ¼ wavelength, i.e., a 90° phase difference between the electric field wave and the magnetic field wave so that the vertically polarized beam is converted to circularly polarized beam (in counterclockwise direction) while passing through the PBS.

This circularly polarized beam is reflected by the radial tracking mirror and a fixed angle mirror and is sent to the objective lens. The tracking mirror is servo-controlled so that the reflected beam is kept correct tracking on the track of the videodisc. The objective lens is similar to a microscope and is servo-controlled so that the beam is kept focused into a tiny spot on the surface of the videodisc pits.

The theory of the servo operation will be detailed later in the description on the servo system.

The beam is reflected back from the surface of the disc and becomes luminance modulated by the pits. (The light reflected from the pit area is less bright than what is reflected from other area than pit area.) The depth of the pit is equal to ¼ the wavelength (90° in terms of phase) of the He-Ne laser as described before. The reflected light from pits is delayed ½ wavelength because ¼ of a wavelength is delayed while going into the pit and another ¼ wavelength is delayed while reflection. The intensity of reflected light from the pit area is weakened by the interfere from the reflected light other than pit area.

The reflected light takes the same path as the projected light all the way back to the ¼ retardation plate. The reflected light is a counterclockwise circularly polarized light and its phase is shifted 90° when passing through the ¼ retardation plate so that the beam is changed to a horizontally polarized light. Fig. 2-11 illustrates the polarity converter using a ½ retardation plate.

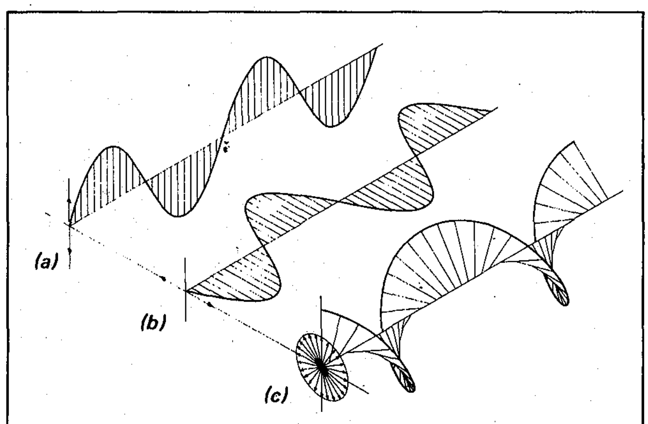


Fig. 2-9. Polarization of light

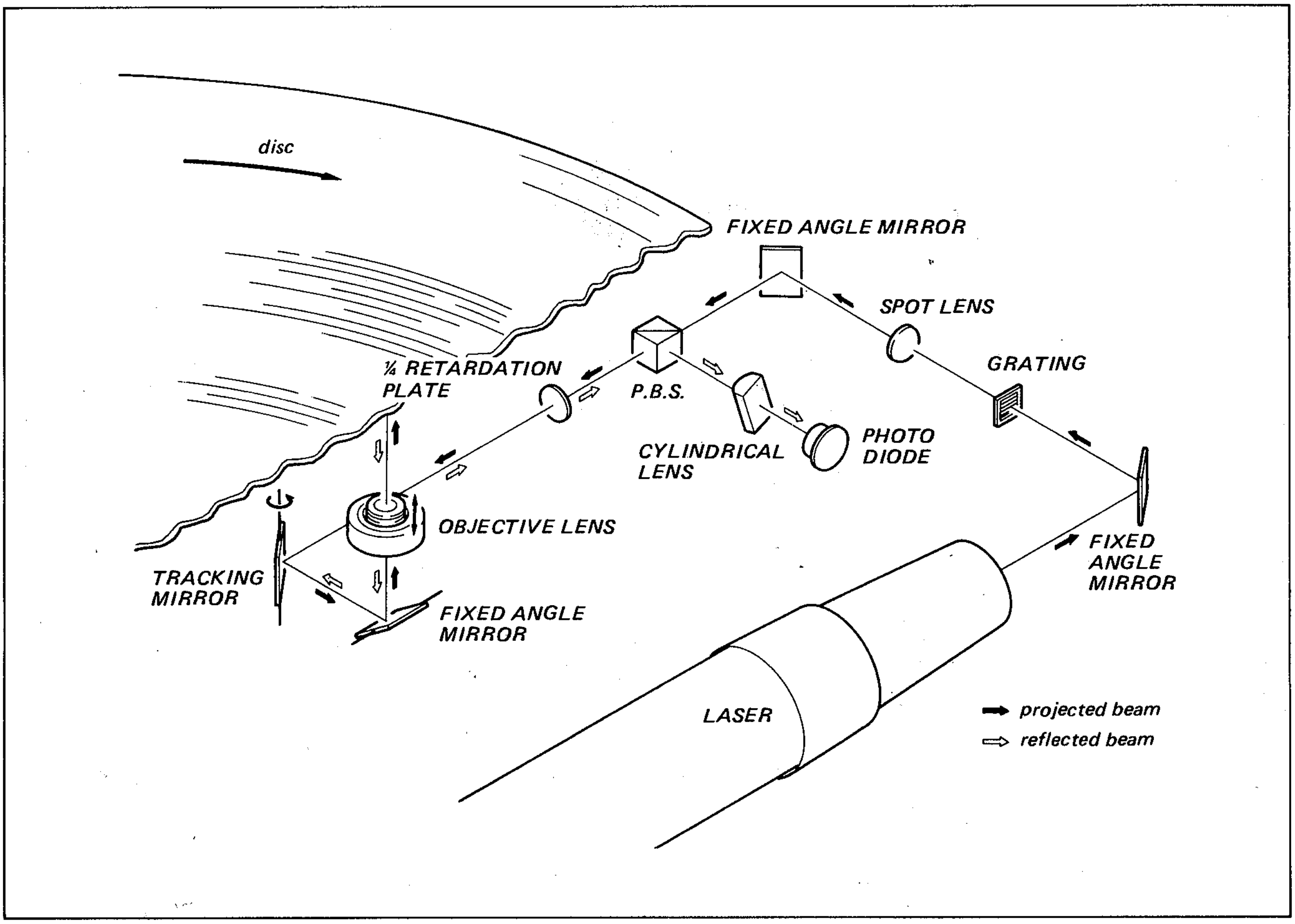


Fig. 2-10. Optical path

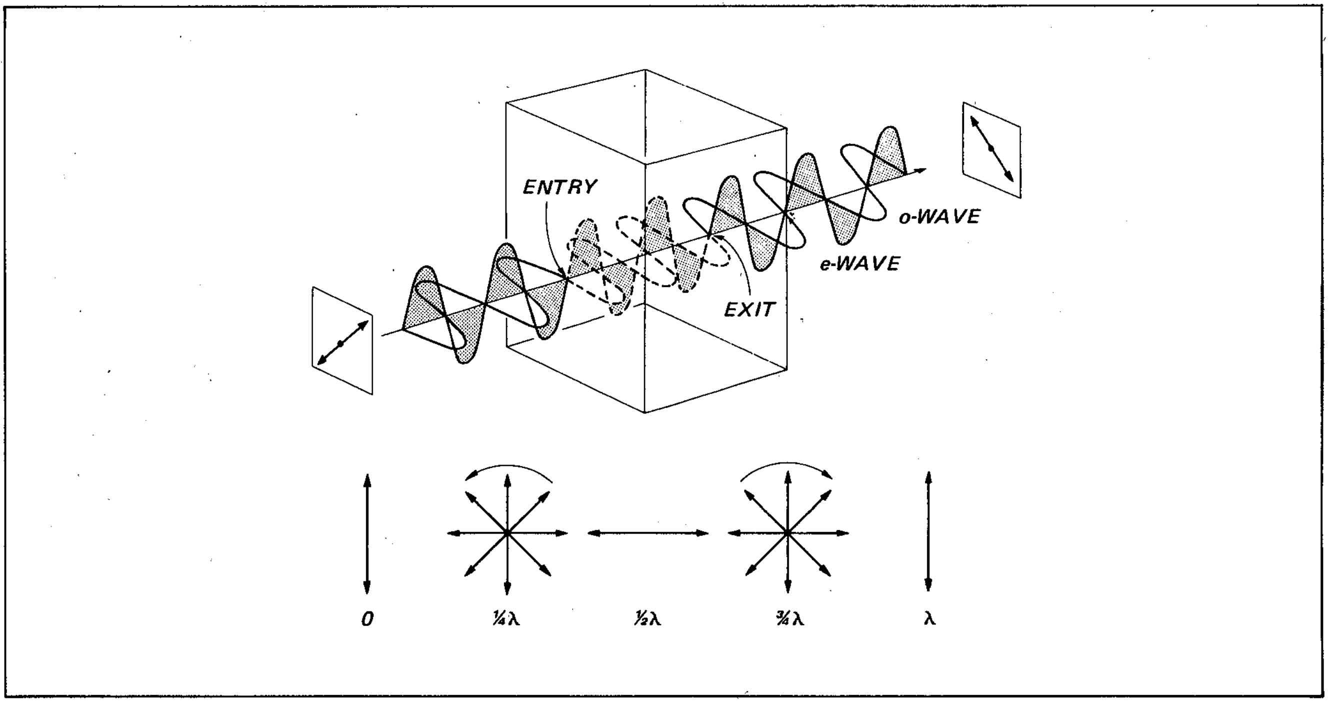


Fig. 2-11. Polarity converter

Since the reflected light coming into the PBS is the horizontally polarized beam, the direction of the light is bent 90°. The projected beam and reflected beam are separated each other by the PBS. The PBS serves to prevent a back-talk that is resulted from the feedback of the reflected beam back into the laser tube.

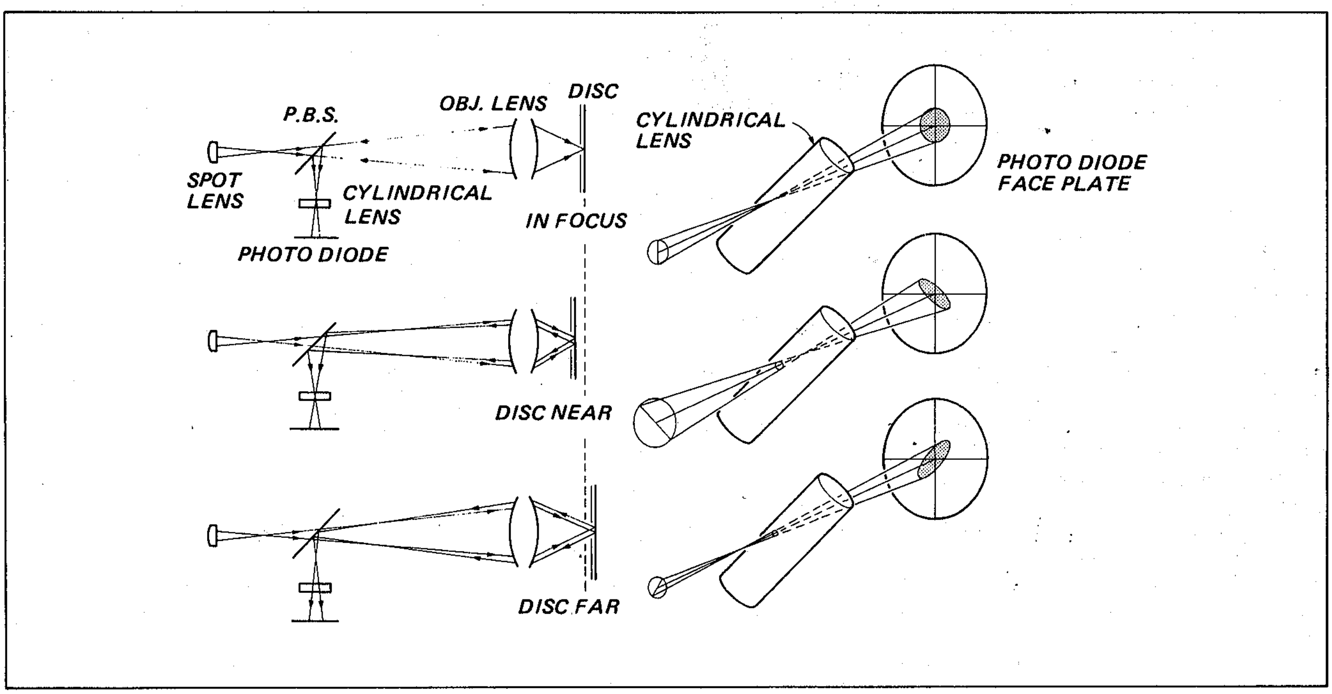


Fig. 2-12. Focus detection using cylindrical lens

The reflected beam that is separated by the PBS is passed through a cylindrical lens and landed on the photo diodes. The characteristics of the cylindrical lens are such that the shape of the beam landing on the diodes is circular only when the beam is perfectly focused onto the videodisc by the objective lens. If the beam becomes unfocused because of the up and down movements of the disc, the shape of the beam becomes elliptical when landed on the diodes.

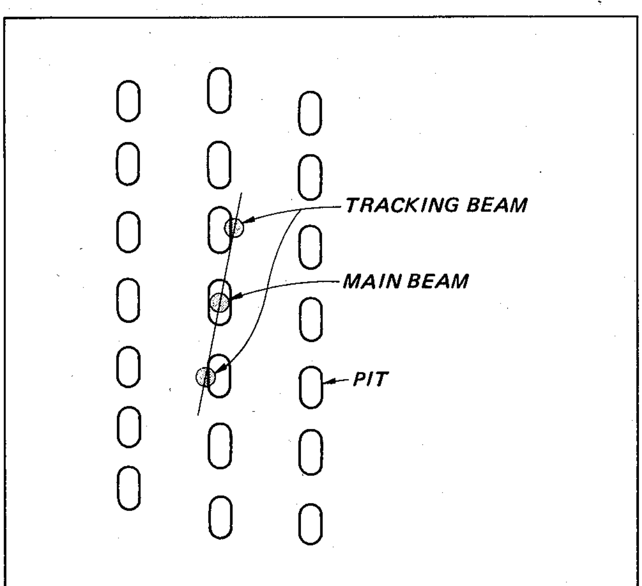


Fig. 2-13. 3-spot astigma method

The reflected light landed on the diodes actually contains the following three information.

1. Luminance variation of the reflected light resulted from pits
   — Video and audio multiplex FM signal
2. Deformation of the reflected spot shape focused on the photo diodes
   — Focus error signal
3. Luminance difference between the two tracking beams among three beams that are landed on the photo diodes
   — Tracking error signal

The photo diodes has a multiple elements structure as shown in Fig. 2-14 to detect the FM signal and the servo control signal contained in the reflected light.

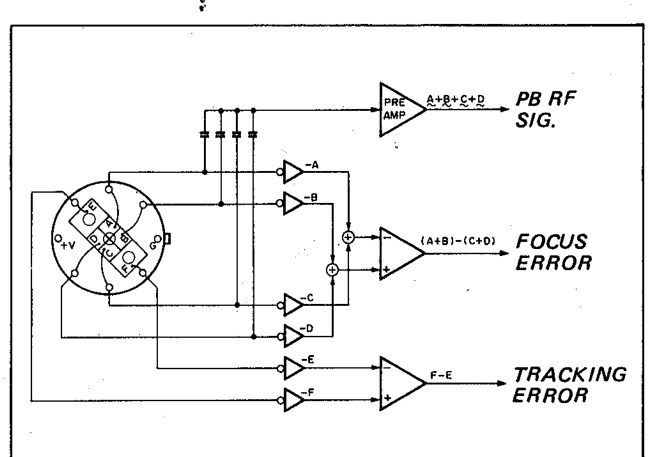


Fig. 2-14. Photo diode

2-3-2. Focus Servo

The distance between the objective lens and the surface of the disc consistingly varies because of the up and down movements of the disc happening together with the rotation of the disc. It is designed that the beam is kept focusing correctly on the disc even if the disc moves up and down. The beam focusing is detected optically by utilizing the reflected beam so that the position of the objective lens is servo-controlled.

Utilizing the fact that the focusing point of the reflected beam is shifted in accordance with the position of the disc reflecting surface, the movement of the focusing point is converted into the shape variation of the beam spot with the use of cylindrical lens. The shape variation of the beam is converted into an electric signal by the four-gang light sensitive photo diode. The signal is fed to the operational circuit of an RF amplifier so that the focus error signal is obtained.

The objective lens has the structure that is similar to that of speaker's voice coil.

The objective lens itself has a coil of wire attached to it while coil is surrounded by a permanent magnet. The objective lens is moved up or down, depending on the polarity and magnitude of current flowing through lens coil. The principle is the same as that of a voice coil in a loudspeaker.
Thus the focus is servo controlled.

The objective lens must be pre-positioned to the optimum point in term of focusing in case when the focus servo system is starting, or in case when the focus point is missed and lost by dust or drop-out on the disc. The sequence of the focus search operation will be described below.

When a focus detection voltage is not obtained due to the above reason, the focus servo loop is opened and a MMV for the focus search is triggered. The rising speed of the objective lens is controlled by a closed loop circuit to constant by detecting a counter-electromotive force of the objective lens driving linear motor and feeding back the signal to the lens driver circuit.

The "S" shaped characteristics of the error signal will appear as shown in Fig. 2-15 when the objective lens is raising its position closer to disc. The servo loop will be closed at the zero cross point of the "S" shaped characteristics (optimum focus point) and the normal focus servo operation is started. If the zero cross point is not detected within the time constant of the focus search MMV, the objective lens will be lowered again and the above search sequence will be repeated again.

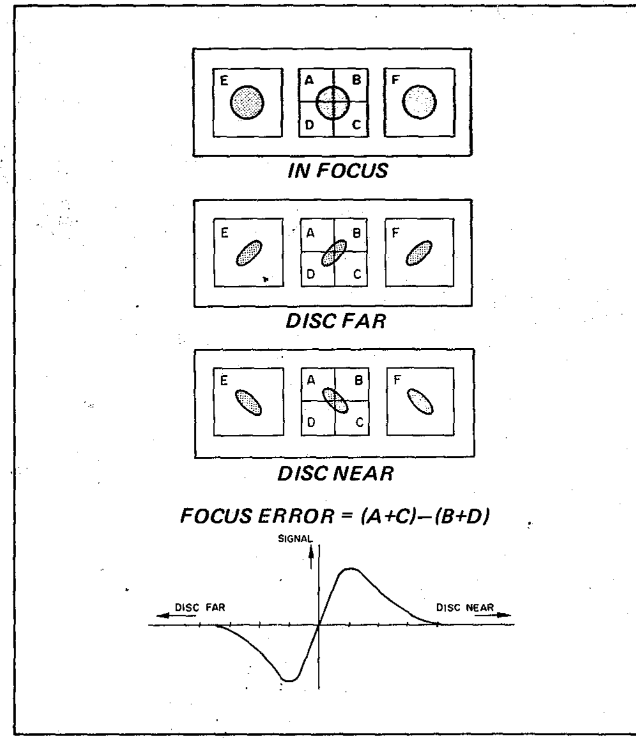


Fig. 2-15. Focuse error derecting system

2-3-3. Tracking Servo

Beam tracking over the pits is detected optically by using the additional two beams focused on the same track.

Position of the beam is controlled by a electromagnetic controlled tracking mirror for a high speed tracking variation such as a disc eccentricity. The overall position of the optical sled is moved along the guide rails by a slide motor for a low speed variation such as to the normal playing.

The three beams separated from one laser beam tube by grating, are focused to three independent spots on the same track by the objective lens. The three lights are reflected by disc and then detected by the three photo diodes. The difference in the amounts of the reflected lights from the two outside tracking beam spots, is detected as a "tracking error signal".

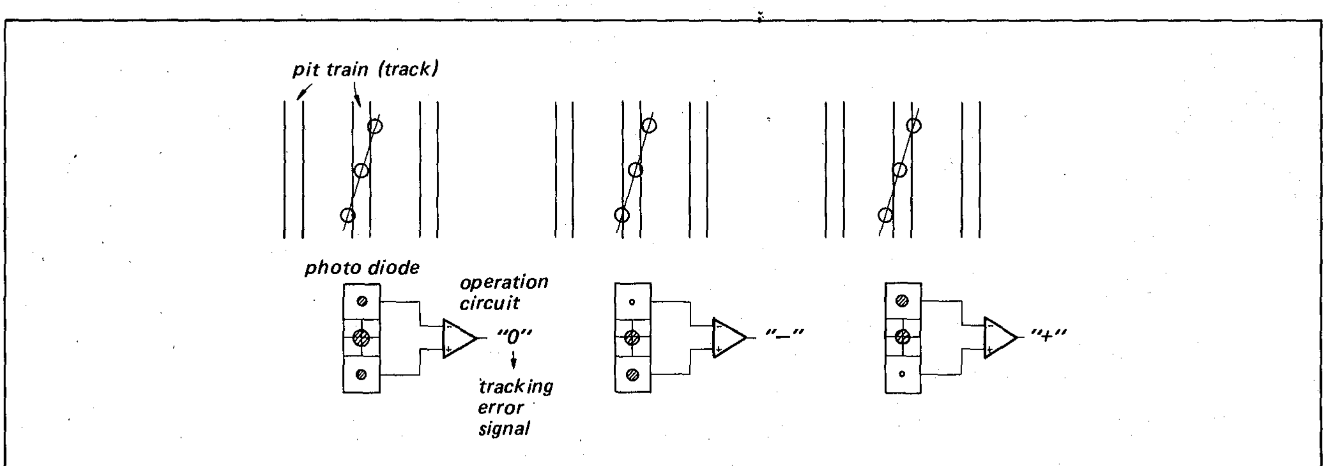


Fig. 2-16. Tracking error derecting system

The construction of the tracking mirror is same as that of galvanometer in the voltmeter. The mirror has a permanent magnet attached to it. Surrounding the mirror, but not attached to it is a coil of wire. Angle of the mirror can be controlled by the current flowing through the coil, moving around the pivot. The mirror alone cannot follow all the tracking from its beginning to end of the videodisc because the angle which the tracking mirror can follow is limited.
As the dc component of the tracking error signal is increased with the advancement of the spiral track, the dc component is supplied to a motor drive control circuit for the sled feeding motor so that the overall optical sled is slided in the radial direction of the disc. Therefore the tracking angle of the mirror is refreshed.

2-3-4. Spindle Servo and Tangential Servo

Both spindle motor and TBC unit are used mutually for removing a time base variation of the playback signal and stabilizing an output signal. The main factor of the time base variation are variation in the rotation of the spindle motor, eccentricity of the center hole on the disc, and about 30 Hz inherent error generated by the fact that the track is not a perfect circle and actually it is spiral. Since the revolution of the spindle motor are different in the inner and the outer circumference plays of the CLV disc, the spindle motor speed must be controlled in accordance with the difference.

The spindle motor speed is controlled by comparing the frequency of the reference sync signal with the one of the PB horizontal sync signal. But about 30 Hz speed error caused by the eccentricity of the track pattern cannot be removed. The TBC unit using a CCD (Charge Coupled Device) is provided for coping with about 30 Hz error and the momentary time base variation.

- **TBC unit using CCD**

CCD is a shift register for analogue signal and its delay time is determined by the frequency of a transfer clock.

$$\text{Delay time (T)} = \frac{\text{Number of CCD's bits (N)}}{\text{Clock frequency } (f_{CL})}$$

The CCD can be used as a variable delay line when the clock frequency is made variable, and can be used as an analogue memory if the clock is stopped temporarily. The TBC unit utilizes the CCD as the variable delay line.

Phases of H-sync extracted from video signal at the CCD-OUT, that of color burst signal, reference H-sync, and reference SC are compared with and a time base error signal is detected. The CCD transfer clock is frequency-modulated by a control signal. The control signal is the sum of the time base error signal and the 30 Hz component signal fed from the spindle servo. A delay time corresponding to the error is obtained and a closed loop is formed. The loop provides outputs of composite video signal without the time base variation at the CCD-OUT.

- **Spindle Servo**

Spindle servo is composed of three servo loops. The first servo loop is an H-SPEED system that is sampling the "period" of the PB H-syncs separated from the PB video signal after period is converted to dc voltage. The second servo loop is an H-ϕ system comparing the phase of the PB H-sync with the that of the REF H-sync in order to detect an phase error. The third is a V-ϕ^2 system that is working to maintain the phase relationship between the PB V-sync and the REF V-sync to constant.

When the PB video signal cannot be obtained due to focus error caused by a scratch or a dropout on the disc, or when the spindle motor is in starting up period, the servo loop is switched to the FG mode. In the FG mode, the voltage obtained by a voltage conversion of the spindle FG period is compared with the reference voltage and the revolution of the spindle motor is controlled. The servo loop switch is set to its original position as soon as the motor speed enters the rated servo lock range. The reference voltage for the FG mode is constant in the CAV mode but not in the CLV mode. Since the revolution speed of the spindle motor for the inner circumference play differs from the one for the outer circumference play on the CLV disc, a voltage corresponding to the optical sled position detected by a variable resistor is generated as the reference voltage.

2-3-5. Trick Play

The trick play, one of the features of the optical videodisc player, will be described below.

The trick plays are made possible because the beam can jump from track to track in FWD or REV modes by controlling the tracking mirror. To prevent the jump from being visible on the TV screen, all track jumping takes place only during the vertical sync interval.

Since two vertical sync intervals occur for each revolution of the CAV disc, a maximum of two jumps per revolution can take place. Fig. 2-18 shows the locus of the beams in the trick play.

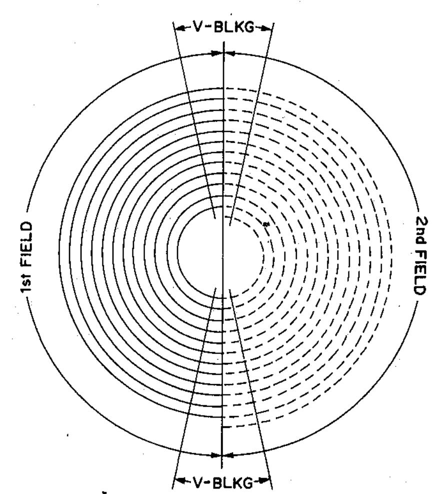


Fig. 2-17. Track pattern of CAV disc

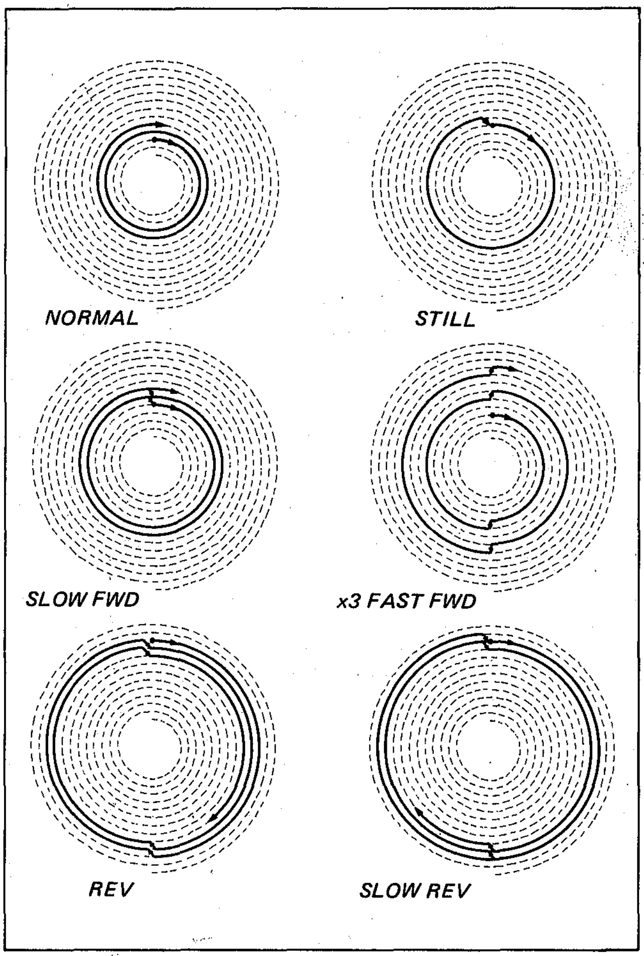


Fig. 2-18. Laser beam trace in each modes of operation

- **STILL Play**

The STILL play is the fundamental operation of the trick play. One track is read and then the beam jumps one track back and repeats. As each revolution of the disc is recorded frame (two fields), the STILL play takes place in the unit of one frame.

- **SLOW FWD Play**

The 1/2 SLOW FWD picture is obtained by repeating the STILL play and the NORMAL play at a constant rate.

- **FAST FWD Play**

The FAST FWD Play is made possible by jumping one track forward after each field and the jumping direction in this case is opposite to that in the STILL or the SLOW FWD.

- **REV Play**

The REV. Play is made possible by jumping two tracks in the reverse direction after each revolution of disc.

- **SLOW REV Play**

The SLOW REV Play is basically the same as that of SLOW FWD Play that is made possible by repeating the STILL Play and the REV Play at a constant rate.

- How the track jump takes place will be described briefly. There are two kinds of the jumps. All the track jumps are the REV jumps except the FWD jump in the FAST FWD mode. Fig. 2-19 shows the timings of the FWD jump and the REV jump.

The tracking servo loop switch is opened at the V-sync timing upon receiving a REV jump command. Then the mirror is driven in the REV direction.

As the mirror is moved, the tracking detection beam is shifted out from the track by 1/2 track amount, that produces the half of the tracking error voltage similar to a sine curve. The error voltage of "zero" is provided for a moment. The "zero" voltage is the zero-cross signal which is produced when the laser beam is located in the middle of two adjacent tracks. A deceleration signal in the FWD direction is impressed on the mirror drive signal at the zero cross moment. When the beam is positioned correctly on the adjacent track, the error voltage becomes zero again and then the tracking servo loop is closed by the zero detection signal. The normal tracking servo operation is restored.

The FWD jump is the same sequence as that of the REV jump except that the drive direction of the mirror is opposite.

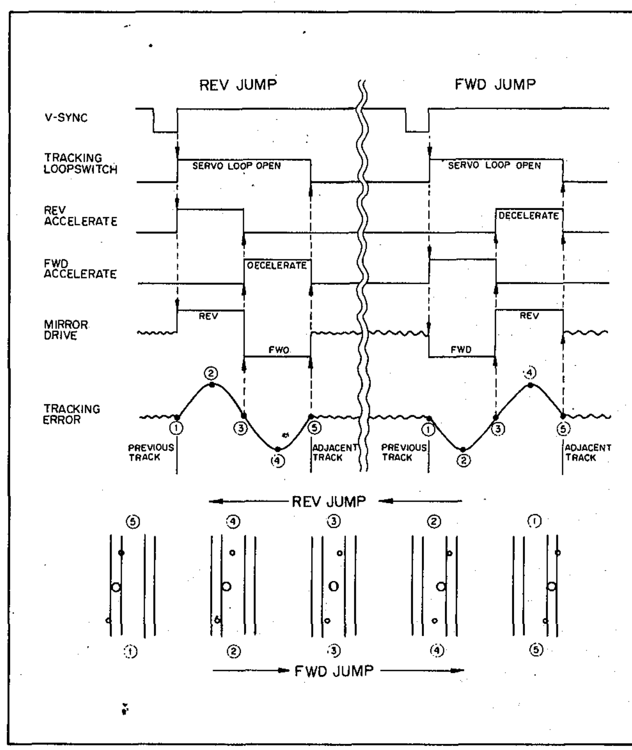


Fig. 2-19. Track jump system

2-3-6. Random Access

LDP-1000 is equipped with an access motor to move the sled at a high speed during the random access mode in addition to the precision motor that moves the sled with advancement of track in the normal playback mode. The access motor is driven by four level dc voltages (FWDx360, FWDx100, REVx360, and REVx100) generated in the access voltage generator.

The slide motor drives the sled via a transmission mechanism that has a large gear ratio to get high precision sled feeding. It is designed that the rotation noise of the motor should not interfere with the PB signal. An electromagnetic clutch is provided to protect the drive circuit from the flash-back of the counter electromotive force of the motor into drive circuit in the access mode that can be resulted from the large gear ratio.

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