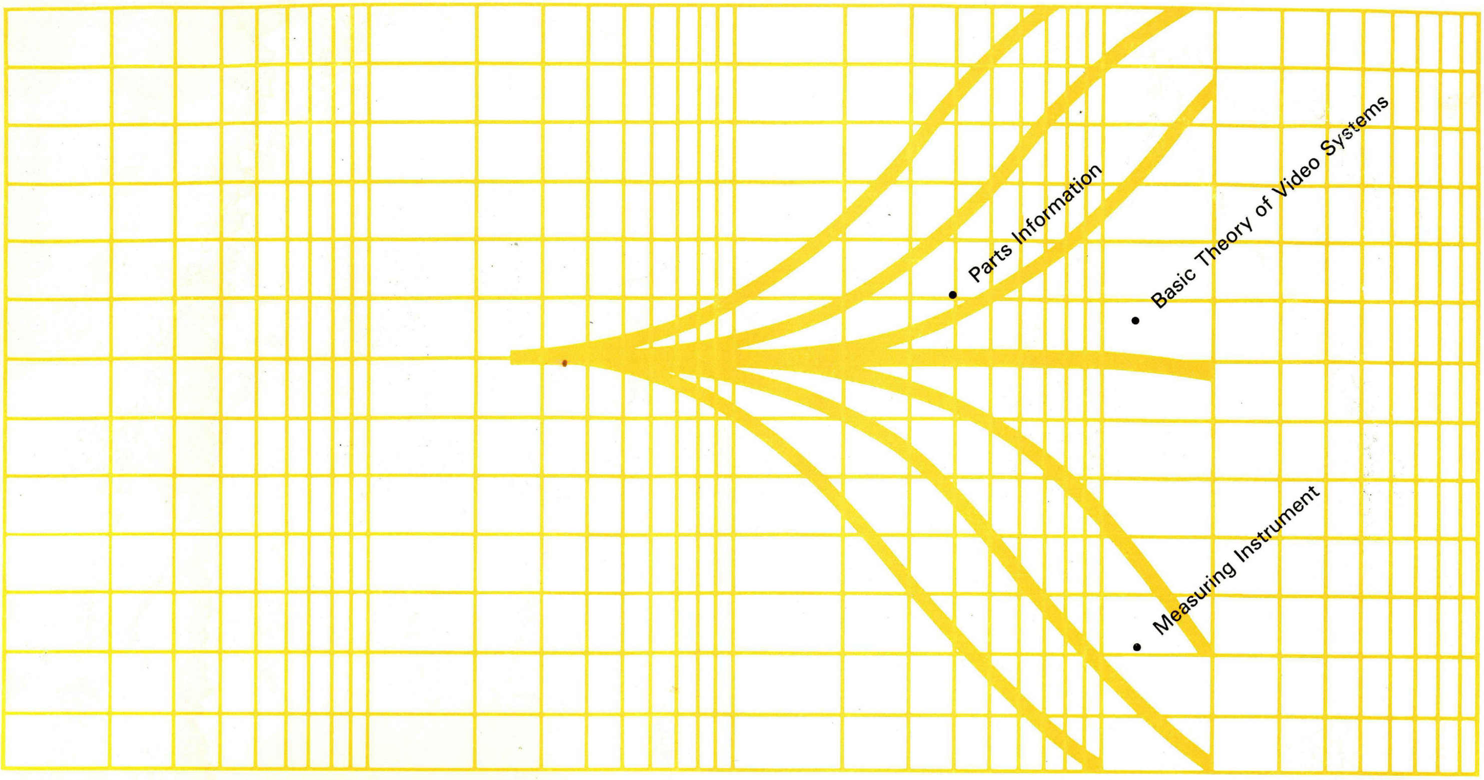
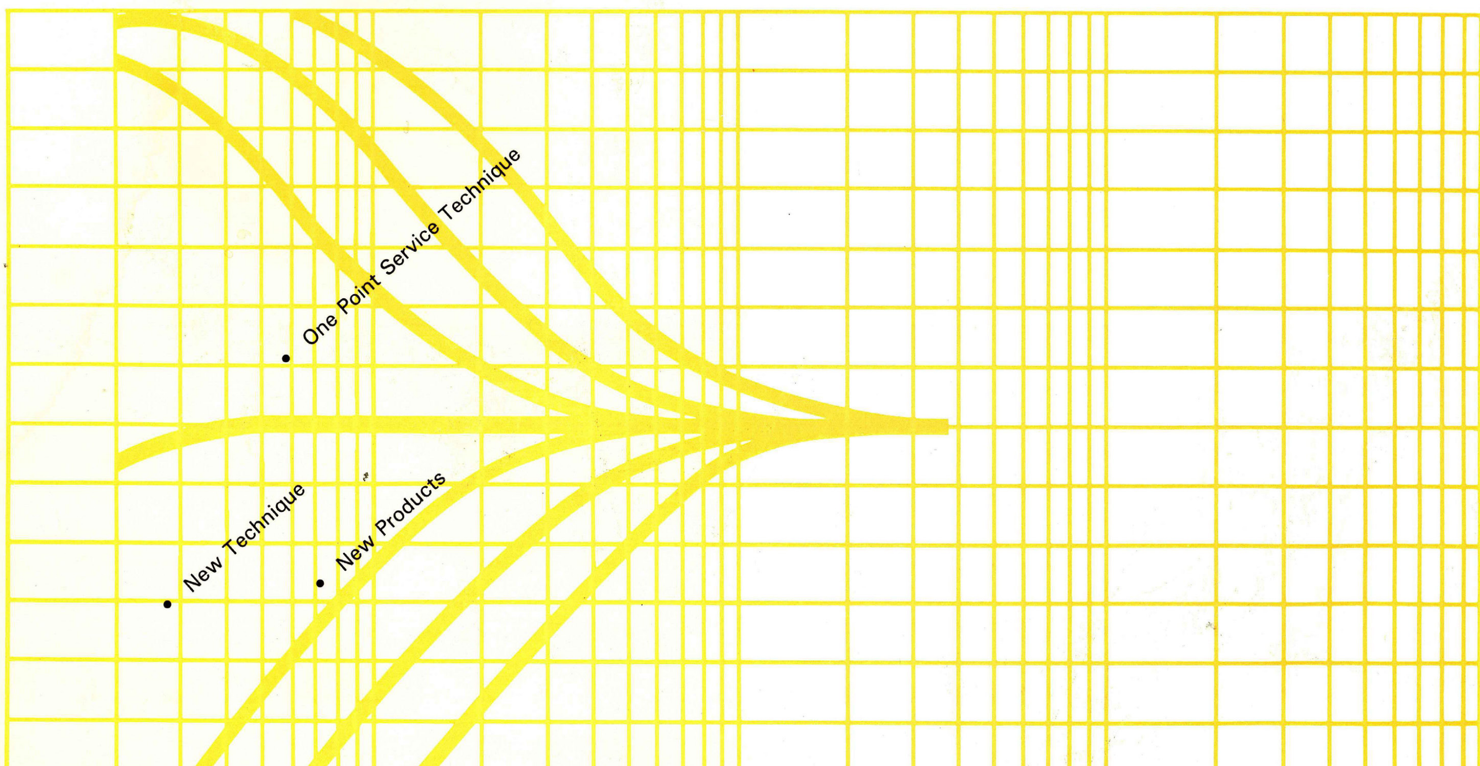



# TUNING FORK

## Audio and Video Service Guide

No.8




PIONEER®

ORDER NO.GGF-606

# CONTENTS

# Parts Information

## Switches and Relays

Various switches and relays are being employed in electronic equipment. They have only one function of opening and closing electric circuits. Their specifications depend on peripheral circuits.

Here we will discuss the features of metal switches and relays employed in Pioneer products.

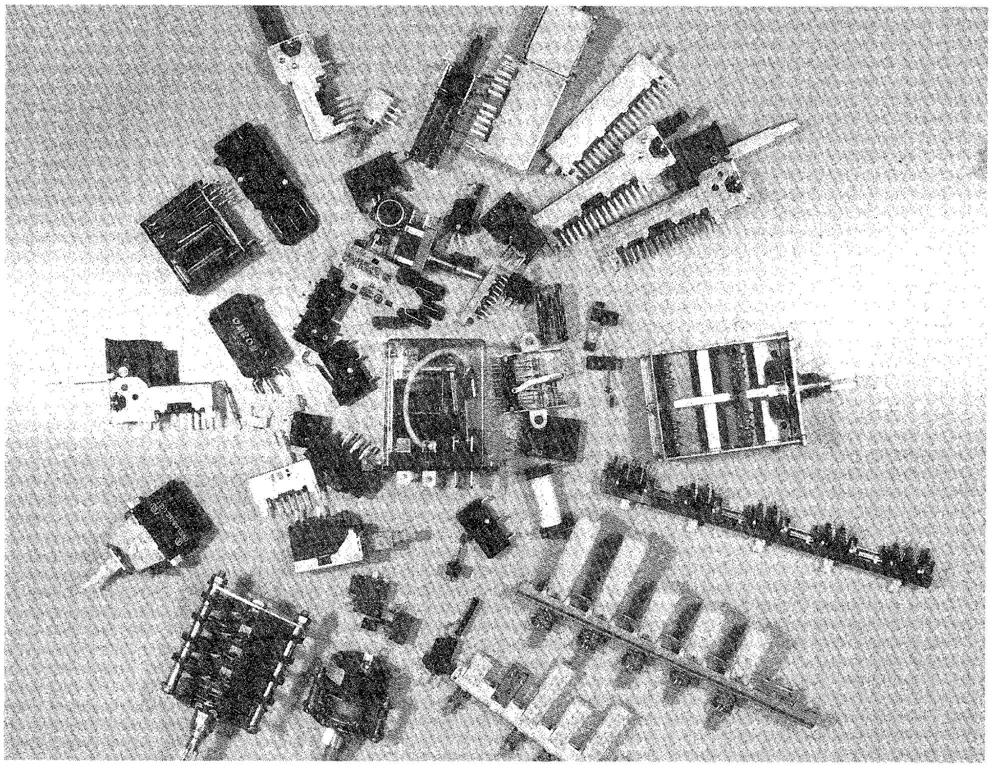


**Photo 1 Switches and Relays**

# Switches

A switch completes or breaks the path of a current or sends it over a different path. Its operation is digital because its output is "1" or "0", or "high" or "low". There are two types in switches, conventional metal-contact switch and contact-pointless switch or electronic switch made of a transistor or an IC. The electronic switch is omitted here.

## 1. Contacts

Contacts are the heart of a switch where an electric circuit is opened or closed.

### 1.1 Material

Contacts are made of silver (Ag) and its alloy, copper (Cu) and its alloy, gold (Au) and its alloy or other highly conductive materials to make the resistance at a contact point lower than 100mΩ. The materials have both merits and demerits. They should be used in the right place.

### 1.2 Structure

There are two types of switches; push type and slide type.

a) Push Type

In this type contact is made by pressing a conductive piece against the other. This is suitable for frequent on-off operation of a large current at a high speed. Fig. 1 shows the principle of push contacts.

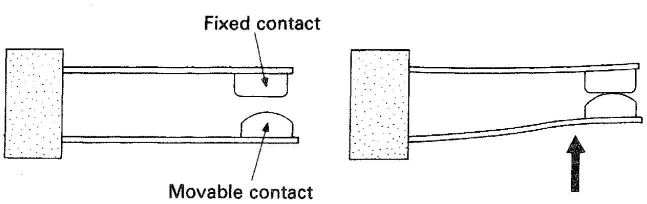



**Fig. 1 Principle of Push Contacts**

b) Slide Type

A conductive piece slides and engages with the other piece. This has a self-cleaning ability. It scrubs off by itself the resistive film of dust and sulfite formed on its contact surface. This is suitable for dealing with small current and not for switching in high frequency. Fig. 2 shows the principle of slide contacts.

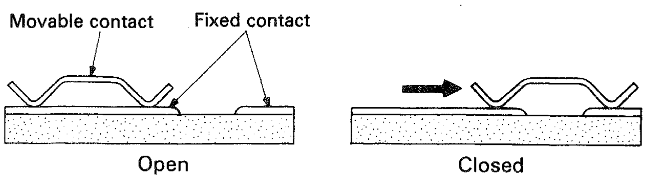



**Fig. 2 Principle of Slide Contacts**

### 1.3 Symbols

There are several kinds of switch symbols as shown in Table 1. The symbols effectively show the mechanism of switches and features of circuits.

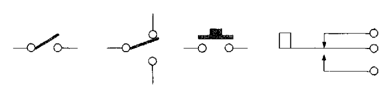
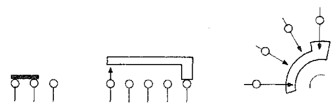
| Contacts | Symbols |
|---|---|
| Push type |  |
| Slide type |  |

**Table 1 Various Switch Symbols**

## 2. Types of Switches

### 2.1 Classification by Uses

They can be classified into three; power, selector and digital switches.

a) Power Switch
Power switch connects or disconnects an AC power line to the primary winding of a power transformer. This switch has been so designed to stand high heat to deal with a large current which generates arcs and heat when switched. The contact pieces should, therefore, be made of a material which has a high melting point and should move quickly to minimize sparks, and the gap between the contact points should be wide enough to prevent the pieces from melting and sticking. If the gap is narrow or the operation is slow, the arc will continue for a long period. Fig. 3 shows a typical power switch. The contact points are made of silver cadmium oxide (AgCdO) and are operated quickly with the help of a spring. All Pioneer products employ power switches which have preliminary been approved by the authorities of safety standards in each country. Major safety standards are UL (USA), CSA (Canada), SEMKO (Sweden), DEMKO (Demmark), NEMKO (Norway), BS (GB), VDE (West Germany), EI (Finland) and SEV (Switzerland).

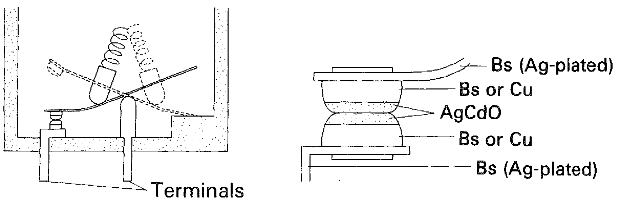



**Fig. 3 Contact Point of Power Switch**

b) Selector Switch
Selector switch is a multiposition switch that permits one or more conductors to be connected to one of other conductors. This is used in the following circuits to the secondary winding of a power transformer. Most switches are for selecting a signal and some for switching a DC current. Here we will discuss the switches for selecting signal channels. As to the switches for opening and closing DC circuits and for sensing various conditions, refer to the item "2.2 Switches Classified by Functions".

Switches for selecting signals usually employ the sliding mechanism which scrubs and clean the contact surface by itself because the signals to be selected are very low in voltage, small in current and are highly affected by the resistive dust film. Figure 4 shows the mechanism of a linear sliding signal selector.
The clip or moving piece is made of silver-plated phosphorous bronze and the fixed piece is silver-plated brass. Low tenacity grease is applied on the contact surfaces to protect silver from being affected by the sulphur in the air. The sulphur affects silver, forms a resistive film on the silver surface and causes poor contact.

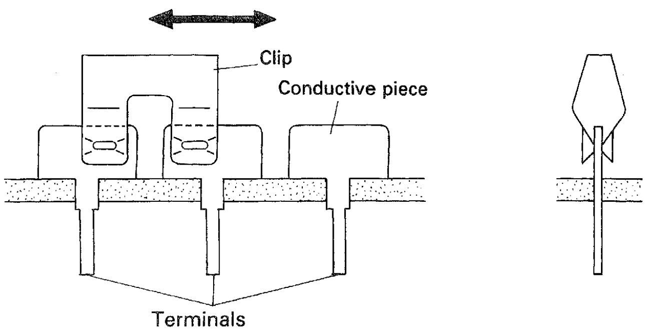



**Fig. 4 Linear Slider Type Signal Selector**

There are shorting (make-before-break) and nonshorting (break-before-make) types in this switch. Fig.5 shows the difference. Type (a) once connects and type (b) once opens all terminals of A, B and C when switching. Generally, shorting type is used in muters, attenuators, mode-selectors, etc. and nonshorting type is used in function selectors, tape monitors, etc.

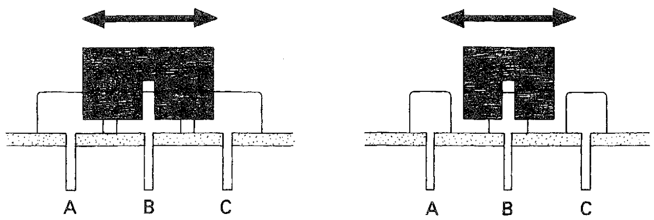



**Fig. 5 Shorting and Nonshorting Types of Contacts**

c) Digital Switch
The switch exclusively used in a digital circuit is called digital switch. This is also a kind of signal selectors. Generally they are used in key input and data circuits.

## 2.2 Switches Classified by Functions

a) Rotary Switch

Rotary switch is capable of selecting, making, or breaking an electric circuit actuated by a rotational torque applied to its shaft. Most switches of this type are for selecting signals and some for switching power. Here we will discuss signal selectors. This switch is capable of switching multiple circuits when switch wafers are assembled in multiple gangs. Generally each wafer can select 11 terminals which are apart from each other by 30°. This switch usually has to step over several unnecessary terminals before reaching a desired point. The contact points are of sliding type and have an ability of self cleaning. With these features, this switch is used for selecting functions, modes, speakers, etc. Photo 2 shows typical rotary switches.

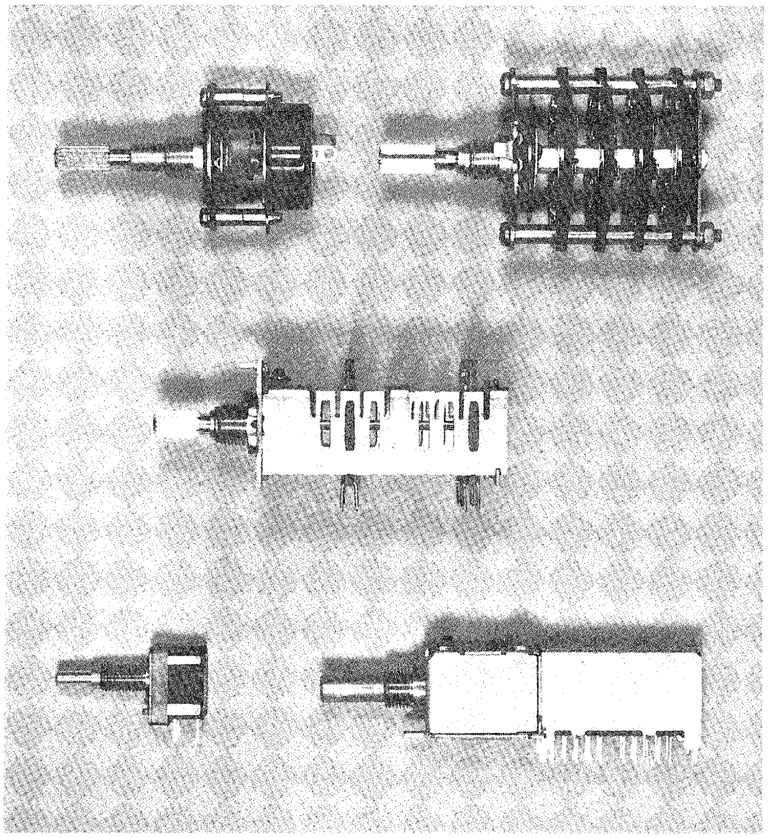


**Photo 2 Typical Rotary Switches**

b) Push-button Switch

A switch in which a button must be depressed each time the contacts are to be opened or closed. Microswitch and tact switch, however, are excluded from this category. Push-button switches can be classified by uses, number of keys, and mechanisms as shown in Table 2.

- Push switch
  - Power switch
  - Signal selector
    - Multiple Key
      - Lock/release
      - Self-lock
      - Nonlock
    - Single Key
      - Self-lock
      - Nonlock

**Table 2 Push-button Switches.**

Lock/release (interlock) type locks the newly depressed key releasing other keys.

Self-locking (latching) type locks by the first press and releases by the second irrelevant to the state of the other keys.

Nonlock (momentary or press-to-talk) type opens or closes a circuit only in the period a key is depressed. Releasing the key deactivates the switch.

Power switches employ press mechanism and signal selectors employ sliding mechanism. A signal selector has generally two contact points for two to eight circuits.

Lock/release type can contain many switches, deals with many circuits and does not require to pass unwanted contact points to reach the desired point unlike the rotary switch. With these features multi-gang push switch of lock/release type is suitable for selecting functions. Switches of single and multi-gang self-lock types are used in muters, filters, tape monitors, etc. and those of nonlock type are used in tape deck REC muters, key inputs of digital circuit, etc. Instead of push switches many tact switches discussed later are being used in digital key input circuit. Multi-gang push switch has all functions of lock/release, self-lock and nonlock types. Photo 3 shows typical push switches.

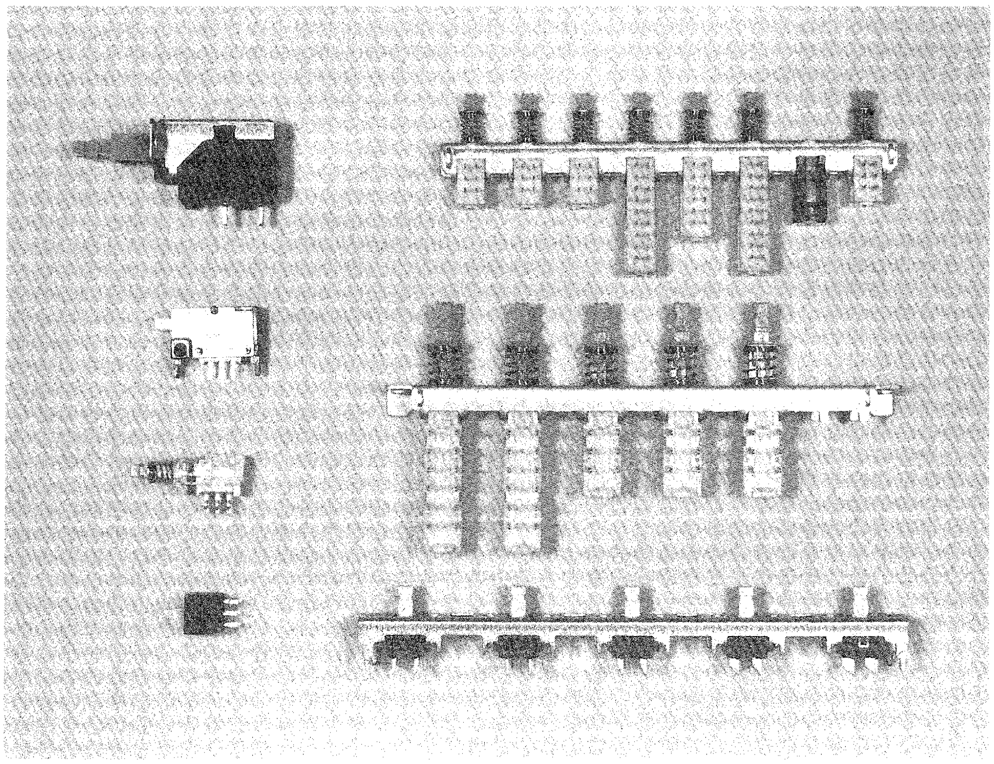


**Photo 3 Push Switches**

c) Slide Switch

The operation of this switch is made by sliding its knob back and forth. This is suitable for switching signals because most of this type slide a contact piece on a fixed piece and scrub and clean the contact surfaces.

This type is divided into two. One is operated directly and the other indirectly with the help of an additional mechanism. The former is not mounted on front panel but is used for selecting subsidiary functions because its operational feeling is poor.

The latter is further divided into two. One simply slides a contact piece back and forth, and the other has a spring inside and returns the piece to the original position when the finger is released.

Most switches of this type have two or three contacts and two to twelve circuits. The direct type is used for selecting FM de-emphasis, AM channel space of 9kHz or 10kHz, carstereo's speakers 2 or 4, etc. The indirect type is for selecting REC/PB of a tapedeck, portable stereo, etc.

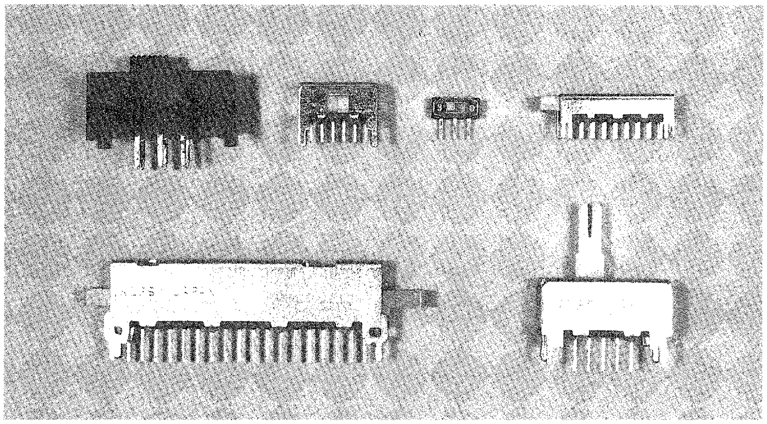


**Photo 4 Slide Switches**

d) Lever switch

Lever switch is basically the same as the single-key push switch and has a lever for rapidly opening and closing a circuit. Snap switch discussed later, however, has been distinguished from it.

It is easy to operate the lever and to feel selector position with a finger although it occupies a large space. This is, therefore, employed only when the panel space is large enough. The use is the same as that of single key push switch such as power switch.

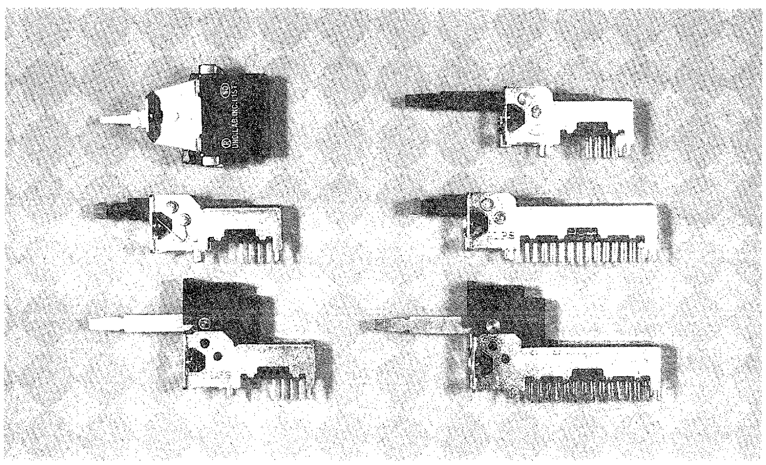
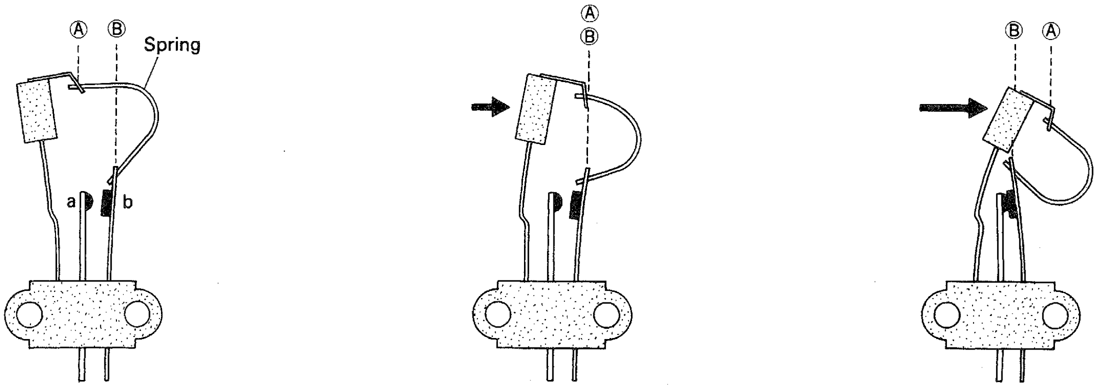


**Photo 5 Lever Switches**

e) Snap Switch (Toggle Switch)

This has a depressing mechanism for operating at a high speed and is mainly used for switching DC power sources and for sensing signals. Toggle switch is a two-position snap switch operated by a lever and is popularly used as a power switch in measuring equipment but not in consumer products because of its unfavourable design and ↗ operational feeling. Here we will discuss the popular mechanically-assisted type employed in DC power supply circuits and signal senser circuits. This has one or two contacts and one to four circuits. This is used as a car stereo's power or motor switch or a position sensor of a mechanism.




(a) Open — (b) is kept away from (a) when it is free.

(b) The moment of closing — (A) and (B) come on the same vertical line.

(c) Closed — The moment (A) moves further rightward, the spring pushes (b) against (a).

**Fig. 6 Snap Switches and its Operating Principle**

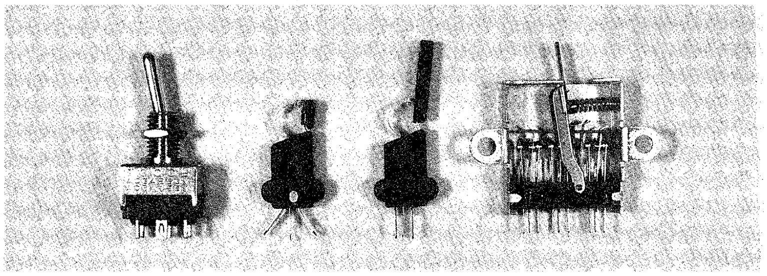


**Photo 6 Snap Switches**

f) Plate Spring Switch (Leaf Switch)

When the operating stroke is long and its dispersion is large, the contact plates made of spring absorb the excessive stroke and maintain stable ON/OFF operation. The mechanism is the press-to-contact type. This is suitable for sensing mechanical operation and switching DC power sources. Fig. 7 shows the structure of plate spring switch. The left one is open-air type and the right one is cased type.

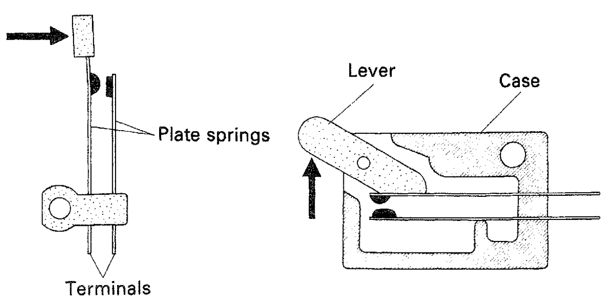



**Fig. 7 Structure of Plate Spring Switch**

Most of the switches have one or two contact points and circuits because of their structure. An additional mecha- ↗ nism is required to operate it at a high speed because it has no such mechanism as that of snap switch.

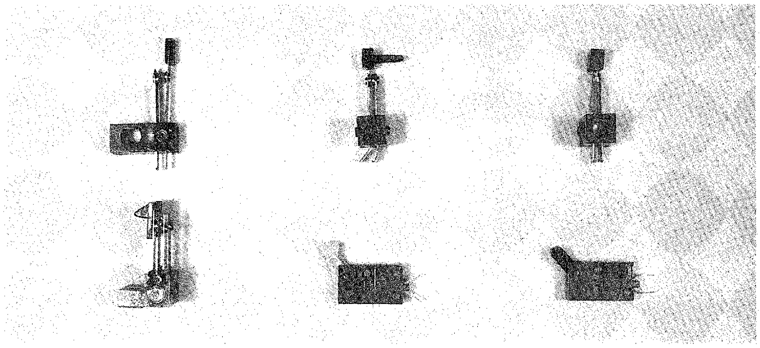


**Photo 7 Plate Spring Switches**

g) Microswitch

This is cased in a small box, is operated at a high speed by a pressure to a spring and allows a large current. This requires an additional mechanism to be operated because of its difficulty in manual operation. This is used for switching power and selecting signal channels. Fig. 8 shows the structure of a typical microswitch.

This has one or two contacts and mostly one or two circuits. Like the plate spring switch the number of circuits is limited. The microswitch which has an actuator has both features of plate-spring switch and snap switch.

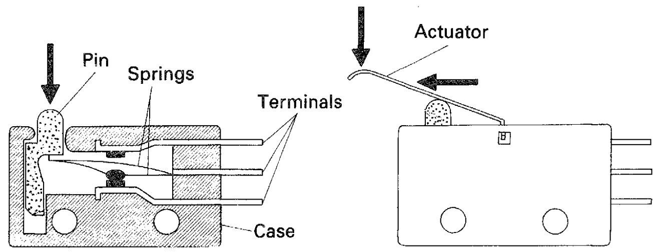



**Fig. 8 Microswitch**

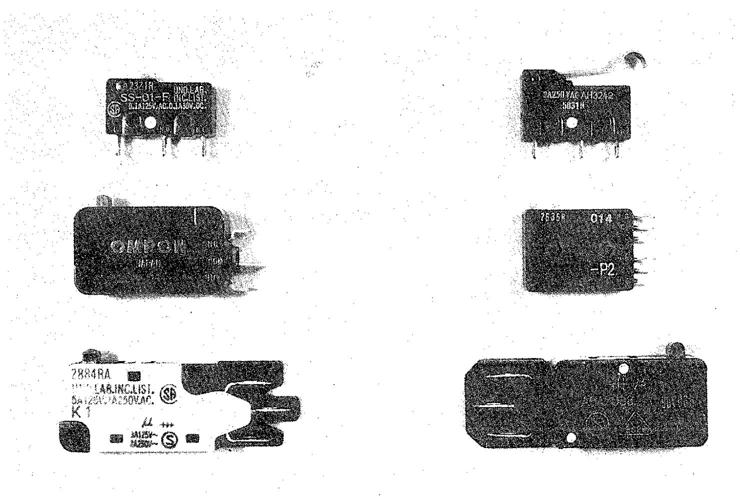


**Photo 8 Microswitches**

h) Tact Switch

This is a kind of digital switches and is popularly used in key input circuits for digital ICs including microcomputer ICs. Voltage drop by the contact resistance in this switch is negligible because the applied voltage is low (5V — 15V) and the current is small in digital circuits. Therefore, comparatively high-resistance conductive rubber is popularly used in place of a metal piece. The resistance of metal contacts is less than one ohm and that of conductive rubber is mostly several hundreds ohms. This has one contact and one circuit. Some switches among those employing conductive rubber directly opens and closes a part of gilded copper pattern of a printed circuit board.

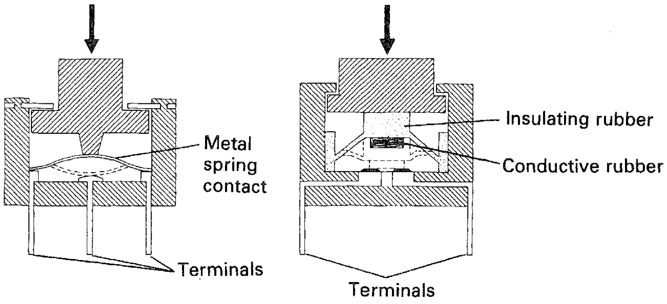



**Fig. 9 Structure of Tact Switch**

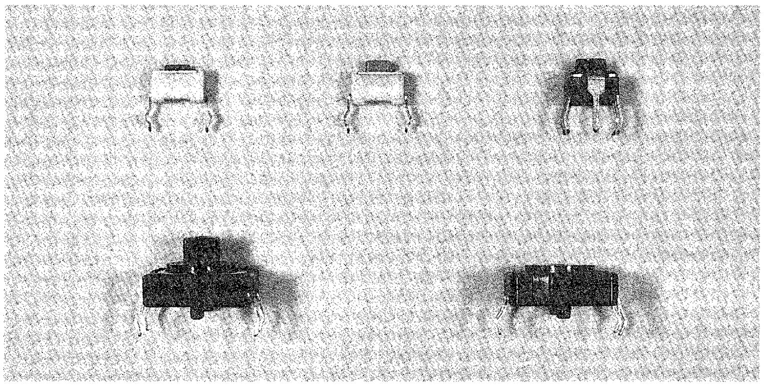


**Photo 9 Tact Switches**

i) Other Switches

The variations of the above switches are:

- Flexible switch (remote control switch): A variation of rotary and push switches which employs a flexible wire for transmitting push-pull force or torque.
- Reed Switch: This has two overlapping magnetic reeds. It keeps an air gap between free reed ends. The reeds attract each other when magnetic induction is applied. This is the switch portion of the relay discussed later.
- See-saw Switch (rocker switch): Popularly used as a power switch years ago. This is omitted here because this is not popular now.

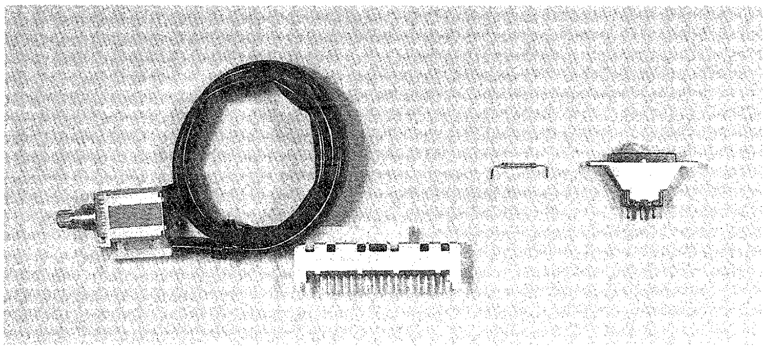


**Photo 10 Other Switches a,b,c**

## 2.3 Parts Numbering System

Our numbering system of switches is as follows:

| Part Number | | Descriptions |
|---|---|---|
| □SA-000 | (□SA0000) | Power switch |
| □SB-000 | (□SB0000) | Rotary switch (to be terminated with a binder) |
| □SC-000 | (□SC0000) | Rotary switch (to be terminated with a binder small type) |
| □SD-000 | (□SD0000) | Rotary switch (others) |
| □SE-000 | (□SE0000) | Rotary switch (slide type) |
| □SF-000 | (□SF0000) | Microswitch |
| □SG-000 | (□SG0000) | Push switch or tact switch |
| □SH-000 | (□SH0000) | Slide switch |
| □SK-000 | (□SK0000) | Lever switch |
| □SL-000 | (□SL0000) | Snap switch |
| □SM-000 | (□SM0000) | Sea-saw switch |
| □SN-000 | (□SN0000) | Plate spring switch |
| □SX-000 | (□SX0000) | Others |

**Table 3 Numbering System of Pioneer Switches**

# Relay

Relay is a kind of switch activated by electro-magnetic force.

## 1. Basic Structure

A relay is made of an electromagnet and contact pieces. While the coil is open, the movable piece C touches the fixed contact piece B (break contact). In Fig. 10, when a current is applied to the coil, C is attracted by the solenoid and touches the fixed piece A (make contact.)

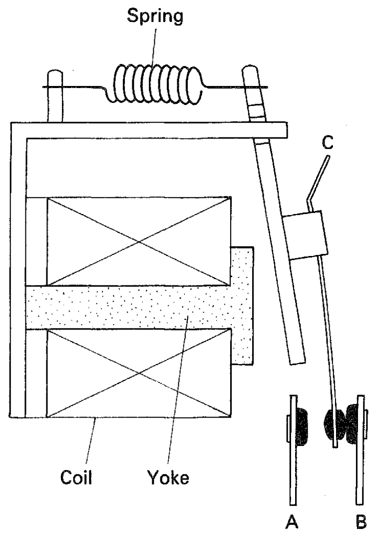



**Fig. 10 Structure of Relay**

## 2. Kinds of Relays

Relays are classified into four; power relay, protective relay, small current relay and reed relay.

### 2.1 Power Relay

Power relay that functions at a predetermined value of power is used in surge killer circuits of high power amplifiers to reduce inrush current which flows when power is turned on or in AC power circuits remote-controlled by an infrared ray. To withstand a high voltage and large current, this relay uses Silver Cadmium Oxide (AgCdO) at contact points. The dimensions of contact pieces are larger than those of the other to radiate heat.

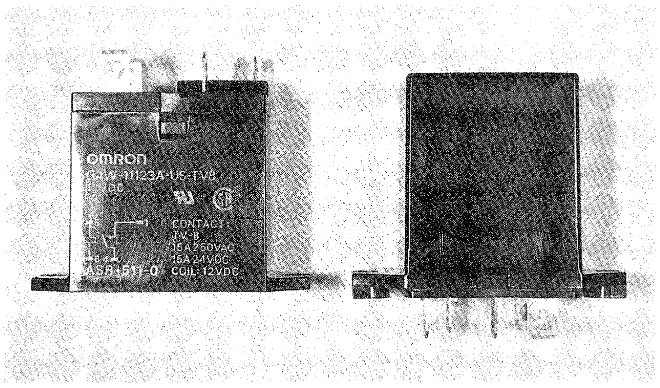



**Photo 11 Power Relays**

## 2.2 Protective Relay

Protective relay is for preventing damage to aparatus. This deals with the signal of a wide dynamic range, from residual noise level (1mV/0.1mA) to the maximum output level (28V/3.5A(100W output)) at 8Ω load. With this switch, when the contact surfaces are oxidized or sulfurized, small signal current will be blocked and sound will be muted by the nonconductive oxide or sulfide film formed on the surface because it can not scrub the film off, or it can not clean by itself. The film can be broken if the power output is high when the power is switched on and off. Such a case, however, is unexpected because amplifier's volume control is usually turned down when power is switched on. Protective relay's contact points are made of gilded silver to prevent the oxidization and sulfurization or doublepointed, or two circuits are used for one purpose to make the contact perfect. In principle, the failure rate of the dual-contact-point relay becomes $1/x^2$ if that of the single contact point relay is $1/x$.

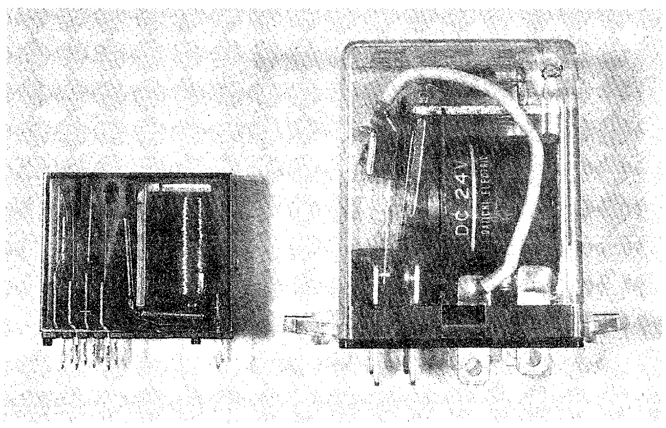



**Photo 12 Protective Relay**

## 2.3 Small Signal Relay

Small signal relay is employed in preamplifiers for muting, selecting equalizer's time constant, etc. Structure is the same as that of protective relay. This can be made small because it deals with a small current of low voltage.

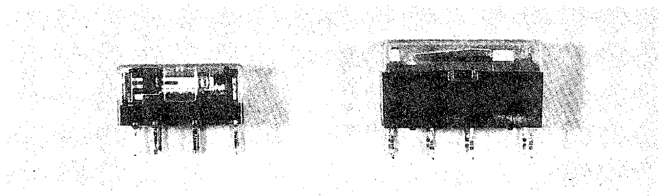


**Photo 13 Small Signal Relay**

## 2.4 Reed Relay

Reed relay is made of two flat magnetic strips of 52-gold sealed in a tube filled with inert gas. Its contact points have been gilded. When a current is applied to the coil, the leads attract each other and close the circuit. When the current stops, the circuit opens. The largest feature of this relay is that contact points of this relay are not affected by the environmental conditions because they are protected by an inert gas. The use of this relay is the same as that of the small signal relay.

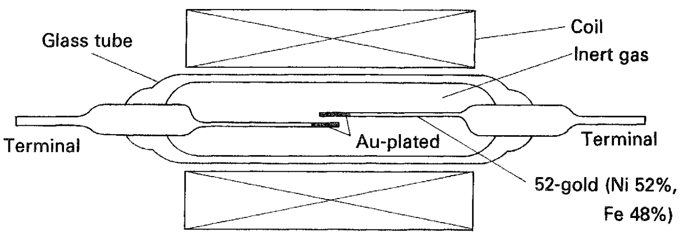



**Fig. 11 Reed Relay**

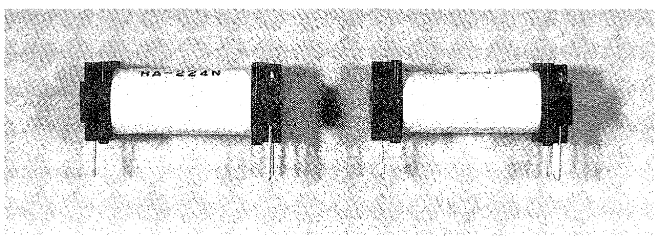



**Photo 14 Reed Relay**

# Basic Theory of Video Systems

## NTSC and PAL TV Systems

The main world color TV systems are only NTSC (National Television System Committee), PAL (Phase Alternation Line-by-Line) and SECAM (Sequential Colours à Memoire) although there are many standards in monochrome system. All of the three systems transmit color information in addition to luminance and sound information to make broadcast signal compatible to both monochrome and color TV receivers.

Composite color TV signal includes luminance and chrominance signals, vertical- and horizontal-sync pulses, vertical- and horizontal-blanking pulses, color-burst signal and sound signal. Table 1 shows the specifications of the systems and countries concerned.

Here we will discuss the NTSC and PAL systems. The main differences between NTSC and PAL are in the modulating method of chrominance signal although both of them employ Quadrature Amplitude Modulation (QAM) system.

<table>
<tr><td>Color System</td><td>NTSC</td><td colspan="6">PAL</td><td colspan="5">SECAM</td></tr>
<tr><td>CCIR Standards</td><td>M</td><td>M</td><td>N</td><td>B,G</td><td>H</td><td>I</td><td>D</td><td>B</td><td>D,K</td><td>K'</td><td>L</td><td>E</td></tr>
<tr><td>Scanning Lines/frame</td><td colspan="2">525</td><td colspan="9">625</td><td>819</td></tr>
<tr><td>Field Frequency (Hz)</td><td>Mono 60<br>Chro 59.94</td><td>59.94</td><td colspan="10">50</td></tr>
<tr><td>Line Frequency (Hz)</td><td>Mono 15750<br>Chro 15734.264</td><td>15734.264</td><td colspan="9">15625</td><td>20475</td></tr>
<tr><td>Vision Width (MHz)</td><td colspan="3">4.2</td><td colspan="2">5</td><td>5.5</td><td>6</td><td>5</td><td colspan="3">6</td><td>10</td></tr>
<tr><td>Channel Width (MHz)</td><td colspan="3">6</td><td>B:7,G:8</td><td colspan="3">8</td><td>7</td><td colspan="3">8</td><td>14</td></tr>
<tr><td>Vision-sound Separation (MHz)</td><td colspan="3">4.5</td><td colspan="2">5.5</td><td>6.0</td><td>6.5</td><td>5.5</td><td colspan="3">6.5</td><td>11.15</td></tr>
<tr><td>Color Subcarrier (Hz)</td><td>3579545</td><td colspan="2">3575611.49</td><td colspan="4">4433618.75</td><td colspan="5">foR: 4406250 foB: 4250000</td></tr>
<tr><td>Residual Sideband (MHz)</td><td colspan="4">0.75</td><td colspan="2">1.25</td><td colspan="3">0.75</td><td colspan="2">1.25</td><td>2</td></tr>
<tr><td>Vision Modulation Polarity</td><td colspan="10">−</td><td colspan="2">+</td></tr>
<tr><td>Sound Modulation</td><td colspan="10">FM</td><td colspan="2">AM</td></tr>
<tr><td>Sound Frequency Deviation (KHz)</td><td colspan="3">± 25</td><td colspan="7">± 50</td><td colspan="2">—</td></tr>
<tr><td>Sound Preemphasis (μs)</td><td colspan="3">75</td><td colspan="7">50</td><td colspan="2">—</td></tr>
<tr><td>2-channel Sound</td><td>Japan, USA</td><td>—</td><td>—</td><td>W. Germany</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td></tr>
<tr><td rowspan="2">Countries</td><td>Barbados [N],</td><td>Brazil</td><td>Argentina, Paraguay, Uruguay,</td><td></td><td>Belgium</td><td rowspan="2">HK, Ireland, UK, S. Africa</td><td rowspan="2">China (PR), Korea (PR)</td><td rowspan="2">E.Germany, Egypt, Greece [BH], Iran, Iraq, Lebanon, Libya, Maulitius, Morocco, Saudi Arabia, Syria, Tunisia</td><td rowspan="2">Bulgaria, Congo, Czecho-slovakia, Djibouti, E.Germany, Hungary, Poland, Reunion, Togo, USSR</td><td rowspan="2">Guyana, Ivory Coast, Martinique, New Caledonia</td><td colspan="2">Monaco</td></tr>
<tr><td colspan="2">Bermuda, Canada, Chile, China (Rep), Colombia, Costa Rica, Cuba, El Salvador [K], Ecuador, Guatemala, Haiti, Honduras, Japan, Korea (Rep), Mexico, Panama, Peru, Philippines, Samoa, St. Kitts, Surinam, Trinidad Tobago, USA, Venezuela</td><td colspan="3">Algeria, Australia, Austria, Bahrain, Denmark, Finland, HK, Holland, Iceland, Indonesia, Italy, Jordan, Kenya, Kuwait, Liberia, Malaysia, Malta, NZ, Nigeria, Norway, Oman, Pakistan, Portugal, Qatar, Saudi Arabia, Spain, Seychelles, Sierra Leone, Singapore, Sri Lanka, Sweden, Switzerland, Tanzania, Thailand, Turkey, Uganda, UAE, W. Germany, Yugoslavia, Zambia</td><td>France, Luxembourg</td><td></td></tr>
</table>

**Table 1 World TV Systems**

## NTSC system

Our eyes are sensitive to orange and cyan on small spots and not so sensitive to magenta and green. When a colored thing becomes small, its color approaches orange or cyan. The color becomes insensible when a colored spot becomes smaller. So, a wider frequency range (1.5MHz) has been allocated to the orange-cyan information than to Green-Magenta information (0.5MHz) in NTSC color TV format.

All colors can be made by mixing red (R), blue (B) and green (G) light. They can also be made of (R – Y) and (B – Y) signals.*

**R, G, B and Y stand for red, green, blue and luminance signals. Y-signal is made up of 0.3R + 0.59G + 0.11B and produces monochrome pictures.*

Color signal is carried by I and Q signals, which are on the axes advanced by 33° from (R – Y) and (B – Y) axes respectively in the phasor diagram shown in Fig 1. They are out of phase each other by 90°. $E_I$ and $E_Q$ signals are made by the following equations:

$$E_I = 0.74\,(E_R - E_Y) - 0.27\,(E_B - E_Y)$$
$$E_Q = 0.48\,(E_R - E_Y) + 0.41\,(E_B - E_Y)$$

TV receiver reproduces ($E_R - E_Y$) and ($E_B - E_Y$) signals instead of reproducing $E_I$ and $E_Q$ with a simplified color circuit which has only 0.5MHz bandwidth because it is practically unnecessary to reproduce $E_I$ and $E_Q$ throughout the frequency range of 1.5MHz being broadcast.
To make the broadcast signal compatible to monochrome and color TV receivers, chrominance signal is being inserted into the vacant spaces of luminance signal in the frequency spectrum as shown in Fig. 2.

When a colored program is reproduced on a monochrome receiver, white dots may appear due to the beating between picture carrier and color carrier as shown in Fig. 3. These dots have been minimized by determining the chrominance subcarrier frequency at a half of the horizontal scanning frequency multiplied by an odd number.

$$fs = f_H/2 \times 455 = 3.579545\ (MHz)$$
*$f_H$: Horizontal scanning frequency, 15.734 Hz*

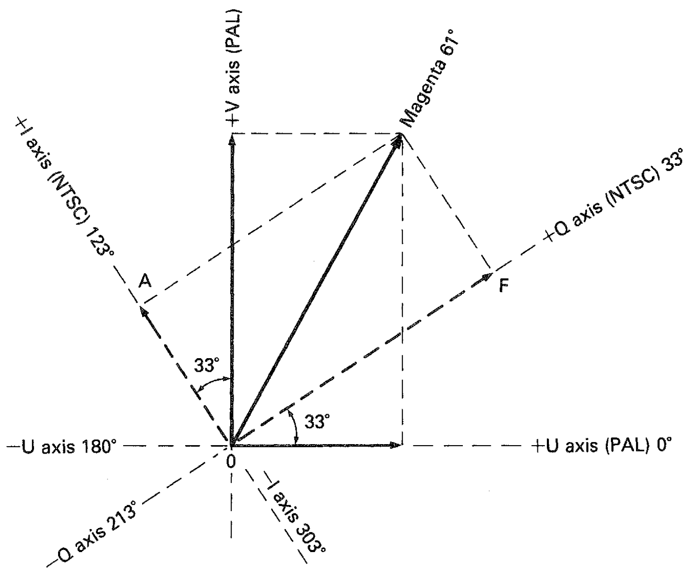



**Fig. 1 I/Q (NTSC) and V/U (PAL) Quadrature Components of a Vector**

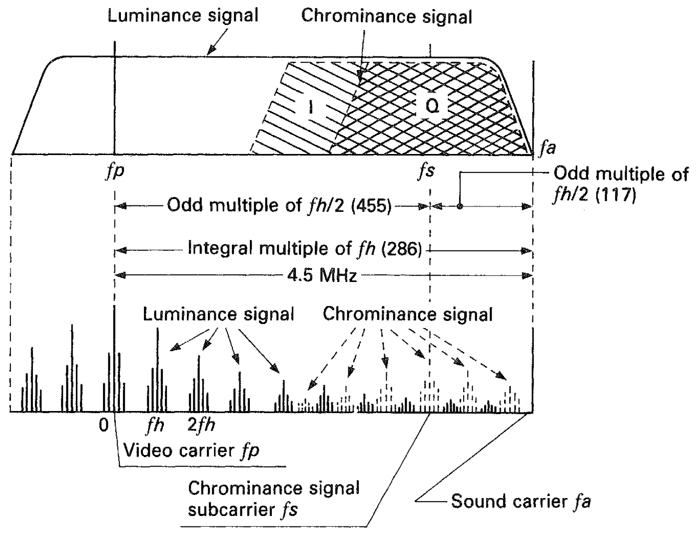
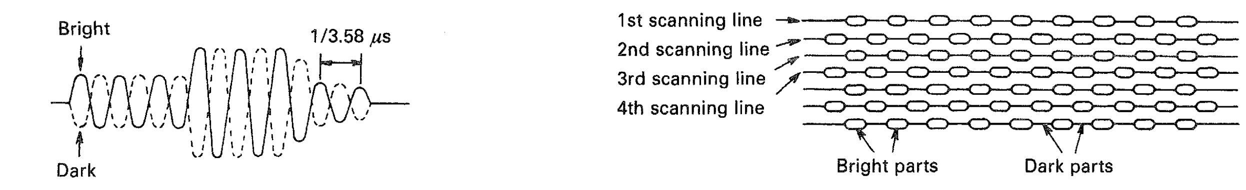



**Fig. 2 Spectral Distribution of the TV Signal**




Brightness reverses in the next frame.

Brightness reverses on the next line.

**Fig. 3 Color Carrier Interference Reduced by Interleaving**

Then the brightness of 3.58MHz dots is inverted line by line and frame by frame and is made insensible. To avoid beating interference between the colour and sound carriers, the horizontal scanning frequency has been determined at 15,734 (15,750 − 16)Hz.
The transmitting method of composite chrominance signal by placing its bands of energy between those of luminance signal is called "interleaving". The luminance and carrier color signals ($E_Y$, $E_{CN}$) are represented by the following equations:

$$E_Y = 0.30E_R + 0.59E_G + 0.11E_B$$
$$E_{CN} = a(E_R - E_Y)\cos\omega st + b(E_B - E_Y)\sin\omega st$$

$a$: 0.877, $b$: 0.493, $f_s$: 3.58MHz

## PAL system

NTSC and PAL employ Q.A.M. system of chrominance signal. They transmit two chrominance information simultaneously, employ a synchronized detector, and hue and chrominance saturation are determined by phase difference and relative level between the burst signal and chrominance signal.
There are, however, some differences between them. PAL uses simple weighted (R′ − Y′) and (B′ − Y′) color-difference signals of equal bandwidth to modulate the two quadrature phase (but equal frequency) subcarriers while NTSC system employs complex I and Q signals which have unequal bandwidths.
The most significant difference is in modulating method. PAL's modulation axis of ($E_R - E_Y$) inverts every 1H while that of NTSC does not. The carrier color signal is represented by the following:

$$E_{CP} = \pm a(E_R - E_Y)\cos\omega st + b(E_B - E_Y)\sin\omega st$$

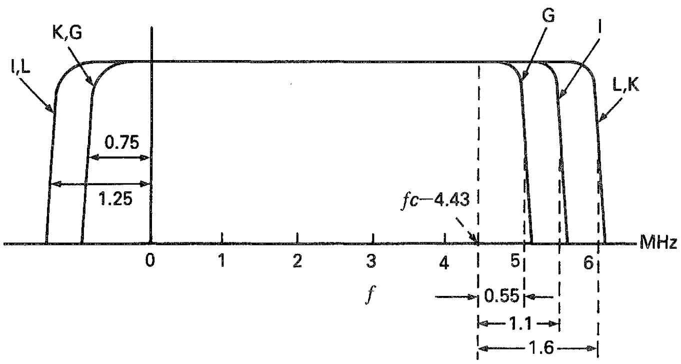


**Fig. 3 Bandwidth of European 625-line System for Bands IV/V (Channel Width: 8MHz).**

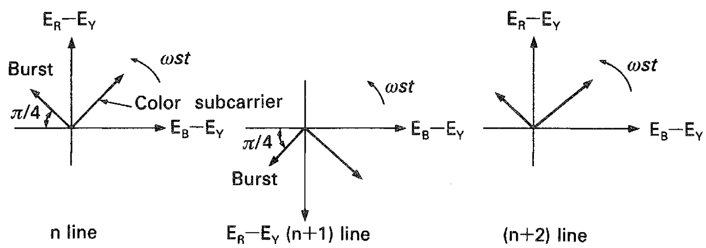


**Fig. 4 PAL's Transmission Vectors**

PAL receiver adds and subtracts the direct and 1H-delayed signals. Adder and subtractor put out (B − Y) and (R − Y) signals respectively. The demodulated signal becomes an average between the two adjacent lines. Thus the resolution becomes a little lower than that of NTSC in principle, and the modulating circuit becomes complicated. PAL system, however, has a higher allowance in phase distortion in the transmission system.

The PAL system nullifies hue error or the phase error of color signal. If the transmitted signal is magenta for several scanning lines and is subjected to a phase lag of $\theta°$, the vectors of a pair of received lines will be as E1 and E2 in Fig. 5. The even or odd lines inverted by a transmitter are reinverted by the receiver and the lower line of the pair leads from the original phase as E2′. When E1 and E2′ are integrated and averaged visually or electrically, the phase error is nullified. If the error is large, the integration becomes difficult and color moves up and down (Hanover bar or Venetian blind).

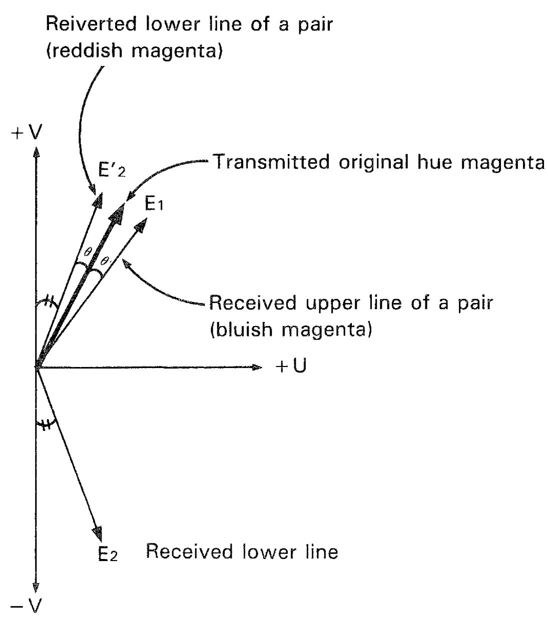
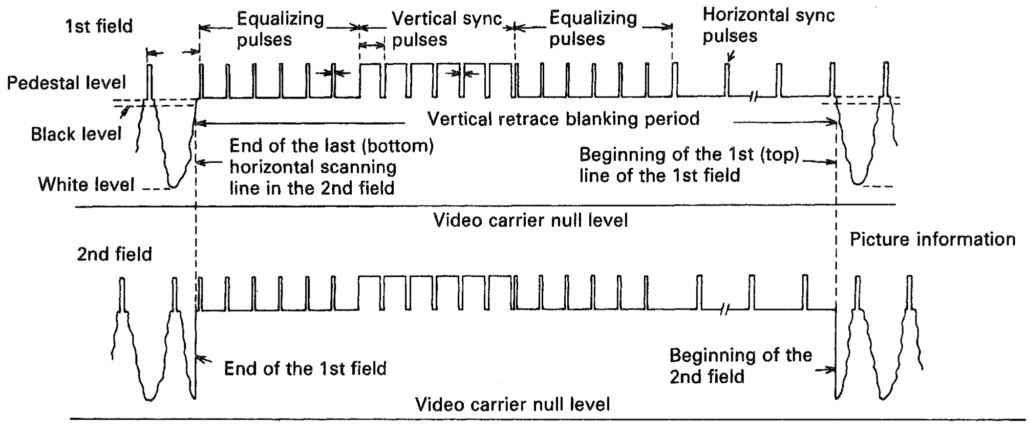


**Fig. 5 Phase Error Correction with the PAL system**

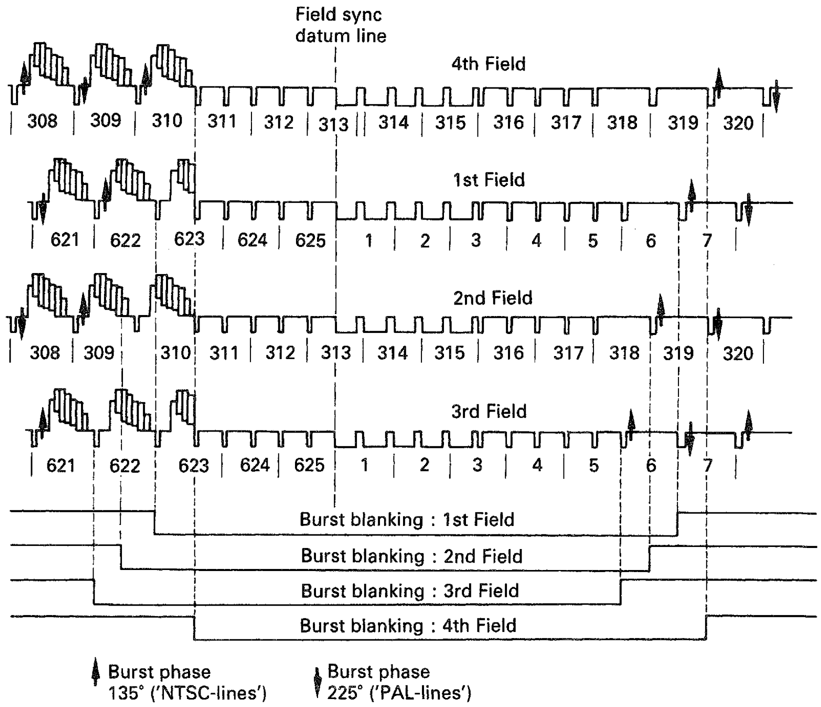
To find out the polarity of the modulation axis of $(E_R - E_Y)$, burst signal phase is shifted by 90° every line. If the chrominance subcarrier frequency (Fc) is made a half of the horizontal scanning frequency multiplied by an odd number as in NTSC system, the (R – Y) component will be in phase between the adjacent scanning lines, and vertical stripes will appear. The chrominance carrier frequency, therefore, is determined by the following equation:

$$fc = (284 - 1/4) \times f_H + (f_H/625) = 4.4336\ MHz$$
$$\text{Provided: } f_H = 15{,}625\ Hz$$

Thus the color carrier energy is interleaved in luminance signal spectrum $f_H/4$ out of phase from it. To make the dots invisible in 625-line system, 25Hz ($f_H/625$) is added. Fig. 6 shows the waveforms of NTSC and PAL video signals during the field blanking period.




a. NTSC signal in the 1st and 2nd Fields




b. 625-line PAL video signal

**Fig. 6 Video signal waveforms during the field blanking period**

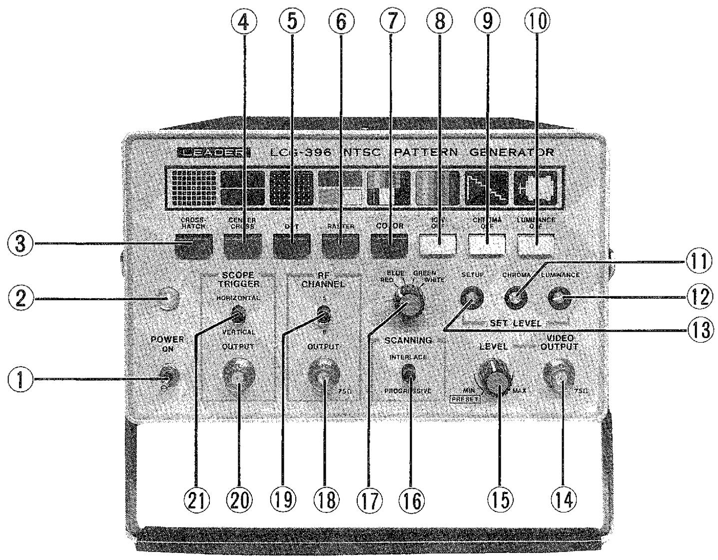
## SECAM system

In the SECAM system the sub-carrier is frequency modulated by (R – Y) on one line and (B – Y) on the next instead of being modulated by the two color difference signals simultaneously. Details are omitted here because we are not manufacturing video equipment of this type at the moment.

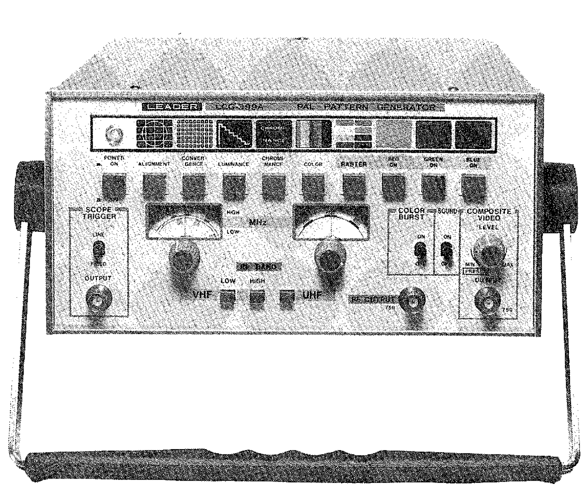
# Measuring Instrument

## Pattern Generator

A TV pattern generator is required for testing and adjusting VCRs (video cassette recorders), TV receivers and TV monitors. Here we will discuss the features and functions of Leader's NTSC type generator LCG-396 referring to the knobs and controls of its front and rear panels. The functions of PAL type generators such as Leader's LCG-399 are similar to those of NTSC type although PAL system is different from the NTSC system in standard.




LCG-396 (NTSC)




LCG-399A (PAL)

**Fig 1 Front Panel of Pattern Generators**

①. *Power Switch*
②. *Power Indicator*
③.—⑦. *Pattern Selectors*

③. *Cross Hatch*
This pattern is made of 21 vertical and 16 horizontal white lines with a dot in the center. (Cross hatch and dots are displayed on the same screen with LCG-399.) This is for adjusting static and dynamic convergence of a color picture, vertical and horizontal amplitude, vertical and horizontal linearity and other raster alignments.

④. *Center Cross*
For centering picture on the screen with the knobs of vertical and horizontal position control.

⑤. *Dot*
20 (vertical) x 15 (horinzontal) white dots for static convergence alignment and focusing. (Cross hatch and dots have been integrated into one pattern in LCG-399.)

⑥. *Raster*
Red, blue, green or white raster is selectable by depressing this button and turning Raster Selector #17. These rasters are used to adjust color purity. White raster level is of 100% luminance and is for adjusting white balance of color picture. Black raster is obtainable by depressing COLOR, CHROMA and LUMINNANCE buttons.

### ⑦. *Color Bars*

Color bar pattern is composed of color bars in order of luminance.

Upper pattern: From left — White, yellow, cyan, green, magenta, red, blue and black

Lower pattern: From left — Q, −I,* white and black

This signal is for chrominance (chroma) circuit adjustment.

*Refer to p-13.

<table>
<tr><td>White (75%)</td><td>Yellow</td><td>Cyan</td><td>Green</td><td>Magenta</td><td>Red</td><td>Blue</td><td>Black</td></tr>
<tr><td>Q</td><td>−I</td><td colspan="3">White (100%)</td><td colspan="3">Black</td></tr>
</table>

**Fig 2 Color Bar Pattern**

Example

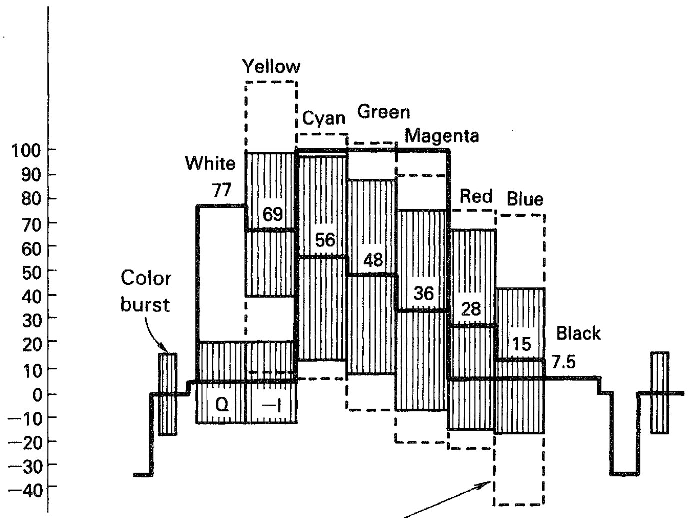
| | |
|---|---|
| VCR | Adjusting luminance and chroma levels<br>Adjusting Auto Colour Control (ACC)<br>Balancing chroma level<br>Setting burst gate — phase and amplitude<br>Measuring moire |
| TV receiver | Adjusting chroma circuit<br>Adjusting ACC circuit |

The white level of upper color bars is 75% in amplitude. When 100% white is required, use the white signal of the lower pattern.

### ⑧. *IQW Off*

Upper bars can be displayed on full screen with this switch depressed. When 100% white is required, turn the IQW on.

*IQ signal: In NTSC system, the color information is broadcast on I and Q signals. These signals are on the orange-cyan and green-magenta axes respectively for effective broadcasting. The axes have a 90° phase difference each other. PAL system uses U and V axes. Ref. p13.




Weighted: The amplitude is reduced to meet the sensitivity of our eyes and to avoid oversaturation.

**Fig. 3 Color Bar Signal with 7.5% Setup**

### ⑨. *Chroma Off*

The color bars can be made colorless by depressing this switch. This gray pattern is used to adjust the linearity of picture amplifier circuit, white balance, etc.

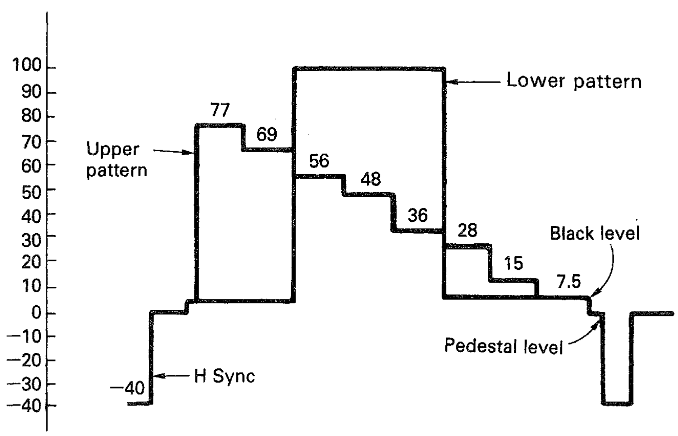



**Fig. 4 Luminance Signal of Color Bar Pattern**

⑩. *Luminance Off*

Luminance signal can be removed from the color bar signal by depressing this switch. This chroma signal is used to check the phase and amplitude variation of chroma signal in the picture amplifier circuit.

⑪. *Chroma*

Chrominance level of color bars and rasters is variable within the range of ±20%.

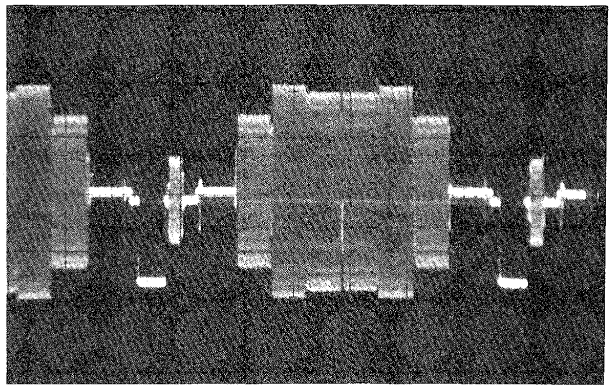
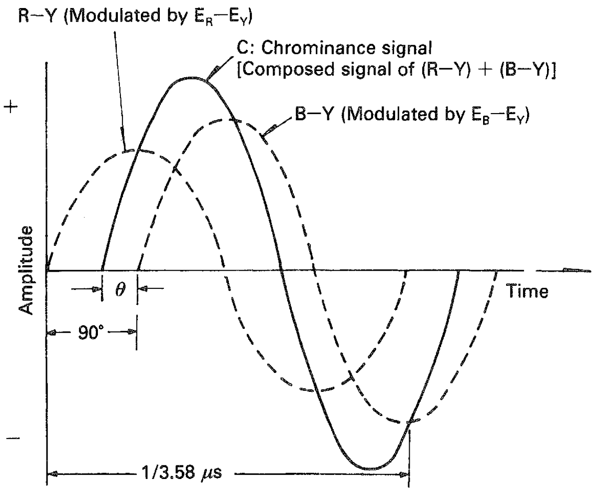


**Fig. 5 Chrominance Signal of Color Bar Pattern**




Two color subcarriers have been modulated by (R – Y) and (B – Y) signals respectively and then added before broadcasting.

**Fig. 6 Enlarged Waveform of Chrominance Signal (3.58 MHz)**

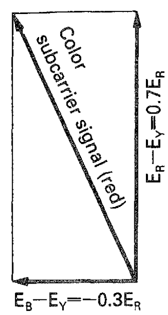
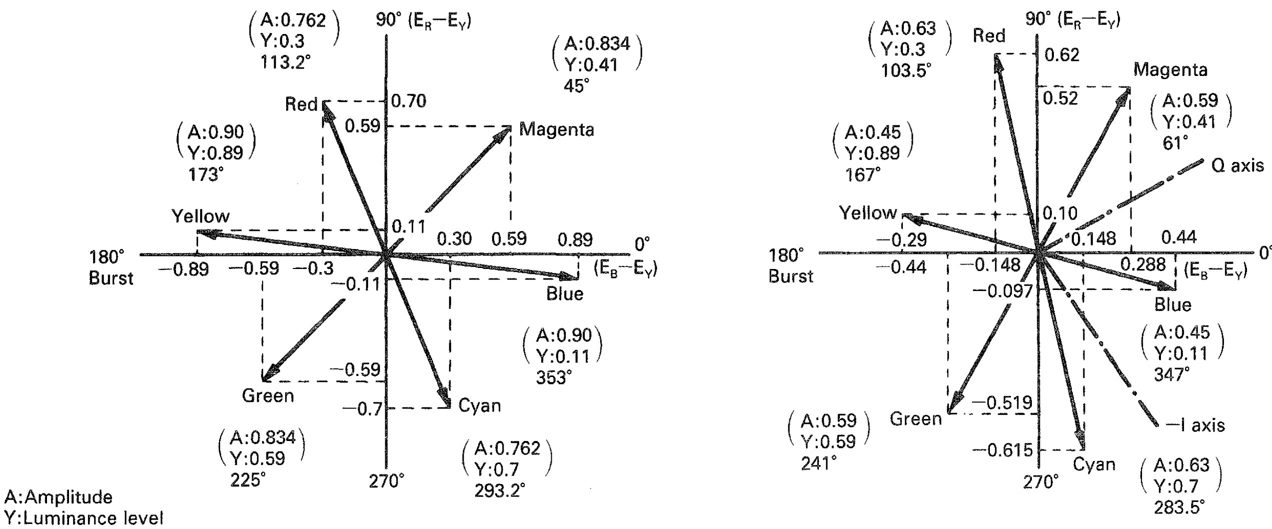



**Fig. 7 Vector Diagram of Carrier Color Signal (Red)**




(b) Non weighted

(c) Weighted

**Fig. 8 Phasor Diagrams of Color Bars (NTSC and PAL)**

⑫. *Luminance Level Control*

Luminance level of color bars is variable within the range of ±20%

⑬. *Setup*

Setup level or black level of all patterns is variable within the range of 0—10%. Adjusting method is shown on the Table 1. Connection and setting of an oscilloscope are as follows:

Connect the generator to the vertical input of a triggered oscilloscope which has a bandwidth more than 10MHz.

Set the oscilloscope's input-mode to DC and sensitivity to 10mV.

When the black level is raised, the percentage of luminance amplitude is raised. Table 3 shows the levels of bars when the black level is adjusted at 7.5% with the setup level control.

| Test Items | Test Point | Panel Control and Value of adjustment | Place of Adjustment | Measuring Instruments |
|---|---|---|---|---|
| Video level (Setup) | VIDEO OUT (Front) | Set the pattern selector to Color and video level control to Preset. Obtain a desired setup value. Adjust chrominance and luminance level so as to produce a video output of 1 Vp-p. | SETUP<br>CHROMA LUMINANCE (Front) | Oscilloscope or Vectorscope |

**Table 1 Video Level Setup**

⑭. *Video Output*

This terminal puts out a composite video signal and accepts a 75 Ω BNC plug.

| | |
|---|---|
| Output voltage | Fixed: Approx. 1Vp-p (75 Ω load) |
| | Variable: 0—1.5Vp-p (75 Ω load) |
| Polarity | Positive (negative sync signals) |

The output is a composite signal of pattern, synchronizing, blanking and burst signals. This has positive polarity with negative sync pulses to conform to the polarity of video equipment.

⑮. *Level Control*

Video output level is variable within the range of 0 — 1.5Vp-p with a 75 Ω load. When this control is set at PRESET, the output is 1Vp-p (75 Ω load). This control does not affect RF modulation.

⑯. *Scanning Selector*

Selects INTERLACED or PROGRESSIVE scanning

Interlaced scanning: The trace lines of a field appear between the lines of the previous field as in the normal TV broadcasting picture. This is used for viewing color bars and rasters.

Progressive scanning: The trace lines of a field appears on the same lines of the previous field making the picture coarse but flickerless. This is better for viewing crosshatch, dots and center cross patters.

⑰. *Raster Selector*

Switch for selecting RED, GREEN, BLUE or WHITE. (On LCG-399 eight colors are selectable by combining RED, GREEN and BLUE raster buttons.)

⑱. *RF Out*
Puts out an RF signal modulated by negative composite video signal.

| LCG-396 | LCG-399 |
|---|---|
| US channel 3 VHF 61.25MHz (10mV rms approx.) | VHF 55 — 63 MHz 5mV |
| US channel 4 VHF 67.25Mhz (without load) | VHF 185 — 205 MHz 5mV<br>UHF 471.25 — 885.25 MHz more than 0.5mV |

Output impedance 75 Ω
Accepts a BNC plug.

⑲. *Channel Selector*
Selects Ch 3 or 4 RF output.

⑳. *Scope Trigger Output*
Connect this to the external trigger input of an oscilloscope to supply it with trigger signal to display H sync or V sync signal.

| | LCG-396 | LCG-399(PAL) |
|---|---|---|
| Frequency | Line: 15,734Hz<br>Field: Interlaced 59.94Hz<br>Progressive 60.05Hz | 15,625Hz<br>50Hz<br>50.08Hz |
| Output voltage | 1Vp-p approx. (without load) | 3Vp-p (10K Ω) |

Output impedance 75 Ω
Accepts a BNC plug.

㉑. *Trigger selector*
Selects scope trigger output frequency either HORIZONTAL or VERTICAL.

㉒. *Subcarrier Output*
Puts out subcarrier signal used for calibrating subcarrier frequency.

| | |
|---|---|
| Frequency 3.579545MHz ± 100Hz (4.43361875MHz ± 100KHz PAL) | Calibration to ± 5Hz is possible |
| Output voltage | 1Vp-p approx. (without load) |
| Output impedance | 75 Ω |

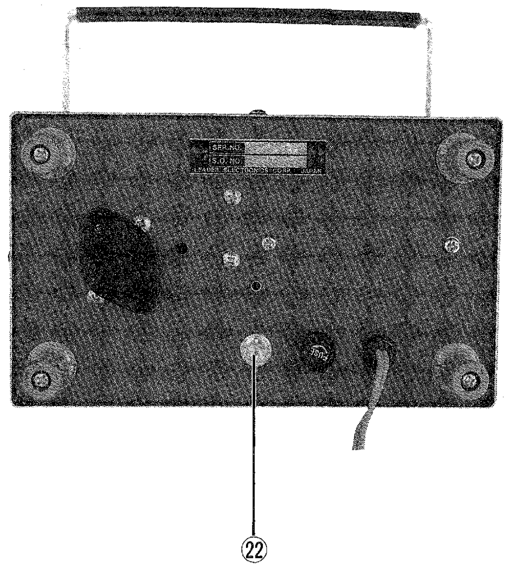
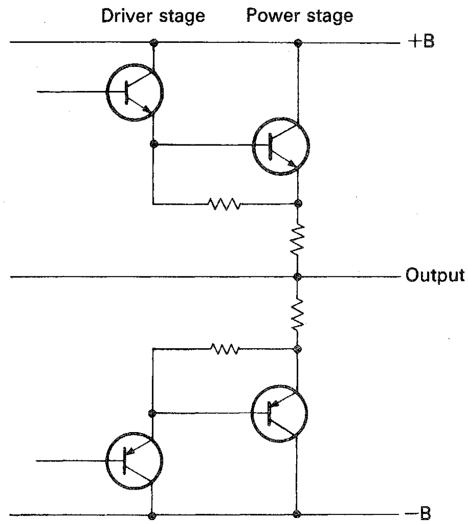



Fig. 8 Rear panel of LCG-396

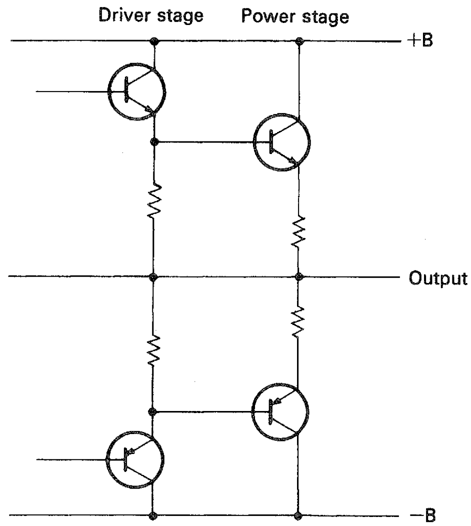
# One Point Service Technique

## Troubleshooting Power Amplifiers After Removing Power Transistors

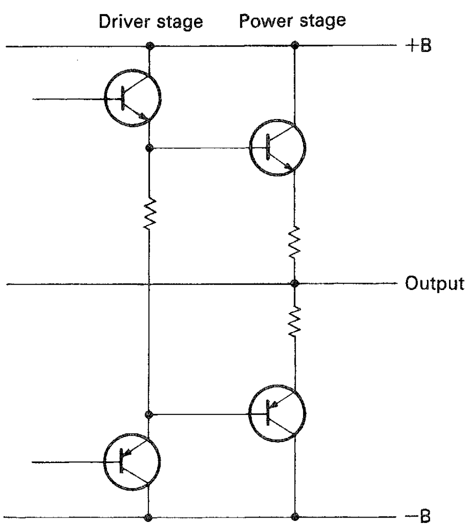
In the supplement to TUNING FORK, "Troubleshooting Power Amplifiers", issued in 1984 we discussed several troubleshooting methods. Here we will discuss the checking method of driver stage and preceding stages of main amplifiers by removing power transistors and heat sinks which occupy large space. The method varies with the type of circuit. Fig. 1 shows three typical circuits of power amplifiers.




(a)




(b)




(c)

**Fig. 1 Typical Amplifier Circuits**

### Checking method

1. Circuits (a) and (b) (Fig. 1 Typical Amplifier Circuit)

Amplifiers employing the circuit (a) or (b) can also be checked by keeping power transistors removed. Output power becomes 1W or less when the emitter resistors on the driver stage are more than 200 Ω.

2. Circuit (c)

In this circuit, output signal is unobtainable when power transistors are removed because driver stage is not connected to the output terminal. There are two ways to obtain the signal from the output.

a.
Disconnect R1 and connect the emitters of Q3 and Q4 with the output terminal via two resistors as illustrated in Fig. 2. Their resistance should be about a half of R1. Low resistance will allow excessive current in Q3 and Q4 and will damage them. High resistance will decrease the output. Their rated power is about 1/4 W.

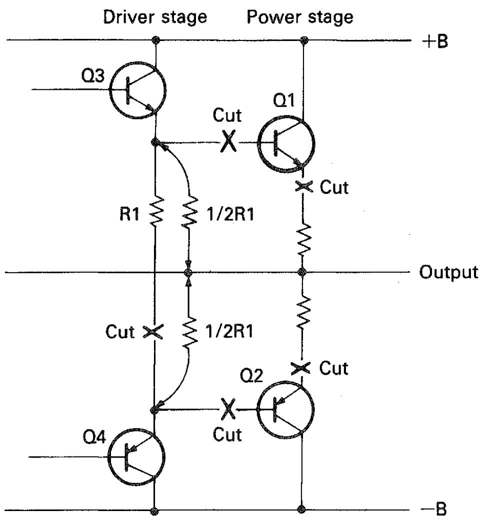



Fig. 2 Circuit (c) — Grounding Emitters

The function of R1
In the circuit (c) R1 inserted between the emitters of Q3 and Q4 is for maintaining idle current in Q3 and Q4 to avoid non-linear range of transistor amplification characteristic.
The current has been made about 5—10mA. In Fig. 4, when the potential difference between TP1 and TP2 is set to 60mV, Q1's collector current becomes 136mA.
Q1's Hfe is 110. Then the base current becomes 1.23mA. To flow 5mA current in Q3, the current from Ⓐ to Ⓑ should be 3.8mA. To make a current of 3.8mA in R1, the potential difference between Ⓐ and Ⓑ should be 1.26V (0.6 + 0.06 + 0.6). So R1 should be 330 Ω.

b.
Insert diodes in place of power transistors as shown in Fig. 3. Leave R1 connected.

Use powerful rectifying diodes used in mains current rectifier or open the output load before checking the circuit because the current in the diodes becomes larger than one ampere when an input signal is applied although the current is negligibly small when no signal is applied.
Diodes' polarities should also be verified to avoid damaging them.

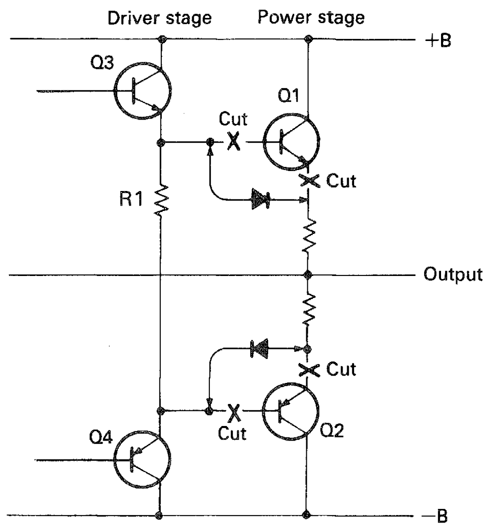



Fig. 3 Circuit (c) — Inseting Diodes

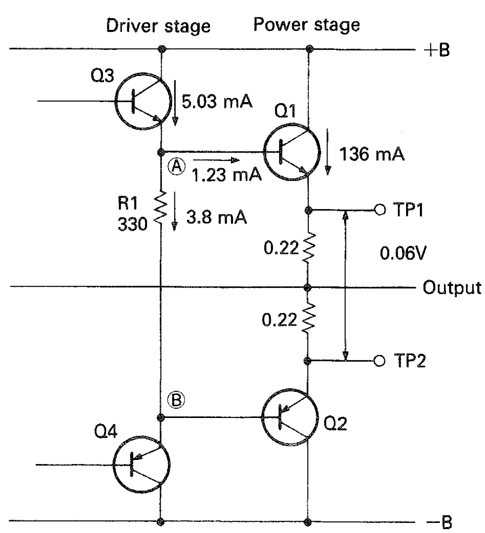


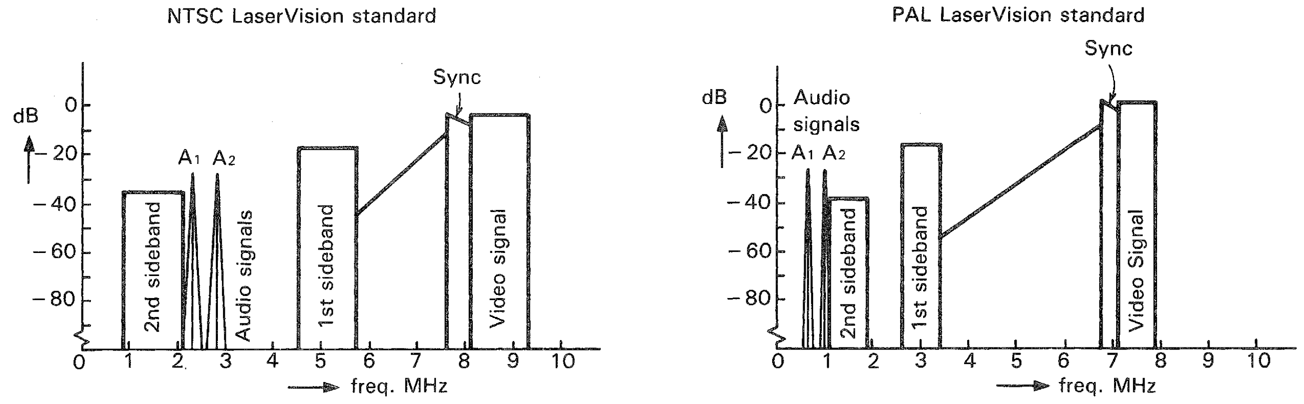

Fig. 4 Circuit (c) — Emitters Floating

# New Technique

## LaserVision with Digital Sound Disc (LDD)

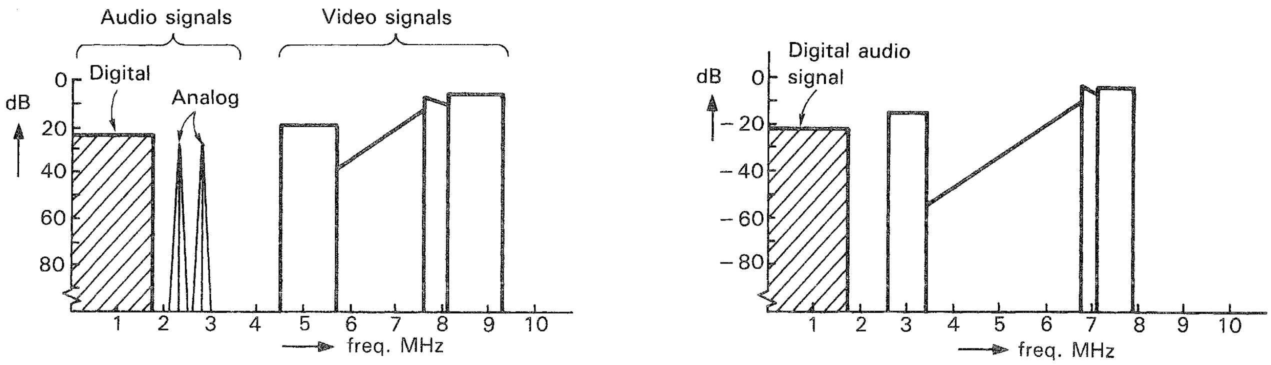
As discussed on the page 74, Vol. 7, NTSC LDD discs have digital sound information in addition to the conventional analog picture and sound information.
The NTSC LDD system allocates a frequency space to digital sound signal which has a frequency band of 0-2MHz as seen in Fig. 1a and 2a.
The level of the digital sound signal is a little higher than the analog sound carriers. If the level is too high, the digital signal will interfere video signal, and if it is too low, bit error rate will increase and random noise will be generated.

Unfortunately, in the frequency spectrum of PAL LV system, there is no room for the digital sound because the range of 0-2MHz has already been occupied by two audio carriers of 684kHz and 1,066kHz as seen in Fig. 1b. It is necessary to remove the two analog sound carriers and the second lower sideband of the video carrier to insert the digital sound signal in the spectrum. The compatibility between the conventional PAL LV disc and PAL LDD disc will be lost if the carriers are removed. PAL LDD discs are not being marketed because of this incompatibility.




a. NTSC b. PAL

**Fig. 1 Frequency Spectra of NTSC and PAL LaserVision Signal**




a. NTSC b. PAL

**Fig. 2 Inserting Digital Signal into LaserVision Signal**

Fig. 3 shows how the digital information is added to the conventional analog information.

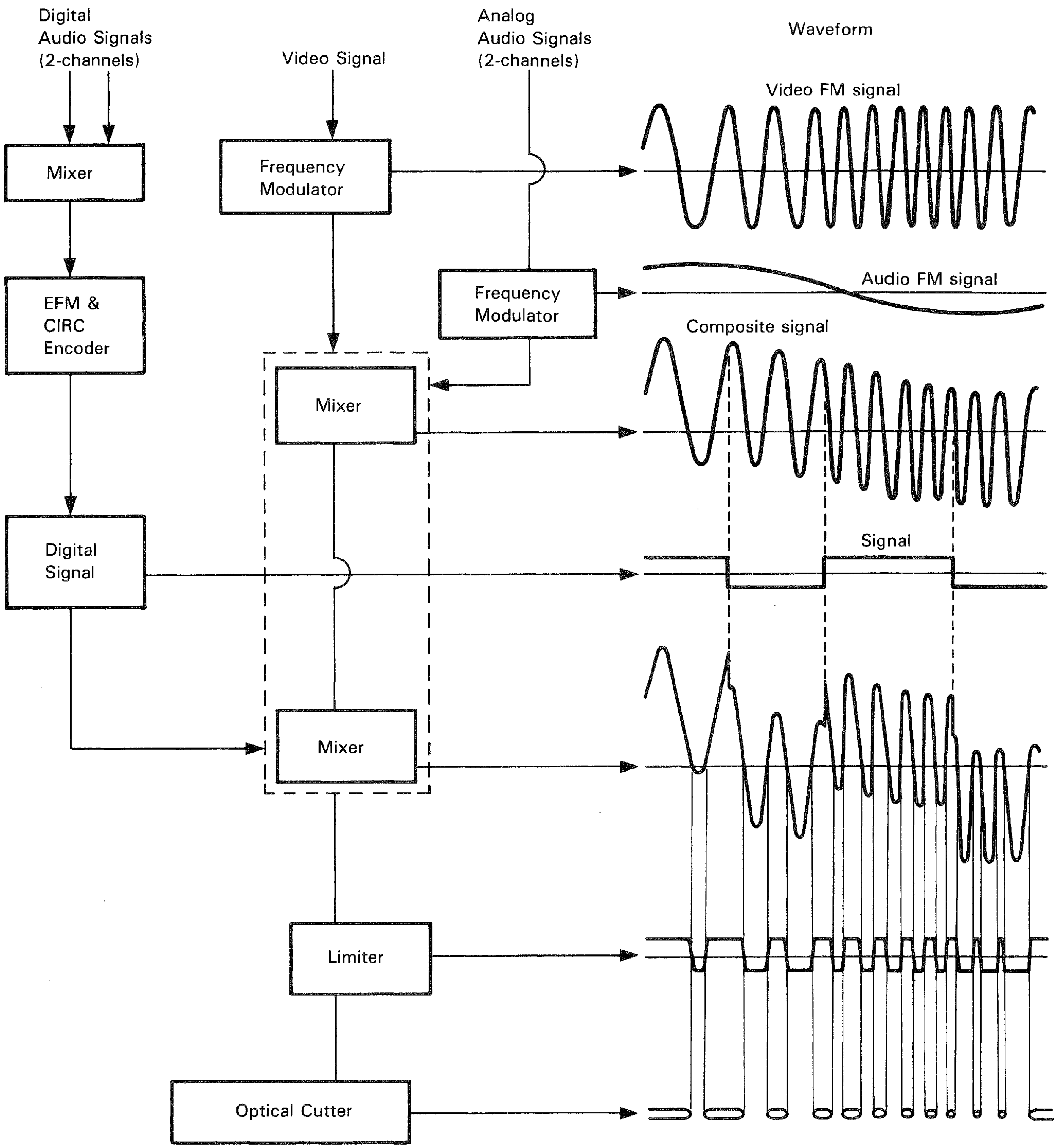



**Fig. 3 Adding Digital Audio Signals to LaserVision Signal**

LDD Playback Circuit of CLD-900, NTSC LV/CD compatible player (Service Manual VRT-050)

The LDD sound signal is decoded by CD circuitry because the LDD digital signal conforms to the CD format. Fig. 4 shows the simplified route of digital sound signal in the circuitry of CLD-900.

The reproduced RF composite signal is amplified in HEAD AMP and PREB (Preprocessing board). The signal is amplified again and video and FM sound signals are removed by 1.75MHz LPF in LDDB (LDD board). The filtered PCM RF(EFM) signal is then de-emphasized by R22, R23 and C17 and goes to CDDM (CD demodulator board). Hereafter the LDD digital signal is processed in the same way as CD signal. Refer to CD System, Vol. 7.

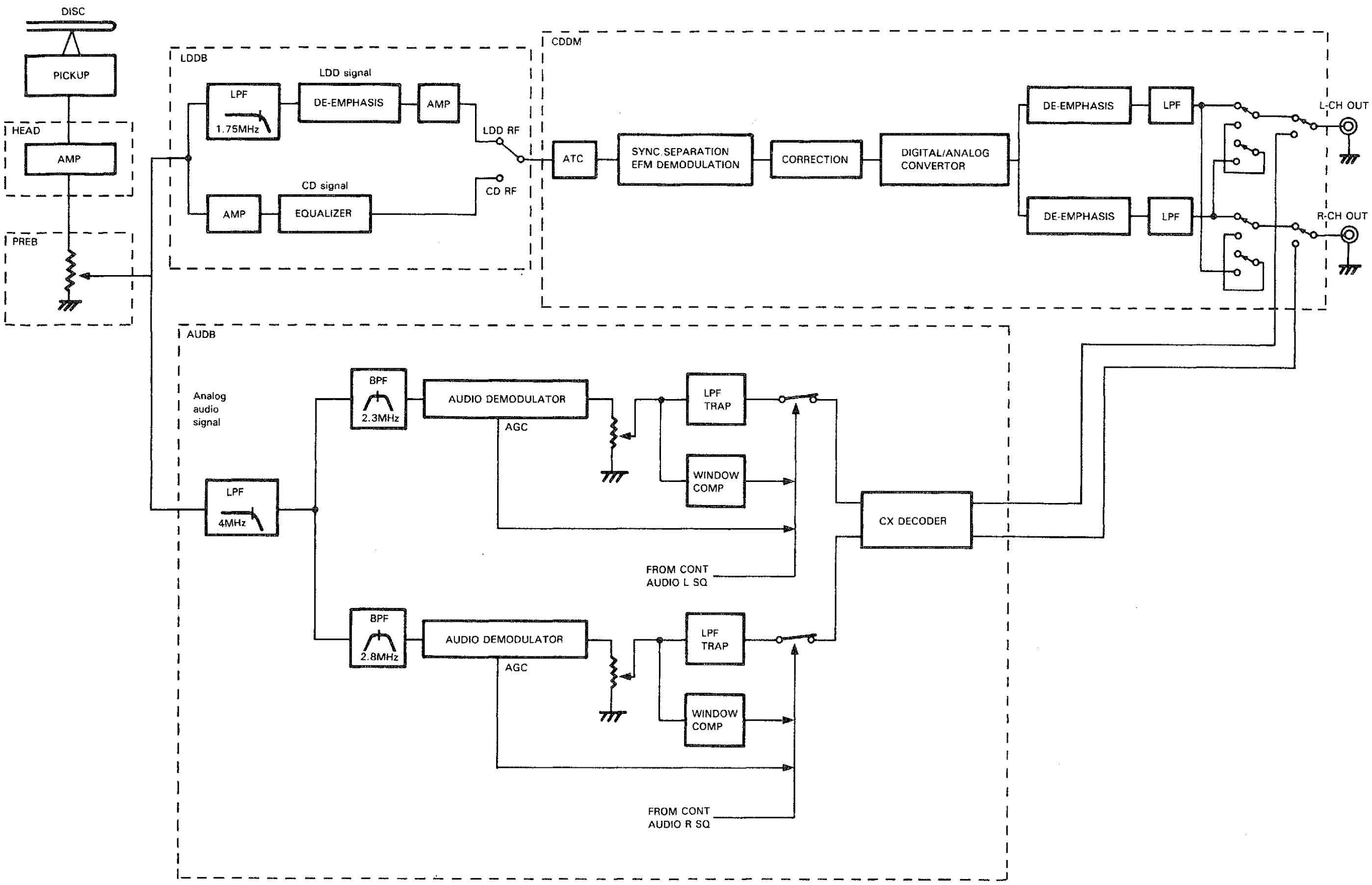



**Fig. 4 Block Diagram of Audio Signal Processing Circuit of CLD-900**

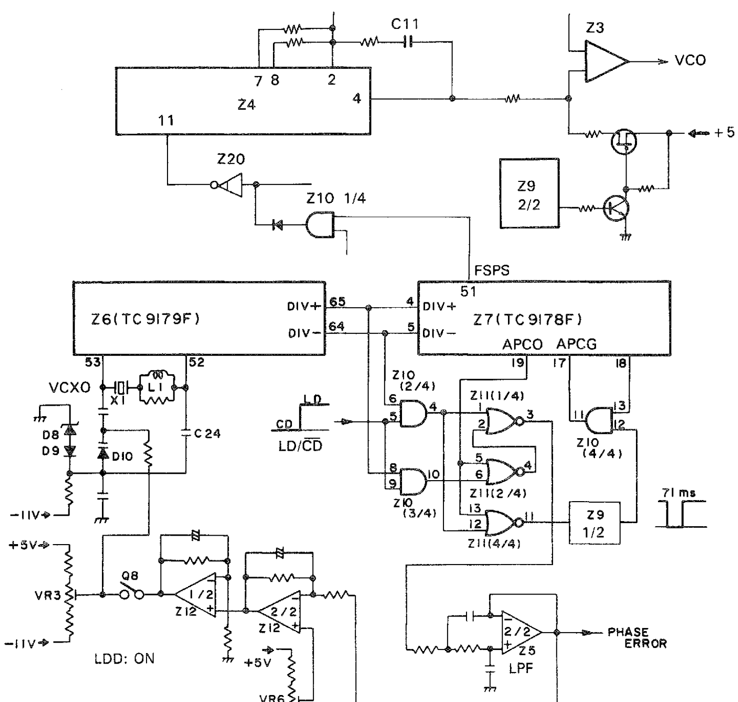
## Servo System

The revolution of the LD-spindle-motor is controlled by LD spindle servo system which synchronizes reproduced H sync with a reference signal while CD system synchronizes reproduced frame sync with its reference signal. The former system is more accurate than the latter.
The LDD frame sync should also synchronize with its reference signal for correct sound reproduction. In the LDD system, however, feeding the phase difference signal back to the spindle motor should be avoided to prevent the signal from interferring the color signal.

To maintain the synchronization when an LDD disc is played, the phase difference APCO (Automatic phase control signal output) between the reference signal generated in the player and the reproduced frame sync is applied from Z7 (TC9178F-19(APCO), CDDM, to VCXO (voltage controlled X'tal oscillator), not to the spindle motor. (Ref. p61, SM VRT-050) The VCXO generates a clock signal for controlling digital signal processing speed. The phase difference signal controls the VCXO when LDD is played and LD/$\overline{\text{CD}}$ signal becomes H. The pulse-width-modulated APCO signal is converted into voltage signal by Z5 2/2 (LPF). The jitter made by disc eccentricity is suppressed by Z12 (LPF). Q8 turns on, and thus the APCO controls the VCXO. Refer to Fig. 5

When a CD is played back, LD/CD signal becomes L, the APCO signal is cut off by Q8, the VCXO frequency is fixed at 8.4672MHz by the voltage set by VR3 while with an LDD disc, this frequency becomes variable in the range of 8.4672MHz ± 3KHz.
The CD's spindle servo system negatively feeds the information of the data quantity stocked in the player's RAM back to the spindle-motor, and the quantity of stored data in the RAM is kept within the range of ± 3 frames of the average.
This is impossible with LDD disc because the LD spindle motor is controlled by H sync. As a substitute for the above, LDD players takes the following method.
When the data in the RAM becomes smaller than the average by 3 frames, Z6 (TC9179F) DIV + signal shifts to H, Z11-3 shifts to H disregarding APCO signal. This decreases the VCXO's oscillating frequency and slows down data processing to recover the average stored data quantity.
When the data quantity exceeds the average by 3 frames, DIV − becomes H, Z11-3 shifts to L, VCXO frequency increases, the processing speed is accelerated and the stored data decreases down to the average.
When the quantity of the stored data becomes normal (average ± 2 frames), DIV + or DIV − shifts to L.
Z9 (SN74LS221N) 1/2, CDDM, is triggered and the Z7-17 APCG signal shifts to L temporarily. The APCO signal is fixed at the duty cycle of 50% (0 phase difference) by the low APCG signal. After the VCXO frequency is returned to its center value, automatic phase comparison is resumed.

As mentioned, CD player generates 4.3218MHz clock (PLCK) signal and synchronizes it with the suppressed pit-repetition signal of the same frequency contained in the reproduced EFM signal. The EFM signal contains some signals close to 4.3218MHz when the pickup is between music pieces.
When searching, PLL circuit opens and the reproduced and generated signals become out of synchronization. If the searching is terminated between music pieces, the oscillation may mislock at a close signal to 4.3218MHz.
The CD system can not sense the frame sync in the mislocked period. So, FSPS (Frame sync pattern synchronization) signal shifts to H, Z4 (TD6315AP)-11 shifts to L. Z4-7&8 become high in impedance. C11 connected to Z4-4 holds the previous value and VCO frequency is fixed. In this period the disc turns at a nonrated speed. When the reproduced pit-repetition frequency reaches the fixed VCO frequency, frame sync is picked up and FSPS signal shifts to L and the PLL loop closes.
In LDD, resynchronization between the frame sync and clock by FSPS is impossible because, as mentioned, the rotation of the spindle motor is not controlled by PCM signal. To resynchronize them, Z10 blocks out the FSPS signal when the LD/$\overline{CD}$ signal shifts to H. When the SEARCH is terminated and the falling edge of SCAN signal triggers Z9 (2/2), Q5 closes and pulls the VCO input to +5V. Then the VCO frequency returns to 4.3218MHz.
LD-707 (NTSC) is also capable of reproducing digital sound signal recorded on LDD discs when combined with a LaserVision Digital Sound Processor DA-1.




VCO
CD: The phase of 4.3218MHz ref clock varies to synchronize with reproduced sync.
LDD: Spindle motor is free from VCO.

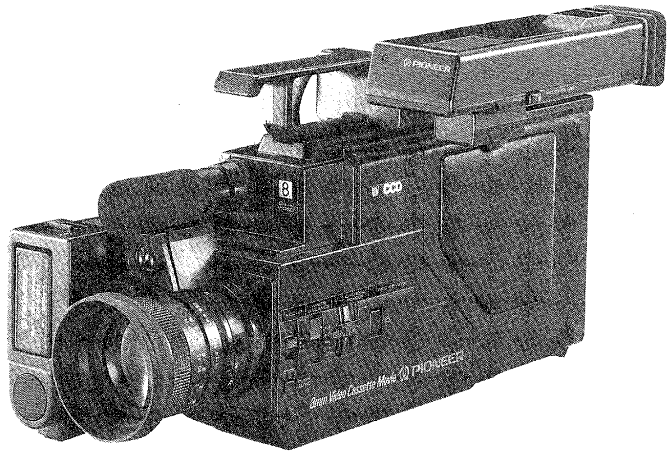
VCXO
CD: Fixed to 8.4672MHz
LDD: 8.4672MHz ± 3kHz to control digital signal processing speed

**Fig. 5 Control Circuit of Reference Signal Frequency(CLD-900)**

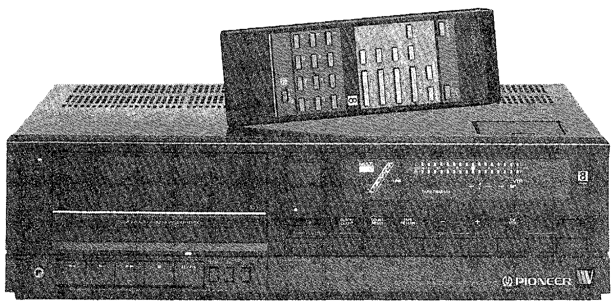
# New Products

## NTSC 1/2" and 8 mm Home Video Cassette Recorder (VCR)

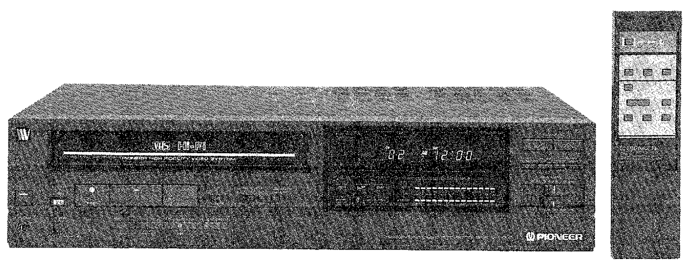
Our home VCRs have recently been introduced into the market. The field of VCR is quite a new to us. The knowledge of audio cassette recorder (ACR) and television (TV) is essential to repair VCRs. Here we will discuss the fundamentals of the 1/2″ nonhi-fi, 1/2″ hi-fi and 8-mm home VCRs. There are two incompatible types in 1/2″ VCR; $\beta$ and VHS.




**8-mm Video Cassette Movie**
**VE-M800**




**8-mm Video/Digital Audio Recorder**
**VE-D70**




**VHS Hi-fi Video Cassette Recorder**
**VH-600**

Their standards are different as shown on Table 1 to 3. As to the principle of TV, refer to the Additional Service Manuals, ARP-675 for SD-25 (NTSC) and ARP-928 for SD-26 (PAL).

VCR is a device for recording TV signal on tape for reproduction. TV signal is composed of luminance(Y)- and ↗ chrominance(C)-signals, vertical(V)- and horizontal(H)-synchronizing(sync)-signals and audio signal. Although the basic functions of VCR are similar to those of ACR, there are some important differences. The main differences between the VCR and ACR are in frequency bandwidth, recording and playback method, synchronization and signal format.

| | 8mm | | β (NTSC) | | | VHS (NTSC) | | Remark |
|---|---|---|---|---|---|---|---|---|
| | NTSC | PAL | βI | βII | βIII | SP | EP | |
| Drum diameter (mm) | 40 | | 74.5 | | | 62 | | |
| Cassette dimensions (mm) | 95x62.5x15 | | 156x96x25 | | | 188x104x25 | | |
| Tape width (mm) | 8 | | 12.65 | | | 12.65 | | |
| Tape speed (m/sec) | 14.345 | 20.051 | 40 | 20 | 13.3 | 33.35 | 11.116 | |
| Writing speed (mm/sec) | 3.8 | 3.1 | 6.973 | 6.993 | 7.00 | | | |
| Time (min) | 90 | 60 | 60 | 120 | 300 (L-830) | 120 | 360 | |
| Video effective width (mm) | 5.351 | | 10.2 | | | 10.7 | | |
| Video track width (μm) | 20.5 | 34.4 | 58.5 | 29.2 | 19.5 | 58 | 19.2 | |
| Video track angle (Stop) | 4°53′6″ | | 5°00′00″ | | | 5°56′7.4″ | | |
| Video track angle (Play) | 4°54′13.2″ | 4°54′58.8″ | 5°01′42″ | — | — | 5°58′9.9″ | — | |
| Video recording | 2-head azimuth | | | | | | | Guard-bandless |
| Video head azimuth | ±10° | | ±7° | | | ±6° | | Cross Talkover 1MHz |
| Y-signal recording | FM | | | | | | | |
| FM carrier | | | | | | | | |
| White peak (MHz) | 5.4 | | 4.8 (5.2 Hi-fi) | | | 4.4 | | |
| Sync tip (MHz) | 4.2 | | 3.6 (4.0 Hi-fi) | | | 3.4 | | |
| Deviation (MHz) | 1.2 | | 1.2 | | | 1.0 | | |
| Resolution (lines) | 240 | | 250 (240 Hi-fi) | | | 240 | | |
| $f_H/2$ carrier offset | ON | | OFF | ON | ON | OFF | ON | Against Y cross talk |
| H-alignment | +1H | +2H | * | 0.75H | * | * | * | *Aligned |
| C-signal recording | Frequency down-conversion | | | | | | | |
| Freq. converted (kHz) | 743.444 | 732.422 | 688.374 | | | 629.371 | | |
| Phase process | PI (CH2) | PS | PI (CH1) | | | PS | | |
| Burst emphasis | ON | | OFF | OFF | ON | ON | | |
| C-emphasis | ON | | OFF | | | OFF | | |
| Carrier | $(47+1/4)f_H$ | $(47-1/8)f_H$ | $43(3/4)\ f_H$ | | | $40\ f_H$ | | |

**Table 1 Specifications of 1/2″ and 8mm VCRs (Video)**

| | 8mm | | β (NTSC) | | VHS (NTSC) | | Remarks |
|---|---|---|---|---|---|---|---|
| | NTSC | PAL | βII | βIII | SP | EP | |
| Linear Audio | Option | | Standard | | Standard | | Dubbing possible |
| Frequency response (Hz) | 50 ~ 8K | | 50 ~ 10K | 50 ~ 8K | 50 ~ 10K | 50 ~ 7K | Depends on tape speed |
| Dynamic range (dB) | | | 47 | | 40 | | |
| Distortion (%) | | | 5 | | 5 | | |
| W/F (%) | | | 0.3 | 0.4 | 0.4 | | |
| Hi-fi Audio | Standard | | Option | | Option | | Dubbing possible |
| Recording system | | | | | | | VHS requires audio heads |
| Carrier | 1-carrier (Mono) | | 4-carrier (Stereo) | | 2-carrier (Stereo) | | β requires 4 |
| Carrier frequency (MHz) | 1.5 | | L: 1.38<br>R: 1.68 | L: 1.53<br>R: 1.83 | L: 1.3<br>R: 1.7 | | Carriers to avoid cross talk. |
| Maximum frequency deviation (kHz) | ±100 | | ±75 | | ±150 | | |
| Frequency response (Hz) | 20 ~ 15K | | 20 ~ 20K | | 20 ~ 20K | | |
| Dynamic range (dB) | 65 | | 80 | | 80 | | |
| Distortion (%) | 0.3 | | 0.3 | | 0.3 | | |
| W/F (%) | 0.005 | | 0.005 | | 0.005 | | |
| PCM Audio | Option (Capable of 24H recording max.) | | | | | | Dubbing possible |
| Recording system | | | | | | | |
| Sampling frequency (KHz) | 31.469 ($2f_H$) (NTSC) | | | 31.25 ($2f_H$) (PAL) | | | |
| Quantization | 10 to 8 bits compression | | | | | | |
| Transfer rate | 368fH (5.790 M bit 1 sec) | | | | | | |
| Error correction | Cross Interleane Code (8 words, 2 parities) | | | | | | |
| Error detection | CRCC (16-bit) | | | | | | |
| Modulation | Biphase mark | | | | | | |
| Frequency response (Hz) | 20 ~ 15K | | | | | | Depends on sampling freq. |
| Distortion (%) | 0.3 | | | | | | |
| W/F (%) | 0.005 | | | | | | |
| Dynamic range (dB) | 80 | | | | | | |

* Dubbing: Addition of sound to a prerecorded tape

**Table 2 Specifications of the Three Systems (Audio)**

| | 8mm | β | VHS |
|---|---|---|---|
| Threading | U | U | M |
| | (U/M compatible) | (Quick function-selection) | (Threading length is short but twisting is large.) |
| Tape-end detection (leader tape) | Transparent tape | Aluminum tape | Transparent tape |
| Erase head | Flying erase (Frame by frame) | Full erase | Full erase |
| Tracking | Automatic Track Finding | Control head | Control head |
| | (Tracking VR unnecessary, stable tracking) | (Tracking VR necessary) | (Tracking VR necessary) |

**Table 3 Specifications of the Three Systems (Others)**

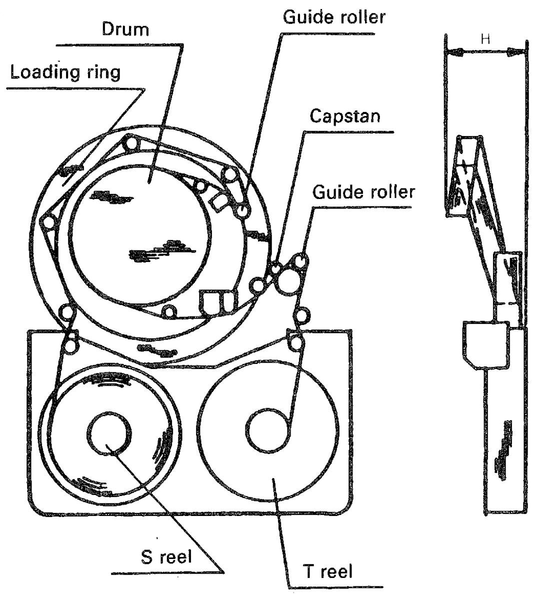
The features of VCR not found in ACR are as follows:
a) Broad frequency bandwidth (DC ~ 4.5 MHz)
b) Helical scanning system for achieving high tape-to-head relative velocity
c) The frequency bandwidth of Y-signal compressed by frequency modulation(FM).
d) C-carrier down-converted to achieve easy phase control High frequency signal is liable to be affected by jitter which causes color distortion.
e) Guard-bandless double-azimuth scanning system to achieve high density recording
f) Phase Invert (PI) or Phase Shift (PS) system to reduce C-signal cross talk

## 1. Structure of VCR

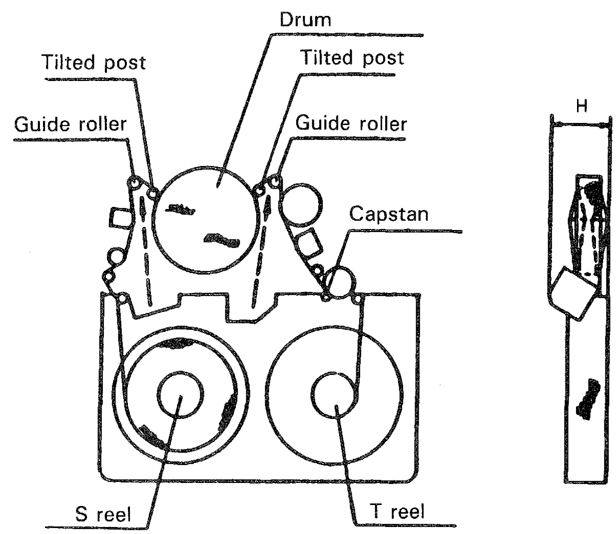
VCR consists of a tape transport mechanism, a drum scanner, video-, audio-, control- and erase-heads, electronic circuits for processing TV signal and servo control systems.

### 1.1 Tape Transport Mechanism

Fig. 1 shows the M-threading (VHS) and U-threading ($\beta$) mechanisms. The tape is pulled out of cassette and wraps a half of the periphery of the tilted drum. It travels in 3 dimensions and is twisted a little, while audio cassette tape travels on a plane. The mechanism requires high accuracy because it deals with signals of megahertz order. The height and tilt of the Drum and tape-guides should be properly adjusted.



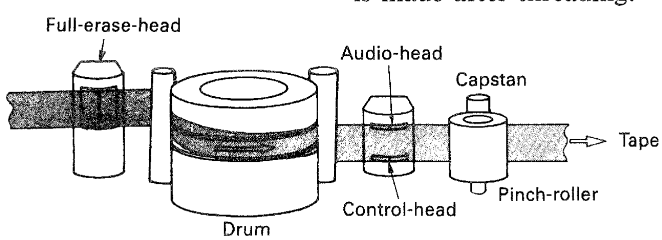
(a) U-loading System



(b) M-loading System

U-loading system: In this system the twisting amount is smaller than that of the M-loading system, and the tape travels smoothly. Quick shifting of the functions and viewing pictures in FF and REW mode is possible because the tape is threaded right after loading.

M-loading system: The tape length required for threading is shorter than that of U-loading system although twisting is larger. Shifting functions takes 2 or 3 seconds because threading is made after PLAY is depressed. Video heads and tape wear well because the tape does not touch the heads in FF and REW modes. However, Picture Search is made after threading.



(c) Simplified Tape Path

**Fig. 1 Tape Transport Mechanism**

## 1.2 Drum (cylinder) Scanner

The Scanner consists of a stationary Lower-drum, a rotary Upper-drum equipped with two REC/PB-video-heads diametrically opposite each other, a Drum-motor for turning the Upper-drum, and a Rotary-transformer for electrically coupling the heads with signal processor. In β VCRs, Upper-drum is also stationary and the heads are mounted on a Rotary-disc inserted between the drums. In 8mm VCR, Upper-drum rotates. The rotary heads and drum driving mechanism are the most important for picking up recorded information correctly. The Upper- and ↗ Lower-drums of aluminum alloy are processed in a weather chamber in the accuracy of submicron order. The Lower-drum has a rail to guide the tape helically. The angle and linearity of the rail determines the tape track pattern. The heads are mounted on the drum or disc so that their faces protrude out of the drum face by 30μm to 50μm. The alignment of the heads have precisely been made in factory. Driving-motor (generally 3-phase) and Rotation-senser (FG & PG) are also very accurate to minimize jitter or time-base error. Video signal is highly affected by jitter. Rotary head is superior than stationary head in minimizing jitter.

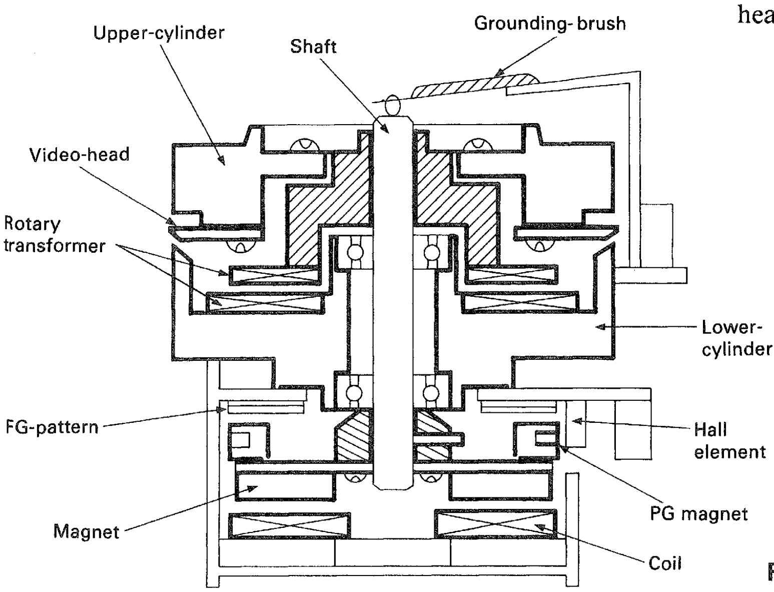



**Fig. 2 Drum (cylinder)**

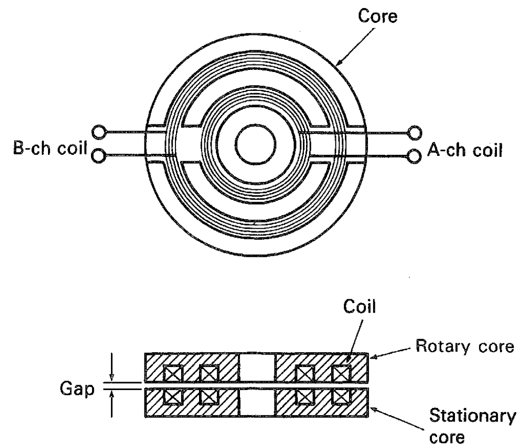



**Fig. 3 Rotary Transformer (Electric signal coupler)**

## 1.3 Video Head

### 1.3.1 Material

The requirements to video head material are the same as those to audio head material. Mn-Zn ferrite among magnetic oxides, and permalloy and sendust among nonoxides are suitable for the head. Home VCRs employ hard-wearing and highly permeable Mn-Zn ferrite. Sendust and amorphous heads of high saturation flux density will be employed in the near future. The characteristics of sendust and ferrite heads obtainable when a metal tape is played back are shown in Fig. 4.

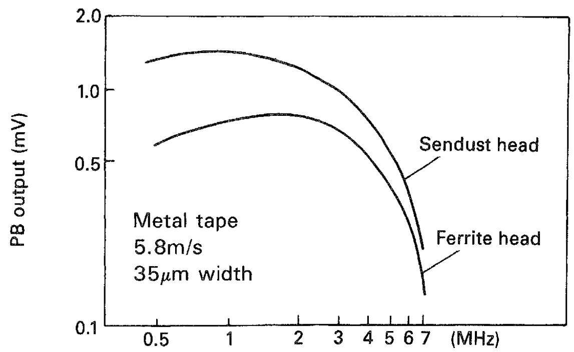



**Fig. 4 Playback Characteristics of Sendust and Ferrite Head**

### 1.3.2 Structure of video-head

The structure of Video head is simple. Its coil has tens of turns. The narrow portion of the head-top is protected by glass as seen in Fig. 5. The head is fixed on a head-base and is mounted on the Upper-drum or Rotary-disc in between the drums. The head deals with the signals of short wavelength having a very narrow gap. The length and width of the head-gap determine the recording/playback performance.

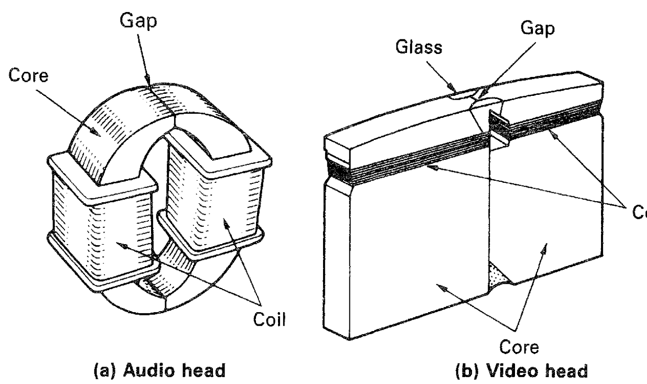
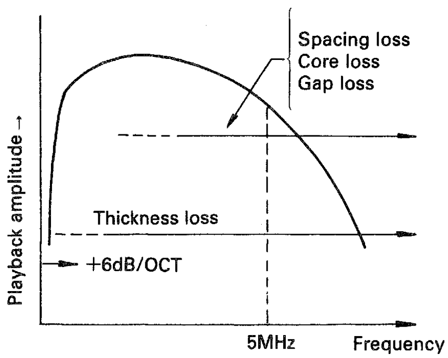


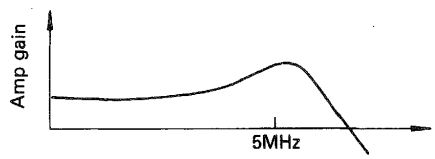

**Fig. 5 Audio and Video Heads**

### 1.3.3 Playback characteristic of video-head

In recording and playback, high frequency signal components are decreased by spacing loss, core loss, thickness loss, etc. as seen in Fig. 6. To minimize the loss the head-gap width should be 1/3 or shorter than the shortest signal wavelength. To make the playback frequency characteristic flat, compensation is made with a resonant circuit consisting of head coils and capacitors and resistors in the input stage of pre-amplifier.




**(a) Tape head frequency response**



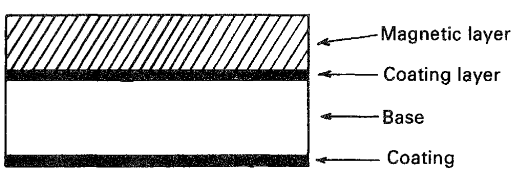

**(b) Compensating**

**Fig. 6 High Frequency Compensation by Preamplifier**

## 2. Video Tape

### 2.1 Structure

There are several kinds of tapes classified by uses; broadcasting, professional and home uses. Their dimensions and magnetic materials are different each other. Home tapes are made of $CrO_2$ and $Cr\text{-}Fe_2O_3$. Coated metal tape for 8mm video high density recording is now available, and vacuum-evaporation tape is under development. The coated tape is basically the same as the audio tape. The back-coated tape shown in Fig. 7 has a carbon layer on the reverse side for minimizing electric resistance and charge and for improving winding characteristic. Some have a binding layer between the magnetic material and base. Vacuum-evaporation tape is made by evaporating a high retentive material and depositing it on a base in a vacuum chamber. After that a protective layer of 100Å thick is formed for protecting the material against wear and corrosion. Pollyester of high Young's modulus and good temperature characteristic is popularly employed for the base.



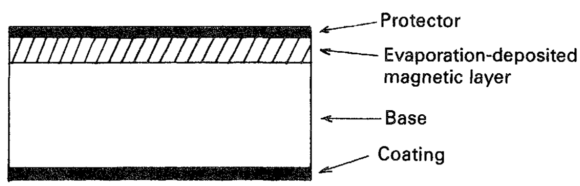




**Fig. 7 Cross-section of Video Tapes**

### 2.2 Performance of Video Tapes

The following performance is required to video tapes:

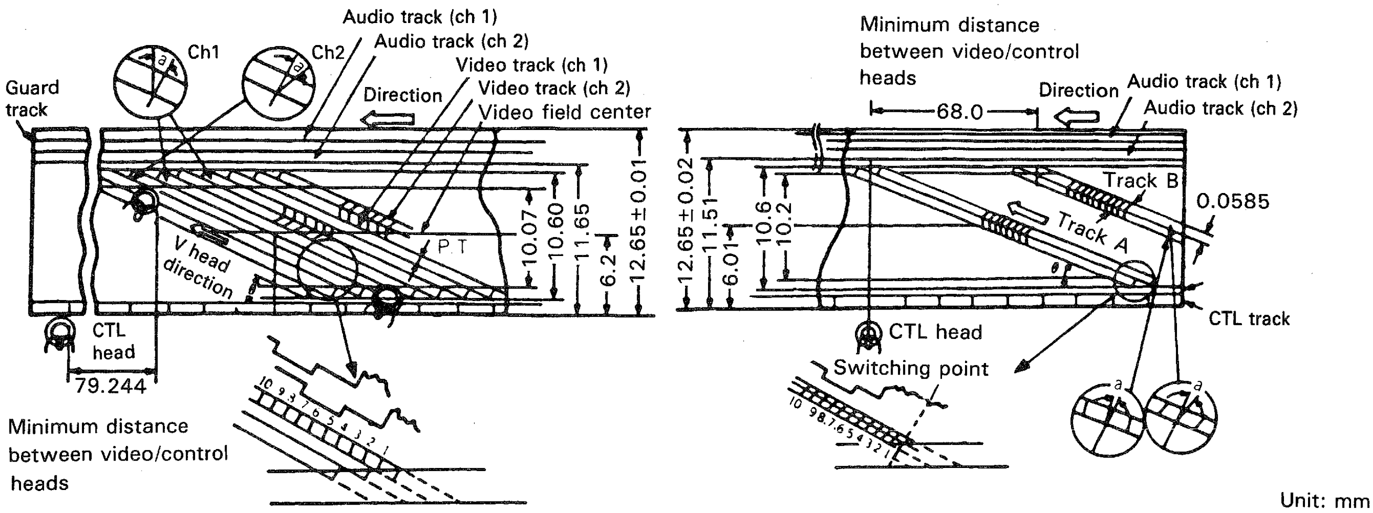
a) Low tape-width variation
b) Hard-wearing
c) Less dropouts
d) Optimum friction coefficient
e) High mechanical strength

| Tape | Co-$\gamma Fe_2O_3$ | Metal | Evaporation-deposited |
|---|---|---|---|
| Bs (Gauss) | 1800 | 2000 | * |
| Br (Gauss) | 1500 | 2300 | * |
| Hc (Oe) | 680 | 1500 | * |
| Thickness of magnetic layer | 5 | 2.5 | 0.15-0.2 |
| Entire thickness ($\mu$m) | 20 | 13 | 13 |
| Use | 1/2″ | 8mm | 8mm |

**Table 4 Specifications of Tapes**

## 2.3 Tape Track Pattern

Fig. 8 shows the track patterns of 1/2″ VHS and β types. Both of them have two tracks for analog audio signals at the top edge, a control track for indicating the starting points of video tracks at the bottom edge and diagonal video tracks between them.

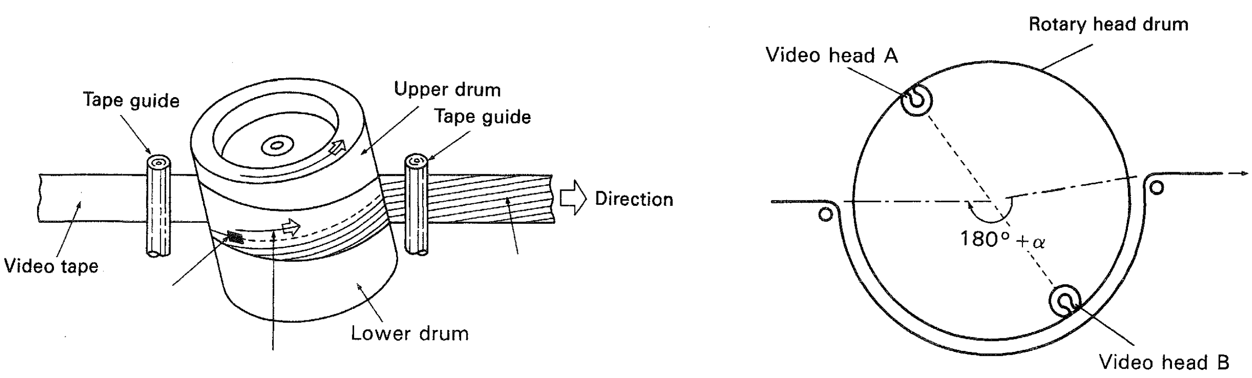



(a) VHS (b) β

**Fig. 8 Track Patterns of 1/2″ VC Tapes Viewed from the Drum**

## 3. Helical Scanning System

The video signal to be recorded is in the frequency range from DC to 4.2MHz (NTSC), 200 times as broad as that of audio signal. The highest recordible signal frequency depends on the gap-width of recording/playback head and writing velocity or tape-to-head velocity. The gaps of 1/2″ VCR and 8mm VCR heads are approximately 0.5$\mu$m and 0.25$\mu$m respectively. With a stationary audio head, a signal is recorded on a track parallelly to the tape direction. To record video signal with an ACR, the tape velocity should be 9.5m/sec, too fast to record for a long time. A 120C audio cassette tape can record video signal only for 35 seconds at 9.5m/sec. To solve the problem, helical scanning system has been developed. By scanning the tape diagonally with revolving two heads, the relative tape-to-head velocity can be made high enough keeping absolute tape velocity low. The heads lay down diagonal tracks at an angle of around 5° to the edge of the tape. All tracks laid down by the A(CH1)-head are called "A(CH1)-tracks" and all those laid down by the B(CH2)-head are called "B(CH2)-tracks". One A-track contains one full TV field (a coarse picture made with 262.5 lines, NTSC) and the following B-track contains the next interlacing field, and successive two fields compose a complete TV picture (525 lines NTSC).




(a) Front view (b) Top view

**Fig. 9 Dram and Tape**

When recording, the video signal is applied to both A- and B-heads. In playback, the picked-up signals coming from A- and B-heads are alternately switched to make one continuous signal channel as shown in Fig. 10. To make one track surely contain one full field information, the tape wraps the head drum a little longer than 1/2 turn. When connecting the two signal, switching noise is generated. To avoid this, the connection is performed about 7H before V-sync appears or at the bottom of the screen where the A- and B-tracks overlap each other. The heads rotates at 1,800rpm to produce 30 frames (1500rpm, 25 frames in PAL) of pictures a second.

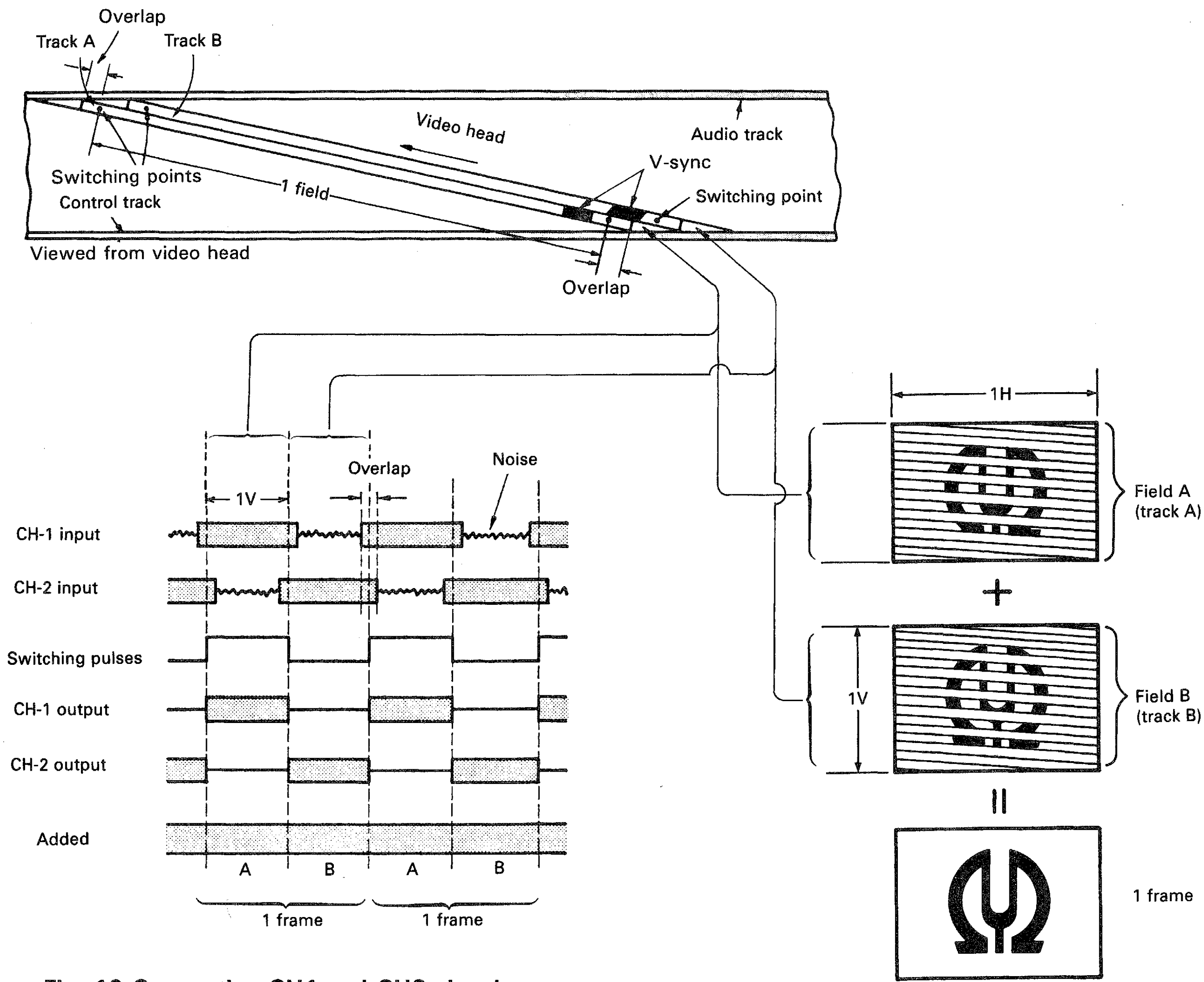



Fig. 10 Connecting CH1 and CH2 signals with a Switching Circuit

Fig. 11 Field and Frame

## 4. Video Signal Processing (NTSC)

Let us see how the picked-up video signal is processed referring to the following block diagram. Although the diagram is of the 8mm VCR, its basic principles are the same as those of 1/2″ VCRs.

Many blocks are used in common for recording and playback.

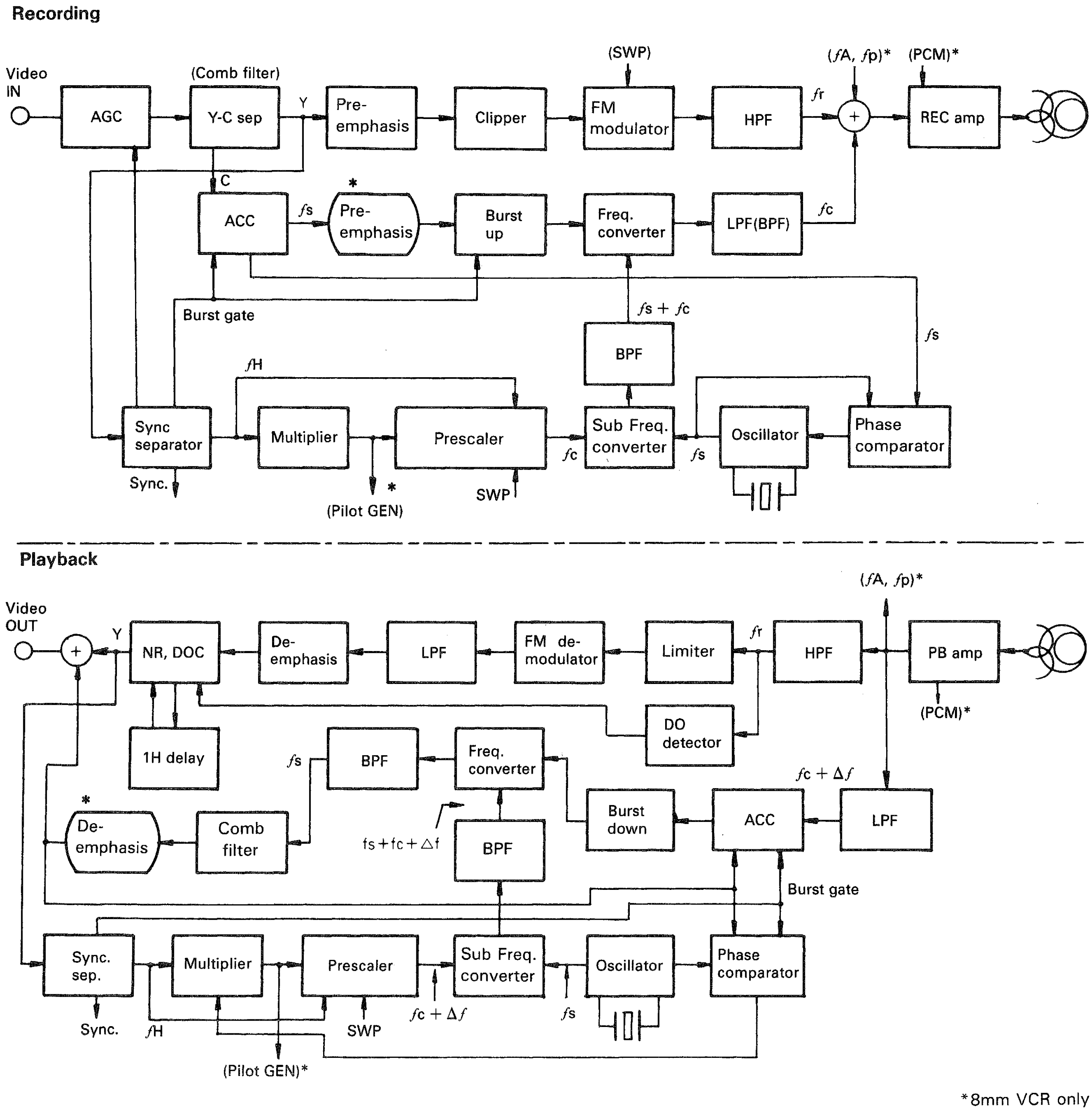



Fig. 12 Block Diagram of 8mm VCR

## 4.1 Recording

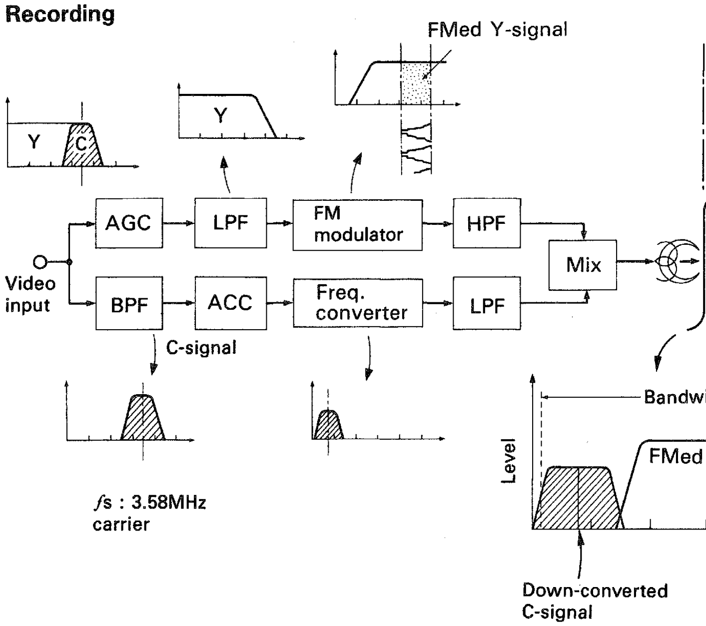
### 4.1.1 Automatic gain control (AGC)

A clamper fixes the sync tip level and makes the video signal amplitude constant.

### 4.1.2 Y-C separation

The Y- and C-signals are separated by Y-C separator to avoid intermodulation distortion because they have been in the same frequency band.

The input signal is added to or subtracted from the 1H-delayed signal. The addition and subtraction yields Y- and C-signals respectively because of the phase difference between adjacent lines (NTSC). Ref. Fig. 2, p13.



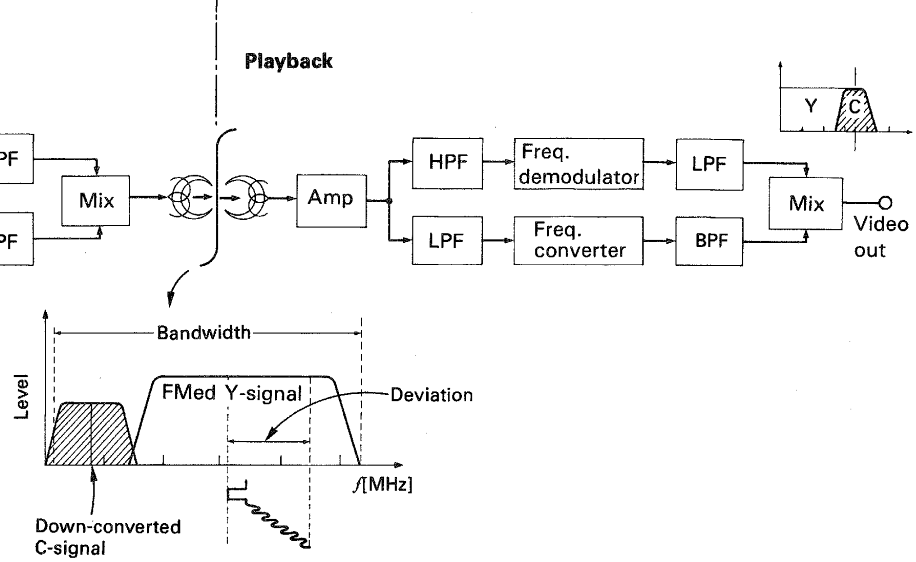




**Fig. 13 Simplified Block Diagram of VCR**

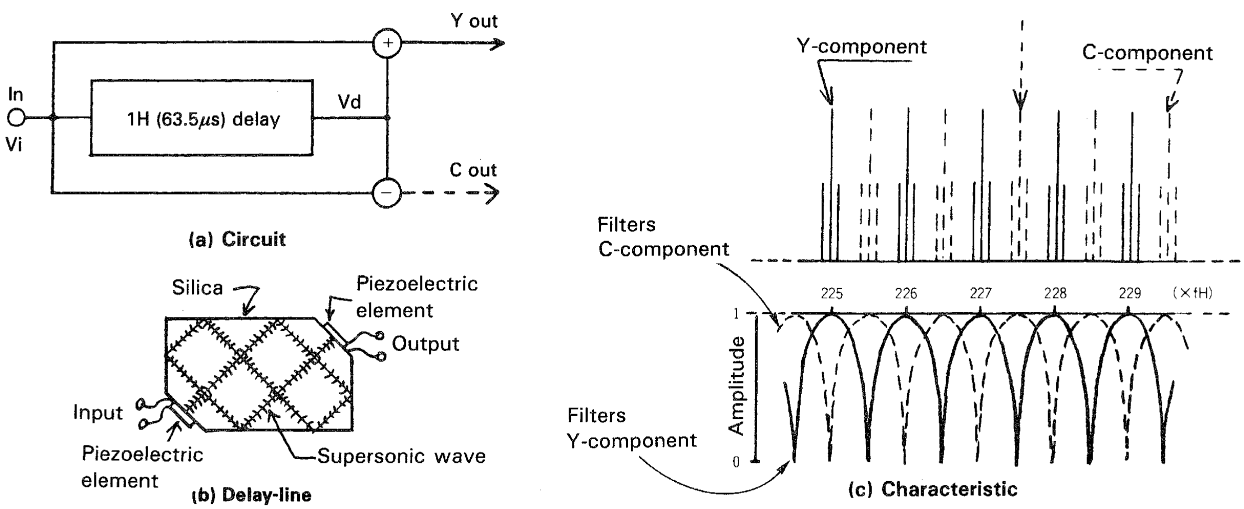



**Fig. 14 Y-C Separation by Comb Filter**

### 4.1.3 Y-signal emphasis

White noise is unavoidable in FM. The noise level of this kind increases in proportion to frequency. The noise, therefore, is suppressed by preemphasis before modulation and deemphasis after demodulation. 8mm VCR and 1/2″ VCRs in $\beta$ II & III and VHS EP modes employ the dynamic emphasis system by which the amount of emphasis is decreased as the input signal level increases to prevent overmodulation. The Y-signal is then clipped and FMed.

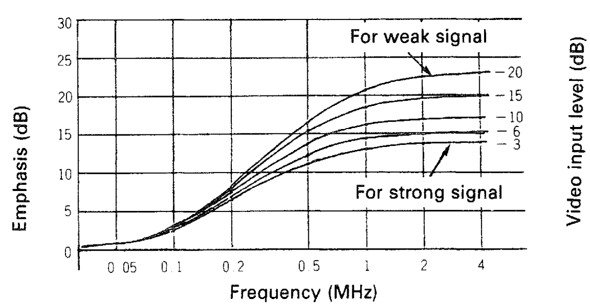



**Fig. 15 An Example of Dynamic Preemphasis ($\beta$)**

### 4.1.4 Frequency modulation (FM)

By frequency modulation Y-carrier frequency is deviated in the range between the frequencies assigned to sync tip and white peak. The reasons why Y-signal requires FM are as follows:

a) FM can transmit DC signal, compress signal bandwith, and make a room for C-signal.
b) In tape recording system playback output level increases in proportion to the signal frequency and decreases rapidly when the half of the signal wavelength becomes shorter than the head-gap width. Y-signal is being distributed in the frequency band too broad to be equalized effectively. Y-signal equalization throughout the wide frequency range becomes unnecessary by FM.
c) Frequency-demodulated signal level is not affected by the level fluctuation of FM signal made in transmission system.
d) FM system makes output signal less affected by the wave distortion made in the transmission system.

The FMed carrier is then filtered by High-pass filter (HPF).

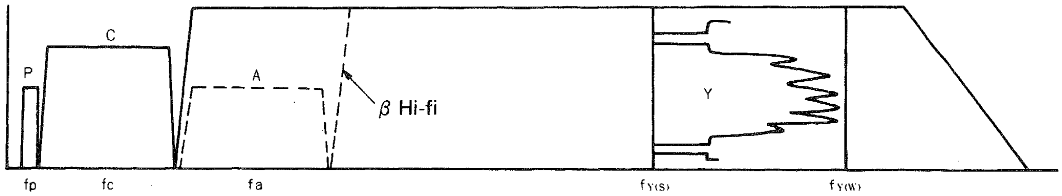



**Fig. 16 Frequency Allocation**

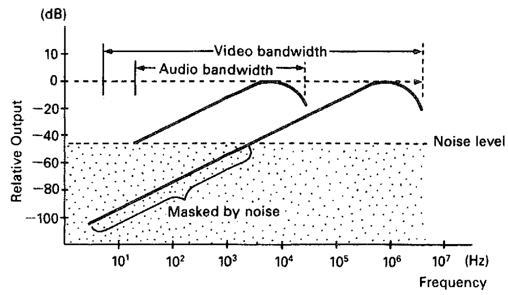



**Fig. 17 Magnetic Recording/Playback Frequency Characteristic**

| Type | fp | fc | fa (fdev) | $f_{Y(s)}$ | $f_{Y(w)}$ | Deviation |
|---|---|---|---|---|---|---|
| Beta | – | 688kHz | – | 3.6MHz | 4.8MHz | 1.2MHz |
| Beta Hi-fi | – | 688kHz | L CH = 1.38, 1.53MHz<br>R CH = 1.68, 1.83<br>(±75kHz) | 4.0MHz | 5.2MHz | 1.2MHz |
| Super Beta (HiFi) | – | 688kHz | L CH = 1.38, 1.53MHz<br>R CH = 1.68, 1.83MHz<br>(±75kHz) | 4.4MHz | 5.6MHz | 1.2MHz |
| VHS (HiFi) | – | 629kHz | L CH = 1.3MHz<br>R CH = 1.7MHz<br>(±150kHz) | 3.4MHz | 4.4MHz | 1MHz |
| 8mm VCR | 102, 118, 149, 165kHz | 743kHz | 1.5MHz<br>(±150kHz) | 4.2MHz | 5.4MHz | 1.2MHz |

**Table 5 Frequency Allocation (NTSC)**

### 4.1.5 Automatic chrominance control (ACC)

The level of C-signal is made constant here.

### 4.1.6 Chroma sideband emphasis (8mm VCR only)

8mm VCR improves the S/N of the reproduced C-signal by varying the amount of sideband emphasis nonlinearly in accordance with the color input level.

### 4.1.7 Burst emphasis

Burst emphasis circuit amplifies only the burst signal. This improves the S/N of the color burst signal.

Color burst signal: A noncontinuous signal bearing a reference phase for the 3.58MHz (4.43MHz PAL) oscillator. Color information is in the phase difference between the reference signal and the modulated carrier.
Refer to Fig. 3, p-17.

#### 4.1.8 Frequency down-conversion

The C-carrier separated by a Comb-filter is frequency-converted from 3.58MHz to about 700±500kHz. The reasons why the C-carrier is down-converted are:

a) Tape recording system is liable to make jitter.
b) Phase-modulated high-frequency signal is highly affected by jitter.

The down-converted C-carrier is then filtered by Low-pass-filter (LPF).

#### 4.1.9 Mixing

In this process the low frequency C-carrier is mixed with the FMed Y-carrier. The Y-carrier is set at a level so that its played-back level becomes the maximum. The Y/C mixing level ratio should be at a value where resultant spurious is kept within specifications. The Y-carrier works as a bias current for C-signal.

### 4.2 Playback

Playback process is the reverse of the above.

#### 4.2.1 Y-signal

The Y-signal passes HPF, Limiter and then Demodulator. The amplitude fluctuation of the signal is suppressed by the Limitter. The upper sideband of the signal is reproduced. The Demodulator is of the pulse count type of low carrier leak. The demodulated Y-signal is filtered in LPF. The modulation noise is suppressed by Deemphasizer. Dropouts are compensated, and the Y-signal is then mixed with C-signal.

#### 4.2.2 C-signal

The down-converted C-signal passes LPF, its amplitude is made constant by ACC, the burst level is reduced to the original level. The C-carrier is reconverted to 3.58MHz. An Automatic Phase Control (APC) loop controls the Voltage Controlled Oscillator (VCO), which puts out local carrier, with the phase difference between those of the burst signal and the signal of quartz oscillator to absorb playback jitter. The C-signal is filtered by a 3.58MHz Band-pass filter (BPF) and Comb-filter to become pure C-signal, deemphasized and then mixed with Y-signal.

## 5. Audio Signal Processing

In the 1/2″ VCRs, audio signal is recorded on the audio tracks with the help of a bias current in the same manner as ACRs. Audio dubbing is possible by this method because the Audio-head is independent from Video-head.

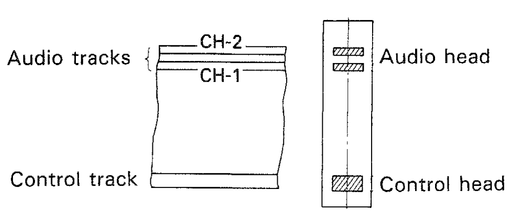
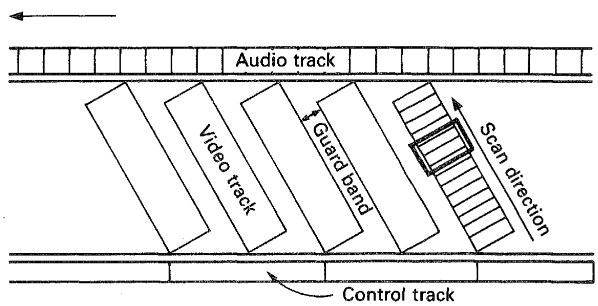



**Fig. 18 Audio and Control Head**

## 6. High Density Recording

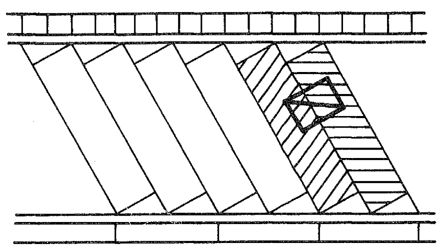
1/2″ and 8mm VCRs employ guard-bandless system to save the tape. Fig. 21 shows video track patterns. In (a) fast-speed mode, the tape allows guard bands or vacant spaces between tracks because the head-gap length is shorter than the track pitch. In (b) medium-speed mode, the tracks are contiguous to each other leaving no space for guard bands.

Further, in (c) slow-speed mode, tracks are overlapped each other. The width of tracks recorded by the overlapping becomes narrower than the head-gap length. In playback the signal on adjacent tracks are picked up together with the necessary signal. These are suppressed by azimuth effect discussed later.



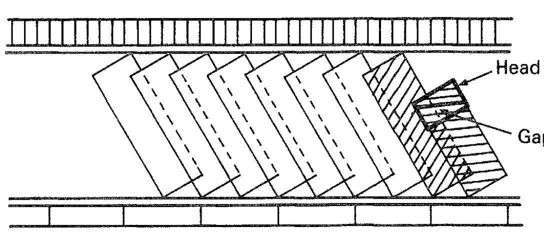

With the help of guard bands cross talk can be avoided even if the azimuth of the Video-head is 0°.

**(a) Fast-speed mode**



Slant head is insensitive to the signal recorded on the adjacent track even when it deviates.

**(b) Medium-speed mode**




Overlapped recording makes the head always pickup the signal on adjacent track(s) in playback.

**(c) Slow-speed mode**

**Fig. 19 Video Track Pattern in Various Speed**

## 7. Cross-talk Suppression

The following methods are taken to suppress cross-talk caused by guard-bandless recording.

### 7.1 Y-signal cross-talk suppression

#### 7.1.1 Azimuth recording

To produce the maximum output, the orientation of the Playback-head should be the same to that of Recording-head with respect to the tape direction or track direction. The azimuth, or orientation of head-gap, of ACR should be at a right angle (0 azimuth) to the tape. As mentioned, each of the A- and B-heads records picture information of one field. The orientation of the gap of video heads is intentionally made off-azimuth or tilted a little in opposite direction each other ($\beta$: $\pm 7°$, 8mm: $\pm 10°$, VHS: $\pm 6°$). Then the azimuth difference between the A-head and B-head becomes 14° in 1/2″ $\beta$, that makes A-head sensitive to the signal on the A-tracks and not to the signal on adjacent B-tracks, and on the other hand it makes B-head sensitive to B-tracks and insensitive to A-tracks. This azimuth effect suppresses the crosstalk from adjacent tracks when there is no guard-band. This method is effective to Y-signal because the azimuth effect increases as the signal frequency increases.

*Azimuth effect: The played back signal is decreased or lost in high frequency range if the orientation of the gap of playback head is not the same as that of recording head. The larger the orientation difference between the two heads, the smaller the reproduced signal.*

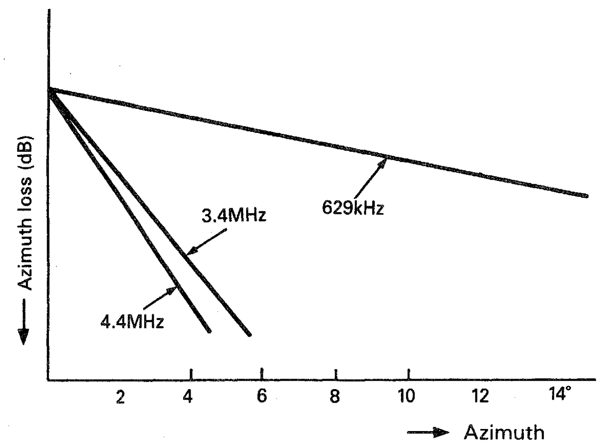



**Fig. 20 Azimuth Loss**

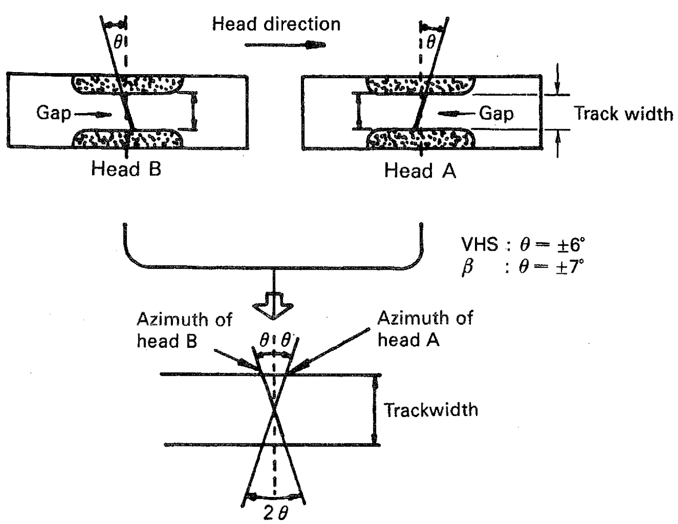



**Fig. 21 Azimuth Recording**

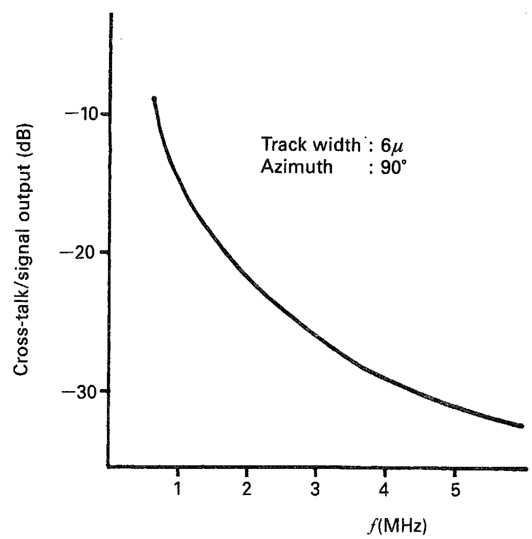
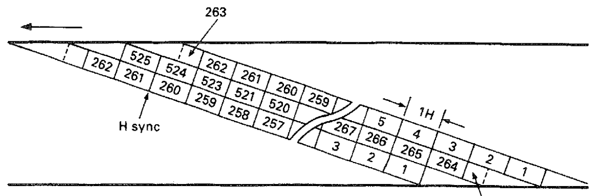


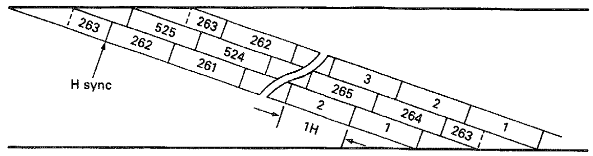

**Fig. 22 Cross-talk Characteristic at 14° Azimuth Difference**

### 7.1.2 Y-carrier fH/2 Shifting (NTSC)

The horizontal sync pulses are aligned in the track pattern when recording in β 1-hour or VHS 2-hour mode as shown in Fig. 23 (a). With this pattern the cross talk H-sync does not interfere with the main H-sync because they are read out at the same time. In the β 2-hour and VHS 4-hour, however, the H-syncs are not aligned. The H-syncs advance or delay from those of the adjacent tracks by 0.75H or 0.25H as shown in Fig. (b). The H-sync cross talk produces vertical stripes on the screen as shown in Fig. 24 because azimuth recording is not so effective to the deeply recorded sync siglal which is much lower than Y-signal in frequency. To avoid this trouble β and VHS (EP mode only) shifts Y-carrier by fH/2(7.9kHz) every other track. The beat frequency becomes an odd multiple of fH/2 and the interferring noise becomes invisible with visual integration effect. Refer to p-13, Carrier Interleaving.




(a) H-sync aligned




(b) H-sync not aligned

Fig. 23 H-sync Alignment

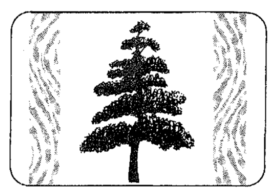


Fig. 24 Vertical Stripes

## 7.2 C-signal cross-talk suppression

Phase Inversion and Phase Shift

An electric method for suppressing the C-signal crosstalk is taken in addition to the azimuth recording method because the latter is not effective to low-frequency converted C-signal. NTSC β and 8mm VCRs employ Phase Inversion system and VHS and PAL 8mm VCRs employ Phase Shift system.

The fact that the signal waveforms on the two adjacent lines are almost the same to each other makes the following noise cancelling process possible.

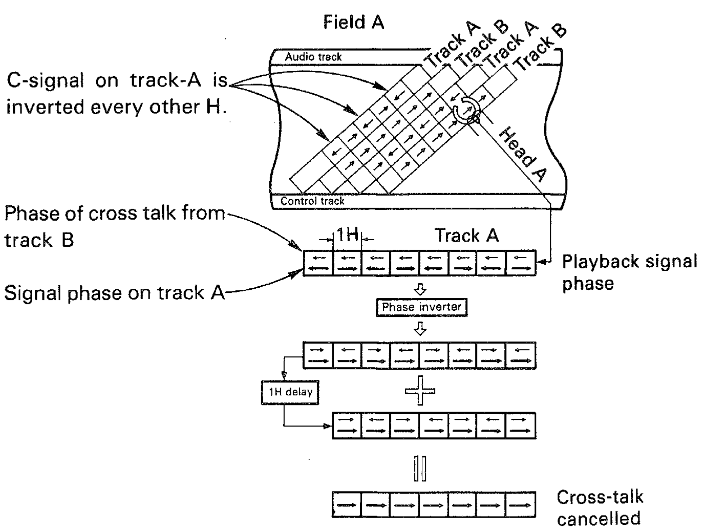
### 7.2.1 Phase Inversion (PI) Fig. 23.

a) This method records information by inverting signal phase every other horizontal period (H) on A-tracks and ↗ leaving the phase uninverted throughout B-tracks. When playing back, the reproduced signal contains cross-talk from an adjacent track.

b) In playback the phase of the signal on every other H of A-track is reinverted and returned to the original. Phase reinversion is unnecessary on B-track because the signal on B-tracks has not been inverted when recording.

c) The phase-returned signal on A-tracks is delayed by 1H and added to the nondelayed signal.

d) Then the crosstalk signal is cancelled and the necessary signal only is taken out because the cross-talk component of the delayed signal is 180° out of phase from the nondelayed.



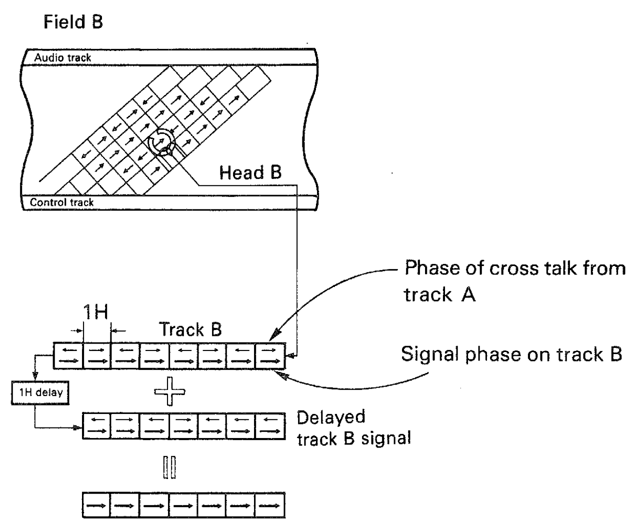




Fig. 25 Phase Inversion System

### 7.2.2 Phase Shift (PS) (NTSC)

a) In recording the signal on A-tracks is shifted counterclockwise by 90° (1/4 fH) in every H period and that on B-tracks clockwise by 90°.

b) In playback the phase is restored; the phase of A-tracks is shifted by 90° clockwise and that of B-tracks counterclockwise H by H.

c) The returned signal is delayed by 1H and is added to the nondelayed signal. Then the cross-talk component is cancelled because the cross-talk component in the delayed signal becomes 180° out of phase from that of the nondelayed.

The PI and PS are performed by a subconverter which generates a local carrier for converting frequency. (Fig. 12)

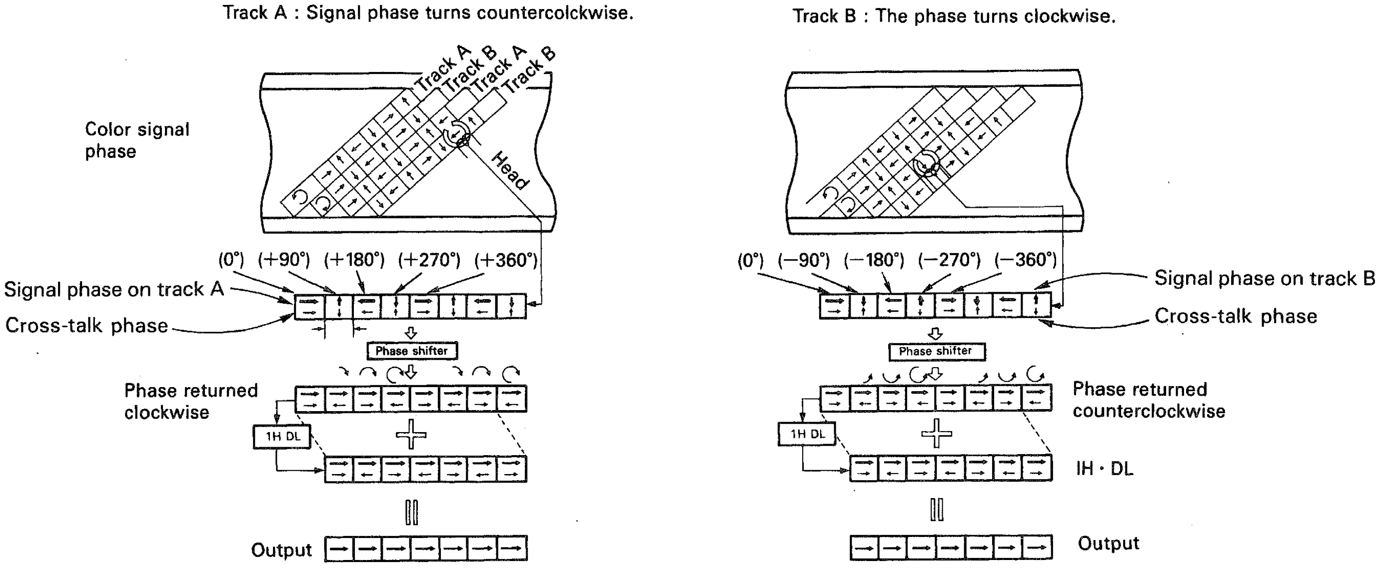



Fig. 26 Phase Shift System

## 8. Other Noise Suppression

### 8.1 1H Correlative Noise Cancellor

The Comb-filter eliminates random noise and the beat caused by the fH/2 shifting. It suppresses vertical image lines on the screen from flickering by minimizing 1H correlative noise, or the signal components unsimilar to those of the adjacent scanning lines. 1H-delayed signal is subtracted from the current 1H signal, and noise components only are taken out and negatively fed back to the current signal. Then the noise components only are cancelled.

### 8.2 Other Noise Cancellor

High frequency noise can not completely be eliminated by preemphasis and deemphasis.

This circuit suppresses the noise appearing in the monotonous portion of pictures. In the high-pass-filter (HPF) in Fig. 27, the sharp edges of Y-signal are differentiated and allowed to pass with high frequency noise components. Their amplitude is clipped in Limiter, and the input signal is subtracted by the limited high frequency signal. The cutoff frequency of HPF and the limiting level of the input signal is determined taking picture quality and S/N into consideration. Then the noise components are cancelled.

### 8.3 Narrow-track Video Head

To avoid scanning two tracks and picking up crosstalk some VCRs employ another pair of short-gap (narrow-track-width) video heads in addition to the standard pair and make the former specialize in slow-speed mode.

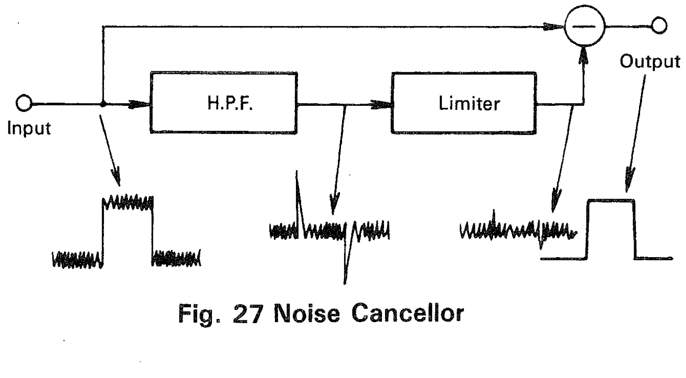



Fig. 27 Noise Cancellor

## 9. Servo System (NTSC)

Precise servo system for capstan and drum motor is required to draw a specified pattern on the tape in recording and to trace it correctly in playback.

The revolution of the Drum or Head-disc should always be at 1800rpm and that of Capstan should be at a specified value depending on the tape velocity mode. A 30Hz control (CTL) signal is recorded as a reference for playback. The Capstan, therefore, should move the tape at a velocity to keep the reproduced control signal at 30Hz at any tape mode. A-head should meet the beginning of A-track when CTL level rises. Fig. 28 and 29 are simplified diagrams of Drum and Capstan servo blocks.

*Drum servo system:*

In recording, the signals generated by Drum-frequency-generator (DFG) is speed-detected, and the error signal, or difference signal, is negatively fed back(NFB) to the Drum-motor. The signal generated by Drum-pulse-generator (DPG) is compared with a reference signal (V-sync/2) made from the video input signal, and the error signal is also NFBed to the motor.

In playback, the internally oscillated 3.58MHz signal is used instead of the video input signal for making the reference.

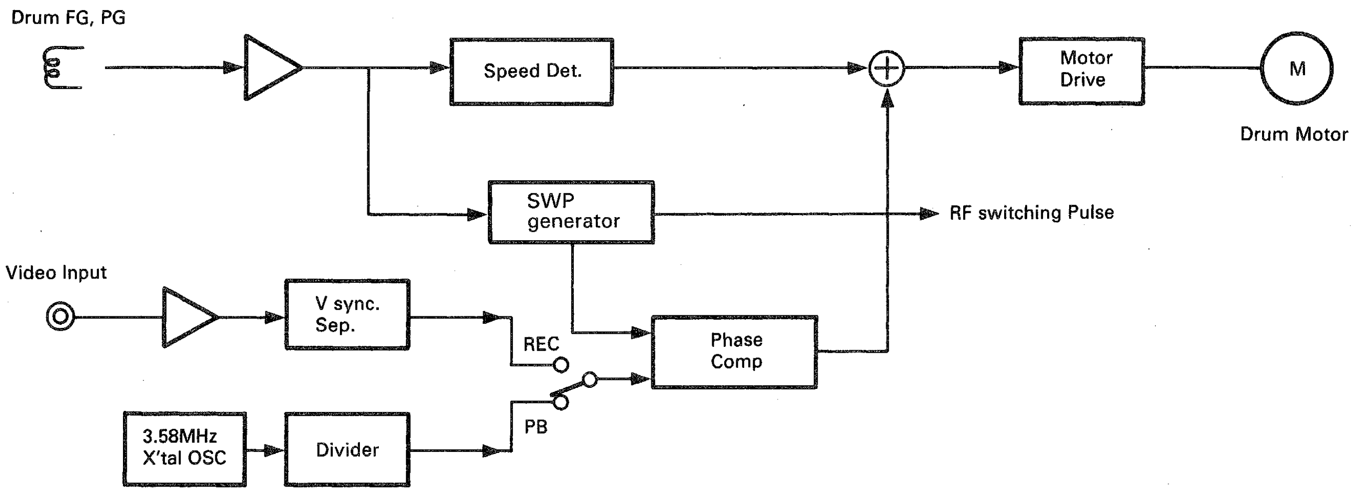



**Fig. 28 Block Diagram of Drum Servo Circuit**

*Capstan servo system:*

In recording, the capstan-FG(CFG) signal generated in Capstan-motor is speed-detected and is NFBed to the Capstan-motor. The CFG signal is compared with the V-sync/2 reference signal, and the error signal is NFBed to the motor. Some models use the reference signal made from the 3.58MHz signal instead of the V-sync/2. The dotted block of Fig. 27 are peculiar to the types indicated.

In playback, the reproduced CTL signal is phase-compared with the reference signal made from the 3.58MHz signal, and the error signal is NFBed to the motor. The CFG signal is speed-detected and NFBed as above. As a result, the FG and CTL signals are phase-compared with the help of the reference signal made from the 3.58MHz signal, and the error signal controls the Capstan-motor to make the movement of Heads and tracks inphase.

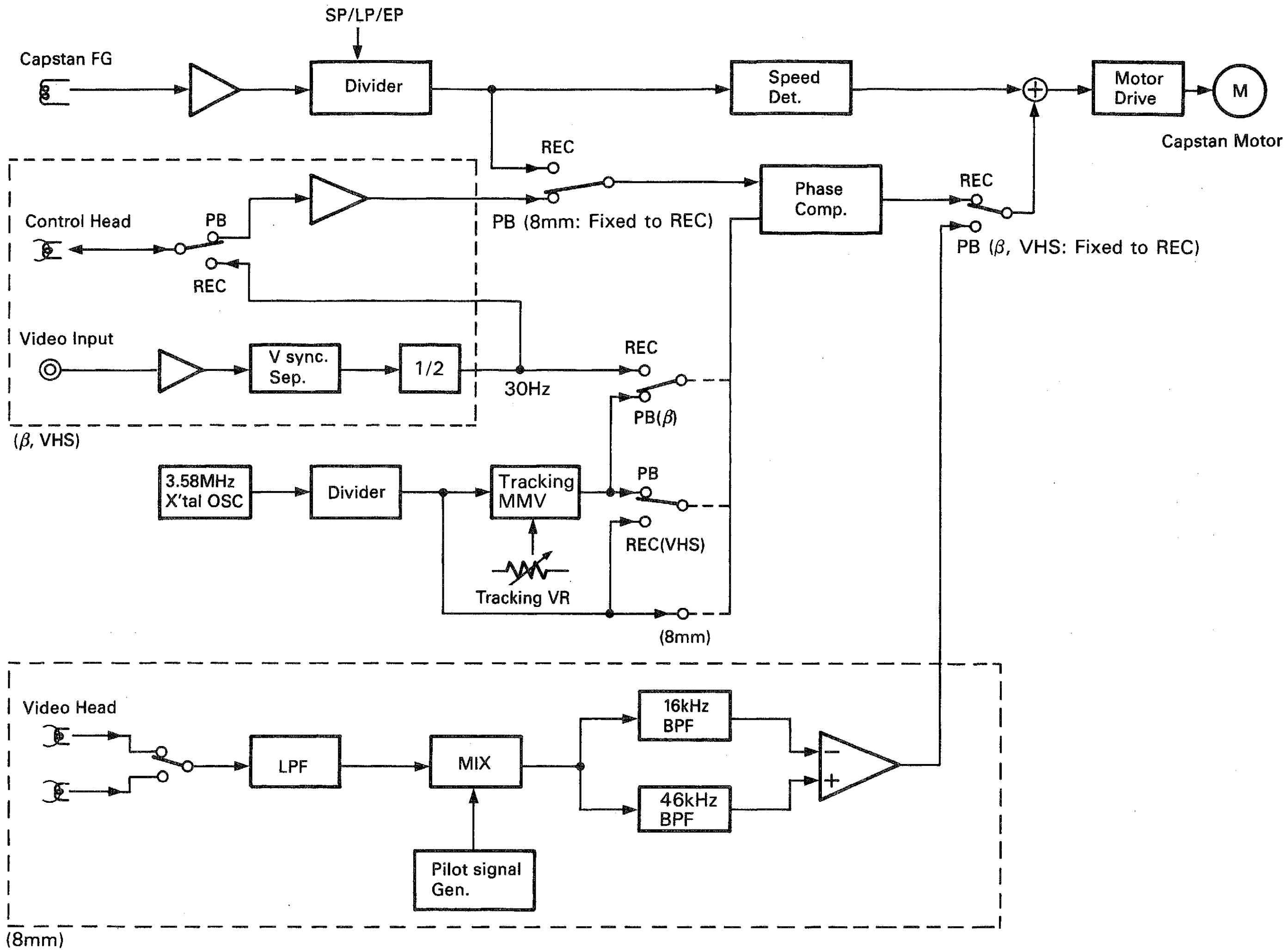



**Fig. 29 Block Diagram of Capstan Servo Circuit**

## 10. Alignment of Tape Transport Mechanism

The tape transport mechanism should correctly be aligned, or the VCR interchangeability will be lost. The height of Tape-guide-poles can be adjusted observing RF signal amplitude on an oscilloscope.

If the distance between Drum and CTL-head of the player is not equal to that of the recorder, the reproduced V-sync will be out of phase from the CTL signal, and servo control will become difficult. A variable resistor, Tracking-VR, has been employed for compensating the phase error caused by the distance error.

## 11. Trick Play

Trick play such as STILL, SLOW and PICTURE SEARCH is possible by shifting tape speed. Tracking control becomes difficult when the tape speed varies because the video heads are forced to trace wrong tracks where a head becomes off-azimuth to the recorded signal.
There are two problems in trick play.

*1) V-sync*

When the tape runs fast or slow, the relative tape-to-head velocity is shifted and the number of scanning lines per frame becomes smaller or larger than 525. Then the vertical synchronization will be lost. To compensate this in trick play quasi V-syncs are added next to the real V-syncs.

*2) Azimuth loss*

Head-A picks up the signal on track A and head-B picks up that of head-B. When the tape speed is shifted, the video heads trace tracks of wrong azimuth causing noise and poor picture. There are two ways to solve this problem. One is adjusting the phase of the tape to the heads with a tracking variable resistor to make the heads trace the ↗ track center and to make the crossing point of the track boarder away from the center.
In this way the noise still remains in the picture. Another is adding extra head(s). An additional head-B′ of opposite azimuth to head A installed close to the main head A will pick up the signal when A derails. A and A′ complement each other and read a complete field.
4-head system has two pairs of complementary heads. The track width of the two additional heads of the 4-head VCR has been made narrow to meet slow mode tracks. Therefore, when slowly recorded tape is played the additional heads become the main heads.

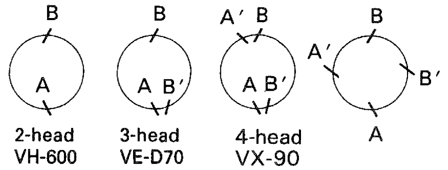


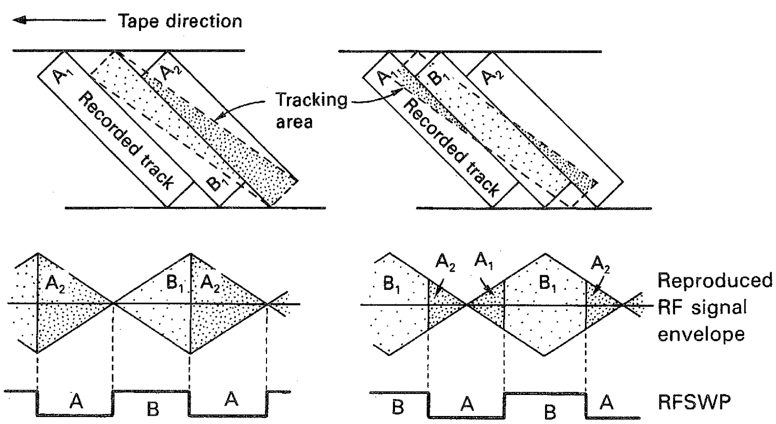

**Fig. 30 Various Types of Head**

### 11.1 Frame STILL

In Frame Still, the picture vibrates when the image in the original picture moves or the signal waveform of the field-B differs from that of field-A because the screen displays field-A and field-B alternately. The locus of heads and the amplitude of reproduced RF signal are shown below.

### 11.2 Field STILL (Fine Still, Clear Still)

When head A and B trace track center as shown in Fig. 31 (b), the picture will become coarse because they trace only one field although the picture does not vibrate and become noiseless.



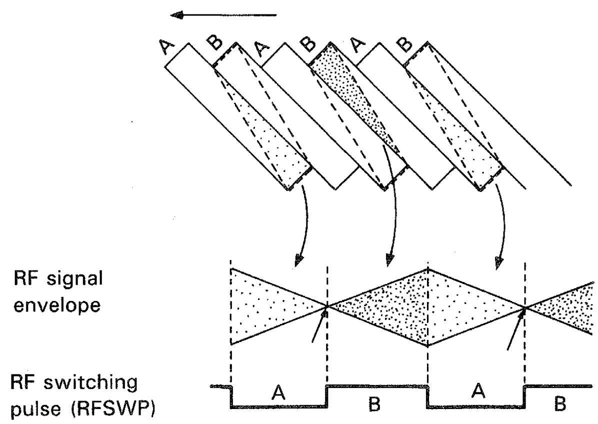

**(a) Frame still** **(b) Field still**

### 11.3 SLOW

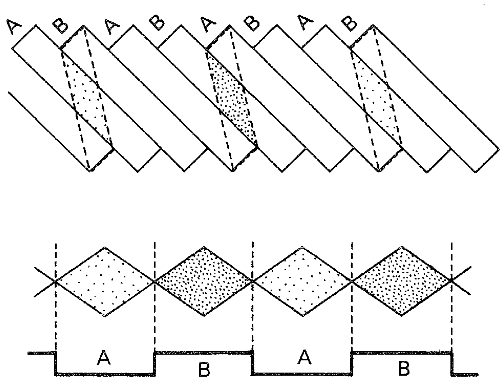
Simple SLOW: This just slows down the tape velocity. The noise appears when a head crosses tracks.
Fine SLOW: This method is a combination of Field Still and Step Forward and is employed in VHS VCRs. The velocity shifts between Slow and Standard alternately.

### 11.4 x2 and x3 SPEED

In Fig. (c) A and B heads read imcomplete two fields.




**(c) x 2 speed**



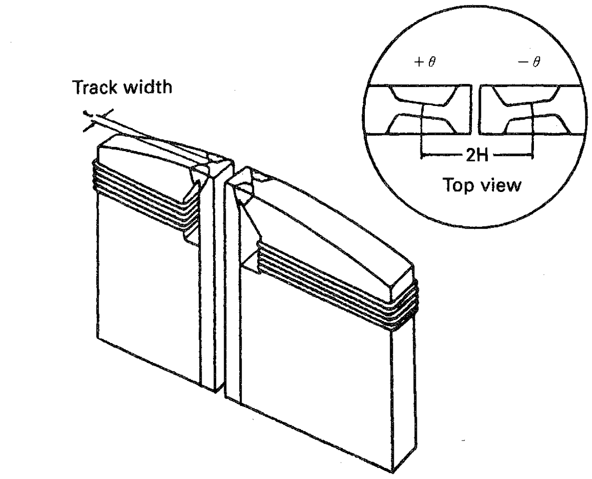
**(d) x 3 speed**

**Fig. 31 Trick Play**

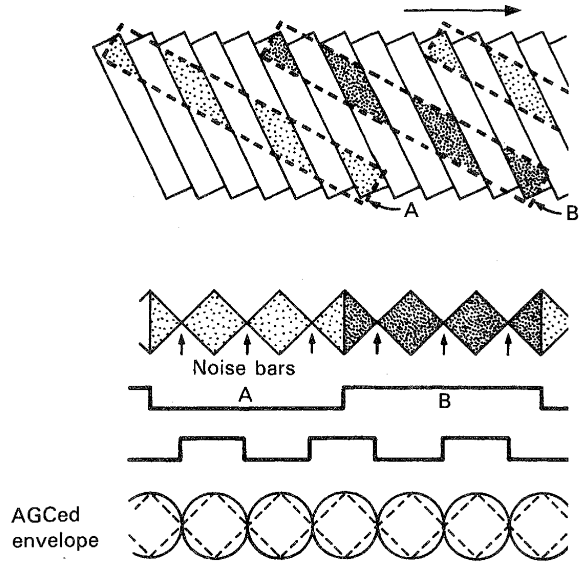
## 11.5 PICTURE SEARCH

In SEARCH mode, heads cross many tracks and reproduce many noise bars as shown in Fig. (b).

As mentioned, 2-head VCR produces noise while the A head is sliding on B-tracks and the B-head is on A-tracks. To suppress the level variation and noise bars Automatic Gain Control (AGC) circuit smoothes the envelope peaks as shown in Fig. (b) bottom.

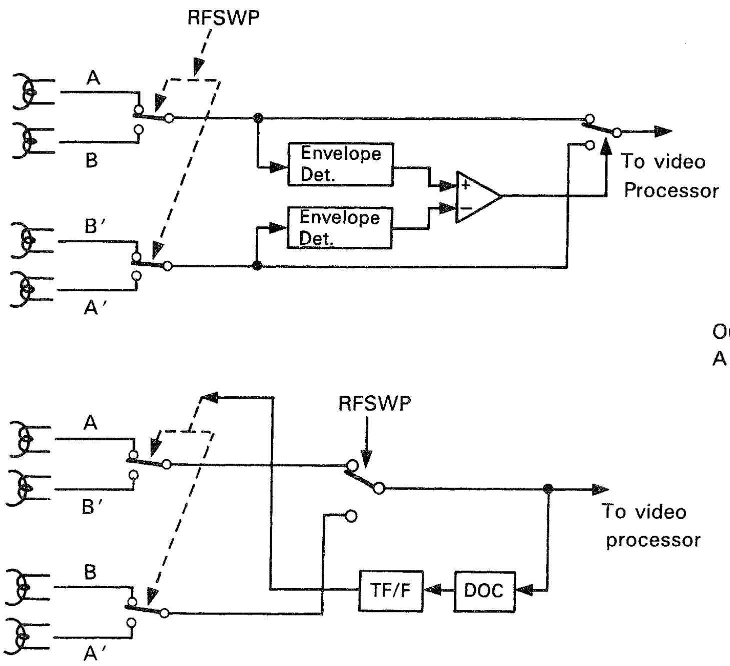



**(a) Double-azimuth head**

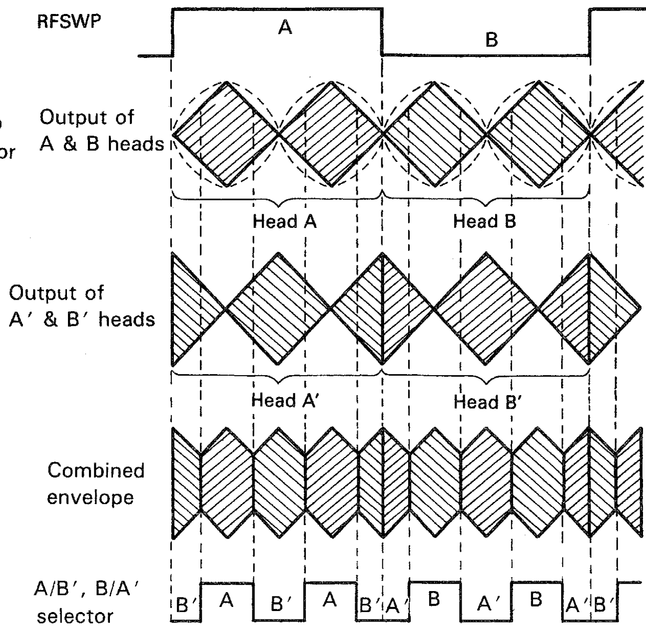



**(b) Picture search**

4-head VCR can pick up B-track signal with the B′-head when A-head is on a B-track, and A-track signal with the A′-head when the B-head is on a A-track. The signals reproduced by the heads are quickly switched between A-B′ and B-A′ and are alternately taken out while they are high in amplitude. Fig. (c) shows two examples of their switching circuit block diagrams.




**(c) Head-selecting circuit**




**(d) Switching A/B′, B/A′ heads**

**Fig. 32 Picture Search**

## 12. Tuner

VCR has a TV tuner and an antenna selector for recording a TV program and an RF converter for putting out TV signal. With the tuner, it is possible to view a program while recording another. The input signal can be put out to the VIDEO OUT terminal directly, after modulation and demodulation, or after recording and playback. Hi-fi VCR equips a multisound decoder and generally employs split-carrier system to achieve hi-fi sound reproduction. It also has a synthesizer-channel-presetter for easy channel presetting, microcomputer controlling and timer-activated recording.

**Split-carrier system: Sound signal is separated from picture signal before video demodulation. Unlike the inter-carrier system, which separates sound signal after the demodulation, this system provides hi-fi sound by suppressing video signal interference.*

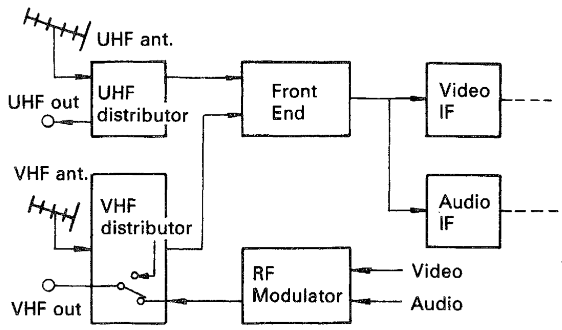



**Fig. 33 Antenna Selector**

## 13. Video Camera

The image coming through the lens is focused on a photo-electric device. The light information transduced into electric one is scanned line by line in the same way as TV receivers do. There are several kinds in the photo-electric device, camera tube and solid imagers.

## 14. 1/2" Hi-fi VCR

1/2 hi-fi VCR has an additional audio recording system to the conventional system. Therefore, dubbing or superimposing completely independent 2-channel audio signals on the audio tracks is possible while recording a video program.
The VCR's conventional audio recording system sacrifices sound quality because the audio head is stationary and the tape-to-head velocity is low. Hi-fi VCRs have solved the problem by recording audio signal through rotating heads which make the tape-to-head velocity high.

### 14.1 $\beta$ Hi-fi (NTSC only)

#### 14.1.1 Standard $\beta$ Hi-fi

$\beta$ Hi-fi system records audio signal on the diagonal video tracks together with video signal. It shifts the Y-carrier up by 400kHz and inserts four separate FM audio carriers between the C- and Y-signals in the frequency spectrum. Two carriers 1.38MHz $f_1$ (LA) and 1.68MHz $f_3$ (RA) are recorded at a time through the A-video-head and 1.53MHz $f_2$ (LB) and 1.83MHz $f_4$ (RB) through the B-video-head. Cross-talk can be suppressed because of their frequency difference. The audio tracks at the top can be used as ever. Therefore, dubbing is possible on a hi-fi VCR through the stationary audio head. In playback, switching the picked-up signals coming from the A- and B-heads are made before or after demodulation.

#### 14.1.2 Super $\beta$ (High-band $\beta$)

VCR's picture resolution depends on the recording frequency bandwidth which depends on the carrier frequency. When the carrier frequency is shifted up by 400kHz, the resolution increases by 30 lines theoretically.
The frequency bandwidth of $\beta$ VCR is wider than that of VHS VCR because the tape-to-head velocity of the former is higher than the latter. $\beta$ Hi-fi has already shifted the Y-carrier up by 400kHz to avoid FM audio interference. Super $\beta$ system shifts the carrier up further 400kHz, 800kHz in total, improving the effective resolution by aproximately 30% compared with the conventional non-hi-fi system.

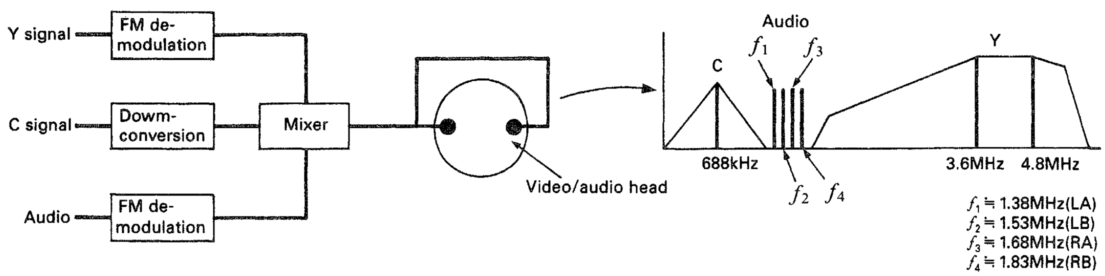
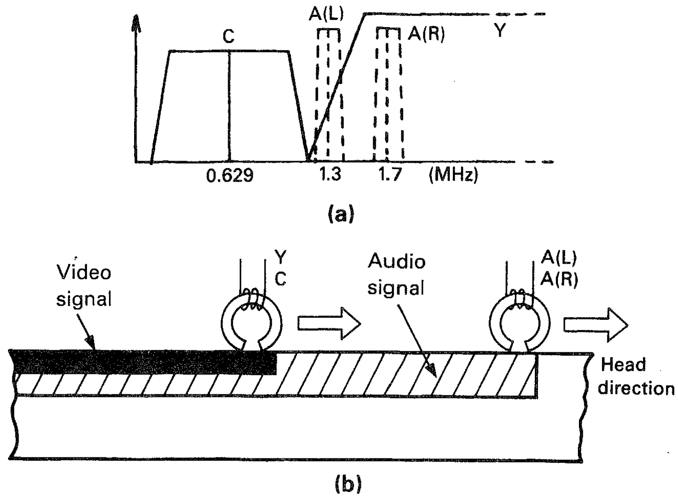
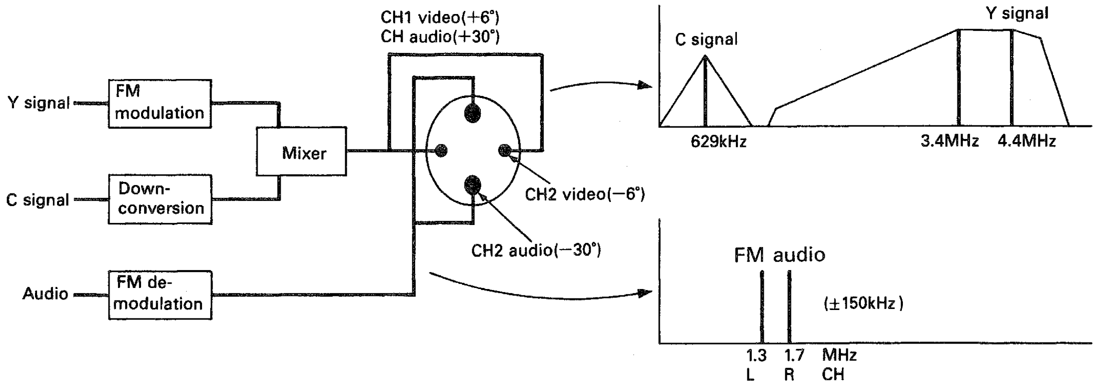



**Fig. 34 Recording System of $\beta$ Hi-fi VCR**

## 14.2 VHS Hi-fi

VHS Hi-fi system employs two additional audio heads with an azimuth of +30° or −30° on the drum as shown in Fig. 35. After FM audio signals of 1.3MHz and 1.7MHz are recorded deeply, video signals are recorded shallowly by ±6° video heads. The audio heads with a wide gap can make a large magnetic field and record signals deeply in the tape while the video heads with a narrow gap can not make a large magnetic field nor record signals deeply. The level of the reproduced audio signal is high enough despite of spacing loss which is caused by video signal recorded on the surface. Although the audio carriers' frequency ranges are included in that of video carrier as shown in Fig. (a), cross-talk can be suppressed by a large azimuth difference of ±30° and ±6°.




(c) VHS

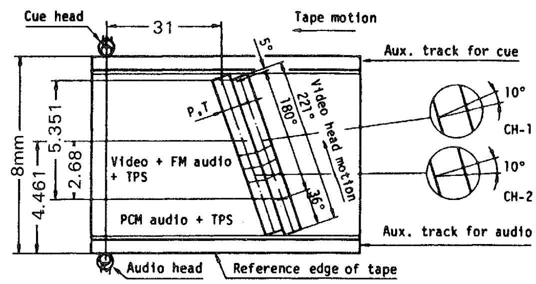
**Fig. 35 Recording System of VHS Hi-fi- VCR**

## 15. 8mm VCR

Fig. 36 and Table 1 show the 8mm video tape format. The top track is for auxiliary functions. The bottom track is for analog audio (1-channel option). The diagonal tracks are for video, FM audio (1-ch), PCM audio (2-ch option) and tracking pilot signals.

### *a. Standard recording format*

The format has been determined to make mechanism and ICs compatible to NTSC and PAL. SECAM signal will be converted to PAL before recording. In addition to the devices of 1/2″ VCR 8mm VCR has employed metal tape and achieved a high picture quality.




※TPS : Tracking Pilot Signal

**Fig. 36 Track Pattern of 8mm VC Tape**

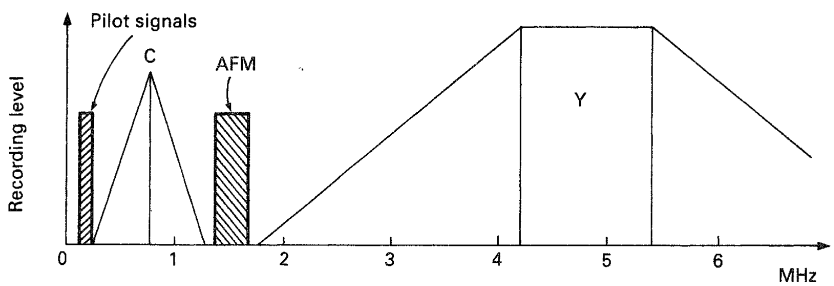


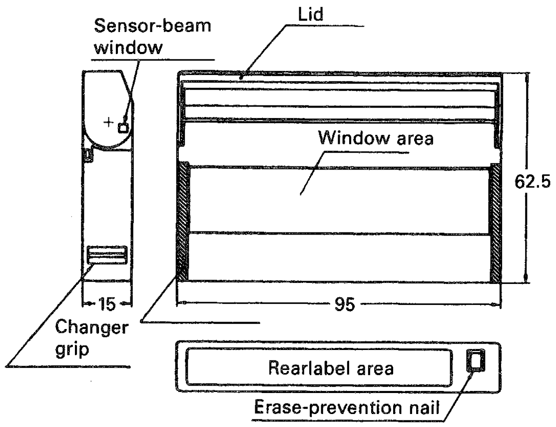

**Fig. 37 Frequency Spectrum of 8mm VCR**

*b. Small cassette*

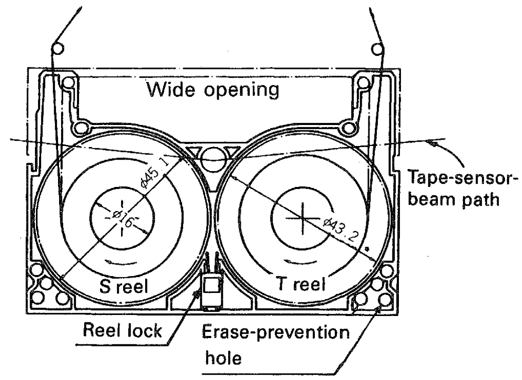
Metal tape has made the cassette small as shown in Fig. 38. The volume is 1/4 ~ 1/6 of that of 1/2″ cassette tapes. The tapes of 13μm and 10μm thick play 90min and 120min (PAL: 60min and 90min) respectively. The playing time can be doubled by shifting capstan motor revolution. Tape guides have been removed from cassette shells and installed in the player mechanism to avoid the effect of warped shells. It has a large window for easy tape threading. The tape protecting lids close like eye lids.

Features of 8mm video cassette

a. No tape guide
b. Double-wall tape protector
c. Slack-preventing reel lock
d. Switchable erase-prevention tab
e. Misload-safe framework
f. Tape-type sensor
g. Optical tape-end sensor
h. Indents for auto-changer arms




(a) Exterier view




(b) Interior view

**Fig. 38 8mm Cassette Tape**

*c. 4F Automatic Track Finding (ATF)*

Narrow tracks made by high density recording make accurate tracking difficult. To solve the problem, 8mm VCR records 4F pilot signal on the diagonal video tracks together with video signal instead of CTL signal. This has made the tracking VR unnecessary.

The pilot signal frequency shifts to 6.5$f_H$, 7.5fH, 10.5$f_H$ and 9.5$f_H$ in turn track by track. With this order the frequency difference between the center-track signal and the cross-talk signal from an adjacent track is $f_H$ (16kHz) or 3$f_H$ (46kHz). Video heads pick up three of the 4F pilot signals recorded on the center and the two side tracks, and the tracking servo circuit compares the levels of the frequency-difference signals between those of the center and adjacent tracks and feeds the output of the comparator, or 4F tracking error signal, back to the capstan motor negatively. In Fig. 39(a), if the tape slows down, the head derail to the left and the level of 16kHz $\Delta f_A(f_1 \sim f_2)$ signal becomes higher than that of 46kHz $\Delta f_B(f_2 \sim f_3)$. Then the level difference between the 16kHz signal and 46kHz signal is applied to the capstan motor to turn it fast.

Here remains a problem. In this method the frequency of the right and left difference signals shift to or from 16kHz or 46kHz every time a video head moves to the next track and it becomes difficult to find out whether the tape is fast or slow.

When an extra pilot signal is mixed with the three picked-up pilot signals in the order of $f_1$, $f_4$, $f_3$, $f_2$ and $f_1$ as shown in Fig. (a), the difference signal or beat between the applied signal and the right pilot signal always becomes 16kHz, and that between the applied signal and the left signal always becomes 46kHz. This time the picked-up center pilot signal is neglected. Then the side of tape velocity error can be detected. The mixing is made in the tracking servo circuit in playback.

When the pilot signals picked up by the solid-line-head are compared,

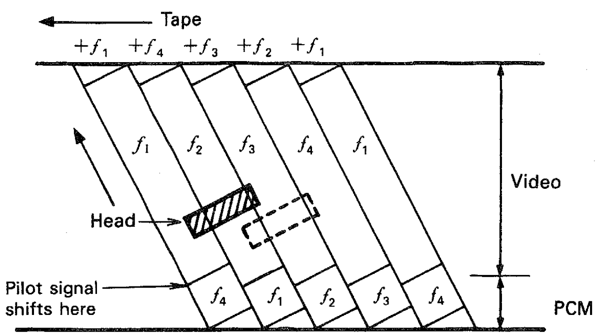
The level of $\underset{(46kHz)}{[f_1 \sim (f_4)]}$ signal > the level of $\underset{(16kHz)}{[f_3 \sim (f_4)]}$ signal

The circuit judges that the head is deviated to the left and puts out a signal to make the motor fast.

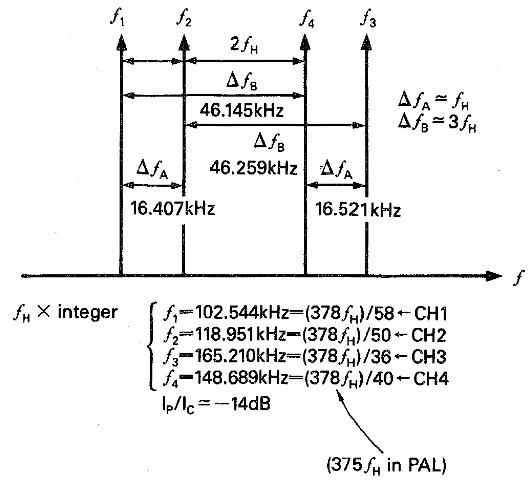
When the head moves to the next track (dotted-line-head),

The level of $\underset{(46kHz)}{[f_2 \sim (f_3)]}$ signal > the level of $\underset{(16kHz)}{[f_4 \sim (f_3)]}$ signal

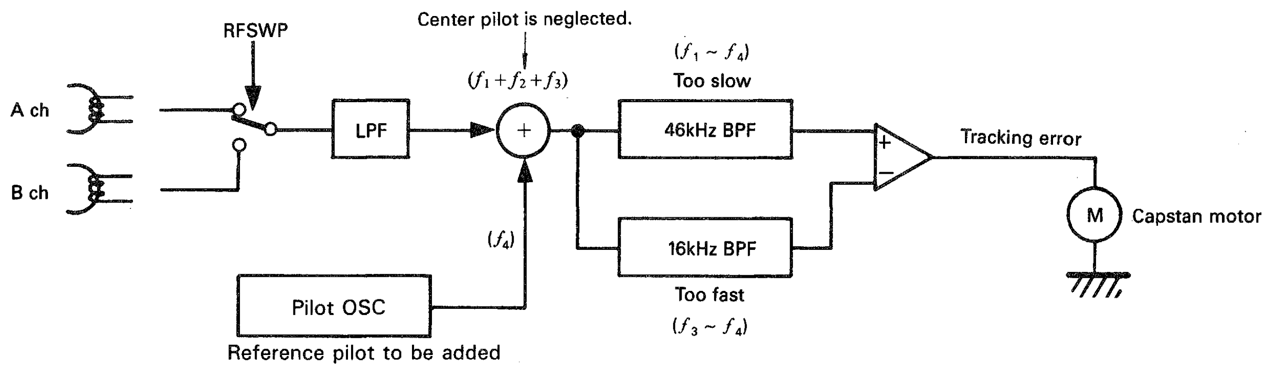
The circuit still judges that the head is deviated to the left.




**(a) When tape is slow.**




**(b) Pilot frequency (NTSC)**

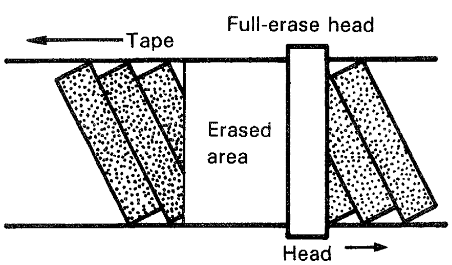



**(C) Tracking Servo Circuit**

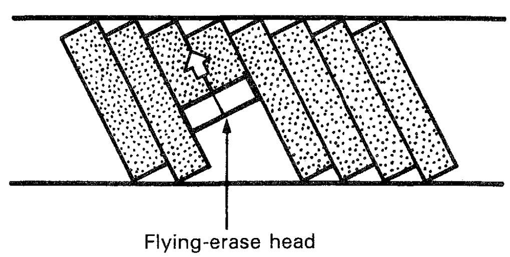
**Fig. 39 Automatic Track Finding(ATF)**

*d. Flying-erase-head*

In the $\beta$ and VHS systems one frame erasing is impossible because the fixed Full-erase-head erases the signal across the full tape width. This produces noise signal when editing. In 8mm VCR an Erase-head installed between the two Video-heads on the Drum can erase signals frame by frame with the help of the ATF system. This makes noise-free editing possible.




**(a) Full erase**




**(b) Flying erase**

**Fig. 40 Erasing Methods**

*e. PCM audio channel*

The tape spares PCM area for the additional 2-channel audio information by wrapping itself over the Drum by 220° while the conventinal VCR tape wraps the Drum a little larger than 180°. PCM audio signal is recorded through Video-heads. In the conventional VCRs, B-head starts scanning when A-head approaches the end of A-track. In the 8mm VCR B-head starts recording PCM signal when A-head traces the point around 35° before it leaves the Drum. The sound information is compressed in this area and expanded in playback. The specifications are a little different from those of Compact Disc.

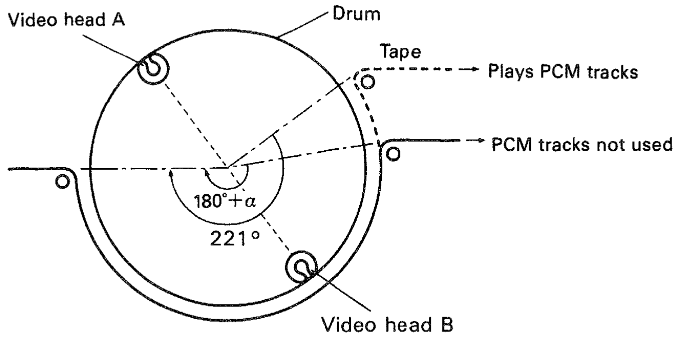
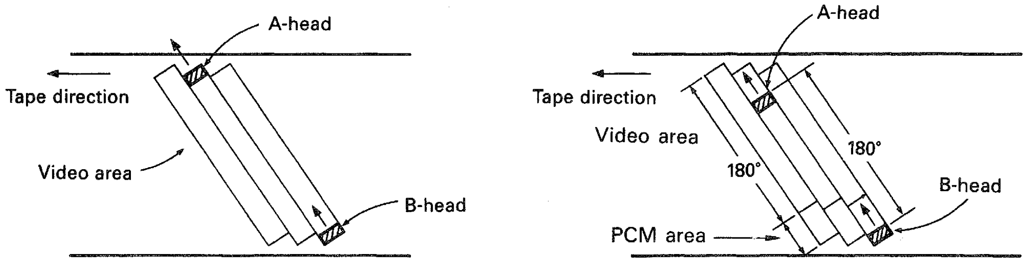



**Fig. 41 Extended Rapping Angle of 8mm VCR**




**(a) 1/2" VCR**

**(b) 8mm VCR**

The PCM signal can be dubbed, or recorded independently, while 1/2" Hi-fi VCRs are incapable of dubbing FM audio signal and have a problem of head switching audio noise. PCM circuit block has an analog noise reduction circuit.

10-bit A/D-converted data are compressed to 8-bit for saving memory space and increasing recording density. The signal is processed by the cross-interleave system. Then it is bi-phase-modulated and applied to a recording amplifier. The bit rate is 5.8Mb/s. 90dB dynamic range can be achieved with only 8-bit data. The sampling frequency is 31.5kHz in NTSC (31.25kHz in PAL).

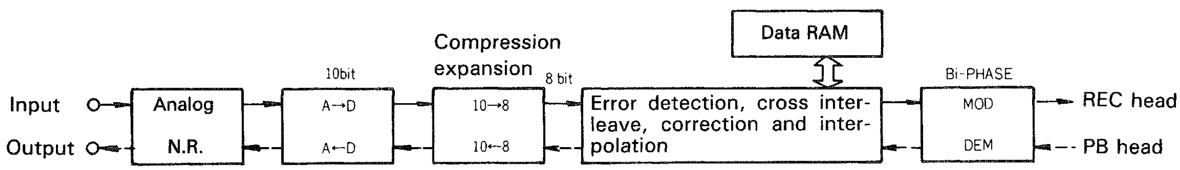



**Fig. 42 PCM Block Diagram**

| | 8mm | CD |
|---|---|---|
| Sampling freq. | 31.5KHz | 44.1KHz |
| Freq. response | 20 – 15KHz | 20 – 20KHz |
| Quantization | 10-bit/ch | 16-bit/ch |
| | 10→8 | 8→14 modulation (EFM) |
| Recorded signal | Biphase mark* | NRZI* |
| Error correction | Cross Interleave | CIRC* |

**Table 6 PCM Standards of 8mm VCR and Compact Disc**

* *CIRC*

*Refer to Compact Disc, Vol. 7.*

* *Bi-phase-mark*

*This signal inverts at every border of bits and in the center of "1" while NRZI inverts only in the center of "1". Synchronizing is easy with this signal because the clock component always appears. The frequency bandwidth is limited; from transfer clock frequency to its double. This has been determined to be in the same band of the video signal to make the Heads compatible to 8mm VCR and PCM ACR.*

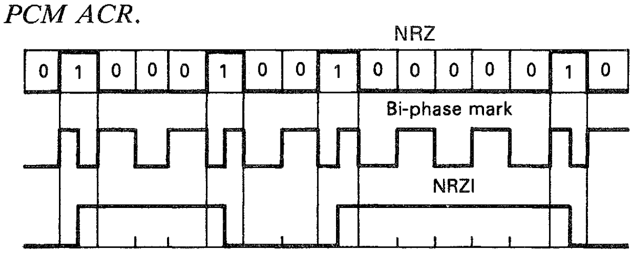



**Fig. 43 BI-PHASE MARK**

*f. Accurate search with PCM-ID*

PCM tracks can be used for the functions of program search, address search, time display and auto edition. PCM data area appears sixty times a second. 6 bytes or 48 bits of Identification (ID) information can be recorded in each of the area. One byte is used for determining format. Another one byte is used for identifying the information stored by the remaining 4 bytes.

*g. PCM audio recording*

Pioneer has developed a compatible 8mm VCR-ACR VE-D70 which can also be used as a PCM audio tape deck. It records for 9 hours with a 90-min tape and 24 hours with a 120-min tape (1/2 speed) in PCM-multi mode. One video track is divided into six PCM audio tracks as shown in Fig. 44, and whole the tape surface is used for audio recording.

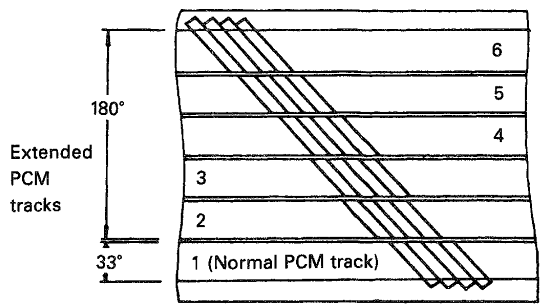



**Fig. 44 8mm Tape Pattern in PCM-multi mode**

This publication is to supplement service manuals with descriptions of fundamental techniques. Your frank advices, opinions and requests on this publication will be highly appreciated. Your contribution with technical knowhow, hints and ideas found in your field service and with news and topics in your daily life is also welcome.

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