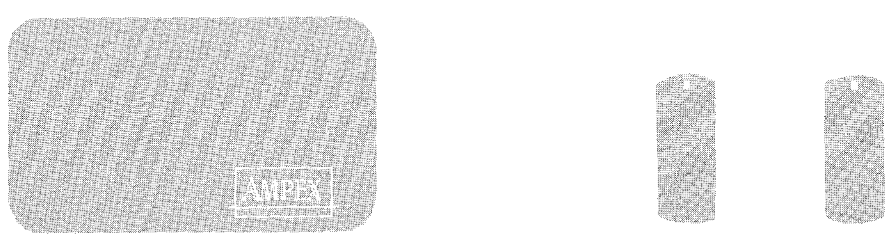
602 AND 602-2

MAGNETIC TAPE RECORDER/REPRODUCERS

89-0080

APRIL, 1963

AMPEX CORPORATION - AUDIO DIVISION



400251

INTRODUCTION

USE OF THE INSTRUCTION MANUAL

This instruction manual is an attempt to give the installation man, the operator, and the maintenance man the most complete and accurate information that is available.

For the installation man:
the description section,
the installation section,
the operating instructions section, and
the checkout and adjustment section
are required reading and the principles of magnetic recording section will provide good background.

For the operator:
the description section, and
the operating instructions section
are required reading. Again, the principles of magnetic recording section will provide good background.

For the maintenance man:
the description section,
the checkout and adjustment section,
the principles of magnetic recording section, and
the individual component sections (i.e., tape transport, etc.)
are required reading.

THE DESCRIPTION SECTION

The description section briefly describes the system, the components, their uses, and their performance characteristics. The section also briefly describes additional related equipment that may be of value to the user.

THE INSTALLATION SECTION

The installation section provides all necessary information for properly installing and connecting the equipment. All mounting dimensions are given for custom installation. Testing of the equipment after installation is *not* covered in this section, but rather is covered in the checkout and adjustment section which follows the operating instructions section.

THE OPERATING INSTRUCTIONS SECTION

The operating instructions section describes the operating controls and their functions, describes the ways in which the equipment can be used, and describes how to use the equipment.

THE CHECKOUT AND ADJUSTMENT SECTION

The checkout and adjustment section provides all the necessary information for checking out and adjusting the system. The checkout procedures are designed to ascertain whether or not the system is operating properly and to adjust the system for optimum results. Any malfunctions found while peforming the checkout procedures should be corrected using the maintenance procedures that will be found in the section of the manual covering the unit concerned.

THE TAPE TRANSPORT SECTION

The tape transport section describes the tape transport in detail and provides all necessary maintenance adjustment procedures. The section also covers the replacement of tape transport parts.

THE HEAD ASSEMBLY SECTION

The head assembly section describes the head assembly in detail provides all necessary maintenance procedures. This section also covers the replacement of head assembly parts. Adjustment procedures, for the most part, are covered in the checkout and adjustment section.

THE ELECTRONIC ASSEMBLY SECTION

The electronic assembly section provides the detailed theory of the electronics along with the maintenance procedures and some trouble-shooting hints. The lists of replacement parts are, of course, included.

THE ACCESSORIES SECTION

The accessories section describes the accessories available for use with the system and describes their use in the system. The accessories are designed to simplify or extend the use of the system.

THE PRINCIPLES OF MAGNETIC RECORDING SECTION

The principles of magnetic recording section provides the user and the maintenance man with a basic knowledge of how a magnetic recorder works and the principles behind the major adjustments.

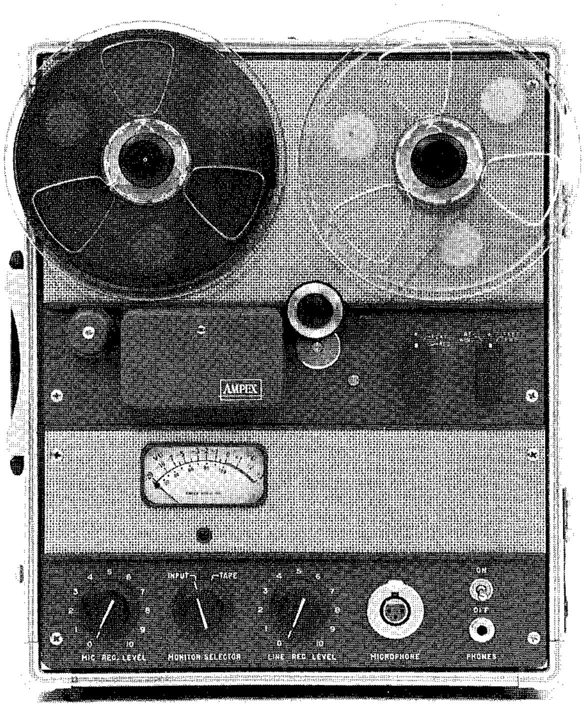
INDEX

In an attempt to give as complete a manual as possible, the index is included to aid in locating the required information as quickly as possible.

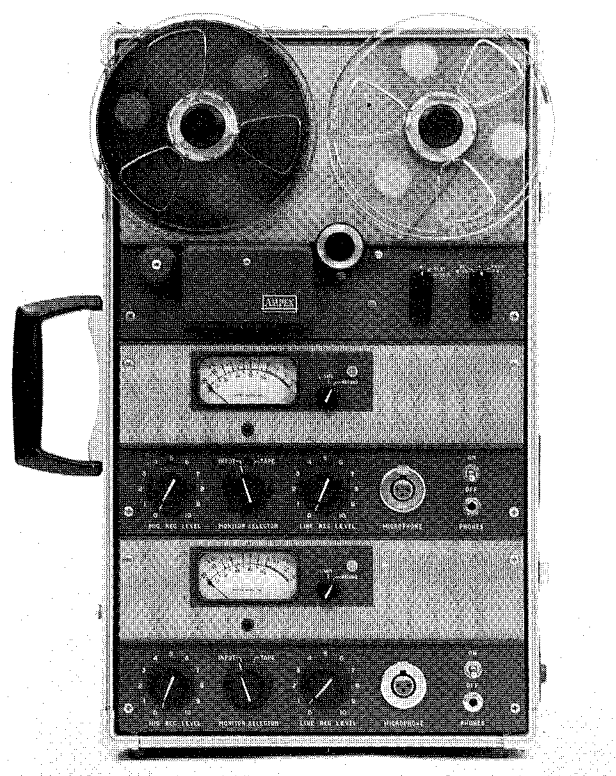
DESCRIPTION

GENERAL

The AMPEX Models 602 and 602-2 are single track and dual track magnetic tape recorder/reproducers, respectively, intended for use in the professional field. They will record two track stereophonic (602-2) or single track (either half track (602 HT & 602-2) or full track (602 FT); and will reproduce two track stereophonic (602-2) and single track tapes (half track (602 HT & 602-2) or full track (all three versions).



Ampex 602 Recorder/Reproducer



Ampex 602-2 Recorder/Reproducer

The 602 and 602-2 recorders are available to operate with either 60 or 50 cycle power (117 volt, single phase), at tape speeds of either 7-1/2 or 3-3/4 inches per second (ips). The complete equipment consists of a tape transport and either one (602) or two (602-2) electronic assemblies and is available either uncased or mounted in a durable, luggage-type, portable carrying case. Mating connectors are provided for all signal input and output receptacles.

The record/reproduce electronic assembly consists of a microphone preamplifier, a record amplifier, a reproduce amplifier, a power supply and (in the single channel electronics and the two channel master electronics) a bias and erase oscillator. Standard equipment includes a dummy plug which—when inserted in the proper receptacle in the electronic assembly—provides an input match for a high impedance unbalanced line. Plug-in transformers and microphone preamplifiers—available as accessory equipment—provide a convenient means of bridging or matching a balanced line or of providing a second microphone input; all that is necessary is to replace the dummy plug with the appropriate plug-in accessory. (See "Accessories" section for a description of these plug-in accessories).

EQUIPMENT AVAILABLE

Unit	Tape Speed*	Line Frequency	Catalog No.
Complete Equipment (in portable case)	7-1/2 HT	60	01-0602-01
	7-1/2 HT	50	01-0602-05
	3-3/4 HT	60	01-0602-17
	3-3/4 HT	50	01-0602-21
	7-1/2 FT	60	01-0602-02
	7-1/2 FT	50	01-0602-06
	3-3/4 FT	60	01-0602-18
	3-3/4 FT	50	01-0602-22
	7-1/2 2T	60	01-6022-01
	7-1/2 2T	50	01-6022-05
	3-3/4 2T	60	01-6022-07
	3-3/4 2T	50	01-6022-09
Complete Equipment (uncased)	7-1/2 HT	60	01-0602-03
	7-1/2 HT	50	01-0602-07
	3-3/4 HT	60	01-0602-19
	3-3/4 HT	50	01-0602-23
	7-1/2 FT	60	01-0602-04
	7-1/2 FT	50	01-0602-08
	3-3/4 FT	60	01-0602-20
	3-3/4 FT	50	01-0602-24
	7-1/2 2T	60	01-6022-02
	7-1/2 2T	50	01-6022-06
	3-3/4 2T	60	01-6022-08
	3-3/4 2T	50	01-6022-10
Tape Transport	7-1/2 HT	60	02-0209-01
	7-1/2 HT	50	02-0209-02
	3-3/4 HT	60	02-0209-09
	3-3/4 HT	50	02-0209-04
	7-1/2 FT	60	02-0209-05
	7-1/2 FT	50	02-0209-06
	3-3/4 FT	60	02-0209-07
	3-3/4 FT	50	02-0209-08
	7-1/2 2T	60	02-0209-09
	7-1/2 2T	50	02-0209-10
	3-3/4 2T	60	02-0209-11
	3-3/4 2T	50	02-0209-12

*HT = Half Track; FT = Full Track; 2T = Two Track

Unit		Catalog No.
Electronic Assembly	—Single Channel	02-0211-01
	—Two Channel Master	02-0211-02
	—Two Channel Slave	02-0211-03
Carrying Case	—Single Channel	15-0102-02
	—Two Channel	15-0103-03
Power Cord		73-0004-03
Input Plugs	(2 for Single Channel; 4 for Two Channel)	64-0009
Output Plugs	(1 for Single Channel; 2 for Two Channel)	64-0010

PERFORMANCE CHARACTERISTCS

Tape Width: 1/4 inch

Tape Speeds 7-1/2 or 3-3/4 ips

Reel Sizes 7 inch, EIA reel (maximum)

Frequency Response: (overall)

Speed (ips)	Response (cps)
3-3/4	±2 db 40 to 6,000
	+2−4 db 40 to 8,000
7-1/2	±2 db 40 to 10,000
	+2−4 db 40 to 15,000

Signal-To-Noise Ratio:

Speed (ips)	Peak Record Level to Unweighted Noise
3-3/4	50 db
7-1/2	55 db

Peak record level is that level at which the overall (input to output) total rms harmonic distortion does not exceed 3 percent when measured on a 400 cycle tone. Noise is measured while erasing a signal of peak record level in the absence of a new signal. Bias, erase and reproduce amplifier noise are included in the measurement. All frequencies between 30 and 15,000 cycles are measured.

Flutter and Wow:

Speed (ips)	Flutter and Wow (percentage rms)
3-3/4	.25%
7-1/2	.17%

Flutter and wow measurements include all components between 0.5 and 250 cycles. The figure quoted is for the reproduction of a relatively flutter-free tape and is measured in accordance with American Standards Association standard number Z57.1-1954.

Playing Time: (7 inch diameter EIA reels, 1200 feet of tape)

Speed (ips)	Half Track (hrs)	Half Track (min)	Full or Two Track (hrs)	Full or Two Track (min)
3-3/4	2	8	1	4
7-1/2	1	4		32

Starting Time: The tape is accelerated to full playing speed in less than 1/5 of a second

Stopping Time: Less than one second.

Reproduce Timing Accuracy:

Accuracy (percent)	Accuracy (seconds)	Length of Tape (minutes)
±.25%	±4.5	30

Rewind Time: Approximately 90 seconds for a full 7-inch 1200 foot EIA reel.

Record Inputs:	Two inputs are provided per electronic assembly; one for microphone and one for line. With accessory plug-in preamplifiers, accessory plug-in transformers or supplied dummy plugs, the line input can accommodate a microphone, a balanced line or an unbalanced line respectively. A RECORD LEVEL control is provided for each input.
Input Impedance:	
Unbalanced Bridging	100 ohms.
Balanced Bridging	100K ohms (for use with 600 ohm source impedance and using optional plug-in balanced bridging input transformer with 0 db gain (unity ratio)).
Balanced Matching	600 ohms (for use with 600 ohm source impedance and using optional plug-in balanced matching input transformer with 14 db gain (step up ratio)).
Microphone	Unloaded transformer (for use with 30 to 250 ohm source impedance using either the microphone input or the line input with optional plug-in microphone preamplifier).
Input Level: (nominal)	
Unbalanced Bridging	−4 to +8 vu lines or cathode follower output of 0.5 volt or more.
Balanced Bridging	−4 to +8 vu using optional plug-in balanced bridging line input transformer.
Balanced Matching	−20 to −4 vu lines using optional plug-in balanced matching line input transformer.
Microphone	−60 to −35 vu microphones using built-in microphone preamplifier. −45 to −35 vu microphones using optional plug-in 40 db microphone preamplifier in the line input. −60 to −50 vu microphones using optional plug-in 60 db microphone preamplifier in the line input.

NOTE

For more detailed information, see "Accessories" section.

Reproduce Output:	+4 vu ± .5 db (Zero indication on the vu meter corresponds to +4 dbm into 600 ohms balanced or unbalanced).
Head Housing:	The erase, record and reproduce heads are contained in a single head housing. (See "Head Assembly" section).
Monitoring: (aural and visual)	The signal on the tape can be monitored while the equipment is recording. A phone jack is available to allow monitoring the record input signal, or the output from the reproduce head. A switch provides a means for making direct comparison between the original program and the recorded program. A vu meter is provided for level comparison and visual monitoring.
Power Requirements:	Single track equipment requires 0.6 amperes at 117 volts a-c. Two track equipment requires 0.9 amperes at 117 volts a-c.

INSTALLATION

GENERAL

The Model 602 and 602-2 Magnetic Tape Recorder/Reproducers are available either in portable cases or unmounted for custom installation. In either instance, the machine can be operated in either the horizontal or vertical position. When used in portable applications, the machine is packaged in a durable, luggage-type carrying case and installation consists only of making up and connecting the required cables (see "Connections" in this section.)

In custom installations, the electronic assembly must be mounted as close as practicable to the tape transport, as any increase in length of the head cables as provided will seriously affect the performance of the equipment. Dimensions and space requirements for the units are shown in the "Mounting Dimensions" illustrations. It is important that sufficient space be planned at the rear of the equipment to allow the interconnecting cables to be installed and to provide proper ventilation for the machine.

For rack-mounted installations, adapter panels (AMPEX AUDIO Part No. 864 for Model 602 or Part No. 865 for Model 602-2) are available.

UNPACKING

Unpacking all the equipment carefully and check, before throwing the packing material away, to determine if all the units are complete. Remove all tape and twine that were used to secure parts during shipment. Check the equipment for any external damage received in transit. If any exists, report it at once to the dealer and, if necessary, file a claim. Examine the springs, contacts, and other moving parts of switches for foreign matter that may have become lodged in these spots.

INSTALLATION OF THE EQUIPMENT

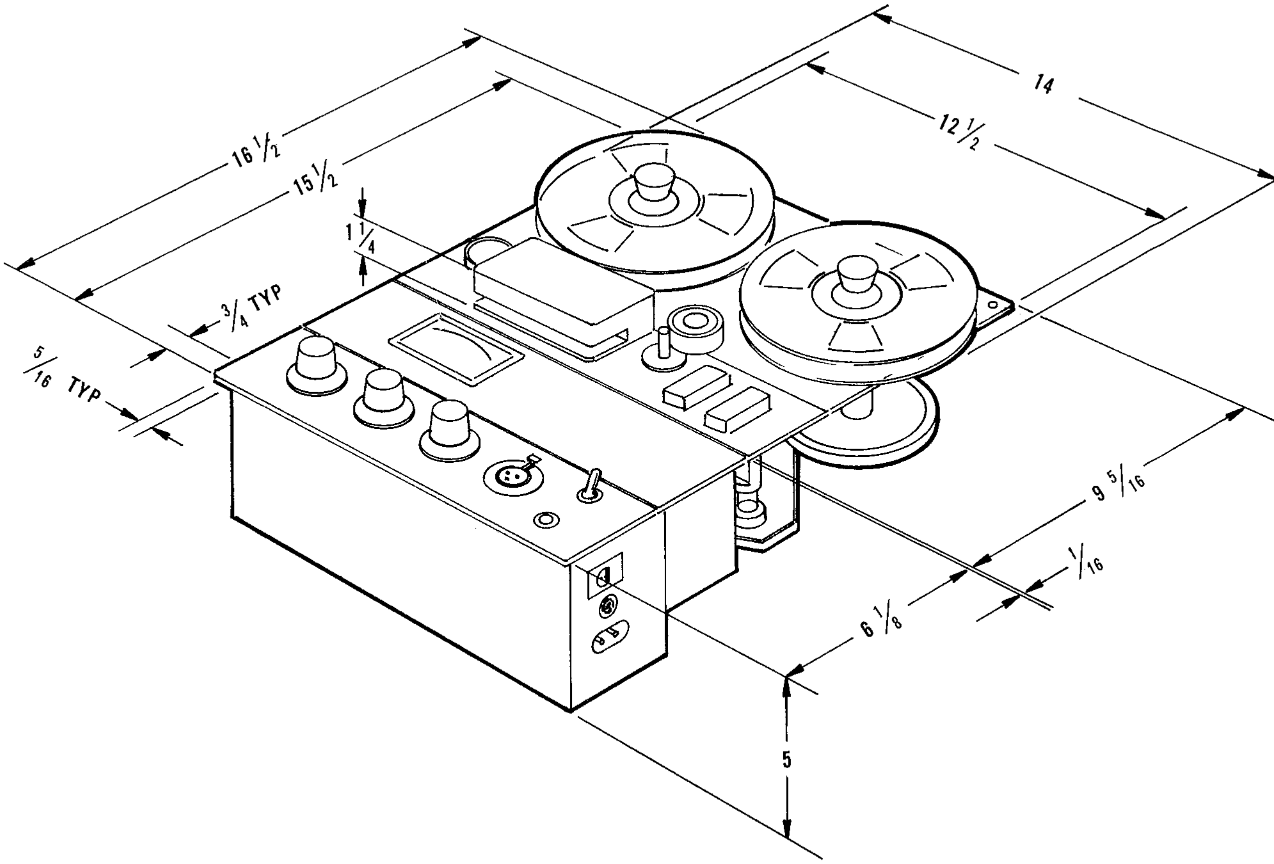
For portable versions of the 602 and 602-2, no installation, as such, is required. However, see "Connections" in this section.

For custom installations, the electronic assembly or assembles must be installed first. After the electronic assemblies have been installed, connect all interconnecting cables between the electronic assemblies and the tape transport (see "Connections" in this section), then install the tape transport.

When rack mounting is desired, the components may be mounted in any rigidly constructed standard 19-inch cabinet rack or equivalent. The mounting rails should be straight and sturdy. Installation consists of mounting the components in the rack adapter as outlined for custom installation above, then mounting the entire assembly in the rack.

INSTALLATION OF PLUG-IN ITEMS

The equipment is normally shipped with a dummy plug (Part No. 03-0034-01) inserted



Mounting Dimensions

in socket J3. If the equipment is to be used with a balanced line input, the dummy plug should be removed and a balanced line input transformer, Catalog No. 58-0116-01 or 58-0116-02, should be inserted in the socket. To use one microphone with the equipment, see "Connections" paragraph.To use two microphones with the equipment (per channel), a plug-in microphone preamplifier, Catalog No. 01-96440-01 (40 db gain—for high output microphones or close pickup) or Catalog No. 01-96440-04 (60 db gain—for low output microphones or distant pickup), should be inserted in place of the dummy plug. Line input transformers and microphone preamplifiers are optional accessories.

CONNECTIONS

Interconnecting the tape transport and the electronic assemblies consists of connecting the control cable, which is captive to the electronic assembly, to receptacle J101 on the tape transport and connecting the reproduce head cable, which is also captive to the electronic assembly, to receptacle J5 on the tape transport.

Connect the power cable from the a-c power input connector, J8, on the electronic assembly (master electronic assembly only in the case of two channel machines) to a convenient 117 volt a-c power source.

Plus 4 vu, 600 ohm line output, balanced or unbalanced, is available at line output connector J6. For unbalanced output, standard phone plug should be used, and the inner conductor of a shielded cable should be connected to the tip of the plug. The shield of the cable should be connected to the sleeve of the plug. For balanced output, a "Stereo" phone plug should be used, and one of the inner conductors of a two-wire shielded cable should be connected to the tip of the plug. The other inner conductor should be connected to the ring of the plug and the shield should be connected to the sleeve of the plug.

Any low impedance mircophone having a nominal impedance between 30 and 250 ohms can be plugged directly into the MICROPHONE input of the equipment. Wire the mating connector so that the microphone is connected to pins 2 and 3 of receptacle J1. The cable shield must be connected to pin 1. Microphones wired in this manner can also be connected to LINE INPUT receptacle J2 provided that an accessory microphone preamplifier is installed in accessory socket J3. (See "Installation of Plug-In Items".)

High impedance microphones are not recommended for use in this equipment because, in general, the quality if not satisfactory for professional work.

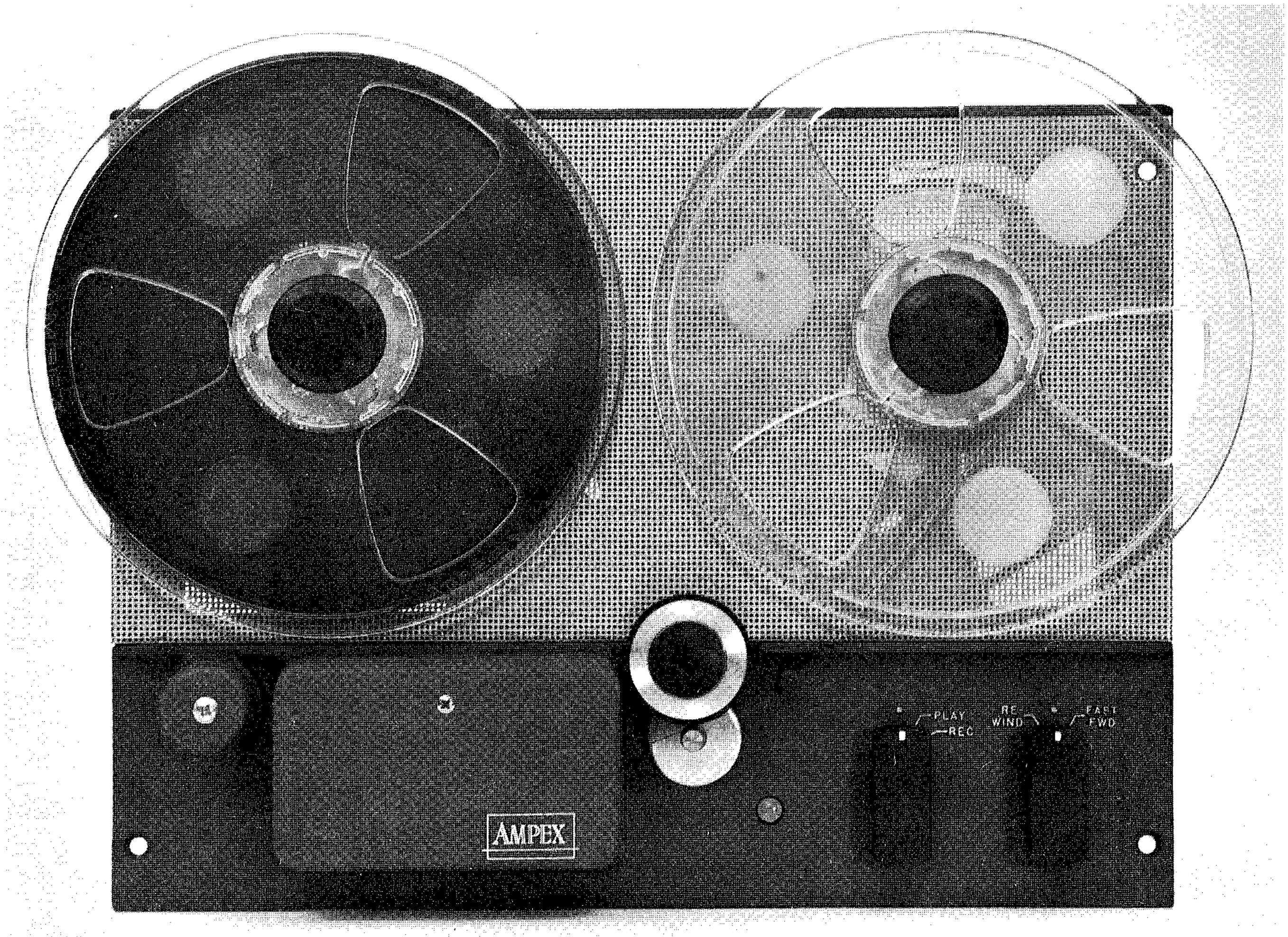
To connect a balanced line to the equipment, wire the mating connector so that the line is connected to pins 2 and 3 of LINE INPUT connector J2. Pin 1 is ground. The accessory plug-in balanced line input transformer (Catalog No. 58-0116-01 or 58-0116-02) must be inserted into the accessory socket J3. (See "Installation of Plug-In Items" and next paragraph.)

To connect an unbalanced line to the equipment, wire the mating connector so that the line is connected to pins 2 and 3 of the input connector, with pin 1 being the ground side, and with pins 1 and 2 jumpered together. The dummy plug (Part No. 03-0034-01) that is supplied with the equipment must be inserted into the accessory socket (J3).

OPERATING INSTRUCTIONS

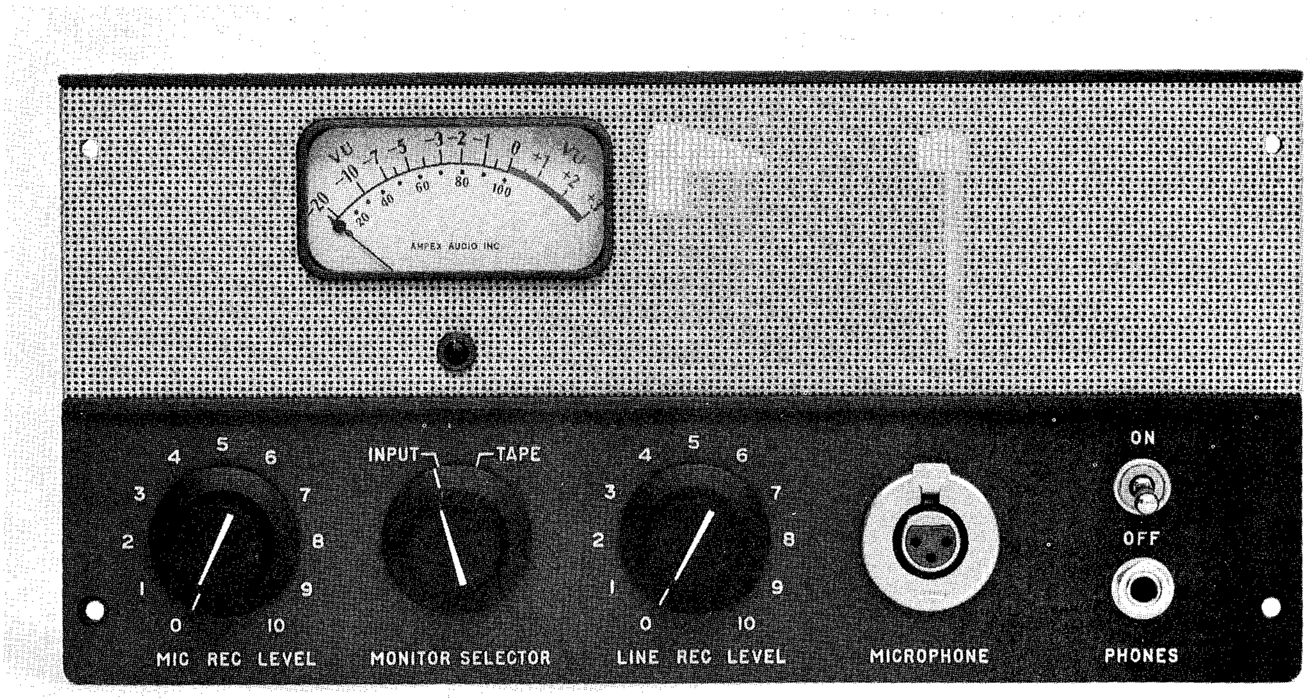
OPERATING CONTROLS AND INDICATORS

Control	*Quantity*	*Location*	*Function*
PLAY-RECORD	1	Transport	Controls tape motion in reproduce (play) or record mode. Places electronic assemblies in the play or record mode. Interlocked with REWIND-FAST FWD control.
REWIND-FAST FWD	1	Transport	Controls tape motion in fast winding modes in forward or reverse direction. Inter-locked with PLAY-RECORD control.
Record Safety Button	1	Transport	Safety feature to prevent equipment being accidentally placed in record mode. Must be pressed while simultaneously turning the PLAY-RECORD control to its RECORD position.
LINE REC LEVEL	1 or 2	Electronics	Adjusts record level when recording from the line input.
ON-OFF	1 or 2	Electronics	Controls power to tape transport and electronic assemblies. (In two channel equipment, the master power switch overrides the slave power switch).



Tape Transport Controls

Control	*Quantity*	*Location*	*Function*
Vu Meter	1 or 2	Electronics	Provides visual monitoring of record or reproduce level.
MIC REC LEVEL	1 or 2	Electronics	Adjusts record level when recording from the microphone input.
MONITOR SELECTOR	1 or 2	Electronics	Provides selection of monitoring actual program (INPUT) or the recorded program off the tape (TAPE). Must be in the TAPE position during reproduce mode.
RECORD-SAFE	None or 2	Electronics	Provides bias and erase current to the heads when in the RECORD position and when the PLAY-RECORD control is in the RECORD. In the SAFE position, bias and erase current cannot be applied to the heads even if the PLAY-RECORD control is in the RECORD position.



Electronic Assembly Controls

THREADING THE TAPE

The tape threading path described below is the same for all modes of operation; but special attention is called to the notes dealing with half track operation.

Step 1:

Place a reel of tape on the left-hand turntable, and an empty reel on the right-hand turntable, making certain that the pins around the base of each spindle engage corresponding slots on the reel hubs.

Step 2:

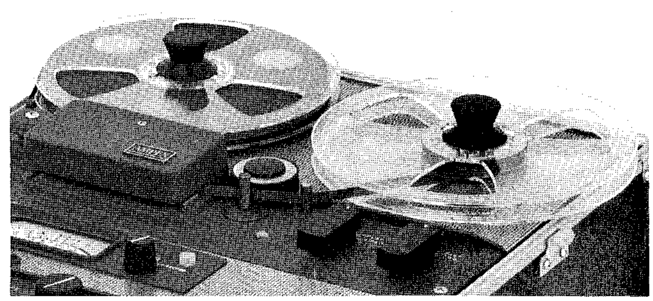
Press a reel hold-down knob in place on each spindle.

Step 3:

Thread the tape as indicated in the illustration. Make sure that the oxide or dull surface of the tape is against the heads.

Step 4:

Anchor the tape in the slot on the empty reel hub if desired, but a full tape turn counterclockwise around the reel hub is usually sufficient.



Threading the Tape

APPLYING POWER

Power to the equipment is supplied through power switch S3 on each electronic assembly. These switches must be placed in the ON position to operate the electronic and mechanical assemblies. The equipment is fused by fuse F1 on the electronic assemblies.

RECORDING

To record a new program on previously recorded tape, or on blank tape, place the MONI-

TOR SELECTOR switches in the INPUT position. Turn the desired record level control or controls clockwise until the level reads 0 (zero) on the vu meter on the maximum program peaks.

NOTE

If the previously recorded tape was recorded using a full track head, the two track erase head on half track or two track equipment will leave a track of the old recording down the center, which may be audible as crosstalk. The tape should be erased by bulk erasure, or if no bulk eraser is available, the tape should be erased on a full track recorder.

The program can be aurally monitored through the phone jack on the front panel of the electronics or the line output connector on the side panel before the tape is in motion. This direct monitor feature allows the program to be set up without actually recording during the set up period. When program level is properly set, place the equipment in the record mode by operating the PLAY-RECORD control and the record safety button on the tape transport.

NOTE

On two channel machines, the RECORD-SAFE switch for the channel or channels concerned must also be turned to the RECORD position before tape is placed in motion.

Once the equipment is recording, the MONITOR SELECTOR switch may be placed in either the INPUT position to monitor the incoming signal or in the TAPE position to monitor the program material after it has been recorded. Switching the MONITOR SELECTOR switch has no effect on the program being recorded and may be switched back and forth as desired.

To stop the recording, merely return the PLAY-RECORD control on the tape transport back to its neutral position, the recording process and tape motion will both be stopped. The tape may be rewound, if desired, by operating the REWIND-FAST FWD control to the REWIND position.

NOTE

It may be desirable not to rewind the tape after recording, since the tape tension of a rewound tape is seldom optimum for prolonged storage of the tape. In the event tapes are not rewound, they should be labelled "Rewind Before Playing."

To reproduce a previously recorded tape, place the MONITOR SELECTOR switch in the TAPE position and turn the PLAY-RECORD control to the PLAY position. The equipment will now be reproducing the pre-recorded program.

NOTE

On two channel machines, the RECORD-SAFE switch should be in the SAFE position to make certain that the recorded program will not be accidentally erased.

CHECKOUT AND ADJUSTMENT

GENERAL

In the following checkout and adjustment procedures, each channel of two channel recorders should be treated separately but both channels should be checked and adjusted before continuing to the next procedure.

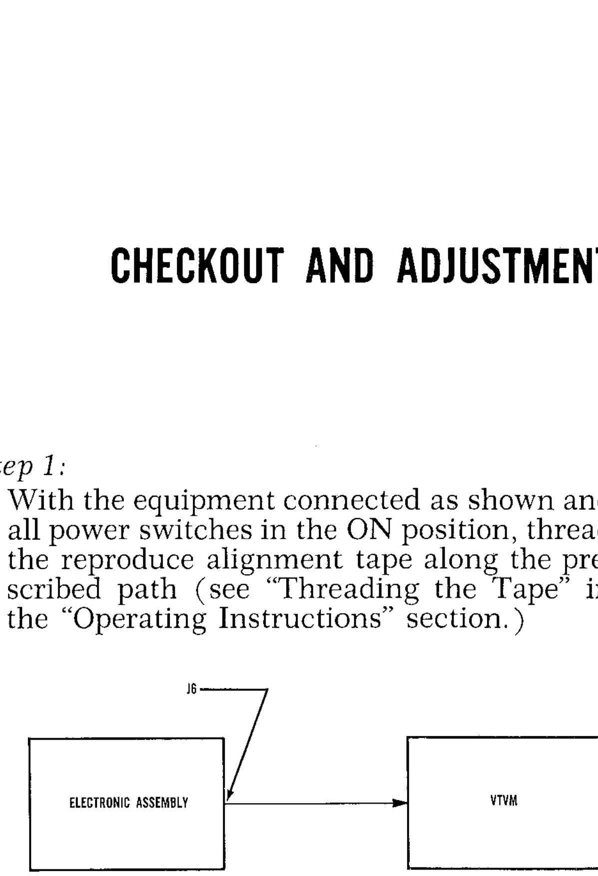
Equipment required for the checkout and adjustment procedures consists of: an AMPEX reproduce alignment tape (Catalog No. 01-31321-01 for 7-1/2 ips or 01-31331-01 for 3-3/4 ips); an a-c vacuum tube voltmeter capable of indicating rms voltages of 0.004 or less; an audio oscillator with a stable output from 30 to 15,000 cycles per second; earphones or a speaker-amplifier for aural monitoring; a small screwdriver (set screw variety); and a reel of tape of the type normally used on the machine.

REPRODUCE ALIGNMENT

CAUTION

The test tape used in the following procedure may be partially erased if the heads or tape guides are permanently magnetized. Demagnetize the heads and guides as outlined in the "Head Assembly" section before proceeding.

Step 1:
With the equipment connected as shown and all power switches in the ON position, thread the reproduce alignment tape along the prescribed path (see "Threading the Tape" in the "Operating Instructions" section.)

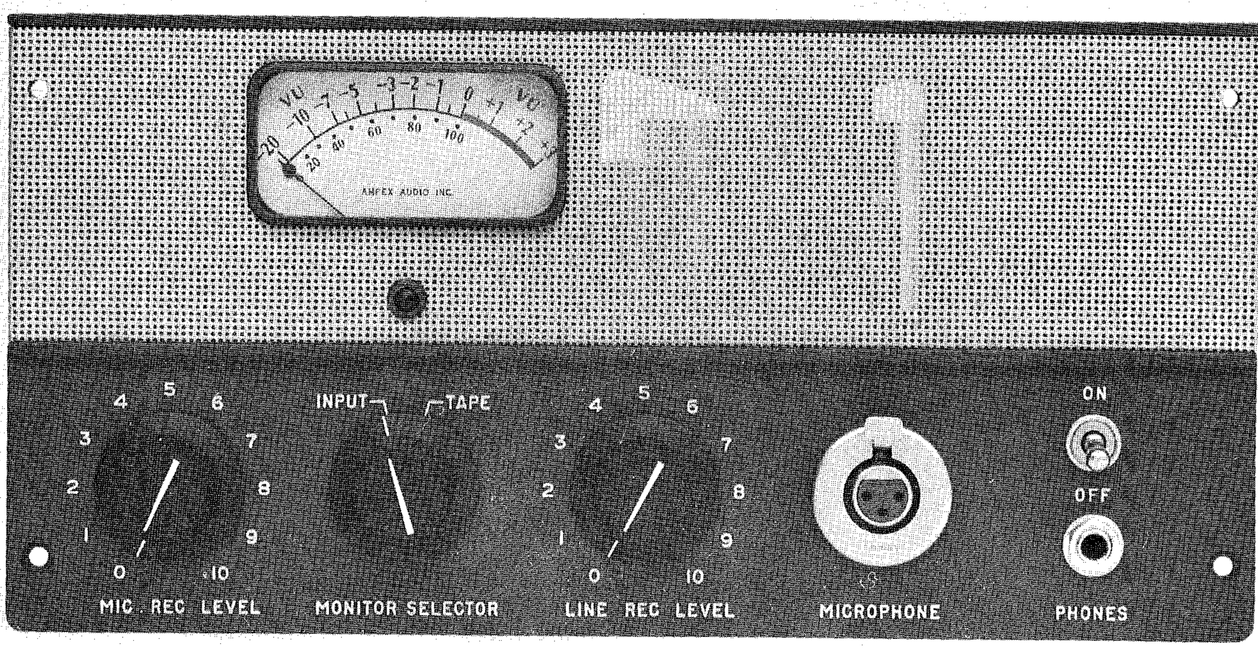


Reproduce Alignment Test Set-Up

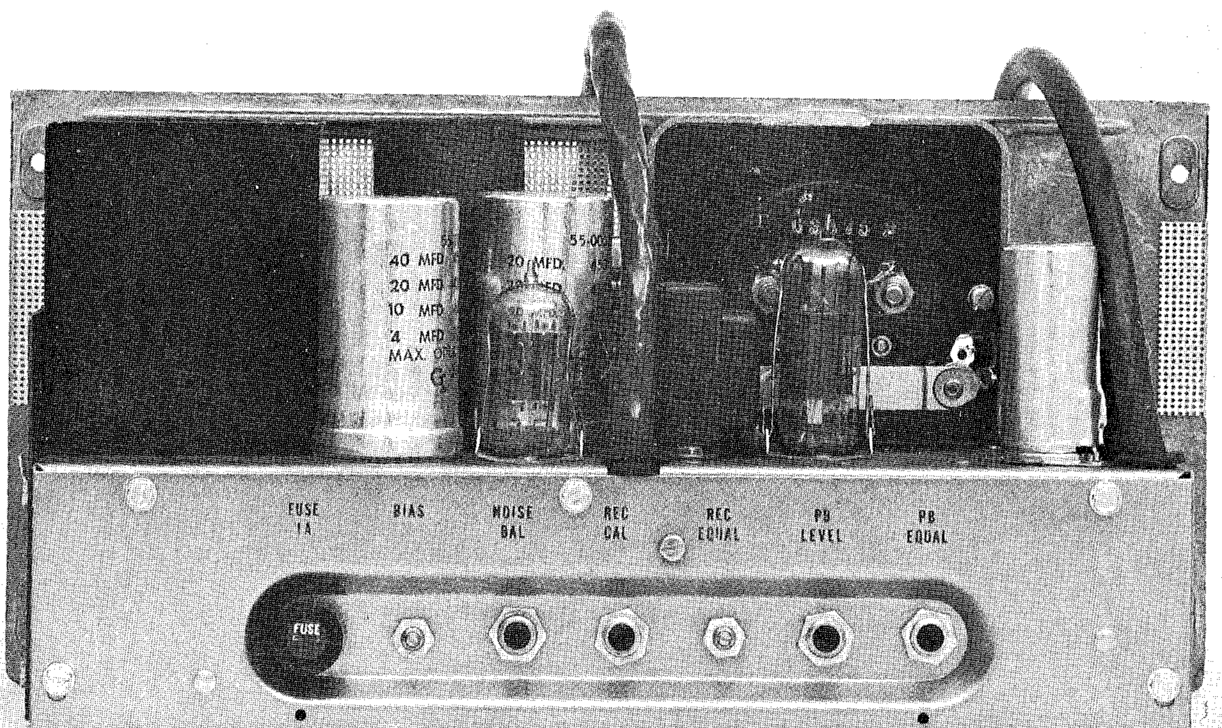
Step 2:
On two track machines only, set the RECORD SELECTOR switch on the electronic assembly to the SAFE position.

Step 3:
Set the MONITOR SELECTOR switch on the electronic assembly to the TAPE position.

Step 4:
Start the reproduce alignment tape. The first tone on the tape is a reference tone at 500



Front Panel Controls



Rear Panel Controls

400490

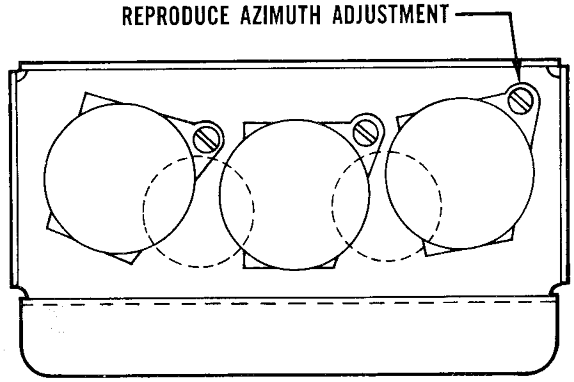
or 700 cps. Adjust the PLAYBACK LEVEL control on the rear panel of the electronic assembly to a convenient reading on the vtvm.

Step 5:

The next tone will be either 7,500 or 15,000 cps for adjusting the reproduce head alignment. Using the small screwdriver, adjust the azimuth adjusting screw on the reproduce head for maximum output on the vtvm.

NOTE

If the head azimuth is far out of alignment (possible if inexperienced personnel without proper equipment have attempted alignment procedures), minor peaks may be observed on both sides of the maximum. The proper setting is 15 to 20 db higher than these minor peaks.



Reproduce Azimuth Adjustment

Step 6:

A series of tones from 5,000 to 50 cps or 12,000 to 50 cps will be reproduced from the test tape. Frequency response should not vary more than 2 db from the standard curve. If a variation of more than 2 db is found or if it is desired to obtain a closer tolerance, adjust the PLAYBACK EQUALIZATION control and repeat the frequency response check.

NOTE

When a full track test tape is used on half track or two track machines, the bass end of the frequency spectrum will rise in response. The actual amount of rise will vary with the width and location of the track. This phenomena is present because the reproduce head "sees" additional flux on each side of the head at long wavelengths since the test tapes are recorded across the complete width of the tape. This fringing effect is not present when recording a track the same width as the reproduce head

Step 7:

The lost tone on the test tape is a reference tone at operating level. Adjust the PLAYBACK LEVEL control to obtain a zero reading on the vu meter of the recorder *not the vtvm.*

Step 8:

Stop tape motion and remove the test tape.

Step 9:

Read the noise level on the vtvm. Noise should be below the level specified in the "Performance Characteristics" paragraph of the "Description" section. Inaudible low frequency bounce can cause the meter to read higher than "Performance Characteristics" tolerances. Disregard these momentary readings because they are frequencies far below the operating range of the recorder.

BIAS ADJUSTMENT

NOTE

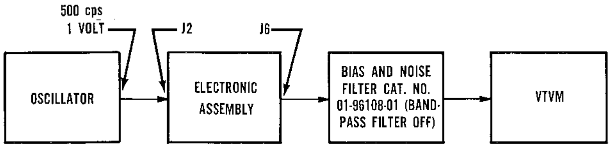
Serious deficiencies in performance (both frequency response and signal to noise ratio) will result if bias is improperly set. Bias settings may vary by more than 2 db from one brand and type of tape to another. It is therefore imperative that the brand and type of tape that will normally be used on the equipment be used in the following procedure.

Step 1:

With the equipment connected as shown and all power switches in the ON position, thread a reel of blank tape along the prescribed path (see "Threading the Tape" in the "Operating Instructions" section).

Step 2:

Set the MONITOR SELECTOR switch to the TAPE position.



Bias Adjustment Test Set-Up

Step 3:
Place the equipment in the record mode.

Step 4:
With the oscillator set at 500 cps and connected to the LINE INPUT jack, set the LINE REC*ord* LEVEL control to a position that will obtain an on-scale vu meter reading.

Step 5:
With a small screwdriver, set the BIAS ADJ*ust* trimmer for a maximum reading on the vu meter.

RECORD LEVEL CALIBRATION

NOTE

The reproduce level must be calibrated using the reproduce alignment tape before calibrating the record level (see "Reproduce Alignment").

Step 1:
With the equipment connected as shown for "Bias Adjustment" and all power switches in the ON position, thread the reel of blank tape along the prescribed path (see "Threading the Tape" in the "Operating Instructions" section).

Step 2:
Set the MONITOR SELECTOR switch to the tape position.

Step 3:
Place the equipment in the record mode.

Step 4:
Set the LINE REC*ord* LEVEL control to a position that will obtain a zero reading on the vu meter.

Step 5:
Set the MONITOR SELECTOR switch to the INPUT position.

Step 6:
Adjust the REC*ord* CAL*ibrate* control for a zero reading on the vu meter.

RECORD AZIMUTH ADJUSTMENT

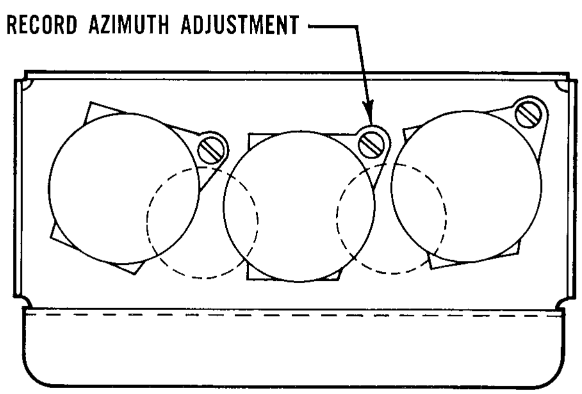
Step 1:
With the equipment connected as shown for "Bias Adjustment" and all power switches in the ON position, thread the reel of blank tape along the prescribed path (see "Threading the Tape" in the "Operating Instructions" section).

Step 2:
Set the MONITOR SELECTOR switch to the INPUT position.

Step 3:
Set the LINE REC*ord* LEVEL control to obtain a reading of approximately −10 dbm on the vtvm.

Step 4:
Set the MONITOR SELECTOR switch to the TAPE position and set the oscillator to 15,000 cps.

Step 5:
Place the equipment in the record mode and using a small screwdriver, adjust the azimuth adjusting screw on the record head for maximum output on the vtvm. Several peaks may appear but the maximum peak is obvious because it is much greater than the minor peaks.

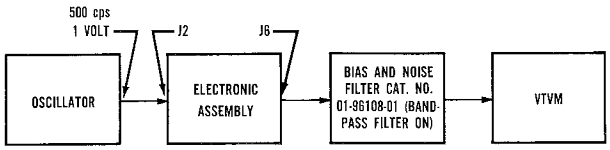


Record Azimuth Adjustment

OVERALL FREQUENCY RESPONSE MEASUREMENT

Step 1:
Demagnetize the heads and tape guides as outlined in the "Head Assembly" section.

Step 2:
Connect the equipment as shown and place the MONITOR SELECTOR in the INPUT position.



Frequency Response Test Set-Up

Step 3:

Adjust the LINE RECord LEVEL control to obtain a vtvm reading of approximately −10 dbm.

Step 4:

Place the MONITOR SELECTOR switch in the TAPE position.

Step 5:

Thread a reel of blank tape along the prescribed path and place the equipment in the record mode.

Step 6:

Make a frequency response check by using at least ten discrete frequencies between the limits specified in the "Performance Characteristics" paragraph of the "Description" section.

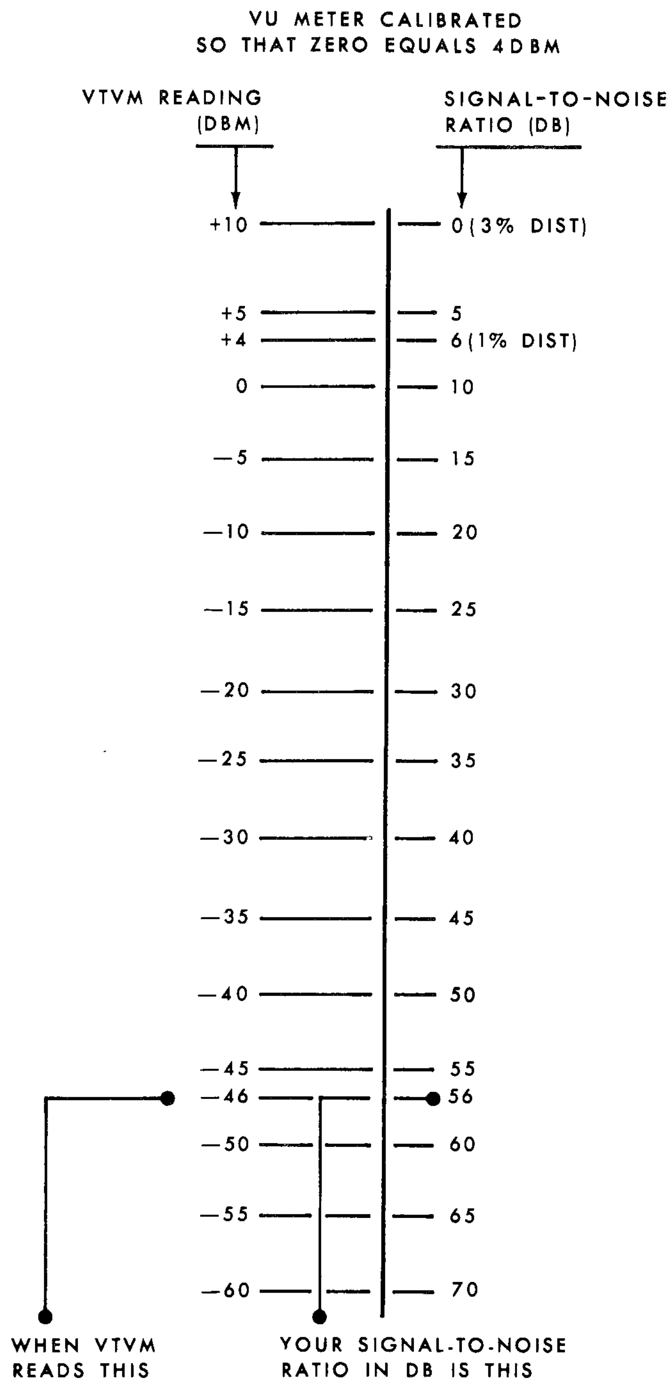
NOTE

Record bias setting, head azimuth adjustment and variation in types of recording tape all affect high frequency response. If the frequency response is not within the limits for the speed concerned and the bias and azimuth adjustments have already been made, adjust the RECord EQUALIZER for the flattest possible response. If the bias and azimuth adjustments have not been made, they should be performed, then frequency response should again be checked and finally, if necessary, the RECord EQUALIZER should be adjusted.

OVERALL SIGNAL-TO-NOISE RATION MEASUREMENT

To translate vtvm readings into specific signal-to-noise ratios when the vu meter is so calibrated that zero on the vu meter corresponds to a +4 dbm output, add 6 db to obtain the output value from the 3% distortion level, arriving at a total of 10 dbm. Having made this computation, bear in mind that, although the noise reading taken on the vtvm is dbm, the measurement is a ratio which must include the 10 dbm computed to arrive at the 3% distortion level. Therefore, the vtvm reading must be converted to the signal-to-noise ratio.

Example: 10 (dbm, includes 4dbm normal level and 6 dbm to the 3% distortion level)
-(-45)
55 db signal-to-noise ratio



Signal-to-noise Ratio Computations

Any reading below —45 dbm meets the "Performance Characteristics" specification of 55 db signal-to-noise ratio and satisfies the signal-to-noise ratio definition.

AMPEX signal-to-noise ratio specifications on audio instruments define in decibels the ratio existing between the level of a steady 400 cycle tone, recorded at a level at which distortion produced by the approach of tape saturation equals 3% total rms, and that level of total rms noise, in a band from 30 to 15,000 cycles, which exists in reproduction under the same gain conditions while erasing the 400 cycle tone in the absence of a new signal.

AMPEX professional audio instruments normally calibrated so that the vu meter reads zero level when reproducing a steady 400 cycle tone the level of which produces 1% total rms distortion caused by tape saturation.

A recorded 400 cycle tone at the 3% distortion level will be 6 db higher in level than the same tone recorded at the 1% distortion level.

Step 1:
Connect the equipment as shown for the "Overall Frequency Response Measurement."

Step 2:
Place the MONITOR SELECTOR switch in the INPUT position.

Step 3:
Adjust the LINE RECord LEVEL control to obtain a vtvm reading 6 db above operating level (+10 dbm).

Step 4:
Thread a reel of blank tape along the prescribed path.

Step 5:
Record the 400 cycle tone on a section of tape, noting where the recording begins for later reference. Stop the tape.

Step 6:
Disconnect the audio oscillator and set the LINE RECord LEVEL control to zero (fully counterclockwise.

Step 7:
Rewind the tape to the beginning of the 400 cycle recording.

Step 8:
Place the MONITOR SELECTOR switch in the TAPE position.

Step 9:
Erase the tape by recording with no input signal, at the same time reading the vtvm, and checking the reading against the table.

TAPE TRANSPORT MECHANISM

GENERAL

The tape transport mechanism incorporates a single-speed synchronous motor and a system of pulleys, belts, and clutches to drive the capstan and the turntables. The three modes of tape motion (PLAY, REWIND, and FAST FORWARD) are determined by two controls located on the top panel of the tape transport. (The neutral position for each control is marked by a dot.)

The bracketed numbers in this section refer to parts shown in the "Mechanical Operation Simplified" illustration and the "Tape Transport Exploded View" and in the parts list at the end of this section. For greatest facility in following the discussion below, it is suggested that the "Tape Transport Exploded View" be opened fully for ready reference.

STANDBY OPERATION

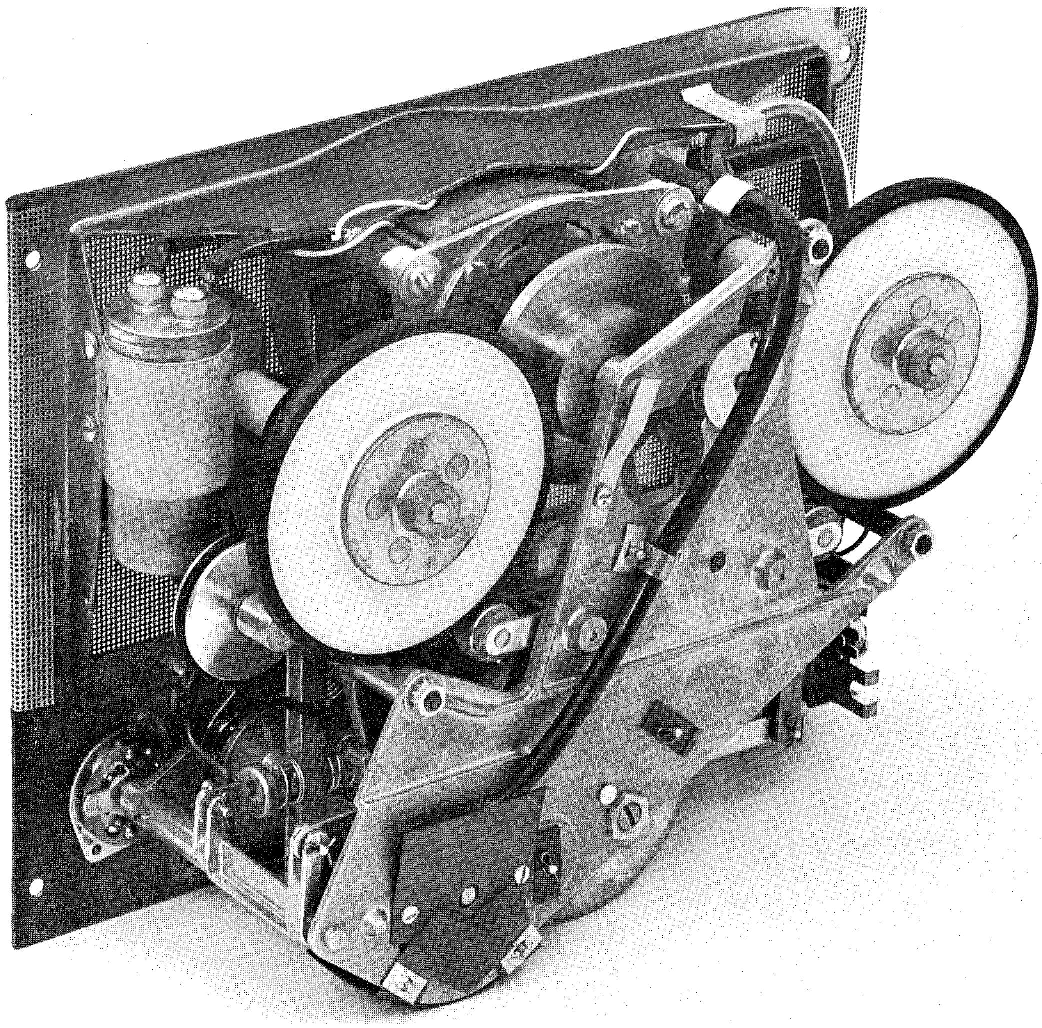
Power is applied to the drive motor (63) when the POWER switch on the front panel of the electronic assembly is turned to the ON position. The capstan (42) begins to rotate immediately, being driven by a nylon belt (68) which runs between the motor pulley (61) and the capstan flywheel. A second belt (69) running in a groove in the capstan flywheel drives the play take-up pulley(40). The shock relief brake rollers (2) are engaged against the rubber-tired fast forward and rewind clutches (16 and 31). Both turntables are motionless, and the machine is in standby condition.

Since the capstan is in motion when the machine is in the standby condition, the tape will accelerate to full play speed almost instantly when the PLAY switch is operated, thus producing a wow-free start.

PLAY MODE

When the PLAY control is energized, the following mechanical sequence occurs:

1. The play takeup pulley (40) and belt (69) are brought to bear on the play takeup clutch (19).
2. The shock relief brake roller (2) on the play takeup side is released from the fast forward clutch tire (16).
3. The capstan idler (79) engages the capstan (42), which drives the tape, pulling it from the tape supply turntable (i.e., the rewind turntable) and feeding it to the takeup turntable, which now begins to rotate. It is especially important to understand that when the machine is operating normally in the play mode, in which the tape is clamped against the capstan by the capstan idler, the turntables are effectively isolated from each other. The takeup turntable, as its name implies, does nothing more than take up the tape fed



Tape Transport Rear View

to it by the capstan. It does not pull the tape from the tape supply turntable.

4. The shock relief brake roller (2) on the rewind side remains engaged against the rewind clutch tire (31), and slippage occurs between the clutch and disc assembly (30). The friction produced in this slippage, and the friction produced by the rewind holdback brake (37) operating on the bakelite drum (35) provide the required holdback tension.

REWIND MODE

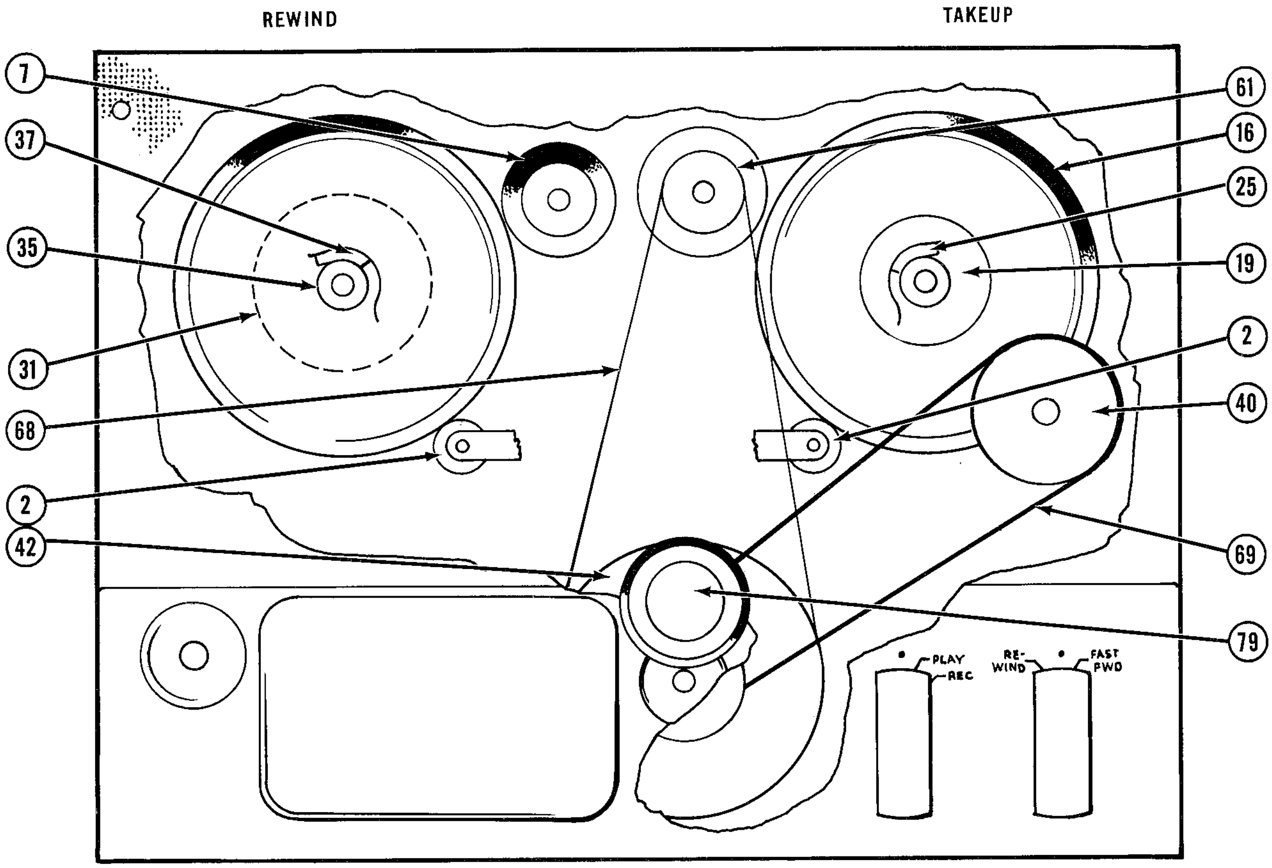
The REWIND-FAST FORWARD control cannot be operated unless the PLAY control is in neutral. When the REWIND-FAST FORWARD control is turned to REWIND:

1. Both shock relief brake rollers (2) are released.
2. The rewind idler (7) is clamped between the motor pulley (61) and the rewind clutch tire (31) and the rewind turntable is driven.
3. Holdback tension is provided by the holdback brake (25) on the takeup assembly as tape is pulled from the takeup turntable.

FAST FORWARD MODE

When the REWIND-FAST FORWARD control is turned to FAST FORWARD:

1. Both shock relief brake rollers (2) are released.
2. The rubber-tired fast forward clutch (16) is brought to bear on the motor pulley (61) and drives the takeup turntable.
3. Holdback tension is produced by the holdback brake (37) on the rewind assembly.



Mechanical Operation Simplified

ROUTINE MAINTENANCE

Lubrication

The recommended standard lubricant for the four places which require periodic lubrication (motor and capstan) is Ampex Audio lubricating oil No. 825.

The upper and lower bearings of the drive motor should be lubricated after every 500 hours of operation. The upper oil hole of the motor is accessible through a hole in the tape transport grille slightly above and to the left of the takeup turntable. For access to the lower oil hole, located in the side of the motor end bell, remove the tape transport from the case (see "Routine Lubrication" illustration).

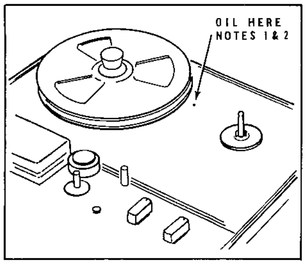
Four or five drops of the recommended lubricant is sufficient. Care should be taken to avoid over-oiling or spills. Any such excess should be wiped away with solvent.

The capstan may require oiling about once for every four oilings of the drive motor. For access to the upper bearing, the capstan idler must first be removed (see "Routine Lubrication" illustration). Remove the rubber cap on the idler. Remove the hairpin retainer and lift the idler off its shaft, taking care not to lose the washers associated with it. The aluminum plug-button over the capstan shaft may now be pried off and the felt washer beneath it removed to expose the upper capstan bearing. Use as much of the recommended lubricant as the bearing will accept, wiping away any excess, and re-assemble.

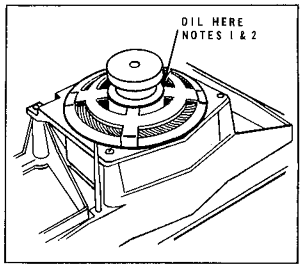
CAUTION

Do not oil the felt washer which serves only as a dust protector and to keep oil from working its way up to the capstan.

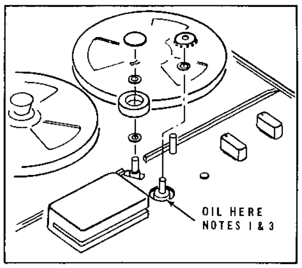
For access to the lower bearing, remove the tape transport from the case. The oil hole is located in the bearing housing as shown in the



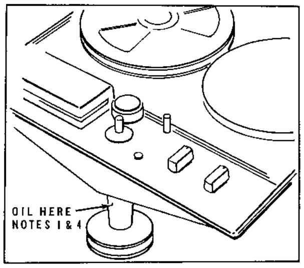
DRIVEMOTOR (UPPER BEARING)



DRIVEMOTOR (LOWER BEARING)



CAPSTAN (UPPER BEARING)



CAPSTAN (LOWER BEARING)

NOTES:

1. RECOMMENDED LUBRICANT: AMPEX NO. 825.
2. FOUR OR FIVE DROPS.
3. AS MUCH OIL AS BEARING WILL TAKE. WIPE AWAY EXCESS. DO NOT SATURATE FELT WASHER TO OIL THIS BEARING.
4. EXACTLY FOUR DROPS.

Routine Lubrication

"Routine Lubrication" illustration. *Use exactly four drops of oil—no more.*

Do not oil any other parts of the tape transport mechanism. All other bearings and moving parts are lubricated for life.

Mechanical Troubleshooting

It may be said in general, that most of the difficulties that will normally be encountered in the tape transport mechanism will be traceable to contamination of belts, pulleys, bearings, and other friction surfaces whether due to carelessness in routine lubrication, or to the gradual accumulation of dirt and other foreign material to be expected over a reasonable length of time. Correction of these difficulties will usually be a matter of careful disassembly and cleaning, rather than readjustment of the mechanism. The normal torques (and hence, tape tension) in this mechanism are, in fact, fixed within strict design specifications, and are not adjustable. The measurement of these torques will frequently provide a rapid means for isolating the source of mechanical troubles.

Torques and Tape Tension

The measurement of torques requires the following equipment:

1. A light-movement spring scale (e.g., Post-A-Let, 0 to 8 oz., Exact Weight Scale Co., Columbus, Ohio).
2. A measuring hub. A standard EIA plastic reel may be used. If the hub diameter is exactly 2 inches, the spring scale will read directly in ounce-inches. Reels with smaller hubs can be brought up to 2-inch diameter by winding on sufficient tape. If a reel of greater than 2-inch hub diameter is used, multiply the spring scale reading by the hub *radius* to obtain the ounce-inch reading.
3. A piece of string, approximately 30 inches long, with a small loop tied at one end.

Torques measured on the driven turntable in any mode, (i.e., the turntable on which the tape is being wound), are a measure of *takeup tension.* Torques measured on the turntable from which the tape is pulled in any mode are a measure of holdback tension. (See "Tape Tension Measurements" illustration.)

Takeup Tension

Step 1:

Place the measuring hub on the driven turntable.

Step 2:

Wind a few turns of string around the hub in the direction of normal tape wrap, and attach the spring scale to the loop at the end.

Step 3:

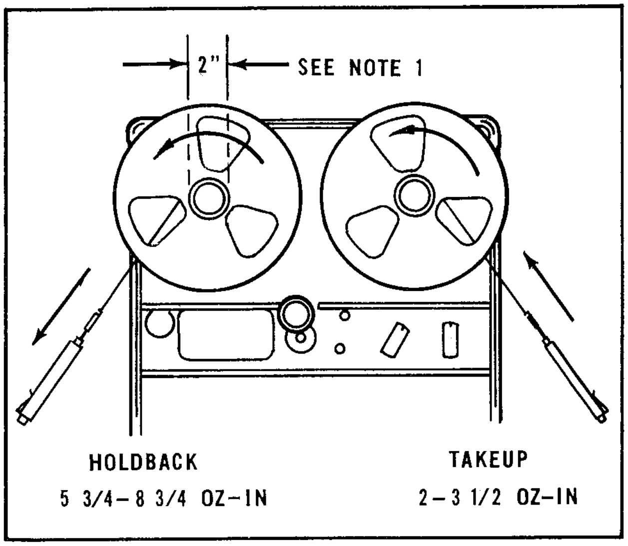
Start the machine in the appropriate mode and, as the string is wound on the hub, allow the scale to move in with it, taking the reading while the scale is in motion. Normal torques are as follows:

Fast Forward	6½ – 7¼ *oz-in*
Rewind	6½ – 7½ *oz-in*
Play	2 – 3½ *oz-in*

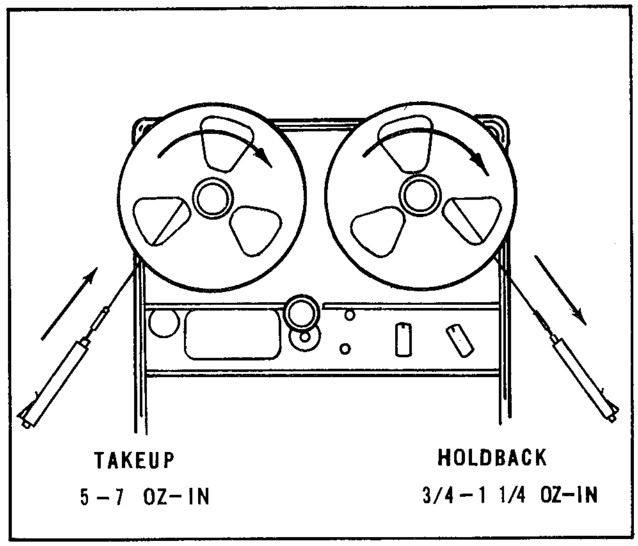
Holdback Tension

Step 1:

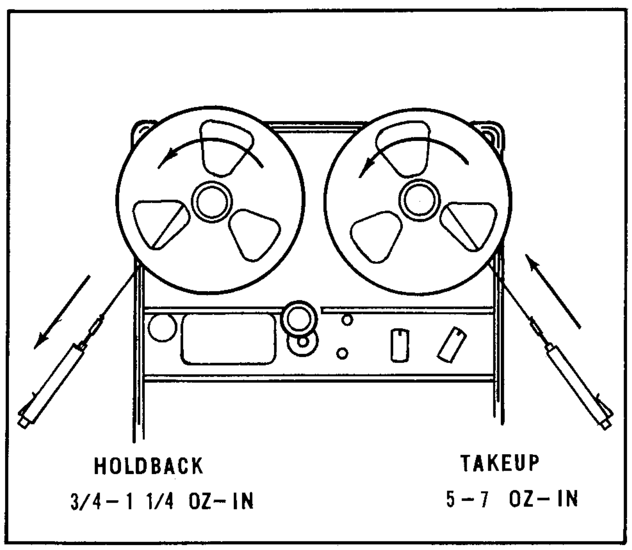
Place the measuring hub on the turntable



PLAY



REWIND



FAST FORWARD

NOTES:

1. IF REEL HUB DIAMETER IS LARGER OR SMALLER THAN 2 INCHES, MULTIPLY SPRING SCALE READINGS BY HUB RADIUS TO OBTAIN OZ.-IN. READING
2. PULL SCALE WITH STEADY MOTION WHEN MEASURING HOLDBACK TENSIONS. ALLOW SCALE TO MOVE IN TOWARD REEL WHEN MEASURING TAKEUP TENSIONS. TAKE ALL READINGS WHILE SCALE IS IN MOTION.

Tape Tension Measurements

from which the tape is pulled in the mode in operation.

Step 2:

Wind the string on fully in the direction of normal tape wrap, and attach the spring scale.

Step 3:

Start the machine in the appropriate mode, and pull the scale slowly in the direction in which tape is normally pulled from this reel, taking the reading while the scale is in steady motion. Normal torques are as follows:

Fast Forward	*1 — 1¼ oz-in*
Rewind	*1 — 1¼ oz-in*
Play	*7½ — 8½ oz-in*

These values listed above for both takeup and holdback tensions may be close to the lower limit when the machine is new, and will usually move up toward the upper limit after the first ten or twelve hours of operation.

Malfunctions in Play Mode

Nearly all malfunctions in the play mode will be reflected as flutter and wow in excess of specifications. A quick check of takeup and holdback tensions, discussed in the previous paragraphs, may lead directly to the source of trouble. Possible causes of flutter and wow are suggested in the following check list:

The word "contaminated" as used here, may indicate either the presence of oil where it is not wanted, or accumulations of dirt and other foreign matter on pulleys and belt. In either case, carbon tetrachloride is recommended as the cleaning agent. After cleaning a contaminated part, clean any other part with which it normally comes into contact whether or not that part shows any immediate evidence of contamination. Bracketed numbers refer to parts shown in the "Tape Transport Exploded View", which should serve as a guide for any necessary disassembly and reassembly.

Malfunctions in Rewind or Fast Forward Mode

Rewind and fast forward malfunctions will usually be reflected as an apparent loss of power in those modes, loose tape wind, erratic tape motion or slippage, and, possibly no rewind or fast forward at all. The first step is to make a quick check of rewind or fast forward takeup and holdback tensions as described previously. The malfunctions discussed below apply to either mode, the turntables, associated components, and tape directions being opposite of each other.

Starting, Stopping and Shuttling Malfunctions

Starting, stopping, and shuttling malfunctions will be evidenced by the throwing of tape loops and, in extreme cases, by tape breakage. These troubles are usually associated with low takeup tension or brake malfunctions produced primarily by tampering or misassembly, or contamination due to careless oiling or accumulation of dirt.

Assembly and Construction Notes

The following paragraph covers some adjustments, critical clearances, and alignment which must be maintained in reassembling parts of the tape transport mechanism that may have been disassembled for servicing. Two general precautions should be observed in any required disassembly.

1. Always note the number, type and location of washers in an assembly very carefully. Should washers, retainers or other small hardware be lost or damaged in servicing, a kit containing an assortment of such hardware (AMPEX Catalog No. 897) is available.
2. To remove the sub-plate (1), a preliminary to any further disassembly of parts under the top plate casting, remove only the three elastic stop-nuts that hold it, and clevis pin that links the slide lever (13) to the lower yoke of the rewind/fast forward actuator (48). It is unnecessary to remove the adjustment screws (70 and 71) for the capstan thrust and the motor thrust. If the settings for these screws are changed, they must be carefully readjusted as described in the following sub-paragraphs. The thrust discs (65) beneath these screws, being coated with grease, will usually stay in place when the sub-plate is removed. It is advisable, however, to be sure that they do not fall out. It will generally be found easiest to reinstall the sub-plate after servicing if the PLAY control is energized.

The tape transport incorporates rubber shock mounts on the screws retaining the motor mounting plate to the top plate casting. These shock mounts provide automatic centering of the drivemotor and no adjustments are necessary.

Drivemotor Thrust

The drivemotor thrust is a hardened steel ball (60) against a nylon disc (65). The capstan thrust is adjusted by a set-screw (70). End play of 0.010 in. to 0.015 in. is required, and is obtained as follows:

Step 1:
Coat the nylon thrust disc liberally with wheel bearing grease and drop it through the threaded hole in the sub-plate (1) over the capstan shaft.

Step 2:

Insert the set-screw, and tighten down until it is felt to bottom on the thrust disc.

Step 3:

Grasp the capstan flywheel (42) between the thumb and index finger.

Step 4:

While maintaining a slight downward pressure on the head of the set-screw with the screwdriver (to simulate the pressure that will later be applied by the locking screw) start backing the screw off slowly, and work the capstan flywheel up and down until an audible click at the ends of its travel indicates the presence of end play. This will usually occur when the set-screw has been backed off approximately ¼ of a turn. At this point, end play should be in the required range.

Step 5:

Tighten the locking nut on the set screw, then recheck end play.

Turntable Height

Turntable height (the distance measured from the top surface of the turntable (78) to the perforated metal grille) should be 0.125 in. ±0.008 in. This height is determined by the replacement of lamicoid washers between the bottom of the turntable pivot (24 or 36) and the hairpin retainer on the shaft through the pivot. Difficulties in tape tracking traced to improper turntable height may be corrected by increasing or decreasing the number or thickness of these washers.

Play Takeup Clutch

The play takeup clutch assembly consists of a felt-lined aluminum disc (18), and a bakelite clutch (19) which is spring-loaded to the disc. When the machine is in the play mode, the clutch is driven by the rubber belt (69) on the play takeup pulley (40). Location of the felt-lined aluminum disc is critical—a clearance of 0.015 in. being required between the end of the oilite bearing (21) which goes through the bakelite clutch (19), and the bottom of the aluminum disc (18). This clearance, which cannot be measured directly with a gauge because of the physical arrangement, can be set quite accurately by the following indirect method:

Step 1:

Insert a removeable 0.015 in. shim or feeler gauge between the thrust washer that rides on the inner race of the lower ball bearing (22) of the takeup turntable pivot (24) and oilite bushing (21).

Step 2:

Assemble the conical spring (20), the bakelite clutch (19), and the felt-lined aluminum disc (18) (in that order) on the turntable shaft (29).

Step 3:

Guide the end of the oilite bushing through the hole in the center of the bakelite clutch, and press the aluminum disc down until it bottoms firmly on the end of the bushing.

Step 4:

Holding the disc plate in place, tighten the set screw in its hub.

Step 5:

Remove the shim or gauge. The expansion of the conical spring will force the oilite bushing back off the aluminum disc, thus creating the required 0.015 in. clearance.

Rewind and Fast Forward Clutch Alignment

The rubber-tired rewind (31) and fast forward (16) clutches must line up with the shock relief brake rollers (5) so that the rollers engage the full width of the tires. In addition, the rewind clutch (31) should be aligned for full-width contact with the rewind idler (7) and the fast forward clutch (16) for full-width contact with the motor pulley (61).

Capstan Speed

The capstan speed will not vary, since the capstan is driven by a non-slipping nylon belt and synchronous motor. No adjustment of the capstan speed will be necessary. If it is desired to check the capstan speed, use a pre-recorded 3000 cycle tape (such as AMPEX Flutter Tape, Catalog No. 01-31326-01 or 01-31336-01) and an electronic frequency counter.

TROUBLESHOOTING PLAY MODE MALFUNCTIONS

Trouble	*Probable Cause*
Excessive or Erratic Holdback Tension	1. Contaminated rewind clutch felt (30). 2. Contaminated rewind clutch tire (31). 3. Rewind clutch spring (32) too stiff. This actually indicates tampering or carelessness in reassembly. It is advisable to replace the spring rather than to attempt makeshift readjustment.
Excessive Takeup Tension	1. Contaminated play takeup clutch felt (18). 2. Oilite bearing (21) bottoming on aluminum clutch disc (18). Minimum clearance should be 0.015 in. 3. Takeup clutch spring (20) too stiff.
Drivemotor Out of Synchronism	1. Line voltage below 105 volts. 2. Excessive play takeup tension. See trouble above. 3. Nylon drive belt (68) tension excessive. 4. Belt tensioning idler (55) dragging. 5. Drivemotor thrust misadjusted. 6. Defective Drivemotor starting capacitor. 7. Dry bearing in drivemotor (63), capstan (42), or capstan idler (79). See Lubrication instructions. 8. Defective drivemotor (63).
Flatted or Dented Capstan Idler Tire	1. If the capstan idler (79) is left engaged over an extended period when the machine is not operating, the idler tire may become dented. If running the machine in the play mode for several hours does not restore the tire to normal, the idler must be replaced.
Defective or Improperly Installed Nylon Drive Belt (68)	1. Belt spliced improperly. 2. Belt installed with splice joint toward pulley. 3. Belt worn because misaligned motor pulley (61) causes the belt to track against one of the capstan pulley flanges (42).
Rewind Idler (7) Not Disengaging from Motor Pulley (61)	1. Contaminated rewind idler guide (8).
Reels Misaligned with Respect to Tape Guides	1. This will usually cause tape scrape which may or may not be audible but will generally appear as flutter.

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	TOP PLATE ASSEMBLY, 7-1/2 ips, 60 cps, Single Channel	02-0210-01
	TOP PLATE ASSEMBLY, 7-1/2 ips, 50 cps, Single Channel	02-0210-02
	TOP PLATE ASSEMBLY, 3-3/4 ips, 60 cps, Single Channel	02-0210-03
	TOP PLATE ASSEMBLY, 3-3/4 ips, 50 cps, Single Channel	02-0210-04
	TOP PLATE ASSEMBLY, 7-1/2 ips, 60 cps, Two Channel	02-0210-05
	TOP PLATE ASSEMBLY, 7-1/2 ips, 50 cps, Two Channel	02-0210-06
	TOP PLATE ASSEMBLY, 3-3/4 ips, 60 cps, Two Channel	02-0210-07
	TOP PLATE ASSEMBLY, 3-3/4 ips, 50 cps, Two Channel	02-0210-08
79	CAPSTAN IDLER ASSEMBLY, With Oilite bearing	03-0024-01
80	CAP, Capstan idler	29-0098
	WASHER, Cambric: 0.24 in. ID by 7/16 in. OD by 0.010 in. thk.	44-0027-01
	RETAINER, Hairpin: for 1/4 in. shaft	32-0031
	ARM ASSEMBLY, Play takeup	03-0025-01
41	SPRING	27-0070
40	PULLEY ASSEMBLY, With Oilite bearing	04-0174
39	ARM ASSEMBLY	23-0069
	WASHER, Cambric: 0.24 in. ID by 7/16 in. OD by 0.010 in. thk.	44-0027-01
	WASHER, Lamicoid: 1/4 in. ID by 1/32 in. thk.	44-0025-01
	RETAINER, Hairpin: for 1/4 in. shaft	32-0031
	MOTOR ASSEMBLY, Drive: 7.5 ips, 60 cps	03-0026-05
	MOTOR ASSEMBLY, Drive: 7.5 ips, 50 cps	03-0026-06
	MOTOR ASSEMBLY, Drive: 3.75 ips, 60 cps	03-0026-07
	MOTOR ASSEMBLY, Drive: 3.75 ips, 50 cps	03-0026-08
	WASHER, Felt: 15/64 in. ID by 3/4 in. OD by 1/16 in. thk.	28-0024-01
63	MOTOR	59-0004-02 ←
62	PLATE, Mounting	33-0042-01
61	PULLEY, 7-1/2 ips: 60 cps	25-0068-01
61	PULLEY, 7-1/2 ips: 50 cps	25-0068-02
61	PULLEY, 3-3/4 ips: 60 cps	25-0068-03
61	PULLEY, 3-3/4 ips: 50 cps	25-0068-04
	SCREW, Machine: steel, 8-32 by 3/8 in. lg.	40-0088
	SCREW, Sem: 8-32 by 3/8 in. lg.	40-0009
	LUG, Solder	65-0003
	ARM ASSEMBLY, Capstan idler	03-0027-01
53	ANCHOR	23-0062
51	ARM SUB-ASSEMBLY	04-0158
52	ROLLER	25-0049
54	SPRING: 21/64 in. dia. by 1-27/64 in. lg.	27-0074
	PIN, Clevis: 1/8 in. dia. by 15/32 in. lg.	16-0025
	ARM ASSEMBLY, Takeup	03-0028-01
20	SPRING, Conical: 1 in. dia. by 31/32 in. lg.	27-0069
26	SPRING, Control: 17/32 in. dia. by 13/16 in. lg.	27-0063
	WASHER, Thrust: spring steel, 1/4 in. ID by 3/8 in. OD by 0.015 in. thk.	44-0062-02
24	ARM, Pivot	23-0067
29	HUB, With shaft	21-0076
17	SPRING, Clutch "U"	27-0068
19	CLUTCH, Play takeup	25-0044
18	DISC ASSEMBLY, With small felt	04-0165-01
15	DISC ASSEMBLY, With large felt	04-0165-02
16	CLUTCH ASSEMBLY, Fast forward	04-0166-01
28	LINK, Turntable control	23-0068
27	WASHER, Cup: spring retaining	44-0072
23	COLLAR, Drum	22-0054
	WASHER, Lamicoid: 1/4 in. ID by 1/32 in. thk.	44-0025-01
21	BEARING, Oilite	20-0024
22	BEARING, Ball	20-0025
	PIN, Cotter: 1/16 in. dia. by 1/2 in. lg.	32-0040
	WASHER, Lock: int. tooth, for No. 4 screw	44-0065
	SCREW, Machine: binder hd, 4-40 by 1/4 in. lg.	40-0159
	NUT, Hex: 4-40	42-0026
	SCREW, Set: socket hd, 6-32 by 1/8 in. lg.	40-0160

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	ARM ASSEMBLY, Rewind	03-0029-01
	WASHER, Thrust: spring steel, 1/4 in. ID by 3/8 in. OD by 0.015 in. thk.	44-0062-02
36	ARM, Pivot	23-0067
38	HUB, With shaft	21-0076
32	SPRING, Clutch "U"	27-0068
30	DISC ASSEMBLY, With large felt	04-0165-02
31	CLUTCH ASSEMBLY, Rewind	04-0166-01
35	COLLAR, Drum	22-0054
33	COLLAR, Spacer	22-0055
	WASHER, Lamicoid: 1/4 in. ID by 1/32 in. thk.	44-0025-01
34	BEARING, Ball	20-0025
	WASHER, Lock: int. tooth, for No. 4 screw	44-0065
	SCREW, Machine: binder hd. 4-40 by 1/4 in. lg.	40-0159
	NUT, Hex: 4-40	42-0026
	SCREW, Set: socket hd, 6-32 by 1/8 in. lg.	40-0160
	SCREW, Set: socket hd, 8-32 by 3/16 in. lg.	40-0158
25 & 37	BRAKE ASSEMBLY, Holdback: replacement kit (contains two No. 04-0167-01 Brake Assemblies)	85-0033-01
64	SPRING, Turntable height: 11/32 in. dia. by 9/32 in. lg.	27-0062
	ARM ASSEMBLY, Belt idler	03-0032-01
58	ARM ASSEMBLY, Capstan belt idler	04-0168-01
55	PULLEY ASSEMBLY	04-0169-01
	SPRING	27-0072-01
	RETAINER, Hairpin: for 1/4 in. shaft	32-0031
	WASHER, Lamicoid: 1/4 in. ID by 1/32 in. thk.	44-0025-01
	WASHER, Lamicoid: 1/4 in. ID by 0.015 in. thk.	44-0025-02
	WASHER, Thrust	44-0101-01
	SUB-PLATE ASSEMBLY, Single channel	03-0175-01
	SUB-PLATE ASSEMBLY, Two channel	03-0175-02
10	SPRING, Rewind idler	27-0058-01
11	SPRING, Release lever	27-0059-01
1	CASTING, Sub-plate	04-0163-01
13	LEVER, Slide: brake actuator	23-0060-01
14	LEVER, Release: play mode brake	23-0061-01
2	SHOCK RELIEF ASSEMBLY, Brake	04-0160-01
	IDLER ASSEMBLY, Rewind	03-0033-01
7	WHEEL, Idler	04-0161-01
8	GUIDE ASSEMBLY	04-0162-01
	WASHER, Cambric: 0.24 in. ID by 7/16 in. OD by 0.010 in. thk.	44-0027-01
	RETAINER, Hairpin: for 1/4 in. shaft	32-0031
12	SPRING, Actuator: 11/64 in. dia. by 1 in. lg.	27-0061-01
	SPRING, Clevis pin	27-0060-01
9	SWITCH DECK ASSEMBLY, Single channel	05-0245-01
9	SWITCH DECK ASSEMBLY, Two channel	05-0245-02
	GUARD, Switch top	26-0061-01
	WASHER, Lamicoid: 1/8 in. ID by 5/8 in. OD by 1/32 in. thk.	44-0064-01
	WASHER, Lock: int. tooth, for No. 4 screw	44-0065
	SCREW, Machine: 4-40 by 5/8 in. lg.	40-0151
	NUT, Hex: 4-40	42-0035
	PIN, Cotter: 1/16 in. dia. by 1/2 in. lg.	32-0040
	PIN, Clevis: 1/8 in. dia. by 15/32 in. lg.	16-0025
	PIN, Clevis: 1/8 in. dia. by 27/32 in. lg.	16-0027
	PIN, Clevis: 1/8 in. dia. by 9/16 in. lg.	16-0039
	WASHER, Flat: for No. 10 screw	44-0066
	RETAINER, Hairpin: for 3/16 in. shaft	32-0030
	ARM ASSEMBLY, Play control	03-0176-01
45	ACTUATOR, Play	23-0064-01
46	SWITCH MECHANISM	62-0035-02
47	PIN, Roll: 3/32 in. dia. by 5/8 in. lg.	16-0028
	ARM ASSEMBLY, Fast forward-rewind control	03-0177-01
48	ACTUATOR, Fast forward-rewind	23-0065-01
49	SWITCH MECHANISM	62-0035-02
50	PIN, Roll: 3/32 in. dia. by 5/8 in. lg.	16-0028
42	FLYWHEEL ASSEMBLY, Capstan	04-0157-01
81	SEAL, Dust: felt, 15/64 in. ID by 3/4 in. OD by 1/16 in. thk.	28-0024
43	WASHER, Felt: 13/16 in. ID by 1-1/8 in. OD by 3/32 in. thk.	44-0068
82	CAP, Dust shield	10-0027-03
65	DISC, Thrust	25-0041

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	WASHER, Cambric: 0.24 in. ID by 7/16 in. OD by 0.010 in. thk.	44-0027-01
70	SCREW, Set	40-0176
	NUT, Hex: jam, 3/8-27	42-0034
	PLATE ASSEMBLY, Top casting	04-0159-03
87	KNOB	10-0145-01
	RESISTOR BARRIER	17-0087-01
	SWITCH GUARD, Side	17-0088-01
60	BALL, 1/4 in. dia.	20-0007
77 & 89	BALL, 5/16 in. dia.	20-0020
71	PLUNGER, Motor thrust	20-0021-01
84	BEARING, Ball	20-0030
	GUIDE, Tape	21-0005-01
83	BAR, Tape guide	21-0069-01
85	CAP, Tape guide	29-0099-03
	SPACER, Motor mount	22-0058-01
75	LINK, Turntable pivot	23-0066-01
	PIN, Cotter: 1/16 in. dia. by 1/2 in. lg.	32-0040
	PIN, Clevis: 1/8 in. dia. by 11/32 in. lg.	16-0029
78	TURNTABLE, Reel	25-0040-01
	SPRING, Leaf: record lock	27-0056-01
	SPRING, Jones plug retainer	27-0064-01
66	SPRING, Motor thrust	27-0065-01
76	SPRING, Detent: rewind arm	27-0071-01
68	BELT, Drive: capstan, 60 cps, 7-1/2 ips	31-0007-03
68	BELT, Drive: capstan, 50 cps, 7-1/2 ips	31-0007-06
68	BELT, Drive: capstan, 60 cps, 3-3/4 ips	31-0007-07
68	BELT, Drive: capstan, 50 cps, 3-3/4 ips	31-0007-14
69	BELT, Takeup	31-0008
	BULB, Neon	61-0008
59	SPRING	27-0072
90	HEAD ASSEMBLY, Half track	02-0101-20
90	HEAD ASSEMBLY, Full tract	02-0101-10
90	HEAD ASSEMBLY, Two track	02-0102-02
86	COVER, Head	29-0429-03
91	TAPE GUIDE, Head	33-0041-01
	SHIELD, Head	29-0092-01
88	KNOB, Reel hold-down	01-0862-01

HEAD ASSEMBLY

GENERAL

The head assembly of an AMPEX magnetic tape recorder is the heart of the equipment. The technical and detailed know-how required for the fabrication of these head assemblies has made AMPEX the foremost manufacturer of magnetic recording equipment in the world today.

In theory, the head assembly of a tape recorder is a simple device. In practice, however, building a head assembly is a complicated task requiring extremely precise manufacturing techniques. There are normally head stacks in an assembly—erase, record, and reproduce. In recording, the erase head eliminates any previous recording from the tape. The record head puts a new signal on the tape by magnetizing the iron oxide particles in the coating on the tape. In reproduction, the magnetic flux in the moving tape induces a voltage in the reproduce head.

The design and construction of these heads is extremely critical. Their surfaces are lapped to finishes so smooth that variations are measured in wavelengths of light. In typical reproduce heads the gap is 0.000180 inch, which gives an indication of the precision required in building the heads.

Each of these heads is designed for a specific function with no compromise in the overall head assembly. Professional use demands top performance and there is no room for design compromise.

The design, engineering and manufacturing care built into AMPEX head assemblies assures dependable long life and economical operation at the lowest cost per operating hours.

MAINTENANCE

Cleaning

Most tape manufacturers lubricate their tapes, and this lubricant (plus oxide) from the tape will gradually be deposited on the head assembly. These deposits cause the loss of high frequencies, therefore the head assembly must be cleaned occasionally. To insure proper operation, the head assembly should be cleaned at least once during each eight hours of actual operation. To clean the head assembly, use a solution of Xylene and 0.1% Aerosal (AMPEX AUDIO Part No. 823). A cotton swab on a stick can be used to accomplish this cleaning.

CAUTION

Do not use any other solvent on the head assembly as some will damage the material which binds the head laminations together. Also do not use any metallic device which will scratch the head.

Demagnetizing

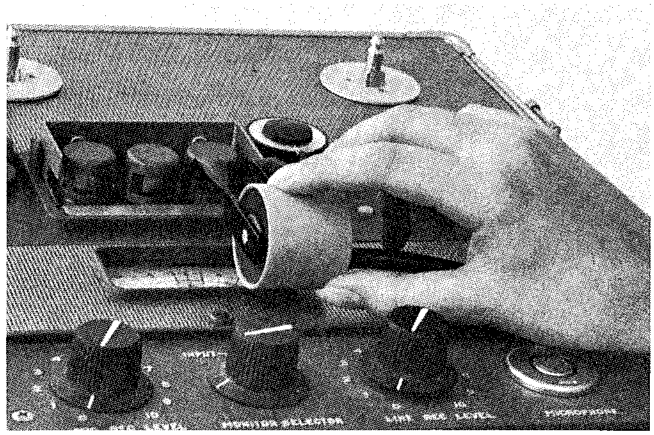
The record and reproduce heads may occasionally acquire a degree of permanent magnetization, which will result in an increase of 5 to 10 db in noise level, distortion of any recorded signal, and a gradual erasure of high frequencies on any recorded tape which passes over them. These heads may be easily demagnetized through the use of an AMPEX head demagnetizer, Part No. 820. To demagnetize the heads, proceed as follows:

Step 1:
Remove the head cover and head shield.

Step 2:
Make certain that power switches are in the OFF position.

Step 3:
Connect the demagnetizer to a source of 110-120 volt, a-c power.

Step 4:
Bring the tips of the demagnetizer in close proximity to, but not in contact with, the record head so that the tips straddle the gap in the center of the head. Run the tips of the demagnetizer up and down the head several times, and then *slowly* withdraw the demagnetizer. The slow withdrawal is essential to proper demagnetization.



Demagnetizing the Heads

Step 5:
Repeat step 4 at the reproduce head *and* the erase head *and* the tape guides.

Step 6:
Disconnect the demagnetizer.

Step 7:
Reinstall the head shield and head cover.

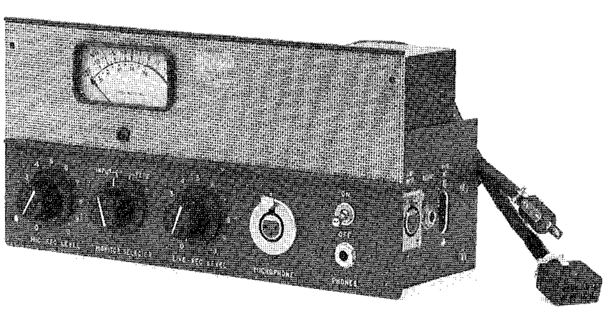
ELECTRONIC ASSEMBLY

GENERAL

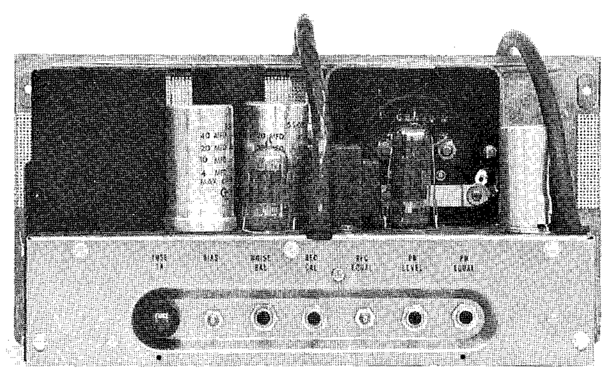
The single channel electronic assembly consists of a record channel, a reproduce channel, a bias and erase oscillator, and a power supply, mounted on a single chassis. The two channel master electronic assembly is similar to the single channel, the only difference being that the master electronics has a RECORD SAFE switch. The two channel slave electronic assembly is similar to the master, the only difference being that the bias and erase oscillator has been eliminated.

On the face panel, facilities are available for setting microphone and line record levels, and switching output circuitry. (On the master and slave there is also a record safe switch available.) Visual monitoring of reproduce and record levels is provided by a single vu meter on the face of each panel. A phone jack for aural monitoring is provided on the face panel. A Cannon input microphone jack completes the front panel arrangement.

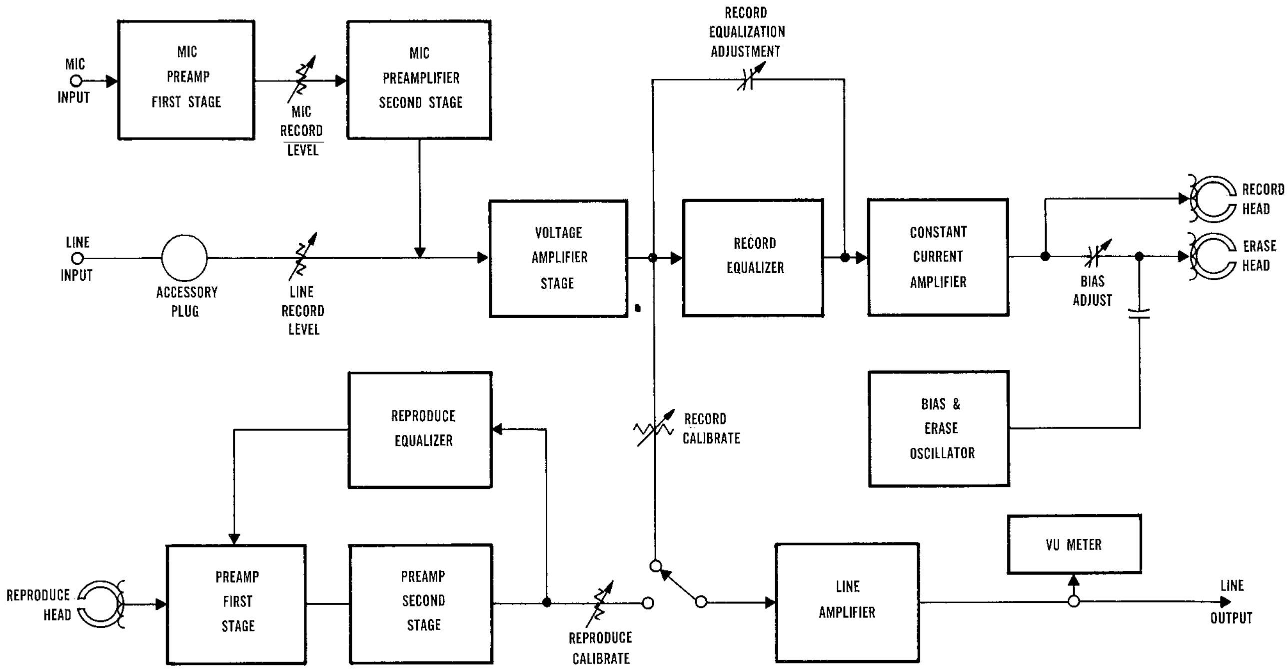
On the right hand side panel of the electronic assembly chassis are the connecting provisions for the line input, line output, and the AC power. On the back panel of the electronic chassis are located all the electronic adjustments for playback equalization, playback level, record equalization, record calibrate, noise balance, and bias. One screw-type fuse is also provided on the chassis back panel. The two cables protruding from the back of the chassis carry AC power and electronic signals to and from the tape transport.



Electronic Chassis, Front Panel



Electronic Chassis, Rear View



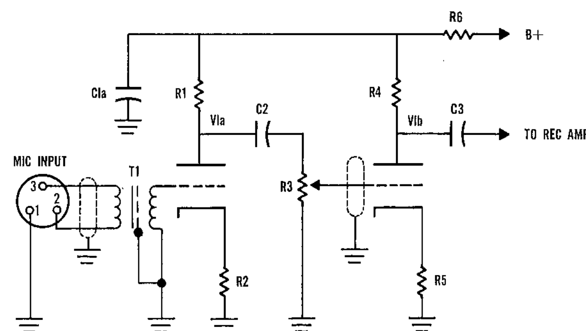
Block Diagram, Electronic Assembly

MICROPHONE PREAMPLIFIER

The built-in microphone preamplifier is a conventional two-stage high-gain voltage amplifier with a transformer input. Low impedance microphones with a minimum output level of −74 dbm (0.155 millivolts) can be accommodated to provide normal record levels.

The signal from J1 appears at the grid of tube V1a through transformer T1. Bias and negative feedback for tube V1a is attained by unbypassed resistor R2. After amplification by tube V1a, the signal is coupled to the grid of tube V1b through capacitor C2 and MIC REC*ord* LEVEL potentiometer R3. Bias and negative feedback for tube V1b is attained by unbypassed resistor R5. After amplification by tube V1b, the signal is coupled to the record amplifier through capacitor C3 and resistor R7. Capacitor C1a and resistor R6 form a plate decoupling network for the preamplifier.

The microphone preamplifier and the line input are connected to the record amplifier in such a manner that both inputs can be used simultaneously and can be mixed with any combination of input levels desired. (A dummy plug is provided in the line input so that an



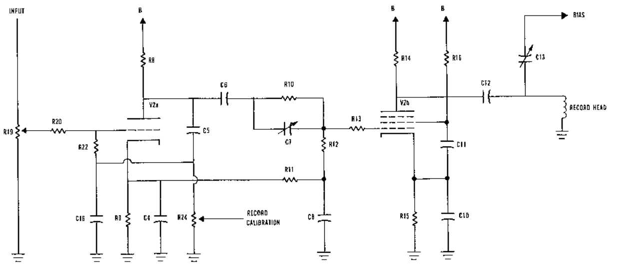
Simplified Schematic, Microphone Preamplifier

accessory plug-in preamplifier may be used in place of the dummy plug when two microphone inputs are desired.)

RECORD AMPLIFIER

The record section of the electronic assembly consists of a two stage, high gain resistance coupled amplifier. A triode-pentode, V2 and its associated circuitry, form the stages of amplification for the record amplifier.

When using line input, the signal from J2 appears at the grid of tube V2a through accessory socket J3, dummy plug P3, potentiometer



Simplified Schematic, Record Circuit

R19, and resistor R20. Potentiometer R19 provides a means of setting LINE REC*ord* LEVEL. Bias is attained by bypassed resistor R9. Capacitor C5 and potentiometer R24 (REC*ord* CAL*ibrate*) provide record calibration circuitry. Resistors R22 and R23 establish negative feedback around V2a. Capacitor C5 in conjunction with resistor R23 and potentiometer R24 provides low frequency pre-emphasis.

NOTE

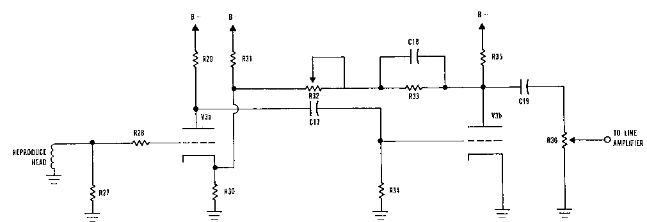
When reading vu meter indications with the MONITOR SELECTOR switch in the INPUT position, only the first stage of the record amplifier and the last two stages of the reproduce amplifier are connected in the circuit. This omits record pre-emphasis and reproduce equalization circuitry so that meter indications will reflect only the flat response of each amplifier.

The signal is now coupled to the grid of tube V2b through capacitor C6, through a pre-emphasis network, and resistor R13. The pre-emphasis network consists of resistors R10, R11, and R12; and capacitors C7 and C8. The pre-emphasis circuitry provides the necessary high frequency pre-emphasis to the control grid of tube V2b. Bias for tube V2b is provided by the difference in voltages developed across resistor R9 and resistor R15, by returning the control grid of V2b to the cathode of V2a through a resistance in the pre-emphasis network. Tube V2b delivers an audio signal current to the record head that is directly proportional to the signal voltage at the control grid. A 100 kc bias signal current from the bias and erase oscillator output is coupled into the record head through capacitor C13.

REPRODUCE AMPLIFIER

The reproduce section of the electronic assembly is a resistance coupled audio amplifier. Two dual triodes are used to provide two stages of amplification and a single-ended push-pull output.

Signals on the moving tape induce voltages in the reproduce head. This induced voltage appears across resistor R27 and then through R28 to the grid of tube V3a. Bias on this first stage is derived from the voltage network consisting of resistors R30 and R31. The amplified output of this first stage is coupled to the second stage grid through capacitor C17. Contact bias is used on V3b. Capacitor C1c and resistor R39 form a plate decoupling network for the first two stages. Reproduce equalization is achieved by means of a negative feedback from the plate of V3b through resistors R32 and R33 and capacitor C18 to the cathode of V3a.

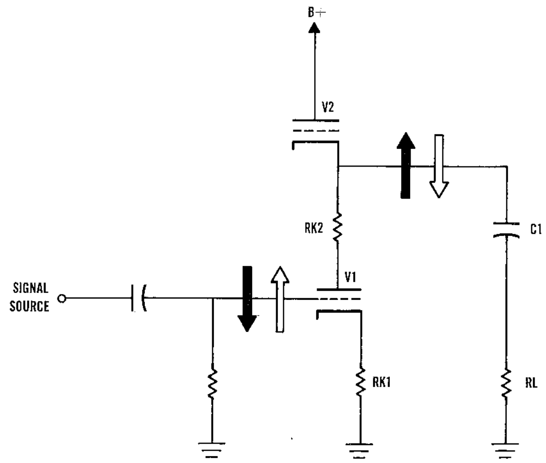


Simplified Schematic, Reproduce Preamplifier

The signal is now delivered to the push-pull amplifier V4, the tube receiving the signal through coupling capacitor C19, PLAYBACK LEVEL potentiometer R36 and MONITOR SELECTOR switch S2 (when the switch is in the TAPE position).

Operation of the output stage can be shown in the simplified schematic diagram. Resistors RK1 and RK2 establish biases for tubes V1 and V2. With no input signal, the d-c voltage drop across tube V1 is controlled by the d-c bias developed across RK1 and the d-c voltage drop across tube V2 is controlled by the bias voltage across RK2.

When a positive going signal is applied to the grid of tube V1, the tube is driven toward saturation. This causes the voltage at the plate of tube V1 to drop, which in turn causes the voltage at the grid of tube V2 to drop. Since the load RL is coupled to the cathode of V2 through coupling capacitor C1 and the grid of V2 is connected to the plate of V1, a signal voltage drop occurs across RK2 which causes



Simplified Schematic, Line Output Amplifier

tube V2 to be driven toward cutoff. When a negative going signal is applied to the grid of tube V1, the converse is true.

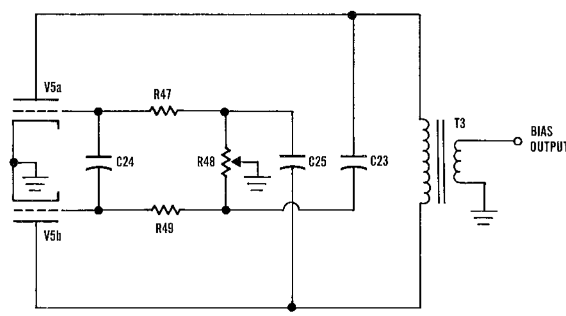
In the actual circuit, shown in the schematic diagram, resistor R41 corresponds to RK1, resistor R40 corresponds to RK2, tube V4b corresponds to V1, tube V4a corresponds to V2, capacitor C21 corresponds to C1, and transformer T2 corresponds to RL.

When the output of transformer T2 is terminated in its characteristic impedance (i.e. 600 ohms), the output level would drop if the basic circuit were used. To partially compensate for this effect, a negative voltage feedback is applied to the grid circuit from the primary of transformer T2 to obtain a regulation of approximately 2 db. At the same time, the negative feedback obtains an improvement in distortion characteristics as well as stability of stage gain. Capacitor C20 compensates the output stage for flat high frequency response.

BIAS AND ERASE OSCILLATOR

A dual triode tube V5, connected as a push-pull oscillator, provides high frequency bias and erase currents. The output of each plate is coupled to the grid of the other triode section through a capacitor. Any signal on the grid of either tube section will be amplified in the plate circuit of that section and coupled to the grid of the other section. The signal then will appear at the second plate and be coupled back to the first grid in phase with the original signal. Frequency of oscillation of approximately 100 kc is determined by the inductance of the primary of transformer T3 and the effective capacity across the primary.

The oscillator output is fed through capacitor C14 to the erase head. The oscillator output is also fed to BIAS ADJUST variable capacitor C13 where record bias current adjustments take place. The bias signal is then mixed with the record signal and delivered to the record head. Plate voltage is supplied to the center tap of oscillator transformer T3 through switch S101 located on the tape transport. (In two channel machines, both the oscillator output signal and the oscillator plate voltage supply are fed through switch S1, RECORD SAFE, for the master and slave electronics. The master electronics contains the oscillator, but can be controlled by either master or slave electronics through the RECORD SAFE switch.)



Simplified Schematic, Bias Oscillator

The NOISE BALANCE potentiometer R48 common to both grids of the oscillator, is adjusted to eliminate any asymmetry in bias wave form, which would introduce a d-c current in the record head, causing permanent magnetization of the head and a resultant distorted signal.

POWER SUPPLY

Silicon rectifiers CR1 and CR2 are used in a conventional full-wave voltage doubler rectifier circuit to supply plate power for all tubes in the electronic assembly. Selenium rectifier CR3 is connected as a conventional full-wave center-tap rectifier to provide d-c heater voltage for all tubes except V5.

The center tap of the V3 tube filament provides a ground for the d-c filaments. Even though this tube is only used for reproduction, it must be in its socket for proper operation of all functions. A-c power input is connected at receptacle J8 and is controlled by the power switch, S3, on the electronics. The power is fed through fuse F1 and impressed across the primary of power transformer T4.

There are three secondary windings on the power transformer—two for filament supply and one for high voltage. One filament winding serves oscillator tube V5 and the panel lights, the second filament winding provides 12.6 volts d-c after rectification, and the third winding furnishes high voltages for the plate supply. The plate supply ripple is filtered by a capacitance-input filter formed by capacitors C26, C27, and C9d, and resistor R50; additional filtering is supplied by the decoupling capacitors.

ADJUSTMENTS

General

The only adjustment procedure not covered in the "Checkout and Adjustment" section of the manual is the "Noise Balance Adjustment." This adjustment is not critical and is normally required only when the bias oscillator tube, V5, is replaced.

Step 1:
Thread a tape on the machine; and connect a 0.1 mfd capacitor and a sensitive vtvm across the OUTPUT connector.

Step 2:
Disconnect all inputs; and turn the LINE REC*ord* LEVEL and MI*crophone* REC*ord* LEVEL controls to zero.

Step 3:
Plug a set of headphones into the PHONES jack; and start the machine in the record mode.

Step 4:
Adjust the NOISE BALANCE potentiometer R48 for a minimum reading on the vtvm or a minimum popping noise in the headphones.

MAINTENANCE AND TROUBLESHOOTING

General Maintenance Information

Careful performance checks will insure excellent equipment operation. When the cleaning, lubricating and demagnetizating procedures are followed as prescribed and the system is set up according to the instructions in this manual, equipment performance should meet the high AMPEX standards.

Neglect of maintenance procedures, such as failure to clean the capstan, the head faces and the tape guides daily can cause deficiencies that are reflected in the amplifiers. For instance, poor tape-to-head contact, due to tape oxide accumulations, will diminish high end frequency response.

Improper head azimuth adjustment will also affect high frequency response.

Preventive Maintenance of the Amplifiers

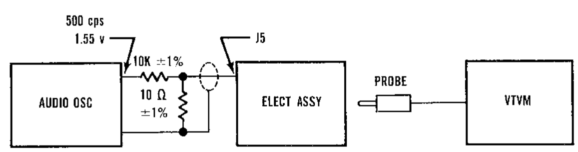
Check B+ voltage at junction of resistor R50 and capacitor C9d; voltages measured will vary with line voltage, the voltages indicated on the schematic diagram were measured with a 117 volt line voltage. Check all tubes using a tube tester. Make certain that tubes are returned to same socket from which they were removed. Check d-c filament voltage to note aging of CR3.

Corrective Maintenance

The first step in any corrective maintenance procedure is localizing the faulty circuit. If a tape recorded on the equipment itself does not reproduce correctly, the trouble can be in either the record or the reproduce circuit. In this case, the faulty circuit can be identified by reproducing a standard alignment tape or a commercially recorded tape; if, while reproducing the standard tape, trouble still exists, the fault is in the reproduce circuit; if the reproduce function is normal, the fault is in the record circuit. A run through of the alignment and performance checks for the offending circuit will further isolate the trouble or may rectify it, and the faulty component or mechanical device then should be identified easily.

Troubleshooting the Reproduce Amplifier

A circuit for troubleshooting the reproduce amplifier is shown below (see also, "Electronic Schematic Diagram").

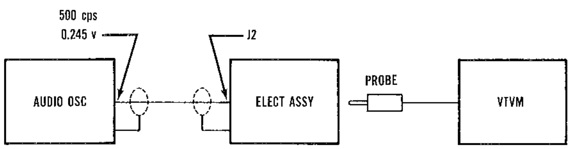


Block Diagram, Troubleshooting the Reproduce Amplifier

Disconnect the head cable at J5 when using this circuit. Using a vtvm probe and working back from the output toward the input, check at the grid and plate of each stage until the point at which a signal is indicated on the vtvm. The trouble then is probably in the stage immediately following that point. When the faulty stage is located, the individual components can be isolated by a check of resistances and voltages. Typical voltage values are shown on the electronic schematic diagram. After the completion of any troubleshooting procedures, using the circuit shown above, check the reproduce amplifier response against the appropriate curve to insure that the equipment conforms to performance characteristics.

Troubleshooting the Record Amplifier

The circuit for troubleshooting the record amplifier is shown below (see also, "Electronic Schematic Diagram").



Block Diagram, Troubleshooting the Record Amplifier

Proceed as in troubleshooting the reproduce amplifier. Typical voltage readings are shown on the electronic schematic diagram. Using the circuit above, check the record amplifier against the appropriate response curve. Response of the amplifier should be checked with the bias oscillator tube removed from its socket and selector switch S101 in record position. (When troubleshooting two channel master or slave electronics record amplifiers, make sure the RECORD SAFE switch is in the RECORD position.)

ORDERING PARTS

The purpose of the parts list is to aid the user of AMPEX equipment in obtaining replacement parts. AMPEX franchised dealers can offer the most convenient service in providing normally replaceable parts when proper information is furnished. Parts are listed according to the schematic reference symbol, a description of the part and the AMPEX part number.

On occasion, AMPEX offers certain replacement parts that are not necessarily exact replicas of those on the original version of the equipment; but these parts are directly interchangeable with the original parts or data is provided to enable the use of the new part. The description column names the part, its composition, electrical value and manufacturer's number (or military specification when available)—and the AMPEX PART NUMBER.

AMPEX part numbers are the exact designation for all parts used in AMPEX equipment. For example, CAPAÇITOR, fixed: ceramic, .02 μf 80% −20%, 500 vdcw; Sprague Part No. 36C205 will always bear the AMPEX part number 54-0265. THIS IS THE NUMBER YOU SHOULD USE WHEN ORDERING REPLACEMENT PARTS. The schematic reference number should NOT be used for ordering purposes as it will vary with different equipment types. Include the following information when ordering parts; Equipment Type, Equipment Number, AMPEX Part Number, Description of Part. Example: 4 ea. 54-0265 capacitors for Series 602, Serial No. XXX.

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	ELECTRONIC ASSEMBLY, Single channel, Catalog No. 02-0211-01	
	ELECTRONIC ASSEMBLY, Two channel master, Catalog No. 02-0211-02	
	ELECTRONIC ASSEMBLY, Two channel slave, Catalog No. 02-0211-03	
C1	CAPACITOR, Fixed: electrolytic; 20-20-20-20 mfd; 450 vdcw; General Instruments Type TM	55-0003
C2	CAPACITOR, Fixed: mylar; 0.15 mfd; ±20%; 400 vdcw; Cornell-Dubilier Type WMF	54-0162
C3	CAPACITOR, Fixed: mylar; 0.047 mfd; ±20%; 400 vdcw; General Instruments Type IMP	54-0235
C4	CAPACITOR, Fixed: electrolytic; 25 mfd; 6 vdcw; General Instruments Type MLV	55-0100
C5	(Same as C3)	54-0235
C6	(Same as C3)	54-0235
C7	CAPACITOR, Variable: mica; 100-550 pfd; 250 vdcw; Elmenco Type 304	54-0247
C8	CAPACITOR, Fixed: mylar; 0.12 mfd, ±10%; 100 vdcw; Cornell-Dubilier Type WMF	54-0167
C9	CAPACITOR, Fixed: electrolytic; 40-20 mfd, 450 vdcw; 10 mfd, 400 vdcw; 4 mfd, 350 vdcw; General Instruments Type TM	55-0013
C10	CAPACITOR, Fixed: mylar; 0.018 mfd; ±10%; 100 vdcw; Cornell-Dubilier Type WMF	54-0291
C11	CAPACITOR, Fixed: electrolytic; 4 mfd; 450 vdcw; General Instruments Type TD	55-0005
C12	CAPACITOR, Fixed: mylar; 0.47 mfd; ±20%; 400 vdcw; Cornell-Dubilier Type WMF	54-0154
C13	CAPACITOR, Variable: mica; 65-340 pfd; 250 vdcw; Elmenco Type 303	54-0272
C14	CAPACITOR, Fixed: mica; 0.001 mfd, ±5%; 500 vdcw; Elmenco Type DM-20	54-0198
C15	CAPACITOR, Fixed: ceramic; 0.01 mfd; GMV; 500 vdcw; Erie Part No. 811-.01 (-02 & -03 versions only)	54-0038
C16	CAPACITOR, Fixed: ceramic; 33 pfd; ±5%; 500 vdcw; Erie Type 831	54-0293
C17	CAPACITOR, Fixed: ceramic; 0.0047 mfd; GMV; 500 vdcw; Erie Type 811	54-0006
C18	CAPACITOR, Fixed: mica, 750 pfd; ±5%; 500 vdcw; Elmenco Type CM-20	54-0034
C19	CAPACITOR, Fixed: mylar; 0.1 mfd; ±20%; 400 vdcw; Cornell-Dubilier Part No. WMF4P1E	54-0156
C20	CAPACITOR, Fixed: ceramic; 56 pfd; ±5%; 500 vdcw; Erie Type 831	54-0294
C21	CAPACITOR, Fixed: electrolytic; 4 mfd; 150 vdcw; General Instruments Type TD	55-0038
C22	(Same as C4)	55-0100
C23	CAPACITOR, Fixed: mica; 350 pfd; ±5%; 500 vdcw, Elmenco Type DM-19 (-01 & -02 versions only)	54-0202
C24	CAPACITOR, Fixed: mica; 0.001 mfd; ±5%; 500 vdcw; Elmenco Type DM-20 (-01 & 02 versions only)	54-0198
C25	(Same as C23)	54-0202
C26	CAPACITOR, Fixed: electrolytic; 40 mfd; 250 vdcw; General Instruments Type TD	55-0134
C27	(Same as C26)	55-0134
C28	CAPACITOR, Fixed: electrolytic; 2000-1000 mfd; 15 vdcw	55-0067-01
CR1	DIODE, Crystal: diff used silicon; 600 PIV; Type 1N2864	57-0012
CR2	(Same as CR1)	57-0012
CR3	RECTIFIER, Selenium: single-phase; full-wave; center-top; 2.2 amps; 26v input; Radio Receptor Part No. C16S1C1E1G	57-0056
DS1	LAMP, Neon: miniature; red; Eldema Part No. B9-CC-B-NE2H (-02 & -03 versions only)	61-0072
DS2	LAMP, Incandescent: General Electric No. 51	61-0073
DS3	(Same as DS2)	61-0073
F1	FUSE, Cartridge: 1 amp; 250v; 1/4 in. dia. by 1-1/4 in. lg.; Littelfuse Part No. 312001 (-01 & -03 versions only)	61-0007

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
F1	FUSE, Cartridge: 2 amp; 250v; 1/4 in. dia. by 1-1/4 in. lg. Littelfuse Part No. 312002 (-02 version only)	61-0005
J1	CONNECTOR, Receptacle: female; 3 pin; Cannon Part No. XLR-3-13N	63-0033
J2	CONNECTOR, Receptacle: female; 3 pin; Cannon Part No. XLR-3-31	63-0103
J3	SOCKET, Accessory: octal; Cinch Part No. 101-12-00-039	63-0011
J4	CONNECTOR, Plug: female; 8 pin; Jones Part No. S-308-CCT (-01 & -02 versions only)	63-0034
J4	CONNECTOR, Plug: male; 8 pin; Jones Part No. P-308-CCT (-03 version only)	64-0014
J5	CONNECTOR, Plug: male; 2 pin; Jones Part No. P-302-CCT	64-0013
J6	JACK, Phone: 3 conductor; closed circuit; Zoron Part No. 2804	63-0041
J7	JACK, Phone: 2 conductor; open circuit; Switchcraft Part No. 11	63-0010
J8	CONNECTOR, Receptacle: male; 2 pin; Tower Part No. 10610A	64-0001
M1	METER, VU	14-0003-01
R1	RESISTOR, Fixed: film; 100K ohms; ±10%; 1/2 watt; Resista Type RSX	51-0397
R2	RESISTOR, Fixed: film; 1.5K ohms; ±5%; 1/2 watt; Resista Type RSX	51-0396
R3	RESISTOR, Variable: carbon; 100K ohms; ±10%; 2 watt; audio taper; Allen Bradley Type J	52-0021
R4	RESISTOR, Fixed: composition; 100K ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0037
R5	RESISTOR, Fixed: composition; 1.5K ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0018
R6	RESISTOR, Fixed: composition; 47K ohms ; ±10%; 1/2 watt; Allen Bradley Type EB	51-0049
R7	RESISTOR, Fixed: composition; 1 megohm; ±10%; 1/2 watt; Allen Bradley Type EB	51-0055
R8	RESISTOR, Fixed: composition; 68K ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0056
R9	RESISTOR, Fixed: composition; 2.2K ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0054
R10	RESISTOR, Fixed: composition; 330K ohms; ±5%; 1/2 watt; Allen Bradley Type FB	51-0213
R11	(Same as R4)	51-0037
R12	RESISTOR, Fixed: composition; 30K ohms; ±5%; 1/2 watt; Allen Bradley Type EB	51-0136
R13	RESISTOR, Fixed: composition; 1K ohm: ±10%; 1/2 watt; Allen Bradley Type EB	51-0017
R14	RESISTOR, Fixed: composition; 22K ohms; ±10%; 2 watt; Allen Bradley Type HB	51-0093
R15	RESISTOR, Fixed: composition; 560 ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0098
R16	RESISTOR, Fixed: composition; 150K ohms; ±10%; 2 watt; Allen Bradley Type HB	51-0276
R17	RESISTOR, Fixed: composition; 8.2K ohms; ±10%; 1 watt; Allen Bradley Type GB	51-0266
R18	RESISTOR, Fixed: composition; 220K ohms; ±10%; 1/2 watt; Allen Bradley Type EB (-02 & -03 versions only)	51-0020
R19	(Same as R3)	52-0021
R20	(Same as R18)	51-0020
R21	(Same as R6)	51-0049
R22	RESISTOR, Fixed: composition; 2.7 megohms; ±10% 1/2 watt; Allen Bradley Type EB	51-0360
R23	RESISTOR, Fixed: composition; 270K ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0040
R24	RESISTOR, Variable: dual; carbon; 500K ohms; linear taper	52-0141
R25	RESISTOR, Fixed: composition; 10K ohms; ±10%; 1 watt; Allen Bradley Type GB	51-0091
R26	RESISTOR, Fixed: composition; 100 ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0077

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
R27	RESISTOR, Fixed: composition; 470K ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0021
R28	RESISTOR, Fixed: composition; 12K ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0051
R29	RESISTOR, Fixed: film; 330K ohms; ±10%; 1/2 watt; Resista Type RSX	51-0029
R30	(Same as R2)	51-0396
R31	(Same as R27)	51-0021
R32	(Same as R24)	52-0141
R33	RESISTOR, Fixed: composition; 22 megohms; ±20%; 1/2 watt; Allen Bradley Type EB	51-0382
R34	RESISTOR, Fixed: composition; 10 megohms; ±20%; 1/2 watt; Allen Bradley Type EB	51-0025
R35	(Same as R20)	51-0020
R36	RESISTOR, Variable: carbon; 250K ohms; ±20%; 1 watt; audio taper; CTS Type M45	52-0022
R37	(Same as R7)	51-0055
R38	RESISTOR, Fixed: composition; 470K ohms; ±5%; 1/2 watt; Allen Bradley Type EB	51-0414
R39	(Same as R6)	51-0049
R40	RESISTOR, Fixed: composition; 680 ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0074
R41	RESISTOR, Fixed: composition; 470 ohms; ±10%; 1/2 watt; Allen Bradley Type EB	51-0047
R42	RESISTOR, Fixed: composition, 6.8 megohms; ±5%; 1/2 watt; Allen Bradley Type EB	51-0392
R43	RESISTOR, Fixed: composition; 6.8K ohms; ±10%; 1 watt; Allen Bradley Type GB	51-0007
R44	(Same as R28)	51-0051
R45	(Same as R15)	51-0098
R46	(Same as R28)	51-0051
R47	RESISTOR, Fixed: composition; 4.7K ohms; ±10%; 1/2 watt; Allen Bradley Type EB (-01 & -02 versions only)	51-0001
R48	RESISTOR, Variable: carbon; 10K ohms; ±20%; 1/4 watt; linear taper; CTS Type 45 (-01 & -02 versions only)	52-0024
R49	(Same as R47)	51-0001
R50	RESISTOR, Fixed: composition; 1.5K ohms; ±5%; 5 watt; Tru-Ohm Type X-60 (-01 & -02 versions only)	51-0398
R50	RESISTOR, Fixed: composition; 3.9K ohms ±10%; 2 watt; Alley Bradley Type HB (-03 version only)	51-0400
R51	RESISTOR, Fixed: composition; 27 ohms; ±5%; 5 watt; Tru-Ohm Type X-60	51-0399
R52	RESISTOR, Fixed: composition; 2 ohms; ±10%; 5 watt; Tru-Ohm Type X-60	51-0210
S1	SWITCH, Record-safe (-02 & -03 versions only)	62-0149-01
S2	SWITCH, Rotary: SPDT; Oak Part No. 159016-23	62-0038
S3	SWITCH, Toggle: SPST, bat handle; Cutler-Hammer Part No. 8280 K15	62-0039
T1	TRANSFORMER, Microphone	58-0100-01
T2	TRANSFORMER, Output	58-0118-01
T3	TRANSFORMER, Oscillator (-01 & -02 versions only)	58-0144-01
T4	TRANSFORMER, Power	58-0153-01
V1	TUBE, Electron: type 12AX7	56-0006
V2	TUBE, Electron: type 6AW8A	56-0069
V3	(Same as V1)	56-0006
V4	TUBE, Electron, type 12AU7	56-0077
V5	(-01 & -02 versions only)	56-0002

ACCESSORIES

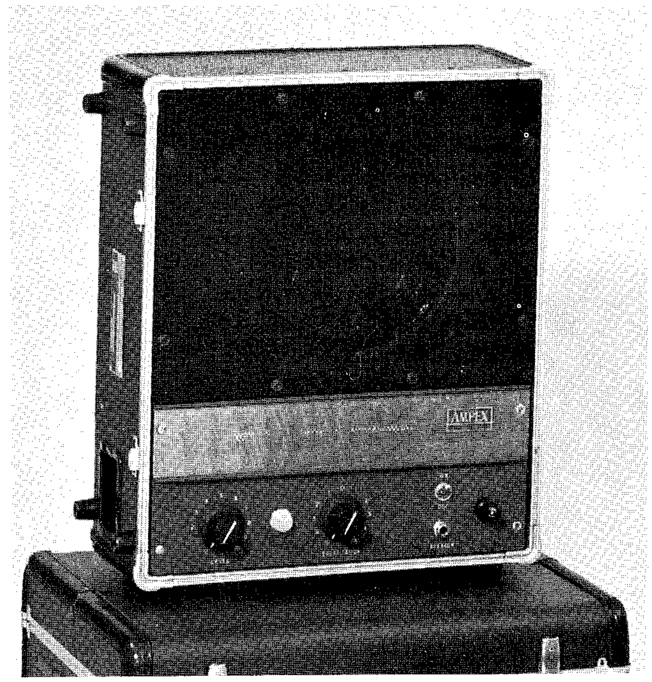
GENERAL

The accessories described on the following pages are designed to add to the versatility of the basic unit or to aid in keeping the unit in the best possible operating condition.

SPEAKER-AMPLIFIER ASSEMBLY

The AMPEX Model 622 speaker-amplifier (Catalog No. 01-0622-01) is a compact unit designed as a companion to the Model 602 and 602-2 recorders. The AMPEX 622 is particularly useful for demonstrating radio programs and pre-recorded commercials before prospective time buyers—for on-location monitoring of broadcast tapes made away from the main studio—for monitoring broadcasts within the station—and similar uses by the professional sound recording services and record companies.

The speaker and amplifier in combination have flat acoustic response from 65 to 10,000 cycles with additional useful range above and below. The amplifier output is 10 watts with less than 1% harmonic distortion. The speaker can use full power if necessary, giving ample volume even for a medium size auditorium. The AMPEX 622 can be used with any sound source. It may be used as a speaker-amplifier or as an amplifier only, since the external speaker jack bypasses the internal speaker and its reciprocal network.



622 Speaker-Amplifier

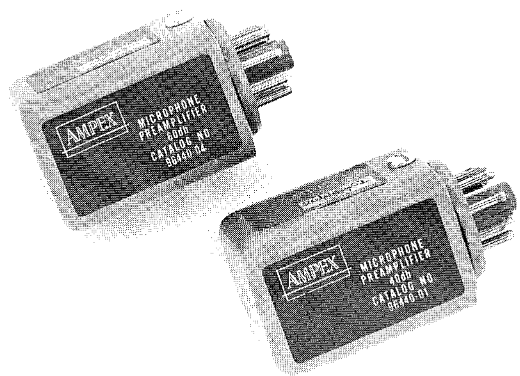
GENERAL PERFORMANCE CHARACTERISTICS AND SPECIFICATIONS

OVERALL FREQUENCY RESPONSE (IN AIR)	65 to better than 10,000 cycles/sec. essentially flat acoustically. *Response curve established by a test microphone in free field on axis with unit radiating into semi-infinite space of 2π steradians solid angle. Actual use will approximate this condition when the 620 is placed in a good acoustical environment. Tests were made with 7 component multitones of quarter octave overall width.
AMPLIFIER FREQUENCY RESPONSE	20 to 20,000 cycles/sec. $\pm$ ½ db.
POWER OUTPUT	10 watts amplifier power with no audible harmonic distortion. Speaker can use full power.
SIGNAL-TO-NOISE RATIO	Amplifier noise (including hum) is 70 db below rated output.
CONTROLS AND CONNECTIONS	Volume control, bass-treble control, power switch and on-off indicator light are provided. Cable for A.C. power is furnished and also an A.C. convenience outlet is built in. Audio input connector is of the concentric pin type. External speaker connection is a headphone type jack.
EQUALIZATION	Single control on front panel gives a level tilt to speaker output, boosting the bass and attenuating the treble or vice versa. Maximum bass boost is 6 db relative to treble. Maximum treble boost is 6 db relative to bass.
EXTERNAL SPEAKER FEED	Use of the external speaker jack automatically cuts out the 620's speaker and reciprocal network. Hence, flat amplifier output is fed to the external speaker.
INPUT IMPEDANCE	20,000 ohms.
OUTPUT IMPEDANCE	12 ohms to external speaker.
POWER REQUIREMENT	117 volts, 50 or 60 cycles, 0.5 amps, 55 watts.
WEIGHT	25 pounds.
DIMENSIONS	13 x 16 x 8 inches.

PLUG-IN MICROPHONE PREAMPLIFIER

General

Two plug-in microphone preamplifiers are offered for use with the PR-10 recorder/reproducer. Both preamplifiers are for use with



Plug-in Microphone Preamplifiers

low impedance microphones. One preamplifier (Catalog No. 01-96440-01) provides 40 db of gain while the other (Catalog No. 01-96440-04) provides 60 db of gain. (See "Equipment Applications" in the Description Section.)

40-db Preamplifier

With the 40-db microphone preamplifier plugged in the system, low impedance microphones with relatively high output levels from −50 dbm (2.4 millivolts) minimum to −25 dbm (43 millivolts) maximum can be accommodated to provide normal record levels. This preamplifier is designed specifically for extremely close pickups with high level microphones.

The preamplifier is a conventional single-stage voltage amplifier with a transformer input. The only unusual portion of the circuit is the partially by-passed cathode which improves the overload characteristics of the amplifier.

60-db Preamplifier

With the 60-db microphones preamplifier plugged in the system, low impedance microphones with relatively low output levels from −70 dbm (0.23 millivolt) minimum to −35 dbm (13.7 millivolts) maximum can be accommodated to provide normal record levels. This preamplifier is designed as the general purpose preamplifier for most of the normal microphones used and for most of the standard pickups. It will overload when used for extremely close pickups with high level microphones.

The preamplifier is a conventional two-stage voltage amplifier with a transformer input. The only unusual portion of the circuit is the use of negative feedback from the plate of the second stage to the cathode of the first stage and the use of the positive feedback from the cathode of the second stage to the cathode of the first stage. In addition to improving the overload characteristics of the amplifier, the negative feedback is part of a bleeder network that protects the tubes from accessive voltage surges when power is first applied to the preamplifier.

PLUG-IN INPUT TRANSFORMER

Two plug-in input transformers are offered. Both transformers are for use with balanced line inputs. One transformer (Catalog No. 58-0116-01) is a balanced bridging, unity ratio transformer with 0 db gain while the other (Catalog No. 58-0116-02) is a balanced matching, step-up ratio transformer with 14 db gain.

Input impedance of the system with the balanced bridging transformer installed is 100,000 ohms and is designed for use with a source impedance of 600 ohms. The system can accommodate input signals from −10 dbm (0.24 volts) minimum to +18 dbm (6.1 volts) maximum to provide normal record levels. The transformer is designed specifically for use −4 to +8 vu lines.

Input impedance of the system with the balanced matching transformer installed is 600 ohms and is designed for use with a source impedance of 600 ohms. The system can accommodate input signals from −24 dbm (48 millivolts) minimum to +18 dbm (6.1 volts) maximum to provide normal record levels. The transformer is designed specifically for use with −20 to −4 vu lines.

CAUTION

These transformers are not designed for and cannot be used with +18 vu lines.

TAPE SPLICER

The AMPEX tape splicer, Model 805, is compact splicer designed for rapid editing and repairing. The splicer employs a replaceable cutter cartridge with two operating positions—miter cut and trimming cut. The first position cuts the tape diagonally, the second position presses the splicing tape over the diagonal cut and trims a concave indentation on either side of the splice to prevent binding. The tape splicer is supplied with a roll of ½ inch wide splicing tape and complete operating instructions.

PROFESSIONAL RECORDER ACCESSORY KIT

The AMPEX Professional Recorder Accessory Kit No. 894, provides the user with the most needed accessories. The kit contains: an AMPEX head demagnetizer, Model 820; a 4 ounce can of AMPEX head cleaner, No. 823; a 1¾ ounce bottle of AMPEX lubricating oil, No. 825; and a package of 'Q-Tips' cotton swabs for applying the head cleaner.

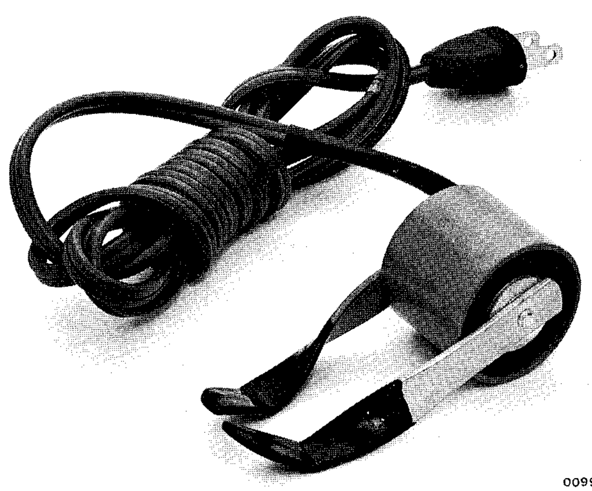
LUBRICATING OIL

The AMPEX lubricating oil, No. 825, is formulated for use in AMPEX tape recorders. The lubricating should be used sparingly and in accordance with the instructions in this manual.

HEAD DEMAGNETIZER AND HEAD CLEANER

The AMPEX head demagnetizer, Model No. 820, quickly demagnetizes the record, reproduce and erase heads to achieve reduced noise and distortion. The demagnetizer neutralizes the residual magnetizing induced in the heads by transients from speech, music and noise thus preventing partial high frequency erasure of the tape. The demagnetizer consists of an a-c magnet with pole pieces shaped to fit the contour of the heads. Operation of the demagnetizer is described in the HEAD ASSEMBLY section.

The AMPEX head cleaner, Model No. 823, is specially formulated for use with AMPEX heads. Do not use any other solvent on the head assembly as some will damage the material which binds the head laminations together. The head cleaner should not be used on plastic parts such as the head cover. Cleaning of the heads is described in the HEAD ASSEMBLY section.



Head Demagnetizer

TEST TAPES

The AMPEX test tape mentioned in the "Checkout and Adjustment" section is specifically designed for use with machines operating at 7½ inches per second using NAB equalization. Under certain circumstances, particularly for "Master Recording", it may be desirable to calibrate the machine with the test tape designed for the specific speed and equalization concerned. The following table lists the various ¼-inch test tapes.

Equalization	*Catalog No.*
15 ips NAB	01-31311-01
7½ ips NAB	01-31321-01
3¾ ips 120 μsec	01-31331-01
3¾ ips 200 μsec	01-31334-01

The 15 ips test tapes contain the following information in the sequence indicated.

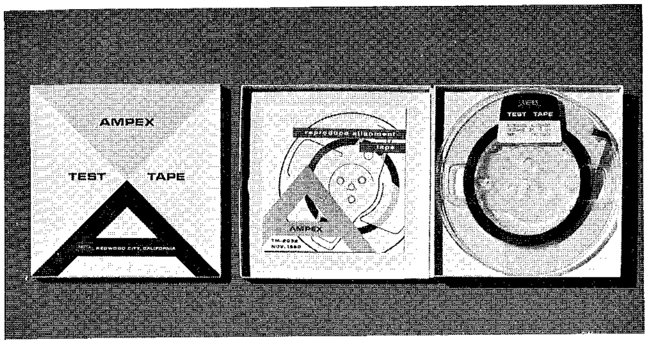
1. A 700 cps tone at operating level for reduce gain calibration and reference.
2. A 15,000 cps tone at operating level for reproduce head alignment.
3. A series of tones (12kc, 10kc, 7.5kc, 5kc, 1kc, 500c, 250c, 100c, 50c, and 30c) at operating level for reproduce frequency response measurements.

The 7½ ips test tapes contain the following information in the sequence indicated.

1. A 700 cps tone at 10 db below operating level for reference.
2. A 15,000 cps tone at 10 db below operating level for reproduce head alignment.
3. A series of tones (12kc, 10kc 7.5kc, 5kc, 2.5kc, 1kc, 250c, 100c, and 50c) at 10 db below operating level for reproduce frequency response measurements.
4. A 700 cps tone at operating level for reproduce gain calibration.

The 3¾ ips test tapes contain the following information in the sequence indicated.

1. A 500 cps tone at 10 db below operating level for reference.
2. A 7,500 cps tone at 10 db below operating level for reproduce head alignment.
3. A series of tones (5kc, 2.5kc, 1kc, 500c, 250c, 100c and 50c) at 10 db below operating level for reproduce frequency response measurements.
4. A 500 cps tone at operating level for reproduce gain calibration.



Ampex Test Tapes

In addition to the alignment tapes, Ampex also produces level set tapes and flutter test tapes. The flutter test tapes are used for checking equipment flutter in accordance with American Standards Association standard number Z57.1-1954. These tapes consist of a 3000 cycle tone (with 0.03% or less flutter) which is reproduced on the machine being checked and the flutter of the machine is measured using a standard flutter bridge. (The flutter introduced by the tape is negligible.) Flutter test tapes are listed in the following table.

Speed	*Catalog No.*
3¾ ips flutter test	01-31336-01
7½ ips flutter test	01-31326-01
15 ips flutter test	01-31316-01

The level set tapes are used to properly set the reproduce level of a tape machine when calibrating the record portions of the machine or when the machine is to be used in conjunction with other equipment that requires a specific input. These tapes are recorded at "normal" operating level and are listed in the following table.

Speed	*Catalog No.*
3¾ ips 500 cps level set	01-31335-01
7½ ips 700 cps level set	01-31325-01
15 ips 700 cps level set	01-31315-01

The test tapes are valuable tools for ensuring proper operation of the equipment, *but only if the tapes are cared for properly.* Like any prerecorded tape, the test tapes are sensitive to magnetic fields, which if sufficient in intensity, will erase or partially reduce the carefully adjusted magnetic orientation of the tape coating, those rendering the tape useless.

The area in which the test tape is to be used *or* stored should be surveyed for equipment which might set up fields of a nature which might affect the accuracy of the tape.

The high frequency signals of the tape can also be partially erased by a record, reproduce or erase head, or a tape guide which is strongly magnetized. Moreover, accurate reproduction of the signals on the test tape is not possible when used with a magnetized head. To preclude any possibility of this type of damage, the heads *and all metallic objects in the tape path* should be demagnetized before using the test tape.

The tape should be stored away from hot radiators, amplifier chassis, or electric lamps which might cause the tape to deform. Wherever possible, the tape should be stored on edge. In hot weather, a tape laid flat will tend to "settle" to the lower side of the reel causing an edge "wrinkle," which is conducive to flutter.

BASIC CONCEPTS OF MAGNETIC TAPE RECORDING

Fundamental Theory And Design Considerations For Professional Audio Equipment

FOREWORD

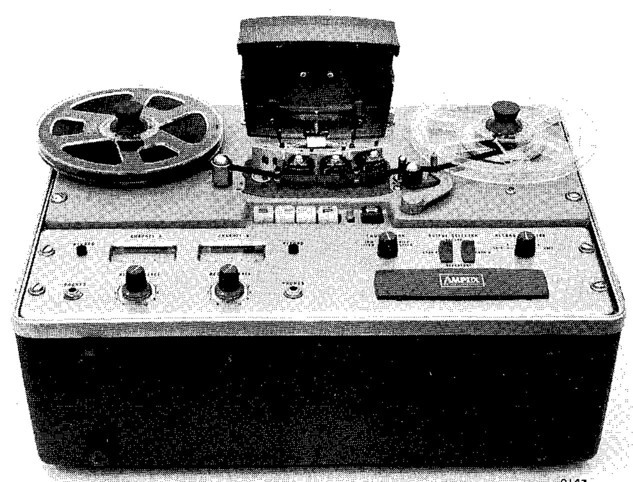
This discussion is intended only as an introduction to magnetic tape recording, an attempt to explain the fundamental theory in the simplest possible terms. As in any such endeavor there will no doubt be areas which are over-simplified, and in these instances it is requested that you remember the basic objective stated above.

Information presented here was obtained from various sources by the Technical Publication Section of AMPEX PROFESSIONAL PRODUCTS CO., Audio Division. Included in the Appendix is a bibliography which lists the published works used. Other sources utilized were AMPEX Engineering Reports (not available for general distribution), and personal interviews with AMPEX engineering personnel.

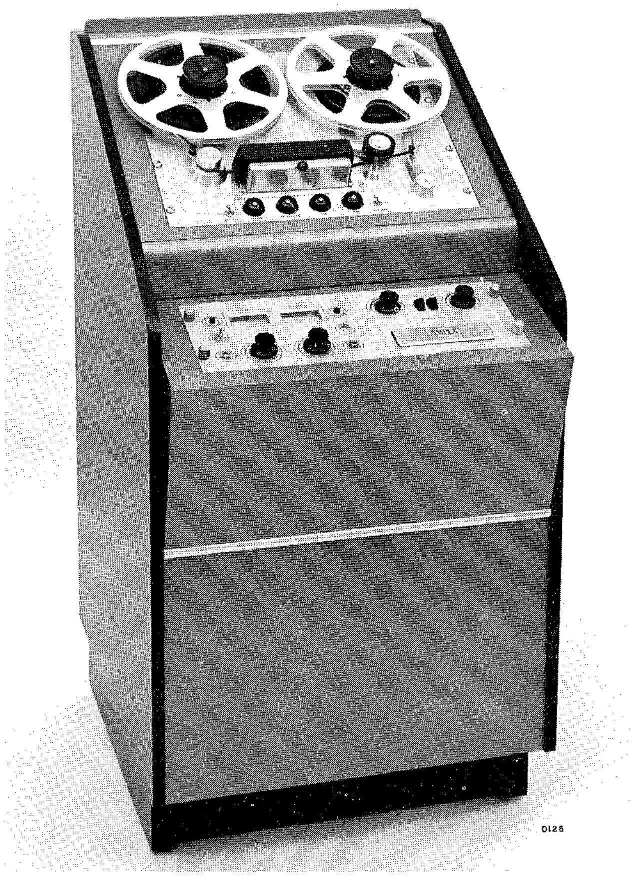
GENERAL

Let it be understood to start with that you are not going to be bored by the long, drawn out, discussion of the history of magnetic recording which is the seemingly inevitable preface to any attempts to explain the basic theory of this process. But it seems pertinent to point out that the first patent on a magnetic recording device was issued some 60 years ago, and it was originally anticipated that its main use would be in the telephone and telegraph industries. So magnetic sound is not a recent innovation.

It is also interesting to note that probably the first magnetic recorder to use tape (steel tape, that is) instead of wire as the recording medium was developed for a motion picture application. About 1920 a British producer named Louis Blattner acquired patent rights to manufacture magnetic recording equipment for use in the entertainment field. His machine, the "Blattnerphone," supplied synchronous sound for some of the first talking pictures in England.



Typical professional quality recorder/reproducer in portable case. Ampex Model PR-10-2 fits either a portable carrying case or will mount without modification in a normal 19-inch rack.



A console mounted Ampex Model 354, two channel recorder/reproducer.

WHY MAGNETIC TAPE?

There are many advantages to recording on today's high quality magnetic tape, using professional grade equipment. No other device can offer comparable fidelity of reproduction. Tape provides the convenience of immediate playback without processing, and the economy of being able to erase and re-record. It furnishes a large storage capacity in a minimum space. Technically one of its greatest attributes is a gradual overload characteristic which exacts a minimum penalty for slightly incorrect record level adjustments. Audio recordings can be stored indefinitely or replayed thousands of times with no deterioration of signal. And tape still is the only practical means of recording professional quality stereophonic sound; though two track discs are used extensively in home music systems, the original master recordings for those discs are made on tape.

Magnetic recording has made possible the presentation of three, four, and six channel sound in the motion picture theater. In this instance, of course, the magnetic material is striped on film rather than on the usual plastic backing.

BASIC COMPONENTS OF A MAGNETIC TAPE RECORDER

Magnetic Tape

Modern magnetic tape consists of a plastic backing, on which is deposited a layer of magnetic material consisting of iron oxide particles suspended in a synthetic resin binder. The iron oxide material is the actual magnetization medium, and since it is in the form of minute particles the recording process must depend on the size, shape, orientation, and uniform distribution of these particles on the tape.

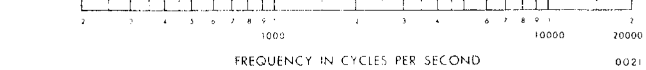
Manufacturers have greatly increased the quality of magnetic tape over the past few years, but it remains true that variations in magnetization within individual wavelengths will occur. The magnitude of these variations will depend on the factors noted in the preceding paragraph.

A random packing density of the oxide particles will impose a random variation of amplitude of a recorded signal, which will appear as noise in the reproduced output. In high frequency applications, where only a surface layer of the tape is involved, the signal-to-noise ratio will be particularly affected.

If the backing which supports the medium is not uniform in thickness, it will create variations in the deposit of oxide coating at the base. In low frequency work the under layers assume importance and such variation in coating will, again, be reproduced as noise.

Any lack of uniformity in the coating implies a lack of perfect flatness at the tape surface, so separation of the tape from the heads will vary. This will affect the output capabilities (see Frequency Response). Suitable polishing of the tape after manufacture will reduce this variation, and some manufacturers are now pre-polishing their professional grade tape. This polishing also minimizes head wear for equipment that will continually run new tape, such as duplicating systems for the commercial recording industry.

Tape width variations can also cause trouble when



The difference in response between polished (curve A) and unpolished (curve B) tape is indicated on this graph. Readings were taken using new tape from the manufacturer (B) and again after mechanical polishing by running the oxided surfaces against each other (A).

the clearance on guides is limited to minimum figures to obtain extremely accurate guiding. If the width of the tape then exceeds tolerances, the guides will bow the tape, and it will again be lifted from contact with the heads. Slitting the tape must, therefore, be rigidly controlled.

The binder material must be wear resistant. This is not primarily a matter of ensuring the durability of the recording, but rather is to minimize oxide deposits on components in the tape threading path (see Cleaning). Of course, if the binder breaks down sufficiently to cause signal drop-outs it would affect the durability, but this will be encountered normally only after prolonged use at high tape speeds not usually employed in audio work.

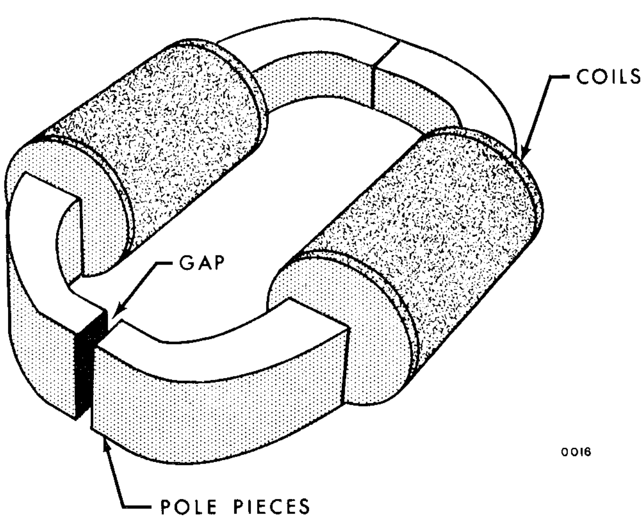
There are several considerations concerning the iron oxide particles which affect tape characteristics. These include the size and shape of the particles, and their physical orientation so that the axes of easy magnetization are longitudinal to the direction of recording.

In addition to all the above, tape must be strong enough to withstand the stresses it will undergo in normal operation, and pliable enough to follow the required turns in the tape threading path.

Recognizing that the quality of magnetic recording is today limited by the properties of the tape, not the equipment, AMPEX recently entered the tape manufacturing field. It is felt that the association of AMPEX and its subsidiary — Orr Industries Co. — will result in definite improvements in the art of magnetic recording.

Heads

No assembly in a magnetic recording system is more important than the heads, which convert the electrical current to a magnetizing force during the recording operation, then reconvert that magnetism to an electrical current during the reproduce mode. Professional quality equipment employs three separate heads — erase, record, and reproduce — each especially designed to perform its specific function.



Construction of a typical magnetic head.

Recording

The operation of the record head is essentially the same as that of an electro-magnet. If we insert a core of permeable material within a coil of wire, then run a direct current through that wire, we can set up an intense magnetic field that will attract any nearby material that is capable of being magnetized. If instead of the direct current, we use an alternating current, we would first attract then repel that material (at a rate controlled by the frequency of our a-c) until it assumed a position that was neutral in respect to the alternating field.

In a magnetic recording head the core is shaped like an incomplete ring — the discontinuity forms the head "gap" — which is inserted within a coil of wire. When the signal to be recorded is converted to an electric current and passed through the coil, a strong magnetic field is created across the gap. If we now pass our magnetic tape across the gap, the iron oxide particles in the tape will be magnetized in a pattern which is a function of the instantaneous magnitude and polarity of the original signal. Understand here that these particles do not physically move, but are simply magnetized by the flux at the head gap so that each individual particle contributes to an overall magnetic pattern.

The wavelength of the signal recorded on the tape depends upon how far the tape moves during each complete alternation of the signal current. For example, if we were recording 60 cycles at 15 inches per second, each cycle would be recorded on a 0.25 inch segment of the tape; if our frequency were 6000 cycles and our tape speed 7½ inches per second, each cycle would be recorded on a 0.00125 inch segment of the tape. Such computations may be continued for any frequency at any tape speed by simply dividing the tape speed (in inches per second) by the frequency (in cycles per second).

This brings up a point that sometimes confuses individuals accustomed to considering wavelength and frequency as being practically synonomous terms — that a certain wavelength can denote only one frequency or vice versa. This cannot hold true on any device which employs a moving medium to store the information. For example, say we record a frequency of 10,000 cycles at a tape speed of 15 ips. If we reproduce that tape at the same speed we will re-create our original signal; but if we reproduce the tape at 7½ ips the same wavelength on the tape will result in a signal of only 5,000 cps, if our reproduce speed is 3¾ ips our signal will be 2,500 cps. Similarly, if we record 10,000 cps at 15 ips the wavelength is 1.5 mils, if we record the same signal at 7½ ips the wavelength is .75 mil, at 3¾ ips the wavelength is .375 mil. Thus, wavelength may vary for a constant frequency and frequency may vary for a constant wavelength, dependent on the speed of our medium.

In magnetic recording such differentiation is important. Certain losses — such as amplifier response, self-resonance of head windings, eddy current losses in head cores, etc. — are frequency-dependent losses. Others — reproduce gap losses, head-to-tape spacing losses, tape thickness losses, etc. — are wavelength-dependent losses.

Erasing

Our major purposes in erasing are to obliterate any prior recording and to leave the tape quiet, so that it may be used again and again for different programs. Permanent magnets will do the erasing job, but it is difficult to prevent these devices from magnetizing the tape in one direction — a single pole on the magnet would magnetize the tape to saturation, and a high noise level would result in the subsequent recording. The common practice, therefore, is to subject the tape to an a-c field which gradually increases to a maximum magnitude, then gradually decreases to zero.

The erase head functions exactly the same as the record head, but it is constructed with a relatively large gap — which allows the flux to leak out over a relatively large longitudinal area in the tape path We send a high frequency a-c signal to the head. As a point on the tape approaches the gap, the alternating magnetic field gets stronger and stronger until a maximum magnitude is reached directly at the gap. Then as the point recedes from the gap, toward the record head, the field grows weaker and weaker until it disappears. Remember here that we are talking of relative distances, and the erasing field will disappear before our point on the tape approaches the record head.

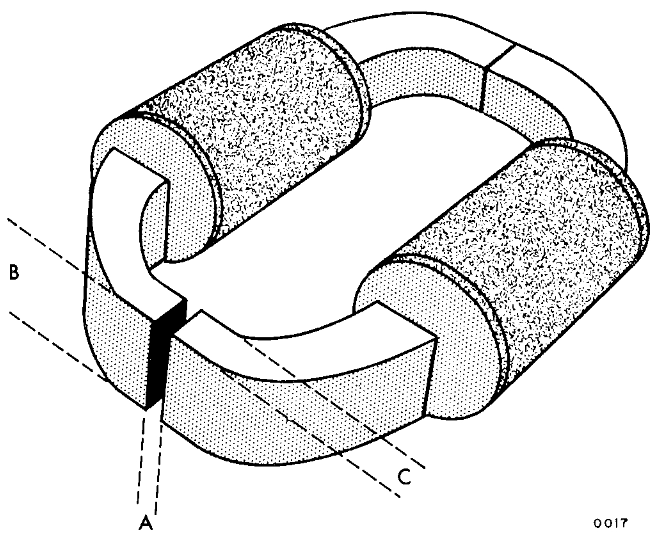
Magnetic reproducing equipment in the motion picture theater. Ampex installation along the far wall (at Warner Theater, New York City) provides six channel stereophonic sound.

Reproducing

Although the reproduce head is constructed almost the same as the record head, it functions more like an electric generator. When we move a conductor through a magnetic field, as we do in a generator, we induce in that conductor a voltage whose amplitude and polarity are functions of the magnitude and direction of the magnetic field. We can, of course, achieve the same results by passing the magnetic field across a stationary conductor, as the only requisite is that the conductor must cut the lines of force. (Note here that, assuming a constant field, the amplitude of the induced voltage is dependent upon the speed with which the conductor cuts the lines of force.)

Similarly, when we move the recorded tape past the gap in a reproduce head, the magnetic flux on the moving tape will induce a voltage in the head coil. This induced voltage will be proportional to the number of turns of wire on the head coil, the permeability of the core material, *and the time rate of change of the magnetic flux.*

Assuming a constant tape speed across the head, the last factor means that the output of a given reproduce head will increase directly with frequency (as frequency rises there is a greater rate of change of flux across the head gap for a given tape speed).



Head gap terminology used in this discussion (A) gap length (B) gap with (C) gap depth.

In reproducing information from a recorded tape, one important factor is the dimension of the reproduce head gap. We have seen that the magnetic flux on the moving tape induces a voltage in the head coil; but what actually occurs here is a little more complex than that simple statement implies.

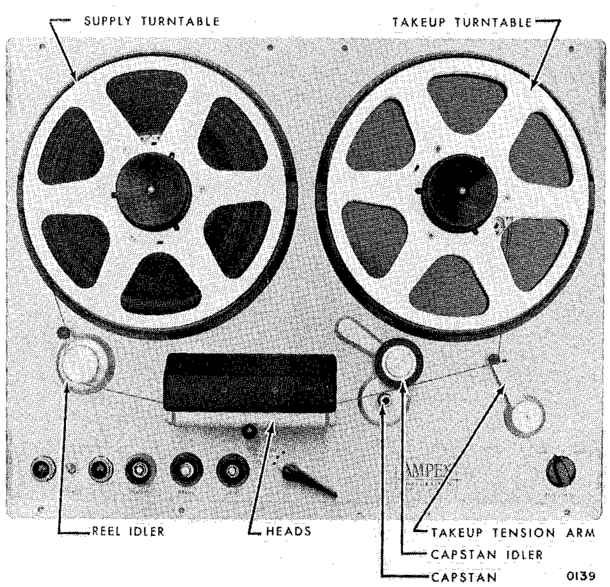
Actually, the flux must travel to the coil through each branch of the head core (forced into that path by the high reluctance of the gap) and must result in a voltage differential across the coil if a current is to be created. Therefore, an instantaneous *difference* in the magnitude of the moving flux must exist across the head gap. This means that the gap must always intercept less than one complete wavelength of the signal recorded on the tape (see High Frequency Response). However, if the gap is too small the flux will not be forced through the core to the coil, and signal level will be reduced. An optimum design, tailored to specific requirements of frequency response and level is thus necessary.

Tape Transport — General

The function of the tape transport is to move the tape accurately across the heads at a precisely constant rate of speed. We can consider that all tape transports consist basically of three major divisions — first a tape supply system, then a tape drive system, and finally a tape takeup system. These divisions can be likened to two reservoirs with a pumping station between them that removes material from one reservoir and adds it to the other. Most professional quality equipment employs three motors (or their equivalents), one each for the supply system, drive system, and takeup system; however, if weight or volume is important (such as in portable machines) high quality results can be obtained by using one motor to drive the tape and employing mechanical coupling to the supply and takeup turntables.

Supply and Takeup Systems

Usually, the tape supply and tape takeup systems can be considered as identical assemblies, with the only probably differences being in the brake configuration and the connection to the power source. Torque motors (or their equivalent) are used to drive the turntables directly. These motors are connected to rotate in opposite directions when power is applied — the supply motor opposing and the takeup motor supporting the normal direction of tape motion.



Typical professional quality tape transport showing the top components on an Ampex Model 300.

In the record and reproduce modes these motors act simply to maintain proper tape tension and have no influence on tape motion, which is controlled entirely by the drive system. During this operation the supply motor imparts tension by opposing tape motion, while the takeup motor attempts to turn slightly faster than necessary to wind in the tape from the drive system.

In the fast winding modes of tape travel, the reel motors *do* control the tape motion. Here one motor is operated under full power and the other with reduced power; the greater torque of the motor under full power overcomes the lesser opposing torque and tape is simply pulled from one reel to the other, again under correct tension.

The Drive System

The drive system utilizes a synchronous motor coupled either directly or through a pulley arrangement to the capstan. The circumference of the capstan and its rotational velocity determine the speed of the tape in the record and reproduce modes.

While tape *speed* is a function only of the capstan, tape *motion* in record and reproduce is instigated when a capstan idler (sometimes called a pressure roller) clamps the tape between the capstan and itself, thus providing a surface against which the capstan can drive the tape. The capstan idler is normally coupled to a solenoid, which in turn is actuated by the play switch. This arrangement allows a "fast start" condition in which the capstan motor is operating whenever power is applied to the equipment, and tape can be quickly brought to full speed whenever the play switch is pressed.

Head-to-Tape Contact

Good head-to-tape contact and proper placement of the tape on the heads is extremely important. An inherent characteristic of magnetic tape recording is that the effective recording or reproducing of a signal on magnetic tape deteriorates with any spacing between the tape and heads. Thus, any loss in good head-to-tape contact will result in impaired performance — in recording there will be signal drop outs, in reproducing there will be a loss in frequency response.

Tape Tracking

If the tape does not track correctly across the heads, frequency response, phasing, and level will be affected. Two guides will thus bridge the head assembly. In professional quality equipment the positioning of the guides will ensure good head-to-tape contact and the accurate placement of the tape.

*Tape Transport — Detailed Discussion**

Flutter and Wow

Flutter (or wow) is the amount of deviation from a mean frequency, caused by anything in the system that will affect tape motion.

*From "Multichannel Recording For Mastering Purposes", Journal of the A.E.S., October 1960.

For instance, to consider an exaggerated example, if we were reproducing a sustained 1000-cycle tone at a tape speed of 7½ inches per second and that speed suddenly dropped to 6 inches per second our tone would be reduced to 800 cycles; then as normal speed was again attained the tone would return to 1,000 cps.

Differentiating between flutter and wow has historically been difficult, but speaking generally we can consider that flutter consists of components about 6 or 7 cycles per second, with wow components falling below that figure. (Normal flutter will extend to approximately 250 cps, but tape scrape flutter is usually about 3500 cps.) Flutter and wow can result from anything that affects tape motion; although the drive system of a transport is most commonly blamed it is not always at fault.

Drive Requirements

Designing a drive system usually entails a compromise between low flutter requirements and the amount of money we can expect in return. There are ways and means of producing transports that exhibit extremely low flutter; the accomplishment, however, is accompanied by a high price. These ultra precision drives are usually employed only in certain instrumentation and data type recorders, with the cost precluding their use in other than very special applications.

CAPSTAN ASSEMBLY — First, the capstan shaft. A small, round shaft seems quite simple and harmless, but it can be a real troublemaker. It must be round within small tolerances (0.2 mil) and mounted in its bearing it must exhibit minimum "run-out" (again, 0.2 mil) at the tape contact point. The shaft must be corrosion resistant, and sufficiently hard to withstand wearing.

The diameter of the capstan should be large enough to hold tape slippage and creep to a minimum, with a compromise normally necessary between the diameter and the speed of the shaft. For a given tape speed an increase in diameter demands a decrease in rotational speed, which in turn requires more flywheel.

We generally will use as much flywheel as the drive motor can handle while maintaining sync; this is simply a matter of filtering any cogging of the drive motor, or other irregularities. As the mass of the flywheel increases, its efficiency in damping out high frequency irregularities improves, but it might start to accentuate low frequency disturbances. If this occurs we must provide some damping arrangement — for example, silicone coupling between the shaft and flywheel.

DRIVE MOTOR — The drive motor must be of the synchronous type in order to maintain the necessary speed accuracy. Hysteresis synchronous motors are usually employed rather than salient pole (reluctance) types, although the latter is less expensive and provides as good results insofar as flutter is concerned. The reason for this preference is that the hysteresis motor will sync a greater mass and thus can handle a larger flywheel.

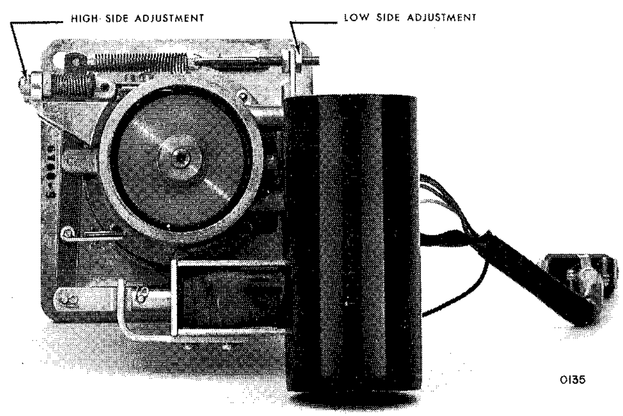
Supply and Takeup Assemblies

When motors are used in the supply and takeup assembly they are usually of the induction type, with high resistance rotors. Reel motors must be as free from cogging as possible, because cogging in the hold back system has been responsible for many flutter problems that have been blamed on the drive assembly. It would be nice if we could discover a reel motor whose torque would change with the tape diameter on the reel, thus providing a constant tape tension throughout the reel of tape. (Many constant tension devices have been used in the past, but those designed for audio equipment have not been too successful.)

AMPEX is now using eddy current clutches on the turntables of some of the latest recorders. These devices provide completely cog-free operation (dependent only on a well-filtered d-c supply voltage) and thus result in improved flutter and wow. There are no commutators or slip rings, therefore no replacement problem, and no rf interference is generated. Faster start times are realized because of the small mass, and an associated low inertia, when compared to the rotor of a conventional torque motor.

The brakes, generally associated with the turntable assemblies, can be either of the mechanical or dynamic type. At AMPEX, the feeling has always been that mechanical brakes are superior. With mechanical brakes, a self-limiting — or at least a non-energizing — configuration should be used. Energizing type brakes that are not limiting will give quite different braking forces as the coefficient of friction changes with variations in temperature and humidity.

Another consideration in designing the brake system is the differential. This differential, as applied to magnetic tape recorders, means the difference in braking force that exists between the two directions of turntable rotation — with the greater force always acting on the trailing turntable (in respect to tape motion). The differential is expressed as a ratio,



Typical mechanical brake assembly as used by Ampex, showing the two adjustment points.

which is chosen to prevent excessive tape slack being thrown in the stopping process from the normal or fast winding modes of operation.

Reel Idlers

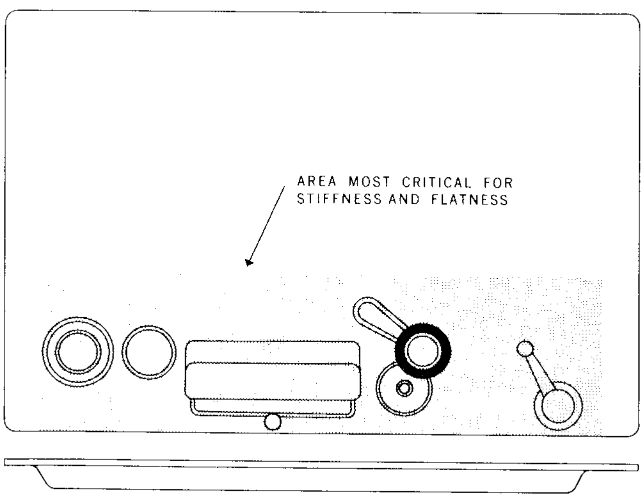
The main purpose of the reel idler is to isolate the heads from the disturbances originating in the supply motor, by tape scraping against the reel flanges, by splices as they leave the reel, or by tape layers slipping as the reel unwinds. (This last effect may be quite prevalent if tape is wound so fast that air is trapped between the layers, thereby producing a very loose pack.)

While the reel idler minimizes such disturbances, we must use care or we will create more flutter than we eliminate. Reel idlers should have minimum run-out, bearings must be selected for low noise and smoothness of operation, and flywheels must be dynamically balanced to close limits. And the diameter of the idler and the tape wrap around it must ensure positive coupling between the tape and the idler. As with the capstan flywheel, a damping arrangement might be necessary.

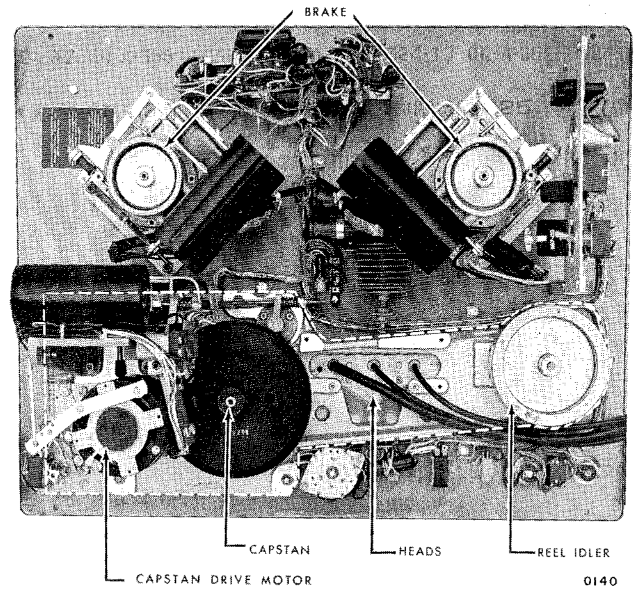
Mounting Plates

Mounting plates should be sufficiently rigid to maintain a natural resonance above 300 cps — or notably higher than the 60 and 120 cps exciting frequencies which emit from torque motors and drive motors. This rigidity is most important in the area surrounding the reel idler, heads and capstan; any flexure in this area will cause flutter.

Of course, another reason for a rigid mounting plate is to hold alignment between the various components that control the tracking of the tape. This is more important on ½-inch tape or 1-inch tape than it is with ¼-inch.



The most critical area of the transport for rigidity and flatness is shown by the shading.



Back view of a typical professional tape transport. Dashed line indicates heavy mounting casting employed in area where rigid construction is critical. (Ampex Model 300.)

Tape Guiding

Next to flutter, our most difficult problem of tape transport design is the tape guiding. Certain design rules must be followed. All components in the tape threading path must be kept in accurate alignment — this means maintaining exacting tolerances on the perpendicularity and flatness of all such components (turntables, reel idlers, heads, capstans, etc.)

The capstan idler must hit the capstan squarely, or the tape will be diverted up or down. Tape guides, either rotary or fixed, should not be too small in diameter, and guide widths must be held to close tolerances — normally not more than 2 mils over tape width and preferably less. (Tape itself is slit to a tolerance of 0 to 6 mils under the nominal dimension.)

Tape guiding problems are multiplied when we use thin base tapes. This is caused by the loss of stiffness at the edge and because we must use lower tensions with this type tape.

Incidently, if we have a well designed tape transport that has received good maintenance and suddenly have tracking problems, we can suspect the tape itself. A quick check on the tape is to stretch out an approximate three foot length beside a straightedge. If it does not line up with the straightedge it has been poorly slitted, or stored on a poorly wound reel, and the best thing to do is dispose of it — quickly!

Takeup Tension Arm

The main duty of the takeup tension arm is to act as a tape storage loop and thus takeup any tape slack that occurs during starting. It also usually incorporates a safety switch that automatically stops operation when tape is exhausted from the reel, or if the tape breaks.

Operational Requirements

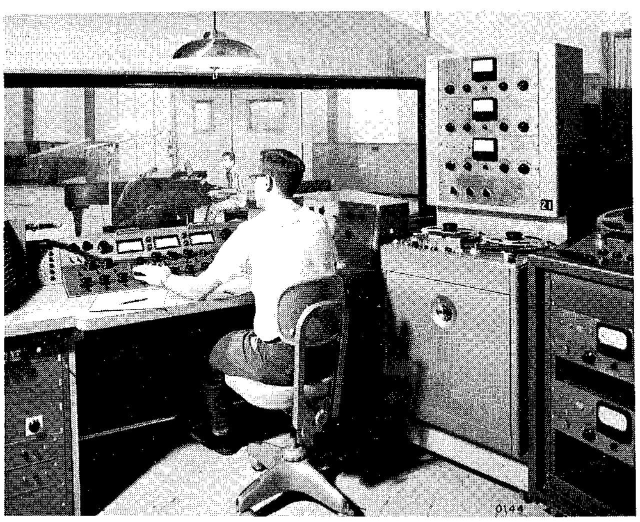
We must provide adequate torque for the fast forward and rewind modes, with the actual torque requirements varying with the tape width. But we must bear in mind that excessive torque might result in our exceeding the elastic limits of the magnetic tape, and result in breaking or deforming the tape.

The tape must be stopped without damage. The elastic limit of the tape again determines our maximum braking force. Since a minimum brake differential must be maintained, this factor also determines our lower braking limit.

We must also have reasonable start and stop times.

Therefore, we must provide optimum torque and braking force, adequate for fast winding and acceptable start and stop times, but which will not exceed the elastic strength of our medium. Typical values for a ½-inch tape equipment would be 35-40 ounce-inches of torque, with a maximum braking force of approximately 30 ounces, measured on a 2¼-inch radius (N.A.B. reel hub).

TAPE THREADING — From the human engineering standpoint, tape threading paths using the wrap-around principle are superior to those utilizing a "drop-through-the-slot" type. The utmost efficiency in threading tape would be provided by a transport that had a simple wrap-around path from supply reel to takeup reel, with no necessity for threading behind idlers, guides, etc. Unfortunately this perfection is impossible of achievement — although it can be approached — because of the necessity for threading the tape between the capstan and the capstan idler. Of course, a transport employing a system of self-threading, with reels compatible with those now existing, offers a definite improvement. The threading path can then be engineered for optimum performance of the equipment, disregarding the human equation.



Magnetic equipment in the recording industry. Ampex Model 300-3 installed at United Recording Studios, Hollywood.

TAPE WRAP — The amount of wrap-around the heads should be held to a minimum, because the build-up of tape tension will increase with the degree of head wrap. Depending on the flexibility of the tape and the geometry of the head, it is possible that a large tape wrap will result in the tape bowing out at the apex of the head and losing contact at the gap. A wrap of 4 to 6 degrees on each side of the head gap has proved quite satisfactory.

Large tape wraps (in degrees) around small diameters should be avoided. This is not only a case of holding tension build-up to a minimum. While there are no qualitative data available *it has been proved that sharp bends around small diameters result in measurable losses of recorded high frequencies during the first three or four playbacks.*

Tape wrap around the reel idler must be sufficient to ensure a good, solid coupling between the tape and the idler. On AMPEX machines operating at 60 and 120 ips, it has been necessary to groove the tape contacting area of the idler pulley so that the air film is dispelled and good coupling is ensured. The effect of insufficient coupling can be seen in the fast forward or rewind modes of a standard recorder; the air film picked up by the fast moving tape acts as a cushion and the idler barely turns. The air film can be advantageous if we wish to operate in a fast winding mode without mechanically lifting the tape from the heads, but it proves quite troublesome at times (especially when we are trying to get a good pack during a fast winding mode using 1-inch tape).

DRIVE LAYOUT — The heads, capstan and capstan idler should be arranged so that the tape from the heads first contacts the capstan not the idler. In those layouts where the tape from the playback head contacts the idler before reaching the capstan, there will be flutter — caused by idler run-out, by variations in the hardness of the rubber around the periphery, and by bumps or voids in the tire.

NUMBER OF COMPONENTS — The number of tape contacting components should be be held to a minimum, because every additional part means more build-up in tape tension. This build-up is a function of the number of tape contacting components, the degree of tape wrap around each, and their surface roughness. The geometry of the layout must eliminate unnecessary guide posts, idlers, etc. Tension build-up can also be reduced by mounting the necessary components on ball bearings, or on other types of low torque bearings.

Electronic Circuits

There are three main electronic circuits which usually are provided — a record amplifier, a bias and erase oscillator, and a reproduce preamplifier. These will normally be quite conventional audio

Typical two channel electronic assembly. Ampex Model PR-10-2 professional recorder/reproducer.

circuits, except for certain minor modifications made necessary by the special application. (Note here that such necessary items as line amplifiers, power amplifiers, loudspeakers, microphones, mixers, etc., are not considered part of the magnetic recorder.)

Record Amplifier

The function of the record amplifier is to present to the record head a signal current of proper amplitude for the recording process. The record head is essentially an inductance whose impedance will vary directly with frequency. The magnetizing force is directly related to the amount of current which flows in the head coil, so high frequencies would suffer if the rising impedance of the head coil at the higher freguency were allowed to decrease the current flow appreciably. Therefore, the output circuit of the amplifier will present a relatively high resistance in respect to the head coil, which will now have a minor effect on the complete circuit; a virtually constant current condition is thus maintained regardless of the frequency involved.

In order to further ensure proper recording of high frequencies, the record amplifier also contains a pre-emphasis circuit which essentially provides more amplification as frequency rises. Because the reproduce curve has been standardized, the pre-emphasis circuit is adjustable to reproduce a flat overall response when the reproduce amplifier is set on the standard curve.

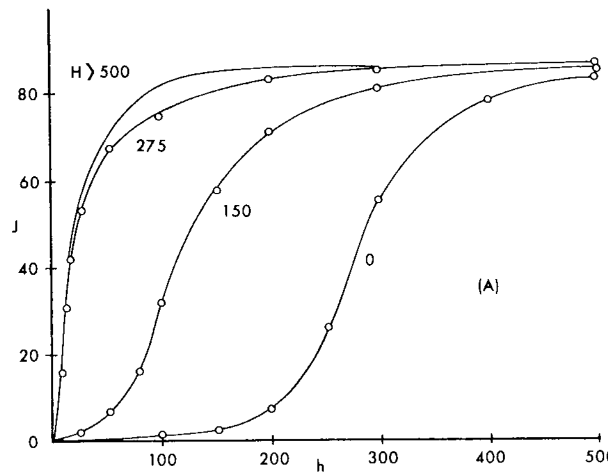
A-C Bias

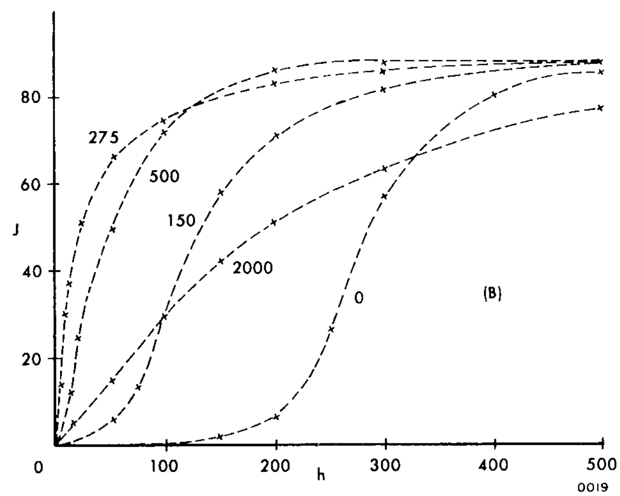
The normal magnetization curve of any ferromagnetic material is extremely non-linear, with the slope near the point of origin practically zero. Theoretically we should be able to record in this region with no correction (it is sufficiently linear) by maintaining signal amplitude at a sufficiently low level. However, such a recorded signal would be so small that the signal-to-noise ratio would be unacceptable.

By using carefully chosen values of d-c bias we can utilize the approximately linear portion of the curve in recording a limited range of alternating signal amplitudes. But lower basic noise and more linear results over a greater range of signal levels can be accomplished by using an a-c bias voltage. The frequency of this a-c bias is not critical, but it should be several times that of the highest signal frequency (in AMPEX audio equipment the bias frequency is normally 100 kc).

Fundamentally, biasing with an a-c field is similar to a long-known method of achieving an "ideal" (or "anhysteretic") magnetization. In this method, an alternating field of high amplitude is superimposed on an unidirectional field, then the amplitude of the alternating field is gradually reduced to zero. The result is a remnant magnetization that is a linear function of the unidirectional field. The maximum amplitude of the alternating field is unimportant as long as it exceeds a certain level, and the final state of magnetization will depend only on the value of the unidirectional field when the alternating field strength falls below a certain level.

If we assume that *while a point on the moving*



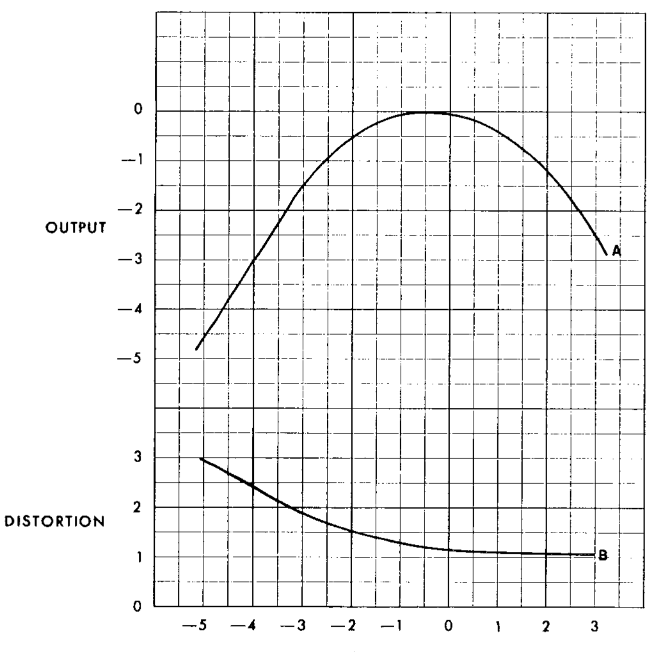


Anhysteretic intensity of magnetization (J) is plotted against the unidirectional field strength (h) for various amplitudes of a-c bias in this chart. In (A) the bias field was reduced while holding the unidirectional field constant. In (B) both fields were reduced simultaneously. Note in (B) that increasing the bias field beyond a certain value decreases the intensity of magnetization.

tape is within the gap of the record head it is subjected to a high frequency alternating field that is maximum at the center of the gap and decreases smoothly to zero on either side, plus a signal field that looks like an unidirectional field for that instant, we can see the degree of similarity that exists between the ideal magnetization method and an a-c biased magnetic recording.

As usual, however, there is one major area of difference. In the ideal method, the unidirectional field strength is held constant while the alternating field decreases to zero. In magnetic recording both fields reduce at the same rate as the point on the tape leaves the record gap, and the remnant magnetization on the tape will be determined by the signal strength when the bias reduces to the critical level. As a consequence, the remanent magnetization in recording, while linear, is always less than could be achieved by the ideal method. Another result is that the amplitude of the bias signal becomes important, because we find that the recorded level falls as the bias is increased beyond a certain value. This is explained by the fact that an excessive bias current can place the critical bias field strength well beyond the trailing edge of the gap, where the signal field strength is low. (Remember here that the only effective signal field is that which exists where the critical bias field is located.)

Using a-c bias, the output of the system can be peaked at any given frequency by the proper adjustment of the bias current. A complication arises in that the bias current necessary to achieve maximum output at low frequencies will result in a decreased output at high frequencies. We therefore adjust the bias at a given wavelength of the signal on the tape (see Record Bias Adjustment).



Typical output (A) and distortion (B) vs. bias current. Readings taken at 1000 cps at 15 ips.

Reproduce Amplifier

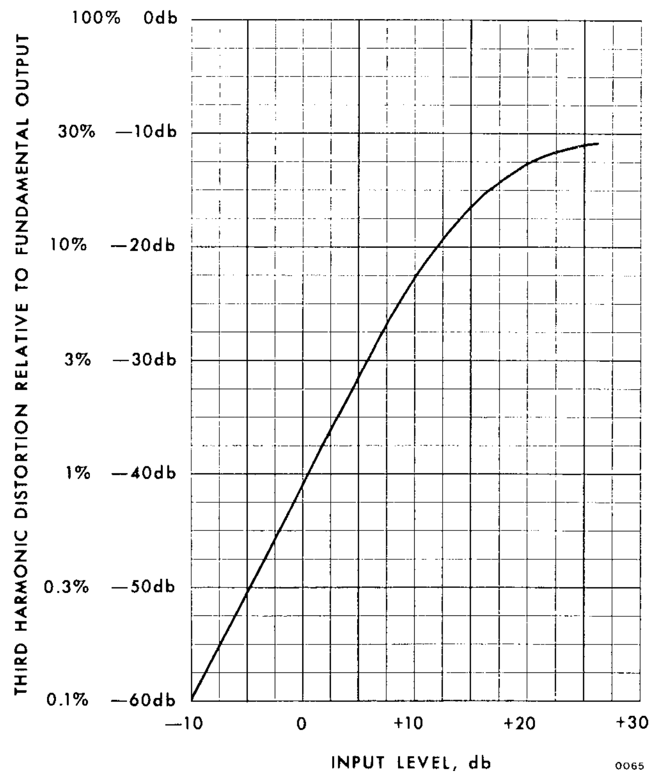
Preliminary amplification of the signal induced in the reproduce head is accomplished in the reproduce (or "playback") preamplifier. You will recall that the output of a reproduce head rises directly with frequency. This increasing output is at an approximate six db per octave rate (a very technical way of saying that the voltage output doubles each time the frequency doubles) so an opposite characteristic is required to obtain a flat overall frequency response.

An integrating amplifier, which attenuates rising frequencies at a 6 db per octave rate, is thus necessary for the reproduce function. The NAB standard curve incorporates this integrating amplifier modified by a rising frequency characteristic (or "post emphasis"). This post emphasis is achieved by an r-c circuit with a time constant dictated by tape speed and set by standards — for example, NAB standards for 7½ or 15 ips calls for a 50 microsecond time constant, which places the +3 db point at 3,180 cycles.

FACTORS IN DETERMINING IMPORTANT OPERATING CHARACTERISTICS

General

The most important operating characteristic in any sound storage device are low distortion, high signal-to-noise, good frequency response, and low flutter and wow. The last was thoroughly covered in



Typical third harmonic distortion vs. input level at 400 cps, measured at 15 ips. Distortion is plotted on a db scale to obtain a logarithmic function in linear steps.

the discussion of the tape transport, so we will treat the first three in this portion and then follow with additional factors encountered in stereophonic recording.

Distortion

Distortion in magnetic recording is a function of both the bias adjustment and the recording level. We have already seen the effect of the bias voltage near the point of zero magnetization on the tape (see Electronic Circuits) so in this we will cover only the effect of the recording level.

To achieve a maximum signal-to-noise ratio, we wish to record at the highest possible signal level. But as we increase our recording level we will eventually reach the point where any further increase has little effect in magnetizing the tape. We have "saturated" the medium, and any additional current in the record head will simply give distortion.

In distortion caused by over-recording, the odd harmonics will stand out, with the third harmonic predominating. Our prevailing standards define the *normal recording level* as the point where there is a 1% third harmonic content of the signal, and the *maximum recording level* as the point where there is a 3% third harmonic content.

Such a standard implies that the professional user will have equipment to adjust his recorder to meet these distortion specifications. It is rare that wave analyzers or distortion meters are available, therefore the calibration is usually made by using a standard tape (see Basic Adjustments).

Signal-To-Noise Ratio

Many factors complicate the signal-to-noise problem, some of them entirely beyond any control of the manufacturer of magnetic tape recorders.

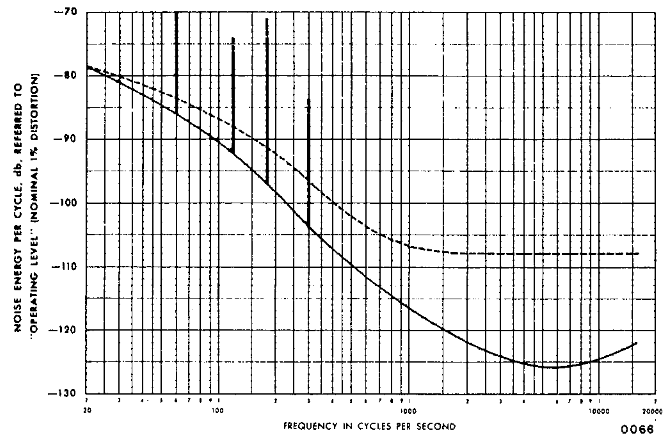
First is the tendency of both studios and "hi-fi" fans to reproduce music at a greater volume than that of the original source. This, of course, also increases the audible noise level.

Then there is the fact that the average loudspeaker is deficient in response, and directional at high frequencies. The deficient response sometimes results in the user increasing the high frequency energy electrically (with an equalizing circuit) during the recording process. This extra high frequency energy increases the problems that exist in high frequency overloading. The directional pattern at high frequencies means that, if the average high frequency energy throughout the room is to equal the energy at lower frequencies, the high frequency energy *on the axis of the speaker* is higher than that of the middle frequencies, and the audible noise level is increased. The noise coming from a small area is also more noticeable than if it emanated from a large source.

But probably the major complication is that the human ear is most sensitive to noise in the 1 to 6 kc area, and the noise below 100 cps must be very great before it is objectionable. The usual meter indication consists largely of the low frequency component of noise, which is inaudible; it is for this reason that a recorder which tests quieter than another on our normal measuring devices sometimes sounds noiser when we actually listen to it. (Significant noise measurements, therefore, can be achieved only by using a weighting network with an inverse response to that of the human ear.)

But these are things we cannot control. What *can* we do to get the best signal-to-noise ratio?

Our major limiting factor today is the magnetic



Typical spectral noise density of the system (dash line) and the equipment (solid line). Readings taken on an Ampex full track Model 351 at 15 ips. Noise spikes occur at 60, 120, 180, and 300 cps on both curves (that at 60 cps rises to —55 db and —57.5 db respectively). System noise taken with tape in motion, equipment noise with tape stopped.

tape. Our "system noise" (which includes the tape) is from 8 to 10 db higher than our "equipment noise". A theoretical study has shown that an improvement in the noise characteristic of the tape should be possible by decreasing the size of the oxide particles, and tape manufacturers are experimenting with this theory.

Assuming a given tape noise, we are mainly concerned with track width, track spacing (in multichannel equipment), tape speed, and equalization.

Track Width

Where the maximum signal-to-noise ratio is necessary, wide tracks are desirable, but there are certain limitations. Economically, the amount of tape used, and therefore the cost, increases roughly in proportion to the track width. Technically, beyond a certain track width it becomes difficult to maintain accurate azimuth alignment.

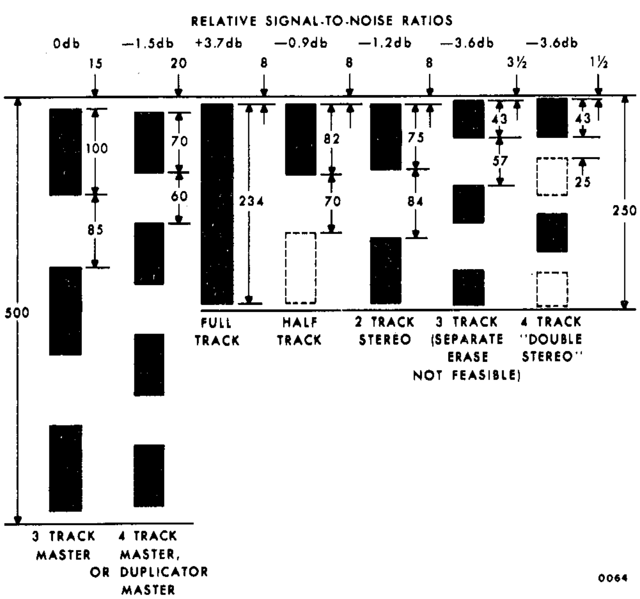
If the signal-to-noise ratio is determined by the medium itself, (the tape noise is at least 8 to 10 db above the equipment noise) then the signal-to-noise of the system is proportional to the square root of the track width.

So, just how wide should the track be? As the track width increases, closer and closer mechanical tolerances must be held to maintain the same linear alignment accuracy, which determines the azimuth alignment and therefore the high frequency response and stability. Experience has shown that, for 15 ips recording speeds, it is practical to maintain azimuth alignment for track widths up to 250 mils. (For lower speeds, say at 7½ ips, it is difficult to maintain azimuth alignment for tracks wider than 100 mils.)

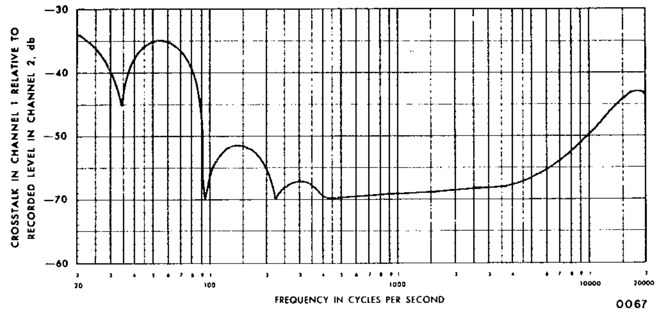
Remembering our practical economic considerations, we can put three 100 mil tracks, separated by 85 mils, on ½-inch tape (or six tracks on 1-inch tape). The three track, ½-inch, equipment is widely used in recording master tapes, and has been accepted as the best compromise between tape utilization and track width. Different configurations of track width and spacing, with the relative signal-to-noise ratios of each, are shown in an accompanying illustration.

Track Spacing

Two crosstalk effects are known to occur: At long wavelengths magnetic coupling occurs in reproduce between the signal recorded on one track and the

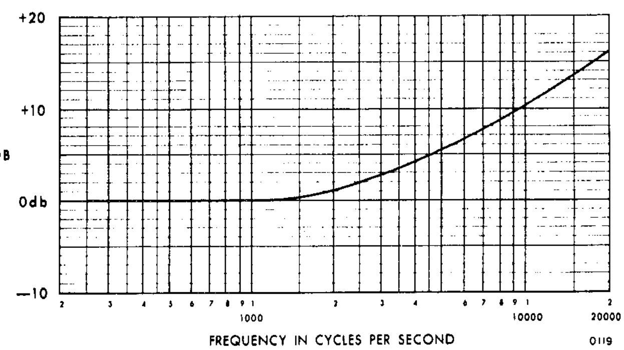


Normal record and reproduce head configurations used by Ampex, with relative signal-to-noise ratios in respect to the 100 mil track width. Dimension of six and eight track heads on 1-inch tape are the same as those shown for the three and four tracks on ½-inch tape. All dimensions are in mils.



Typical crosstalk vs. frequency curve on adjacent channels of an Ampex three channel Model 300. Channel 2 was recording at normal operating level and the record head of Channel 1 was connected. Normal bias and NAB equalization were used.

reproduce head of the other track. At high frequencies, the mutual inductance and capacitance between the two record heads causes the signal from one record head to be present in the other record head, and therefore to get recorded on that other track. Therefore spacing and shielding between cores is important in both the record and reproduce heads. Obviously the closer together the tracks the more coupling exists (assuming the same shielding). With good shielding, an 85 mil track-to-track spacing (used for Ampex ¼-inch two track, and ½-inch three track recorders) is a good compromise — more spacing to reduce crosstalk is unnecessary and would waste space, but any less would result in the increased crosstalk becoming audible above the noise.



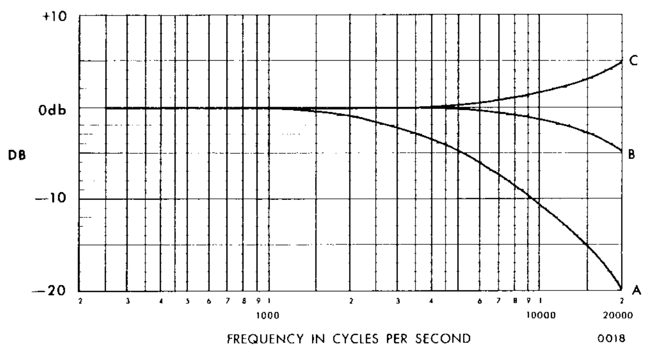
Standard NAB post-emphasis curve for 15 ips.

Equalization

Reproduce equalization has been standardized for some time, with the curve in general use specified by the NAB (standard equalization in Europe usually follows the CCIR curve). Any pre-emphasis curve, therefore, must be tailored to the standard reproduce curve.

It is the feeling at Ampex that the present NAB specifications are convenient curves, which give constant overall response through the tape machine using simple networks in both record and playback. The design at 15 ips has been very conservative with respect to overload capabilities, *but the signal-to-noise ratio has been inadequate.* Greater attention to the characteristics of the ear, the tape, and the music would provide a system with a greater signal-to-noise ratio.

AMPEX engineers therefore devised a 15 ips equalization known as AMPEX Master Equalization (AME) wherein a post-emphasis is designed to minimize audible noise, and then the pre-emphasis is employed to make the overall system flat. AME admittedly trades overload margin for a lower noise level, and must be properly used to obtain the intended results without distortion. It is intended for professional use, such as the recording industry, and is not to be considered as supplanting the NAB standard for publicly released tapes.

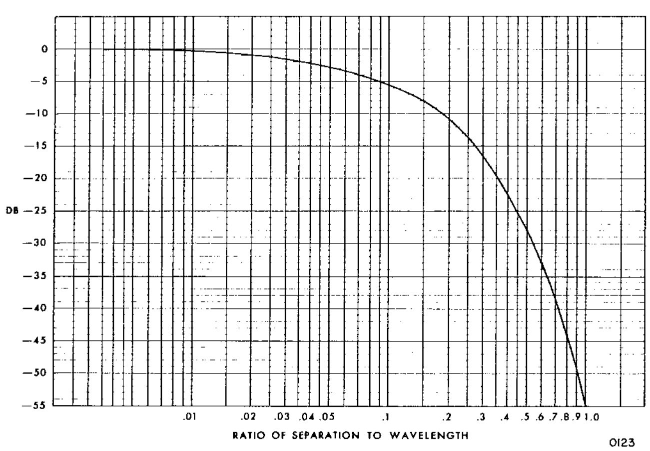


This graph shows how a flat overall frequency response is achieved. Curve A is an "ideal" record-reproduce response. Curve B is the result of adding the standard NAB post-emphasis to the ideal response. Curve C indicates the amount of record pre-emphasis needed to achieve flat response. As the post-emphasis curve is established as a standard, any deviation from the ideal response must be accompanied by a change in pre-emphasis.

FREQUENCY RESPONSE

Head-To-Tape Contact

A knowledge of the effects of losing good head-to-tape contact will help us realize the importance of



This curve indicates the result of poor head-to-tape contact as a function of the amount of separation and the signal wavelength.

maintaining good contact. The predicted loss in separating the reproduce head from the surface of the medium is 54.6 db per wavelength separation. Thus at short wavelengths, say ½ mil (15,000 cps at 7½ ips), it takes very little space to result in a 5 db loss in signal strength. When we remember that commensurate losses also could occur in the record mode, it becomes evident why good contact is a major consideration in achieving top performance in a magnetic tape recorder.

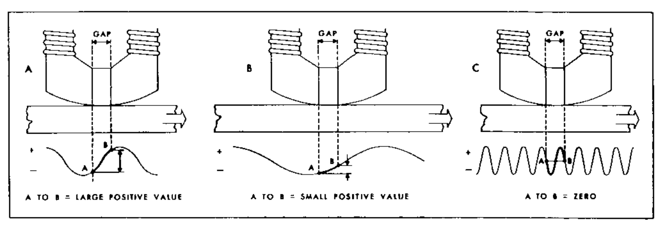
High Frequency Response

In audio applications, and at tape speeds normally used in professional work, the high frequency response is almost entirely limited by the tape and magnetic heads, in what are referred to as "wavelength losses". Despite numerous tomes attempting to explain these losses they are as yet not fully understood, and we would be presumptuous if we attempted any explanation on this plane.

As our high frequency requirement rises — in video or instrumentation applications — or as our tape speed is lowered, we enter a region where the dimensions of the reproduce head gap, and the resonant frequency of the heads become important factors.

Gap Effect

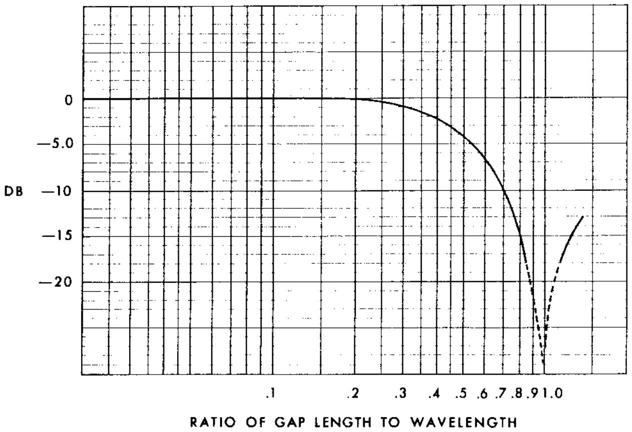
As shown on the accompanying diagram, when the recorded frequency rises to a degree where the reproduce head gap intercepts a complete wavelength of the signal on the tape, there can be no difference in flux magnitude across the gap, and the head output will be reduced to zero. Practically, this will occur at the "effective" gap length, which is slightly longer than the physical length. For all practicable purposes this effect causes the head output at this frequency and above to be useless.



In this illustration sinusoidal waveforms are used to denote the average state of tape magnetization and to indicate how the reproduce head gap derives a large output from a medium wavelength signal (A), a small output from a long wavelength signal (B), or no output when the wavelength equals the gap length (C).

Two methods may be employed to counteract this "gap" effect — either the gap can be made smaller or the record-reproduce tape speed can be increased. We can reduce the dimension of the gap only so far and retain adequate signal levels and realistic manufacturing tolerances; as this point is reached any further extension of high frequency response must be accompanied by a corresponding increase in tape speed.

The gap effect may be negligible when we are dealing with audio frequencies at 7½ or 15 ips tape speeds. For instance, the AMPEX reproduce heads have a gap of 0.2 mil, and the gap loss is unimportant at the wavelengths involved. However, at lower tape speeds, or for instrumentation or video applications where the high frequency requirements are greatly extended, it becomes a serious limitation.



The loss that occurs when the wavelength of the recorded signal approaches the length of the reproduce head gap is indicated on this graph.

Head Resonance

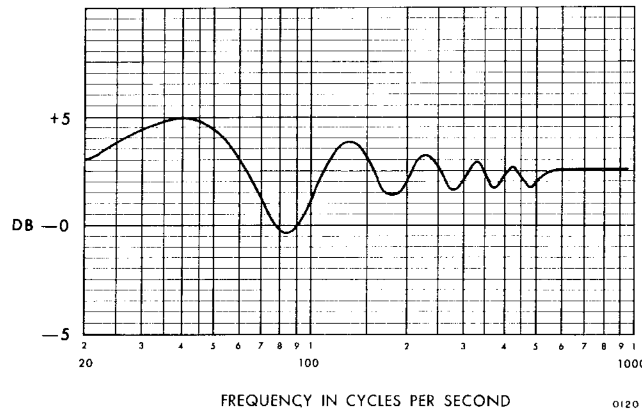
The coils of the heads are inductances which will resonate with lumped or distributed capacity in the circuit. At the resonant frequency of the reproduce head there is an increased output, but a sharp drop of approximately 12 db per octave occurs directly after this point. Thus the resonant frequency must normally be outside the pass band of the system, or placed (in video and data recorders) at the extreme upper limit so that it actually provides a shelf at the point of resonance to extend the response.

As circuit capacitance is reduced to an absolute minimum, only one way remains to place the point of resonance at a higher frequency, and that is to reduce the inductance of the head coil by employing a lesser number of turns of wire. A reduction in the number of turns, however, will reduce head output over the entire frequency range, so a compromise design must be provided.

Low Frequency Response

Low frequency response is almost completely a function of the effects generally known as "head bumps". This effect will occur in the reproduce mode at the low frequencies, as the recorded wavelength of the signal on the tape begins to approach the overall dimension of the two pole pieces on either side of the head gap. In effect, the two pole pieces now begin to act as a second gap, because they *can* pick up magnetic flux on the tape quite efficiently.

As our frequency decreases we may start to notice bumps and dips in the output of the head. The largest *bump* will occur when one-half wavelength of the recorded signal equals the combined distance across the two pole pieces, but there will be progressively smaller bumps at 1½ wavelengths, 2½ wavelengths, etc. Similarly the largest *dip* will occur when one complete wavelength of the recorded signal equals the distance across the pole pieces, and again there will be progressively smaller dips at 2 wavelengths,



Uncorrected head bump curve produced artificially by excessive tape wrap around an experimental reproduce head.

3 wavelengths, etc. So as our frequency goes lower and lower the bumps and dips will get bigger and bigger. Below the largest bump, at ½ wavelength, the output rapidly falls to zero.

It is interesting to note the similarity between the head bumps at the low frequencies and the gap effect at the high frequencies. When the head gap intercepts a complete wavelength we have no output; when the pole pieces intercept a complete wavelength we have a decline in output. The largest theoretical output occurs when the head gap intercepts one-half wavelength, there is an increase in output when the pole pieces intercept one-half wavelength. There is of course one great difference — *increasing* the tape speed diminishes the gap affected by spreading the signal over a greater length of tape, but *decreasing* the tape speed dimishes the head bumps by shortening the wavelength on the tape. At 15 ips tape speed the head bump is a rather serious problem, at 7½ ips the problem is reduced, and at 3¾ ips it has practically disappeared.

Good engineering design is the only way to alleviate the head bump situation. The physical configuration of the pole pieces and shields, and the angle of wrap of the tape around the head, can be designed so that the extremities of the pole pieces are farther from the tape and cannot pickup the signal so readily. An ideal solution, but rather impractical in today's compact equipments, would be to make the pole pieces so large that no problem would exist down to 10 or 15 cps.

In any event, the head assembly must be designed so that the head bumps occur at the lowest possible frequency, so that if possible no more than one smooth bump or dip is in the audio spectrum. We can then compensate for this in the electronic circuits.

Additional Factors For Multi-Channel Recording

For stereophonic recording we must add two additional factors — precise phasing between channels and adequate cross-talk rejection.

Phasing Between Channels

The directional quality of stereophonic sound, or of any sound we hear, is dependent on the ability of the brain to distinguish subtle differences in phase and intensity as sound waves arrive first in one ear and then the other. If, in storing and reproducing stereo sound, we destroy the normal phasing between channels, it will result in a most confusing end product.

When we are recording largely independent sources on separate tracks of the tape, phasing is not too much of a problem. When those sources are not isolated — for example, when we are recording an instrument on two channels simultaneously to achieve a center effect — it becomes more important. And when we are mixing and recombining in the recording industry to produce two channel tapes from a three channel master, it becomes quite critical.

Phasing between channels is a function of the alignment of head gaps and the wavelength involved. Tolerances are most critical at slower tape speeds.

At the present state of the art, AMEPX multi-channel heads are manufactured so that all record or reproduce head gaps will fall within two parallel lines spaced 0.2 mils apart.

Crosstalk Rejection

Crosstalk rejection acts the opposite of phasing, in that it becomes more critical as sources on separate channels become more independent. When adjacent tracks are completely independent, such as in our present 4 track ¼-inch tapes, crosstalk rejection on the order of 60 db in the midrange is adequate. Regular stereo tapes (2 track on ¼-inch tape) require less rejection.

Adequate shielding between heads, and maximum track spacing in conjunction with the practical compromises we have already covered (see Signal-to-Noise) are our major means of combating crosstalk. This entails a typical spacing between tracks of 70-100 mils.

Head Assemblies

Finally, we must take a quick look at the magnetic heads. We have already seen the precise tolerances we must secure in aligning the different heads in a stack. The same careful precision must be taken to ensure the straightness of the individual gaps and their perpendicularity, if we are to achieve interchangeability of tapes.

In older, sandwich-type heads it was practically impossible to achieve the required tolerances, with the result that the master tapes could consistently be reproduced only on the equipment that recorded them and then not too sucessfully because of differences in the record and reproduce head stacks. Quoted specifications were thus at times inaccurate when tapes from one equipment were played back on another.

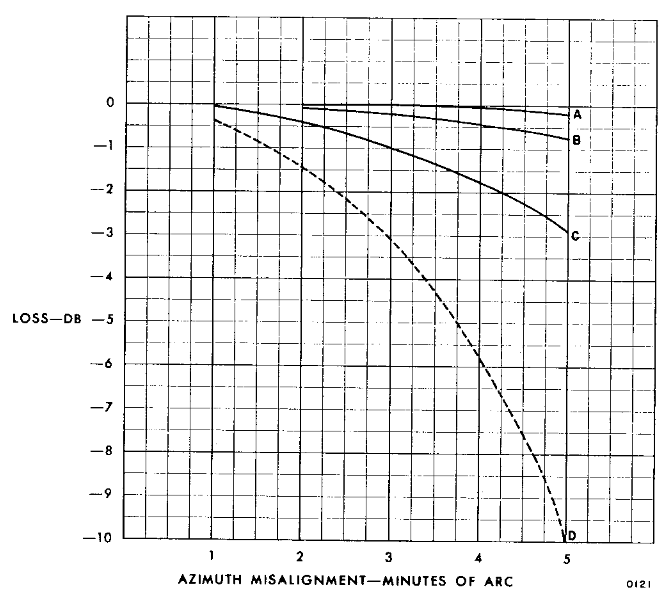
The introduction of cast type heads, with tolerances held by mechancial considerations, has alleviated this problem — but only recently. Today we should be able to play back tape from any recorder on any other comparable equipment, and do it within quoted specifications.

The sandwich type heads were constructed by completely assembling each individual head intended for multi-channel use, stacking those heads one on top of the other, then bolting them together. It was impossible to produce heads with consistent characteristics; you can see that even a slight difference in tightening the bolts that held the head together could cause gaps to be misplaced with respect to each other or the azimuth of each head to be misaligned.

Cast heads are constructed by assembling, potting, and lapping the pole pieces separately. The two pole pieces are then placed in a rigid fixture and potted together. Using this technique, all gaps can be aligned within 0.2 mils with a maximum tilt of less than three minutes from the perpendicular.

BASIC ADJUSTMENTS ON MAGNETIC TAPE RECORDERS

There are certain basic adjustments usually provided on professional quality magnetic tape recorders.



This graph shows the effect of head azimuth misalignment. Curves A, B, and C were taken using a 75 mil gap width at wavelengths of 1, .5, and .25 mil respectively. In Curve D a gap width of 250 mils and a wavelength of .5 mil were used.

Underlying each of these adjustments is at least one of the principles of magnetic recording we have been discussing.

Head Azimuth Adjustment

It is important that the heads be aligned so that the gaps are exactly perpendicular to the top and bottom edges of the moving tape. If the gaps are slanted across the width of the tape we have created a situation where the signal reproduced from the upper part of the tape is out of phase with the signal from the lower part of the tape. This phasing condition causes a cancellation of signal, accentuated at the higher frequencies. Of course, if the record and reproduce head gaps on an individual single channel recorder were exactly parallel, it would make little difference if they were slanted slightly, *as long as the equipment played only those tapes it had recorded and as long as those tapes were not to be reproduced on other equipment.* But as soon as we want interchangeability of tapes from machine to machine we must establish a universal head alignment. Also, as we have seen, we cannot tolerate phasing problems in stereophonic equipment.

The best method in procuring this alignment is to use a standard alignment tape, produced under stringent laboratory conditions. This tape will be recorded with a head alignment signal, and the reproduce head is adjusted to give a maximum output of this signal. The standard tape is then removed, and the record head is aligned so the its recordings result in a maximum output on the previously aligned reproduce head. Both heads are thus set to a universal standard.

Level Adjustments

The volume level in reproduction is strictly a matter of personal preference, but the record level must be accurately calibrated if optimum noise and distortion are to be maintained. This is again most easily accomplished by using a standard alignment tape to set the reproduce level to a reference amplitude. The record level is then calibrated to produce this reference playback level.

The record calibration *can* be set by using a distortion meter to measure the third harmonic content. Normal record level is usually at a 1% harmonic distortion level, so it can be adjusted to that value. However, distortion meters are seldom available in practice, the record level is nominal, and different tapes may vary by ± 1 (or even ± 2) db. Therefore the standard alignment tape procedure is certainly adequate.

Equalization Adjustment

A series of tones will be recorded on the standard alignment tape so that the reproduce amplifier response can be set on curve.

The rising characteristic of the reproduce head is not only the consideration in achieving an overall flat response; there are certain wavelength losses which, as we have already stated, are not fully understood. Therefore, a certain variable pre-emphasis is employed in the recording process, which is adjusted to achieve a flat response when the reproduce amplifier is set on a standard curve.

The easiest way to set the playback response on curve is to play a standard alignment tape, and adjust the variable equalizing components for a *flat* response as the precisely recorded tones are reproduced. Another widely used method is to use an audio oscillator and a vtvm to actually follow the response curve provided with the equipment; this, however, does not allow for variations in head characteristics.

The record pre-emphasis is then adjusted for a flat overall frequency response through the previously standardized reproduce system.

Record Bias Adjustment

We make the high frequency bias adjustment using a signal of specific wavelength (normally 15 mils — 1000 cycles at 15 ips, 500 cycles at 7½ ips, etc.) at the normal tape operating level. The bias is set, while recording this signal, to achieve a maximum output.

Because the output vs bias current is very broad near the peak bias current setting, the adjustment is simplified by increasing the bias current until the output drops ½ db then decreasing the bias until the output again drops ½ db; the correct setting is the average of the over- and under-bias.

The maximum amplitude point at the given wavelength will give low distortion and reasonable short wavelength losses. It is also comparatively easy to adjust and can be consistently repeated using simple test equipment.

Because the magnetization curve varies with different tapes, the bias voltage ideally should be adjusted each time the tape is changed — particularly if the change is to a tape from a different manufacturer. However, this would normally be done only when extreme fidelity was required, such as when recording a master tape for a commercial recording company. Usually, a carefully adjusted "average" bias setting will produce excellent results with a wide variety of tapes.

Tape Tension

As indicated in our discussion of Tape Transport Design, the tension of the tape as it winds through the system is very important. Proper tape guiding is, to a large degree, dependent on correct tensions. A good tape pack on the takeup reel is also determined by this function. And very importantly, if tape is stored under excessive tension, it will tend to stretch; also the phenomenon known as "print through" (where the magnetic signal on one layer of tape on the reel is transfered to adjacent layers) will be accentuated.

Tape tension control in professional quality equipment is normally adjusted by varying the resistance

Duplicating equipment at Magnetic Tape Duplicators, Hollywood. Ampex duplicating equipment produces copies of master tapes at high speed with as many as ten copies produced with each run of the master.

in series with the reel motor (or clutch) and thus the torque of the turntable. Measurement is made with a spring-type scale and adjusted to the manufacturer's specifications.

Braking Adjustment

Our brakes control our stopping function, and must be correctly adjusted if we are to stop tape motion without throwing loops (all tape tension imparted by the turntables is lost the moment we press the stop button). So we must always have a greater braking force acting on the turntable which is supplying the tape than on the turntable reeling in the tape.

Mechanical adjustments, where we control braking forces, are provided for each turntable. In some cases we must adjust for each direction of rotation of the reel; in others, we will adjust only for one direction of rotation and the other direction will be automatically acceptable.

Demagnetization

If any of the components in our tape threading path become permanently magnetized, we might partially erase any high frequencies recorded on the tape. If magnetization occurs at our magnetic heads we can at least expect an increase in noise level. Some means of demagnetizing these components must therefore be available.

Demagnetization is usually achieved through a small, hand type, device that is readily available on the open market or from tape equipment manufacturers. It is easily operated and very effective when used correctly.

Noise Balance

One of our greatest potential sources of noise is in our bias and erase oscillator. If there is any asymmetry from this circuit it will show up as a d-c component — capable of permanently magnetizing our record and erase heads and causing distortion and noise in our recorded signal.

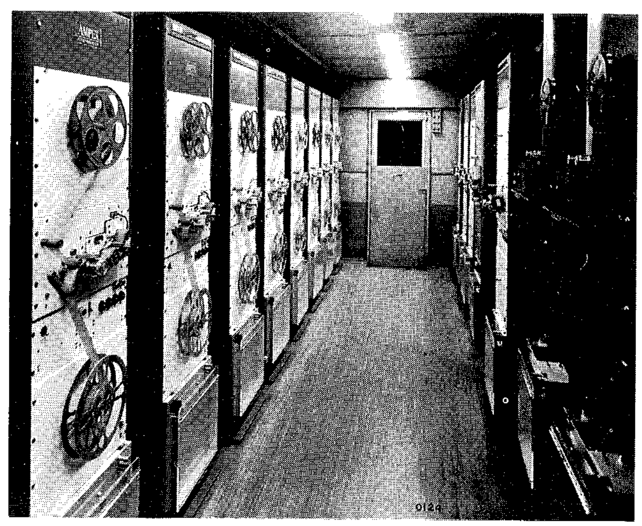
When we use a push-pull oscillator we can balance out any asymmetry by using a variable cathode resistor common to each tube in the circuit. This resistor is adjusted for a minimum noise as read at the output of the equipment.

Cleaning

It does little good to buy professional quality equipment if we allow accumulations of matter to build up on the tape transport. One of the easiest, one of the most important, and probably one of the most neglected maintenance procedures is the cleaning of the transport.

The major source of foreign material on the transport is the magnetic tape. Oxide and lubricant from the tape will gradually accumulate on the components in the tape threading path, and if it is not removed our equipment will not operate satisfactorily — even though everything else on the recorder is in perfect condition. For example, if the accumulation is on our precisely machined capstan (or the capstan idler) we will have excessive flutter. If it is on a tape guiding component it is apt to cause a vibration in the tape — similar to the vibration that occurs when we pluck a violin string — and again, we will have excessive flutter. If it accumulates on the heads, the tape will not maintain good contact, and our recorded level and/or frequency response will suffer.

So we must clean the transport on a regularly scheduled basis, with each component in the tape threading path receiving attention. *But we must be*



Magnetic film transports are used extensively in the motion picture industry for dubbing master sound tracks. Here is the Ampex 35-mil film transport installation at Glen Glenn Sound Studios, Hollywood.

careful to use only the cleaning agent recommended by the manufacturer of the equipment. This is extremely important in cleaning the heads, as some agents will damage those precise assemblies.

CONCLUSION

In this discussion, we have tried to present the principles of magnetic recording in a way that will aid the persons who operate and maintain the equipment. Most aspects of the process have been merely introduced, but if we have succeeded in imparting some realization of what is taking place in our alignment and maintenance procedures the discussion will have been worthwhile.

This industry has been just born in the commercial sense, but it is already expanding. Today we are using magnetic recording not only in audio, but also in digital and analog instrumentation applications. And recently we entered the age of magnetic photography when we started putting the television picture on tape. The principles involved are the same, whether it is VIDEOTAPE* recorder, a theater sound system, a computer application, or a home installation. We hope this discussion has aided you in understanding those principles.

*T.M. AMPEX Corporation

BIBLIOGRAPHY

E. D. Daniel and P. E. Axon: The Standardization of Magnetic Tape Recording Systems; The B.B.C. Quarterly, Vol. VIII, No. 4, Winter 1953-54.

E. D. Daniel and P. E. Axon: The Reproduction of Signals Recorded on Magnetic Tape; The Proceedings of the Institute of Electrical Engineers, Vol. 100, Part III, No. 65, May 1953.

E. D. Daniels: The Influence of Some Head and Tape Constants on the Signal Recorded on a Magnetic Tape; The Proceedings of the Institution of Electrical Engineers, Vol. 100, Part III, No. 65, May 1953.

E. D. Daniel, P. E. Axon, and W. T. Frost: A Survey of Factors Limiting the Performance of Magnetic Recording Systems; Journal of the Audio Engineering Society, Vol. 5, No. 1, Jaunary 1957.

J. G. McKnight: The Frequency Response of Magnetic Recorders for Audio; Journal of the Audio Engineering Society, Vol. 8. No. 3, July 1960.

J. G. McKnight: Signal-to-Noise Problems and a New Equalization for Magnetic Recording of Music; Journal of the Audio Engineering Society, Vol. 7, No. 1, January 1959.

F. G. Lennert: Equalization of Magnetic Tape Recorders for Audio and Instrumentation Applications; Trans. IRE-PGA, AU-1, No. 2, March 1953.

R. J. Tinkham: Solution to Some Problems in Making Master Tapes; Journal of the Audio Engineering Society, Vol. 5, No. 2, April 1957.

G. B. Goodall: The Videotape Recorder; International Projectionist, April to August 1959 issues.

R. J. Tinkham: Magnetic Recording Media Considerations for Improving Masters and Dubs; Journal of the SMPTE, Vol. 67, October 1958.

John G. McKnight: The Distribution of Peak Energy in Recorded Music, and Its Relation to Magnetic Recording Systems; Journal of the Audio Engineering Society, Vol. 7, No. 2, April 1959.

R. A. Isberg: The 120-ips Tape Duplicator for Four-Track Commercial Stereo Tapes; Journal of the Audio Engineering Society, Vol. 8, No. 2, April 1960.

C. B. Stanley: How Magnetic Tape Characteristics Affect System Performance *and* Determining Optimum Bias; Ampex Publication,. Technical Information Brochure No. 4.

C. B. Stanley: An Approach to Quantative Methods for Evaluation of Magnetic Recording Performance; Ampex Publication, Technical Information Brochure No. 1.

W. M. Fujii, G. Rehklau, J. McKnight, W. Miltenberg: Multi-Channel Recording for Mastering Purposes; Journal of the Audio Engineering Society, Vol. 8, No. 4, October 1960.

W. Earl Stewart: Magnetic Recording Techniques; McGraw-Hill Book Co., Inc; 1958.

S. J. Begun: Magnetic Recording; Rinehart Books, Inc; 1949.

W. K. Westmijze: Studies on Magnetic Recording; Phillips Research Laboratories, Reprinted from Research Reports 8, Reprint R213, R214, R217, R222.