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MAGNETIC TAPE RECORDER/REPRODUCER

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AMPEX
EX 2124

AMPEX CORPORATION, AUDIO DIVISION

TM-2011B
89-0131

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MAGNETIC TAPE RECORDER/REPRODUCER

TM-2011B
89-0131
JANUARY, 1962

AMPEX CORPORATION, AUDIO DIVISION

Issue A

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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 and performance characteristics section,
the installation section, and
the operating instructions section

are required reading and the principles of magnetic recording section will provide good background.

For the operator:

the description and performance characteristics 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 and performance characteristics section,
the principles of magnetic recording section, and
the individual component sections (i.e., tape transport, etc.)

are required reading.

THE DESCRIPTION AND PERFORMANCE CHARACTERISTICS SECTION

The description and performance characteristics section briefly describes the system, the components, their uses, and their performance characteristics. This section also 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 electronic assembly 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 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.

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 parts.

THE HEAD ASSEMBLY SECTION

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

THE ELECTRONIC ASSEMBLY SECTION

The electronic assembly section provides the detailed theory of the electronics along with the maintenance procedures and some troubleshooting 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 provided to simplify or extend the use of the system.

THE 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.

Section 2 DESCRIPTION

AMPEX PROFESSIONAL AUDIO EQUIPMENT

ONE YEAR WARRANTY

Congratulations and thanks. You now own the finest instrument of its kind in the world today. This equipment meets standards of performance, durability and reliability that surpass anything in its market. The warranty covering this equipment is valuable to you.

This warranty is effective only when the warranty-registration card is fully and properly filled and returned to the factory within ten (10) days of delivery.

A validated one year warranty identification card will be returned immediately to the purchaser to be used when in-warranty service is necessary in order to protect you within the terms of this warranty.

Before your unit left the factory, all phases of its performance were carefully checked by sensitive test instruments. This individual Ampex unit equalled or exceeded all current specifications for its model. Hence, if properly used, it should meet your most exacting requirements.

Should you experience difficulty in the operation of this equipment or should servicing of any kind be necessary, please contact the dealer from whom you purchased it.

If the equipment has been damaged in transit, you should report the fact immediately to your dealer.

Ampex reserves the right to modify or change the equipment, in whole or in part, at any time prior to delivery thereof, in order to include therein electrical or mechanical refinements deemed appropriate by Ampex, but without incurring any liability to modify or change any equipment previously delivered, or to supply new equipment in accordance with earlier specifications.

WARRANTY

Ampex warrants to the original using purchaser that all new Professional Audio Equipment shall be free from defects in workmanship and material under normal and proper use and service for a period of one year from date of delivery to original using purchaser and agrees to repair or replace all parts (except tubes and tape) thereof showing such defects, subject to all of the following provisions.

Ampex Warranty Obligation

(a) **Parts returned within 0-90 Days from Date Equipment Delivered to Original Using Purchaser** — All such defective parts will be repaired or replaced at no charge for labor or materials;

(b) **Parts returned within 91-365 Days from Date Equipment Delivered to Original Using Purchaser** — All such defective parts will be repaired or replaced at no charge for material and a labor charge equal to actual labor costs incurred in such repair or replacement.

(c) **In all warranty transactions** the responsibility of Ampex shall be limited to making a new or factory-reconditioned replacement part available to the dealer; it is the responsibility of the dealer to repair or replace defective parts.

Conditions of Ampex Warranty

(a) Defective equipment shall be returned, transportation prepaid, to the Ampex dealer from whom the equipment was originally purchased unless such dealer agrees to inspect or repair at purchaser's premises; and

(b) **Warranty registration card shall have been fully and properly filled out and returned to the factory within ten (10) days from the date the equipment was delivered to original using purchaser;**

(c) **Purchaser, for warranty service, must present one year warranty identification card to Ampex Dealer; and**

(d) Purchaser shall not have used or allowed to have been used in the equipment any parts not supplied by Ampex through its dealers (tape and vacuum tubes excepted); and

(e) Inspection shall disclose to Ampex's satisfaction that the defects are as above specified and that the equipment has not been altered or repaired by other than factory approved procedures, subjected to negligence, misuse or accident, or damaged by excessive current or otherwise, or had its serial number or any part thereof altered, defaced or removed.

Exceptions to Ampex Warranty

(a) Vacuum tubes carry their respective manufacturer's warranties and shall be and are hereby excluded from the provisions of this warranty (as to this item, no warranty, expressed or implied, is made by Ampex);

(b) Replacement parts supplied under this warranty carry only the unexpired portion of the original warranty.

Sole Warranty

This warranty is expressly in lieu of all other warranties, expressed or implied, and all other obligations or liabilities on the part of Ampex. No person, including any dealer, agent or representative of Ampex, is authorized to assume for Ampex any liability on its behalf or in its name except to refer purchasers to this warranty. In no event shall Ampex be liable for claims, demands or damages of any nature, however denominated; Ampex's sole warranty liability shall be to repair defective items or to supply replacement parts in accordance with the terms of this warranty.

DESCRIPTION

GENERAL

The AMPEX Series 354 Magnetic Tape Recorder/Reproducers are high quality precision instruments designed for the professional user who requires the finest and most faithful recording and reproduction.

A basic recorder/reproducer in the 354 series consists of a tape transport for operation at tape speed pairs of 3¾ inches per second (ips) and 7½ ips or 7½ and 15 ips; a two-track head assembly for use with the ¼-inch magnetic tape; and an electronic assembly which contains two record amplifiers, two reproduce amplifiers, a bias and erase oscillator, and a power supply — all featuring etched board construction.

CCIR equalization can be obtained on request when ordering equipment.

Several mounting arrangements are offered —console, two case portable, and rack mount. In the portable equipment, one case contains the tape transport and the other houses the electronic assembly

PERFORMANCE CHARACTERISTICS

Tape Width

¼-inch

Tape Speed Pairs

3¾-7½ ips
7½-15 ips

Frequency Response

Speed (ips)	*Response (Cycles per second)*
3¾	±2 db 40 to 8,000
7½	±2 db 40 to 12,000
15	±2 db 30 to 18,000

Signal-to-Noise Ratio

Speed (ips)	*Peak Record Level to Unweighted Noise (db)*
3¾	50
7½	55
15	Same as 7½ ips

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 after erasing a signal of peak recording level in the absence of new signal. Bias, erase and reproduce amplifier noise are included in the measurement. All frequencies between 50 and 15,000 cycles are measured.

Flutter and Wow

Speed (ips)	*Flutter and Wow (percentage rms)*
3¾	.18%
7½	.14%
15	.11%

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 test tape and is measured in accordance with American Standards Association standard number Z57.1-1954. (The alternate non-standard method of measuring flutter as described in Appendix II of the ASA standard was previously used by Ampex in determining flutter specifications.)

Recording or Reproducing Time (NAB 10½ Inch Diameter Reels, 2400 feet of tape)

	Half Track		*Two Track*	
Speed (ips)	*(hrs)*	*(min)*	*(hrs)*	*(min)*
3¾	4	16	2	8
7½	2	8	1	4
15	1	4		32

Starting Time

The tape is accelerated to full speed in less than 1/10 of a second.

Stopping Time

When operating at 15 ips, the tape moves less than two inches after the STOP button is pressed.

Reproduce Timing Accuracy

Accuracy (percentage)	*Accuracy (second)*	*Length of Recording (min)*
±.2%	±3.6	30

Rewind Time	Approximately 1 minute for a full 2,400 foot NAB reel.
Controls	
Tape Motion	All tape motion is controlled by four pushbuttons, PLAY, STOP, FAST FORWARD and REWIND.
Record Control	A separate RECORD button on the face of the electronic assembly, when pressed, energizes the record relay which drops out when the STOP button is pressed. Selection of record channel(s) desired, is accomplished by the RECORD SELECTOR switch on the electronic assembly.
Tape Speed	Tape speed can be changed by the TAPE SPEED switch. LOW or HIGH positions are used to select drive motor windings.
Equalization	An EQUALIZATION switch on the face of the electronic assembly provides a means for selecting LOW or HIGH speed equalization appropriate to the tape speed used.
Reel Size	A REEL SIZE toggle switch on the tape transport makes possible selection of the proper tape tensioning for the NAB 10½ inch diameter reel or the EIA 5 inch and 7 inch reels.
Record Inputs	Two inputs are supplied; one for each channel. With optional plug-in preamplifiers, optional plug-in transformers of supplied dummy plugs, the inputs can accommodate microphones, balanced lines or unbalanced lines respectively. A RECORD LEVEL control is included for each channel.
Reproduce Outputs	+4 vu ±0.5 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 SECTION 7 on HEAD ASSEMBLIES).
Monitoring (aural and visual)	The signal on the tape can be monitored while the equipment is recording. Two phone jacks are available to allow monitoring the record input signal, or the output signal from the reproduce head. A switch provides a means for making direct comparison between the original program and the recorded program. Two 2½-inch vu meters are provided for level comparison and visual monitoring of each channel.
Power Requirements	Two track equipment requires 2.5 amperes at 117 volts ac, 50 or 60 cycles. When the Ampex Model 375 Precision Frequency 60 cycle amplifier is used with the equipment, power requirements are greater by 2.5 amperes.

EQUIPMENT AVAILABLE

Dimensions and Weight *(in.)* *(lb.)*	*Item*	*Height*	*Depth*	*Width*	*Weight*
Rack Mount	Tape Transport	15¾ (rack space)	8 (behind rack)	19	50
	Electronic Assembly	7 (rack space)	8½ (behind rack)	19	18
Console	Console	48 (max)	28½ (max)	24½	155
Two Case Portable	Tape Transport Case (Equipment in Case)	15½	17	20¼	69
	Electronic Ass'y. Case (Equipment in Case)	9	13	21	38

EQUIPMENT APPLICATIONS

The Stereophonic Technique

In stereophonic recording, two or more microphones, each transmitting its signal independently, sample the complex wave-fronts of sound at separated points in an imaginary curtain between the performers and the intended audience. A microphone at the left of an orchestra picks up first and most strongly the instruments on the left. The right-hand microphone, then, picks up first and most strongly the instruments on the right.

In the reproduction, the listener is faced with two or more loudspeakers, each connected through time and space with the microphone corresponding. Each is located in about the same angular relation to him as the microphones were during recording. The speaker on the left reproduces first and most strongly the sounds which were nearest its microphone, while the speaker on the right does the converse.

Mixture occurs only at the time of reproduction, and performs a sort of minor miracle of re-creation. Not only are the instruments on the left stronger from the left loudspeaker, but they are reproduced there momentarily earlier than they are heard, at a distance, in the right speaker. Since the reverse is going on between sounds at the right and their speaker, there results a melting of sound between them. With a strong sense of direction, the whole orchestra seems to be spread out before the audience, when the mixture is correct. There is no hole in the middle; indeed, in a perfectly microphoned and balanced presentation, a soloist can be made to appear exactly front and center, where there is no loudspeaker at all in a two-channel presentation.

It is curious that a certain amount of left-hand sound must be present in the right-hand speaker, subdued a little and delayed by distance, of course, if the effects of spread and realism are to be heard. When there is little or none of this mixing, we hear a kind of musical ping-pong, which certainly may be used synthetically by the director for good novelty effect, but is unsuitable for most musical reproduction.

The balance of sound which places the soloist in the middle must be established at the time of the recording. It might be thought, at first, that errors in microphone placement might be compensated later in the dubbing studio by raising or lowering the strength of one signal in relation to the other. Within limits, where the error was only one of gain setting during the recording, it is true that this can be done. But after the recording is made it is not possible to vary individually the multitude of small variations in the delay of sound from each of many sound sources to each of the microphones, so good microphone placement at the time of recording is greatly to be desired.

Some Applications Outside of Stereo

Many examples may be given. Music and dialogue for an elaborate puppet-show have been recorded on one channel of a two-channel recorder, while advance cues, and signals for entrances and effects have been recorded on the other channel. Since there is no possibility for one channel to get off synchronism from the other, every performance is letter perfect, every cue and every line on time.

Such an arrangement is also used for a well-known ice-skating show. On one channel is the music for the performance, played into the auditorium's sound system. Synchronized, on the other channel, are the backstage signals. Not only are the performer calls recorded here, but metronome ticks, in perfect synchronism with the music which will follow, permit all the performers to make their entrances, in perfect time with music which begins only when they are on stage.

Reconstructing Historical Events

The ability to record several different sound sources on tape, all simultaneous but unmixed, offers many other possibilities. Often tape recorders are used to record sounds which cannot be repeated, either because of cost or because of their unique character An important occasion, perhaps an inauguration or conference, cannot be rehearsed or repeated. Yet a commentary on it, made simultaneously with the event, may be needed later to present a meaningful record. This, of course, may be recorded on a separate channel on the same tape as the recording of the event itself, when a multi-channel recorder is used.

Often on such occasions it is not possible to make a perfect "mix" of the several microphones which may be used. Yet a perfect recording can be obtained later if each of several microphones or groups of microphones are fed to individual channels for separation and mixing later at leisure in the studio, then to be dubbed to one-channel tape or disc.

Scientific Uses

In science and industry it is useful sometimes to record simultaneously one or more sounds under study, or to present previously recorded sounds to separate locations repeatedly, always in synchronism, in exact time sequence. An effect may be recorded in one channel, while the operations producing that effect are described on another channel. Or, in a psychological experiment, entirely different stimuli may need to be presented simultaneously to different subjects.

Educational Uses

Both single-channel standard recorders and multi-channel machines have been used to improve the efficiency of language instruction. In one language department, for example, each student is provided with a standard tape recorder into which he plugs an earphone All the recorders receive the output of a master tape in the control room, on which is a series of phrases or sentences spoken by an instructor, for students to imitate.

Because the instructor is on tape, his voice quality is the same throughout, and he never makes an error. Each student hears this example in his headphone as it is simultaneously recorded on his tape. With his own microphone the student then records his imitation after each of the instructor's examples. After the session, each student rewinds his tape and plays back the entire sequence of the instructor's voice followed by his own, in direct comparison. The tape can now be rewound and the lesson repeated, the master tape once again being fed to all students. While they record a new version the previous recording is automatically erased. Each successive attempt of the student is made more nearly correct by the experience of hearing himself as others do.

Binaural vs. Stereo

Stereophonic recording has received so much attention that the binaural technique seems to be somewhat neglected lately, and most multi-channel recorders are called "stereophonic" recorders. Fortunately, any good quality stereo machine of two or more channels will also serve well as a binaural recorder or reproducer.

The binaural technique implies the use of headphones or separate earpieces, which is usually impractical for commercial systems. Yet for special purposes this technique has its advantages. It might be said that stereophonic reproduction brings the scene of the sound to the listener, while binaural transmission takes the listener to the scene of the sound.

The binaural method takes into account the fact that a substantial part of our human ability to sense the direction of sound results from small differences in its character at one ear, compared with its character at the other. A whistle at our left not only strikes our left ear first, but is much weaker at the right than the left because our head deflects and absorbs it. Lower pitched sounds on the left will reach the left ear first, but be about the same level, only later, at the right ear. In either case, experience has taught us how to interpret the result and to know where the sound is coming from. It is interesting to find that very low pitched hum, without harmonic overtones, is almost impossible to locate.

A binaural recorder uses two separate channels, one for each ear. Two microphones are used, each of which has as nearly as possible the same pickup characteristics as one ear. They are separated approximately the distance between our ears by an artificial head of much the same size and sound-absorption as a human head. This apparatus is then placed wherever we wish our eventual headphoned listener to seem to be when he plays back the binaural tape.

In actual practice a matched pair of almost any professional quality cardioid or one-direction microphones serve well, separated by a small pillow, their diaphragms about six inches apart, facing opposite from one another and slightly forward. Each microphone then feeds its own channel on one track of the recorder. In playback, that track which carries the left ear impression is fed individually through amplifiers to the left headphone alone, the right track to the right headphone. The effect is as if the listener has been transported to the location of the microphones, so far as sound is concerned. Of course, if he turns, the sound scene will turn with him.

This arrangement has special usefulness in the recording of conferences, courtroom proceedings, debates or other gatherings where a verbatim written transcription will be needed later. If a simple single-channel recorder were used, only the voice quality would identify the speaker, while with the binaural recording his location as well would be apparent. In a single-channel recording it is almost impossible to extract one voice from another when two or more speak at once, yet with the binaural playback we are able to exercise our normal power to select one at a time, then replay for each of the others.

Sound-On-Sound

The phenomenal success of Les Paul and Mary Ford in their unique multi-voice records focused attention on the technique which they pioneered, and which has great usefulness for other purposes as well.

In the earliest days, "sound on sound" was accomplished with a single recorder, and a single-channel recorder at that, to produce those remarkable masters on which Les is heard accompanying himself, many times over, while Mary becomes a vocal soloist and all the members of the chorus behind her.

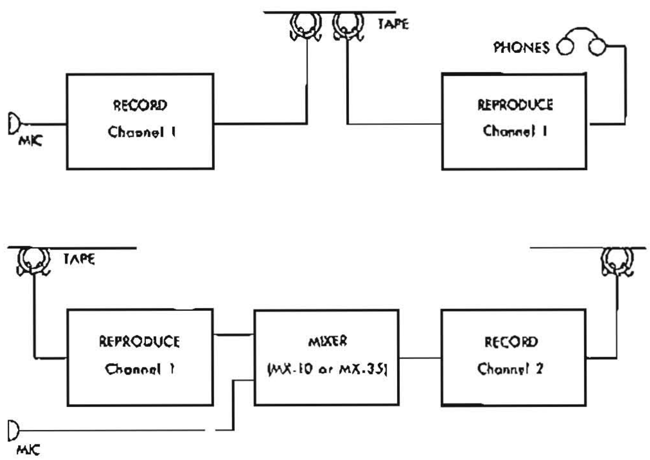
The machine was unusual in one way only: its heads were arranged in an unusual manner. In a normal machine the tape passes first an erase head, which removes all previous recording, then a recording head, which impresses a new recording, and then a playback head, which independently reproduces the newly recorded program. Les and Mary had a machine custom-built with the heads arranged Playback, Erase, and Record.

Using this machine,Les would record first a solo version of his music. This would go on the tape through the recording head. He would then rewind the tape. The playback amplifier was then connected into the recording amplifier, while simultaneously being mixed with the output of Les' microphone preamplifier. He wore a pair of headphones which monitored the mixture going into the recording circuit. And then he would record an accompaniment to his own previously recorded solo, which he would hear in his headphones. The original solo would be copied along with the new part. Thus, the playback head would feed out the original solo line which would simultaneously be recorded with the new part a little further along the tape.

The solo passage would then move past the erase head, leaving a clean tape for the record head to continue operation. The process would then be repeated, again and again, until all of Les' guitar parts and all of Mary's vocals had been collected. The difficulty with this arrangement was that a fluff anywhere along the line would make all of the previous work useless, and it would be necessary to start over again. Nevertheless, for many successful releases, this is how it was done.

A better solution was to use two normal recorders. In this case, the solo would start on one recorder. This would be rewound, the playback fed to the recording circuit of the second recorder, mixed with the output of the microphone. On the second recorder solo and first accompaniment would be recorded together, but the first tape was not erased, and errors in stage two would not affect it. The third part was added by playing the second tape back into the first machine, while adding part three, and so on.

With the advent of two-track recorders, the recording of sound-on-sound became even easier because it no longer required two recorders. In this case, the solo would start on the upper track. This would be rewound, the playback fed to the recording circuit of the second track, mixed with the output of the microphone. On the second track, solo and first accompaniment would be recorded together, but the first track was not erased, and errors in stage two would not affect it. The third part was added by playing the second track into the first track, while adding part three, and so on.



Sound-on-sound with a stereo recorder

But even this arrangement has its disadvantages. Fine as they are, magnetic recordings can be subjected only to a certain number of successive dubbings before audible degradation sets in. By the time the first voice on one of these tapes gets mixed onto the second tape it is a copy; when it gets to the third tape, it is a copy of a copy, until, if eighteen parts are added it is a long chain descendant of its original self.

Several things happen to the sound. If, for example, the original recordings were to deviate in frequency response only ±½ db from 30 to 15,000 cycles, thus, perhaps down ½ db at 30 and 15,000 cycles, then its copy on an equally flat recorder would be —1 at 30 and 15,000, —1½ in the third generation, and so on, until at eighteen generations the response would be —9 db at 30 and at 15,000 cycles. Any little bumps or hollows in the frequency response curve would similarly be exaggerated.

In well-designed recorders, whose noise depends solely on tape, noise also accumulates when generation after generation of copies are made. The noise increase, over the master recording, follows the "square root of the sum of the squares" law. This means that the S/N ratio decrease is 3 db in the first copy, and that it will total 6 db at the 4th generation, 9 db at the eighth generation, and 12 db at the 16th generation. Thus it is desirable to begin with great S/N ratio in the original, if the final release is to be several generations removed.

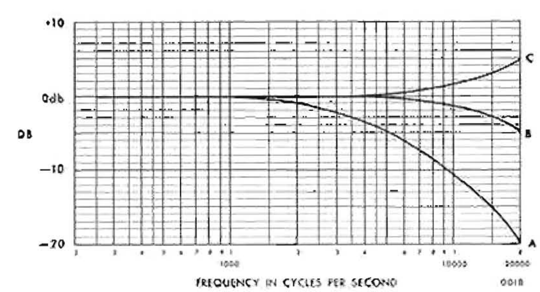
Distortion collects, too, although luckily it is not the arithmetic sum of the distortions occurring with each successive generation, either. There is a limit to the dodges which can be employed to make each recording ten or more times better than it need be for single generation copies. It would be much better if most parts could be kept separate on their own original magnetic tracks, undiminished by multiple-generation copying, the ultimate number of generations being held to two or three.

EQUALIZATION CHARACTERISTICS

General

The following paragraphs briefly describe the various equalization characteristics available so that the user may choose the equalization best suited to his application. Proper equalization requires the use of a reproduce equalizer which follows a standardized reproduce curve and a complementary record equalizer which is used to achieve flat over-all response.

Up to a certain frequency (in the neighborhood of 1000 to 2000 cps depending on tape speed), the output of the reproduce head of a tape recorder will increase directly with frequency. Above this frequency, the output of the reproduce head decreases. The reproduce equalizer produces a decaying slope that compensates for the increasing output of the reproduce head below the frequency at which peak output is obtained. The record equalizer is used to compensate for the decreasing output above this frequency. The equalizers have been designed to obtain an optimum in the overall record/reproduce system between signal-to-noise ratio on



Head output and compensating equalization one hand and tape overload characteristics on the other and are related to considerations of the relative spectrum energy distribution of speech and music.

Reproduce equalizers may be either fixed or variable. Fixed equalizers will follow the equalization curve within the tolerances allowed and for most practical purposes are adequate. However, under certain circumstances such as critical master recordings which may have many generations of copies, a variable equalizer would be more desirable since it can be adjusted to follow the equalization curve exactly, overcoming the effects of small variables introduced by reproduce head differences and the like. There is, of course, a disadvantage to variable equalization in that it can also be misadjusted whereas fixed equalizers can not.

Record equalizers are always variable since the amount of equalization necessary to achieve flat response will vary from machine to machine and will vary when tapes from different sources are used on the same machine. In all cases, there is a corresponding record equalizer for each reproduce equalizer

15 ips NAB Reproduce Equalization

The 15 ips NAB (National Association of Broadcasters) reproduce equalization curve is the American broadcast and recording industry standard. The equalization curve consists of a 6 db per octave decaying slope with a 3180 microsecond low end time constant and a 50 microsecond high end time constant. This curve is used for most of the master recordings made by the recording studios.

7½ ips NAB Reproduce Equalization

The National Association of Broadcasters has not set up a standard for 7½ ips. However, industry practice has been to use the 15 ips NAB reproduce curve for 7½ ips hence it is called the 7½ ips NAB curve. This curve is used for all of the 7½ ips pre-recorded tapes (both two track and four track) made in the United States.

3¾ ips Reproduce Equalization

Prior to the introduction of the 3¾ ips prerecorded tape cartridge, industry practice was to use the 3¾ ips 200 microsecond reproduce curve. This curve, which consisted of a 6 db per octave decaying slope with a 3180 microsecond low end time constant and a 200 microsecond high end time constant, provided good quality speech recordings but, because of limited signal-to-noise ratio, it was not adequate for good quality music recordings. When the tape cartridge was introduced, the high end time constant was changed to 120 microseconds. This change improved the signal-to-noise ratio considerably (with some sacrifice in overload characteristics) and allowed music recordings of passable quality to be made. The 120 microsecond curve is now used for all 3¾ ips recordings, both cartridge type and reel-to-reel type.

The choice between the 120 microsecond and the 200 microsecond time constant will depend on the number of recordings of each type in the user's tape library. If there are no 3¾ ips recordings in the library, the 120 microsecond time constant is preferred.

15 ips AME Equalization

Tape noise, or "hiss" is perhaps the greatest limiting factor in the quality of present-day tape recordings. The noise generated by the tape cannot actually be reduced by any means outside of improving the tape itself However, an increase in the signal-to-noise ratio can be obtained by increasing the signal level. As the input signal amplitude increases to a high level, however, the amount of signal actually recorded on the tape reaches a limit called saturation. At this point, the signal on the tape is much less than the input signal, or is *compressed* to about one-half the amplitude or less of the input signal. Since this saturation level varies with frequency, a very uneven response is obtained when recording at too high a level. If the high-frequency input level is increased still more beyond the saturation point, the signal on the tape decreases. This phenomenon is known as self-erasure. A high-level, high-frequency signal not only erases itself as it is being recorded, but partially erases any other tone which is also being recorded.

The 15 ips Ampex Master Equalization (AME) curve is designed to obtain a somewhat better apparent signal-to-noise ratio than is obtainable with the standard NAB equalization (see note). It was found that a greater signal amplitude could be recorded in the 2000 to 6000 cps region than is presently allowed by NAB equalization — without significant increase in overall distortion. This region is the band to which the ear is most sensitive.

NOTE

The apparent signal-to-noise ratio is increased by approximately 8 db although the actual measured signal-to-noise ratio remains unchanged. Note also that the recorded signal amplitude is increased ONLY in the 2000 to 6000 cps band, thus avoiding self-erasure at high frequencies.

The 15 ips AME curve is intended for internal use in companies specializing in producing "master" recordings and is not to be considered as supplanting the NAB standard for commercially released tapes.

7½ and 15 ips CCIR Reproduce Equalization

The 7½ and 15 ips CCIR equalization curves are the European counter parts of the 7½ and 15 ips NAB curves. The CCIR curves and the NAB curves are *not* the same. The 7½ ips CCIR curve consists of a 6 db per octave decaying slope with a 100 microsecond high end time constant and no low end equalization. The 15 ips CCIR curve consists of a 6 db per octave decaying slope with a 35 microsecond high end time constant and no low end equalization. When 7½ ips CCIR tape is played back on a machine with 7½ ips NAB equalization, it has the affect of decreasing high frequency response by approximately 6 db. When a 15 ips CCIR tape is played back using 15 ips NAB equalization, it has the affect of increasing high frequency response by approximately 4 db. When NAB tapes are played back using CCIR equalization, the opposite affects occur.

NOTE

The CCIR specifications do not include a low end time constant. However, the frequency response tolerances at the low end are broad enough that most machines that do have a low end time constant are still within CCIR specifications. (Most manufacturer's include the low end time constant.)

Section 3 INSTALLATION

Section 3 INSTALLATION

INSTALLATION

NOTE

Before operating the equipment read this SECTION AND SECTION 4, OPERATION.

GENERAL

The 354 Series equipment is shipped mounted in consoles or portable cases after a thorough inspection and performance check at the factory. In the event that the equipment is requested disassembled, for customer rack mounting, all assembly hardware is provided.

INTERCONNECTING

See the appropriate interconnecting diagrams at the back of this section.

MOUNTING

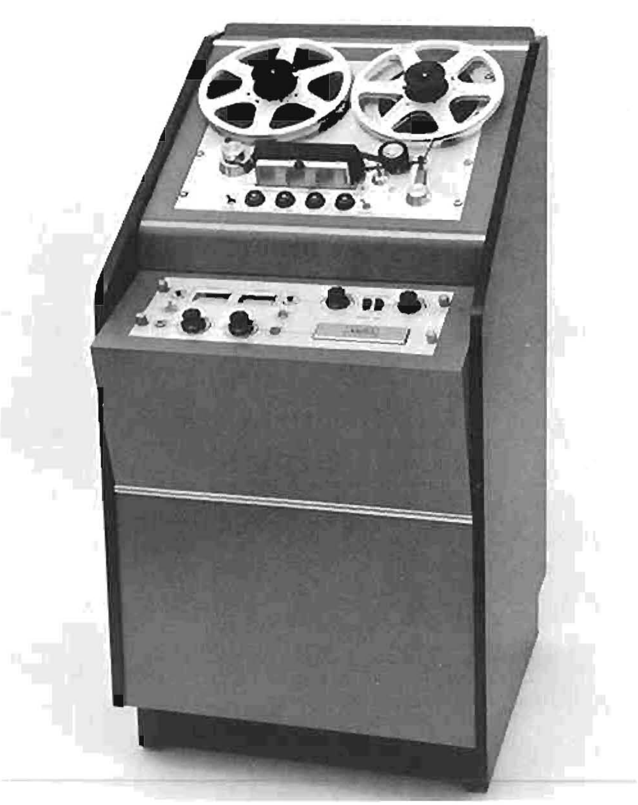
Console Models

To assemble the console model proceed as follows:

Step 1: Install the tape transport in the cabinet frame, securing the 8 oval-head screws and finishing washers.

Step 2: Place the two springs in the holes for the electronic assembly cabinet frame.

Step 3. Attach the two rails to the electronic assembly using the number 8 screws.



Series 354 Recorder/Reproducer— ¾ View

Step 4: Slide the cabinet back panel up and out to allow connecting of the a-c power cable and plug the input cable and the output cable into their receptacles on the back of the electronic assembly.

Step 5. Install the electronic assembly, tightening the four knurled nuts to fasten it to the frame.

Step 6. Connect the captive head cables at their locations on the electronic assembly.

Step 7: Connect the captive CABLE TO ELECTRONICS to the electronic assembly.

Step 8: Replace the back panel, making certain that all cables run freely through the semi-circular cut-outs at the bottom of the sliding panel.

Two Case Portable Models

The two case portable models are shipped in a ready to operate condition, except for the connection of interconnecting cables. Convenient rubber feet are located at both ends of each case, and metal rests are provided on the backs of each case. To set up the equipment follow these steps:

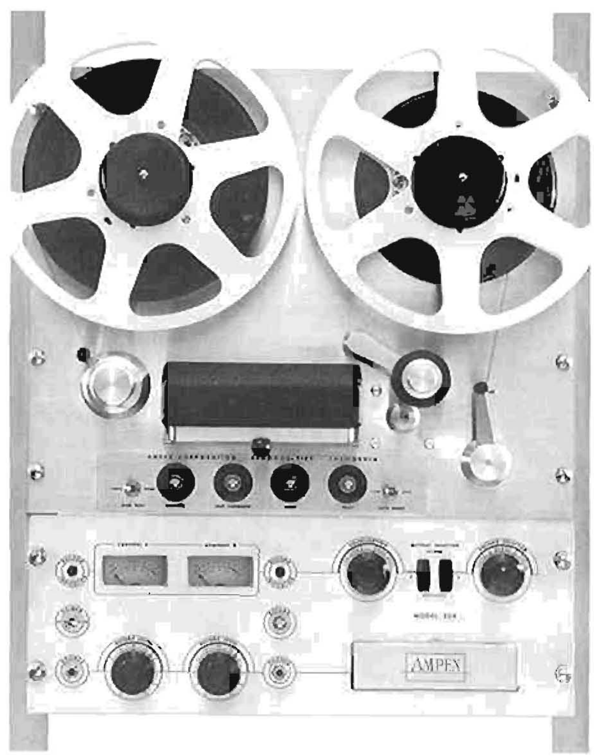
Step 1: Arrange the cases so that the mechanical assembly case is to the right of the electronic assembly case.

Step 2: Unlatch and remove the top cover and the side access door on the mechanical assembly case.

Step 3. Unlatch and remove the front and rear covers on the electronic assembly case.

Step 4: Uncoil the interconnecting cables from behind the cable access door on the tape transport case and plug them into mating receptacles at the rear of the electronic assembly.

Step 5: Connect the a-c power, and the input and output to the rear of the electronic assembly



Rack Layout (Model 354)

Rack Mounted Models

Mount these versions of the equipment on a standard 19-inch relay rack with the mechanical assembly above the main electronic panel

POWER CONNECTION

Connect the power cable from the a-c POWER input connector, J20, on the electronic assembly to a convenient 117 volt a-c power source.

OUTPUT

A mating connector for LINE OUTPUT is supplied. The user must fabricate his own cables, using the connectors supplied with the recorder.

Studio Line

Plus 4 vu, 600 ohm line output, balanced or unbalanced, is available at line output connectors J3 and J4. A two-wire shielded cable should be used and should be wired to the supplied mating connector so that the two wires of the cable are connected to pins 2 and 3 and shield is connected to pin 1. This will provide balanced output. If unbalanced output is desired, a jumper should be wired between pins 1 and 2 of the mating connector.

High Impedance Amplifier Input

Wire the mating connector so that pin 3 of the line output connector, J3 or J4, is connected to the high side of the amplifier input Strap pins 1 and 2 of the mating connector for connection to the ground side of the amplifier input.

INPUT

During this discussion refer to the foldout illustration - Schematic Diagram-Electronic Assemblies at the back of SECTION 8.

Microphone Input

Any low impedance microphone having a nominal impedance between 30 and 250 ohms can be plugged into the equipment. The use of microphones requires that an optional microphone preamplifier be inserted into transformer socket 4J15 (channel A) and/or 4J16 (channel B). Wire the mating connector so that the microphone is connected to pins 2 and 3 of the line input connector, J1 (channel A) or J2 (channel B). The cable shield must be connected to pin 1.

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

Bridging a Balanced Studio Line

Connect a balanced line to pins 2 and 3 of the input connector, J1 or J2. Pin 1 is ground. The plug-in line input transformer must be inserted into the transformer socket. Rms input levels of zero to plus five dbm can be accommodated. The load placed on the line is approximately 20K ohms.

Bridging an Unbalanced Source

Connect an unbalanced line, radio tuner, etc., to pins 1 and 3 of the input connector. Pin 1 is the ground side. The shorting bar must be inserted between pins 3 and 8 of the transformer socket. This connection provides a 100K ohm bridging input An rms program voltage of one volt is adequate

PHONES

High impedance head phones must be used. To monitor the incoming line or reproduce output, plug the high impedance phones into phone jack J17 (channel A) or J18 (channel B) on the amplifier face panel To preserve low frequency response, feed into an input impedance of 50K ohms or higher. To preserve high frequency response, the cable capacity should not exceed 500 pfd total.

60 CYCLE AMPLIFIER

The Ampex Model 375 Precision 60 Cycle Amplifier can be plugged directly into the equipment at J503S. No other connections are necessary. The Model 375 is used where power sources are erratic and there is need for a precision 60 cycle time base for driving the capstan.

CAUTION

If this unit is used with the Recorder/Reproducer, the control circuit fuse F402 must be increased to 5 amperes.

NOTE

Do not remove the dummy plug P503P unless the 60 cycles amplifier is connected.

OVERALL PERFORMANCE CHECK

(Read SECTION 4, OPERATION before making these checks.)

Make the following equipment performance checks at the time of installation and when necessary thereafter:

REPRODUCE (Playback) LEVEL
REPRODUCE (Playback) RESPONSE
REPRODUCE (Playback) NOISE MEASUREMENT

RECORD CALIBRATION
FREQUENCY RESPONSE
RECORD NOISE MEASUREMENT

NOTE

It should be noted that this machine has been adjusted at the factory to produce frequency response within specifications when recording on an average tape. In the last few years the high frequency output from tape has improved tremendously. In order to keep pace with these improvements, in the summer of 1959 Ampex selected a new "average" tape to adjust bias and record equalization.

Complete instructions for making the above checks are given in SECTION 8 ALIGNMENT AND PERFORMANCE CHECKS.

DISTORTION

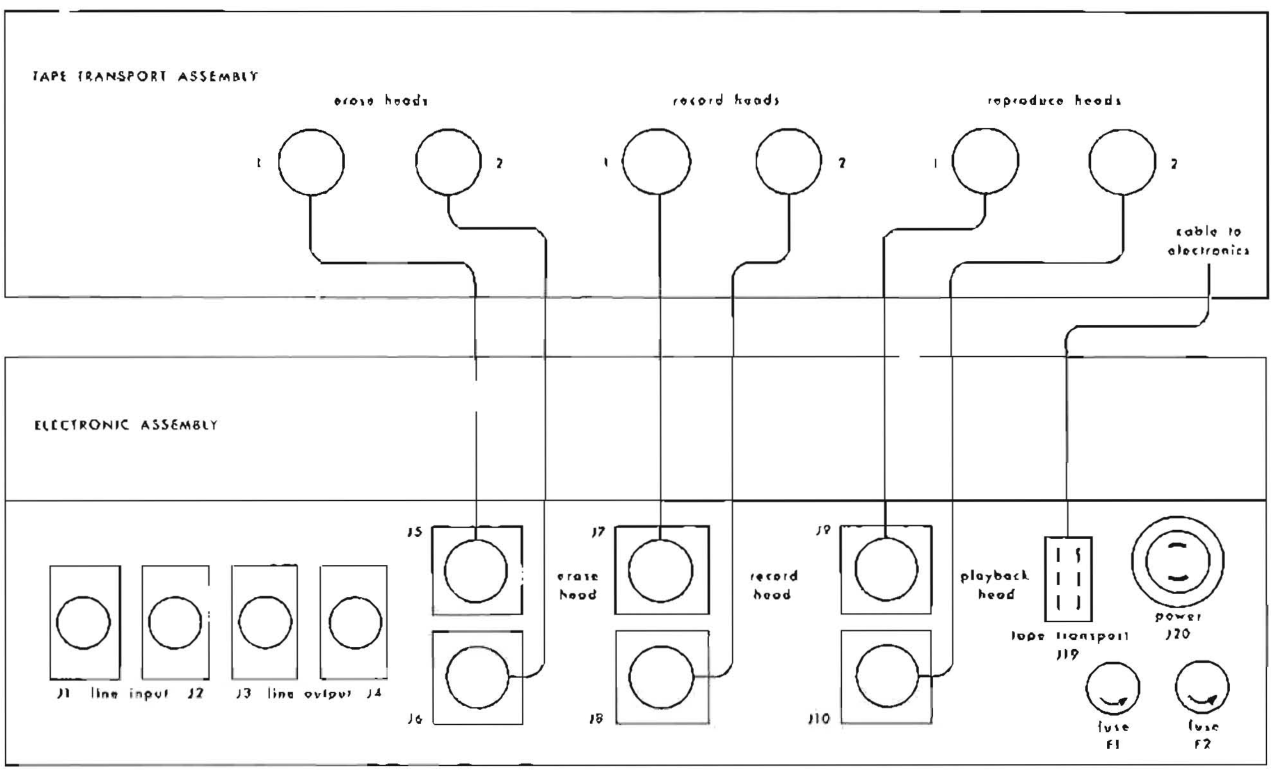
Overall distortion can be measured by connecting any standard distortion measurement apparatus across the output. The readings from a wave analyzer or selective frequency distortion meter will be more accurate than those from a null type instrument at lower distortion levels. Distortion readings are somewhat dependent on tape. A reading of 1% is normal at operating level while a reading of 3% is normal at 6 db above operating level. Second harmonic distortion is negligible, measured distortion is predominately third order.

FLUTTER AND WOW

Flutter and wow are produced by periodic irregularities in tape speed and appear as frequency deviations in recording or reproduction. They can be measured by means of a calibrated flutter test tape (see "Accessories" section) and a standard flutter bridge. Readings will be near or below 0.11% rms at 15 ips, 0.14% rms at 7½ ips, and 0.18% at 3¾ ips. The Ampex primary standard of measurements is based on the use of a flutter meter calibrated to indicate the deviation from mean carrier frequency of any rate between 0.5 and 250 cps expressed in percent rms.

INTERCONNECTING

Cable	Catalog Number	Qty	From Receptacle	From Chassis	To Receptacle	To Chassis
A-c	2413-00	(1)	J20 POWER	Electronic Assembly	A-c Source	
Power Inter-connecting		(1)	J19 TAPE TRANSPORT	Electronic Assembly	CABLE TO ELECTRONICS	Captive at Tape Transport
Reproduce Head (Ch. A)		(1)	J9 PLAYBACK HEAD	Electronic Assembly	Captive at Tape Transport	
Reproduce Head (Ch. B)		(1)	J10 PLAYBACK HEAD	Electronic Assembly	Captive at Tape Transport	
Record Head (Ch. A)		(1)	J7 RECORD HEAD	Electronic Assembly	Captive at Tape Transport	
Record Head (Ch. B)		(1)	J8 RECORD HEAD	Electronic Assembly	Captive at Tape Transport	
Erase Head (Ch. A)		(1)	J5 ERASE HEAD	Electronic Assembly	Captive at Tape Transport	
Erase Head (Ch. B)		(1)	J6 ERASE HEAD	Electronic Assembly	Captive at Tape Transport	



Interconnecting

Section 4 OPERATING INSTRUCTIONS

Section 4 OPERATING INSTRUCTIONS

OPERATING INSTRUCTIONS

GENERAL

The 354 Series recorder/reproducers are available for two track stereophonic operation. All operating controls are located on the tape transport with the exception of the record control which is on the front panel of the electronic assembly. When the remote control unit is furnished, duplicate tape motion controls, a RECORD button, a RECORD INDICATOR light and a TAPE MOTION indicator light are mounted on the remote unit.

The equipment can accommodate the NAB 10½ inch diameter tape reels or the EIA 5 and 7-inch reels. Provision is made for selection of proper tape tensioning at the REEL SIZE switch on the tape transport for the LARGE or SMALL size reels.

NOTE

In the LARGE reel position both the rewind and take-up reels must be NAB type and in the SMALL reel position both reels must be EIA.

Either of two capstan drive motor speeds can be selected at the LOW-HIGH TAPE SPEED switch on the tape transport.

On the front panel of the electronic assembly are facilities for setting RECORD LEVEL, selecting the channel(s) to be recorded, and selecting LOW SPEED or HIGH SPEED EQUALIZATION. Two phone jacks (PHONES) for monitoring, a RECORD button, two RECORD INDICATOR lights, and a POWER ON-OFF switch are also mounted on the electronic assembly front panel.

SUMMARY OF CONTROLS, SWITCHES AND INDICATORS

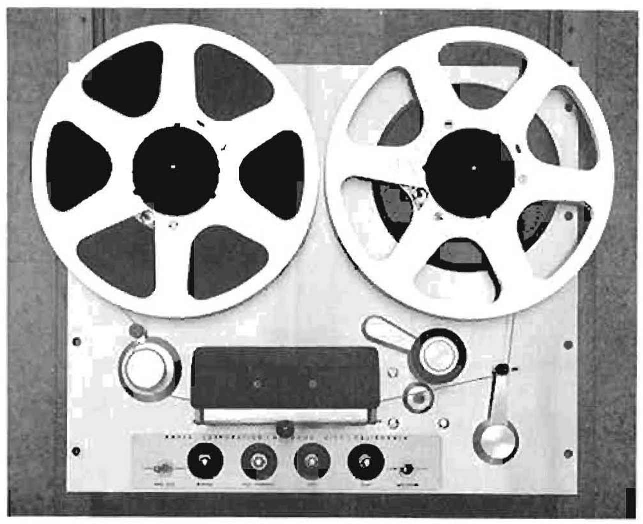
Item	*Schematic Reference Symbol*	*Location*	*Function*
POWER	S6	Electronic Assembly front panel	Controls power to the electronic and mechanical assemblies. When power is on, capstan will rotate if tape is properly threaded or the tension arm safety switch is mechanically closed. The vu meter lamps light when power is on, and are not affected by the safety switch. Provides a means for visually monitoring record input level and reproduce output level.
TAPE SPEED	S503	Tape Transport control cluster	Determines speed of the capstan drive motor by high or low speed winding. Used in conjunction with EQUALIZATION switch S2.
EQUALIZATION	S1	Electronic Assembly front panel	Used to select appropriate equalization circuitry for tape speed chosen.
REEL SIZE	S504	Tape Transport	Adjusts tape tensioning circuitry for the reel size used. The switch is closed when (LARGE position) NAB 10½ inch reels are used. In the SMALL position the switch is open, connecting resistance R502 in series with the torque motors, thereby reducing holdback and take-up tension.
RECORD SELECTOR	S4	Electronic Assembly front panel	Provides bias and erase current to channel A only when in channel "A" position if RECORD button is pressed, provides bias and erase current to channel B when in channel "B" position if RECORD button is pressed; provides bias and erase current to both channels when in "A & B" position if RECORD button is pressed; and does not provide bias or erase current to either channel when in either SAFE position regardless of whether or not the RECORD button is pressed.
RECORD LEVEL	R1 R2	Electronic Assembly front panel	Adjusts record level.
VU METER	M1 M2	Electronic Assembly front panel	Provides a means for visually monitoring record input level and reproduce level.

PLAY button	S505	Tape Transport control cluster	Controls tape motion in the reproduce (PLAY) and record modes. Interlocked with rewind and fast forward modes.
RECORD button	S5	Electronic Assembly front panel	Controls the record relay in the electronic assembly. Power is applied to the bias erase oscillator when this button is pressed. The PLAY button must be pressed to put the tape in motion before the record button is used.
REWIND button	S507	Tape Transport control cluster	Controls the rewind relay. Full a-c power is connected directly to the rewind (supply) motor when this button is pressed, the resistance R504 is placed in the a-c circuit to the take-up motor.
FAST FORWARD button	S506	Tape Transport control cluster	Controls the fast forward relay. Connects full a-c power to the take-up motor and places resistance R504 in the a-c circuit to the rewind motor when this button is pressed
STOP button	S502	Tape Transport control cluster	When this button is pressed, the brake solenoids and all relays are de-energized.
OUTPUT SELECTOR	S2 S3	Electronic Assembly front panel	In the REPRODUCE position, the v-u meters indicate the signal level at the secondary of the output transformer. In the RECORD position, the v-u meters indicate a "flat" reading of the input signal.

OPERATING TECHNIQUES

Threading the Tape

Thread the tape as shown in the illustration. Unwind and inspect all new factory wound reels of tape by running them through in the FAST FORWARD mode. New tapes may be looped to the hub in such a manner that the tape will not come free at the end of the reel. This will prevent the safety switch (S501) from disengaging the capstan idler from the capstan, which in turn results in a flat being worn on the capstan idler wheel. (Any adhesive material accumulation on the reel hub may also keep the tape from coming free at the end of the reel, and should therefore be removed with solvent.)



Tape threading path

Power

Power is supplied through power switch S6 which must be turned on to operate the electronic and mechanical assemblies. The mechanical assembly and electronic assembly are individually fused by the 3 ampere control circuit fuse F1 and the ¾ ampere electronic fuse F2.

Speed Switches

There are two switches associated with operating speed. The tape speed switch S503 determines the speed of the capstan drive motor, and the equalization switch S1 changes the equalization in the amplifiers appropriately

Tape Motion

The tape motion is controlled by means of four pushbuttons labeled REWIND, FAST FWD, STOP and PLAY.

PLAY OR RECORD

The tape is set into play motion at the speed selected by the tape speed switch when the PLAY button S505 is pressed. To change from play to the record mode with the tape in motion, press the RECORD button S5 on the electronic assembly.

STOP

To stop the tape while it is moving in any mode, press the STOP button S502. The equipment will stop automatically if the tape breaks or runs off either reel.

FAST FORWARD

The equipment can be started in fast forward or switched to fast forward from any of the operating modes by pressing the fast forward button S506.

REWIND

The equipment can be started in rewind or switched to rewind from any of the operating modes by pressing the rewind button S507.

NOTE

In using either the fast forward or rewind mode, it is desirable to remove the tape from direct contact with the heads by opening the gate of the head assembly. This will reduce wear on the heads and prevent the oxide coating on the tape from depositing on the heads and impairing their performance.

Editing and Cueing

Indexing the tape as in editing or cueing, or when approaching the end of the reel, is simplified by holding down a combination of buttons. Tape motion can be reduced by holding down the fast forward and rewind buttons simultaneously, and then alternating between the two to control tape direction. When the desired point is reached, the STOP button must be held down until the fast forward and rewind buttons are released.

CAUTION

Never press the STOP and PLAY buttons in rapid sequence when the tape is traveling at high speed in the REWIND or FAST FORWARD modes. This will almost invariably break the tape since it does not allow the tape to stop before the capstan idler locks it to the capstan.

Reproduce (Playback)

To reproduce a previously recorded tape, place the OUTPUT SELECTOR switch, S2 or S3 or both, in the REPRODUCE position, then start the tape in motion as indicated under PLAY. RECORD SELECTOR switch, S4, should be in either of the two SAFE positions.

Record

To record a new program on previously recorded tape, or on blank tape, place the OUTPUT SELECTOR switch, S2 or S3 or both, in the RECORD position and the RECORD SELECTOR switch, S4, in either of the SAFE positions. Turn the RECORD LEVEL control, R1 or R2 or both, clockwise until the level reads 0 (zero) on the associated vu meter on the most intense program peaks. The program can be audibly monitored through either the phone jacks (PHONES), J17 and J18, or the line out connectors (LINE OUTPUT), J3 and J4, before the tape is in motion. This direct monitor feature allows the program to be set up through the machine without actually recording during the set up period.

When the program level is properly set, turn the RECORD SELECTOR switch, S4 to the "A," "A & B," or "B" position as applicable and start the tape in motion as indicated under PLAY. Then press the RECORD button, S5 The RECORD INDICATOR, DS1 or DS2 or both, will now glow and the equipment is recording.

Section 5 BASIC CONCEPTS OF MAGNETIC TAPE RECORDING

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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.

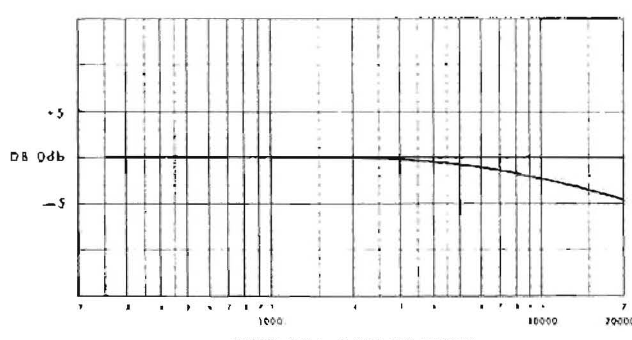
Manufacturers have greatly increased the quality of magnetic tape over the past few years, but it remains true that variations in magnetization within individual wavelengths will occur. The magnitude of these variations will depend on the factors noted in the preceding paragraph.

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.

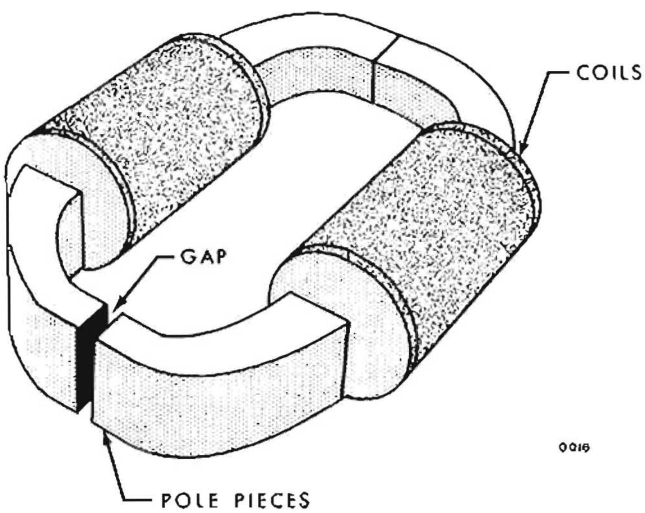
There are several considerations concerning the iron oxide particles which affect tape characteristics. These include the size and shape of the particles, and their physical orientation so that the axes of easy magnetization are longitudinal to the direction of recording.

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.

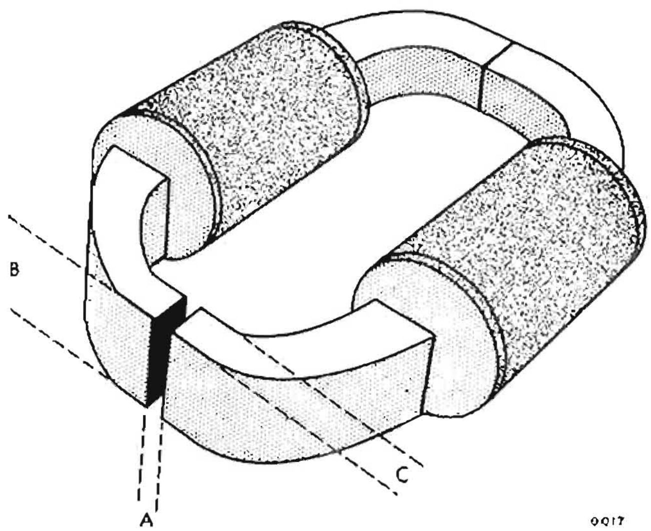
Magnetic reproducing equipment in the motion picture theater. Ampex installation along the far wall (at Warner Theater, New York City) provides six channel stereophonic sound.

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.

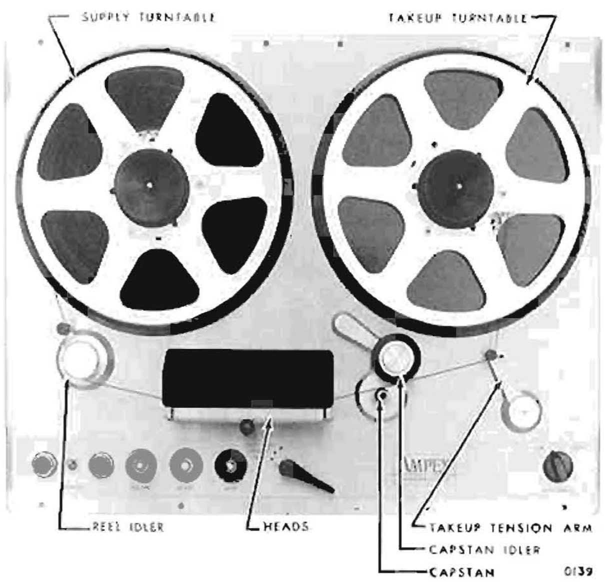
Actually, the flux must travel to the coil through each branch of the head core (forced into that path by the high reluctance of the gap) and must result in a voltage differential across the coil if a current is to be created. Therefore, an instantaneous *difference* in the magnitude of the moving flux 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.

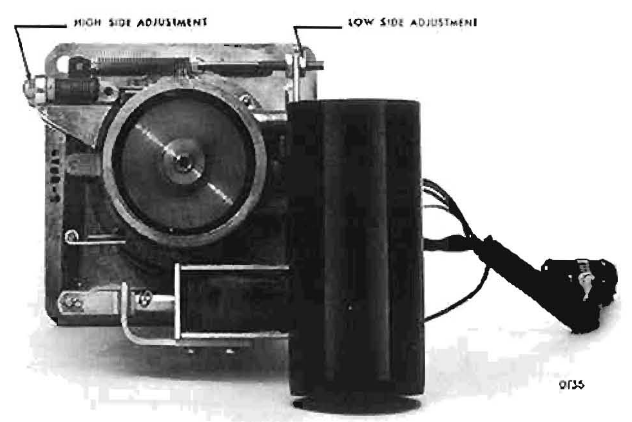
Supply and Takeup Assemblies

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

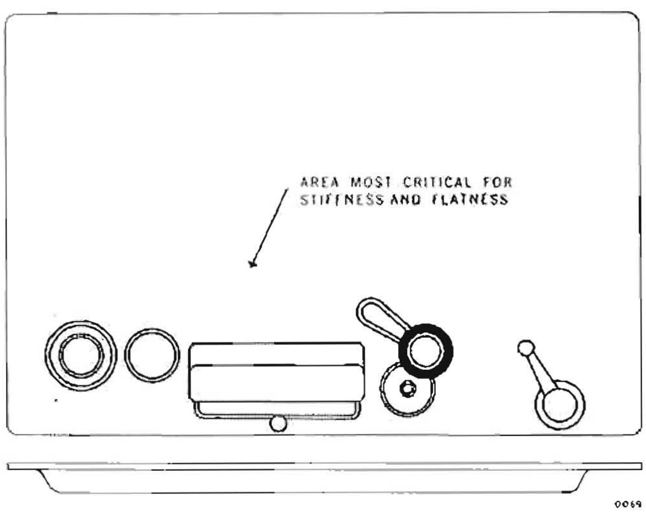
The main purpose of the reel idler is to isolate the heads from the disturbances originating in the supply motor, by tape scraping against the reel flanges, by splices as they leave the reel, or by tape layers slipping as the reel unwinds (This last effect may be quite prevalent if tape is wound so fast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

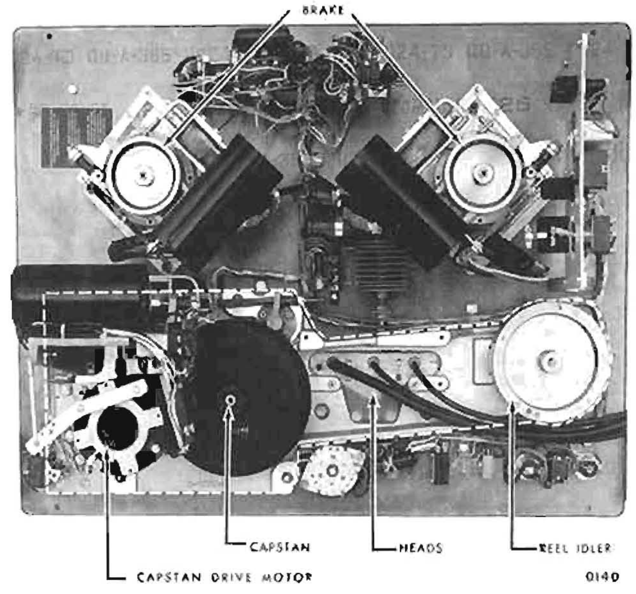
Mounting Plates

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

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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 frequency 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.

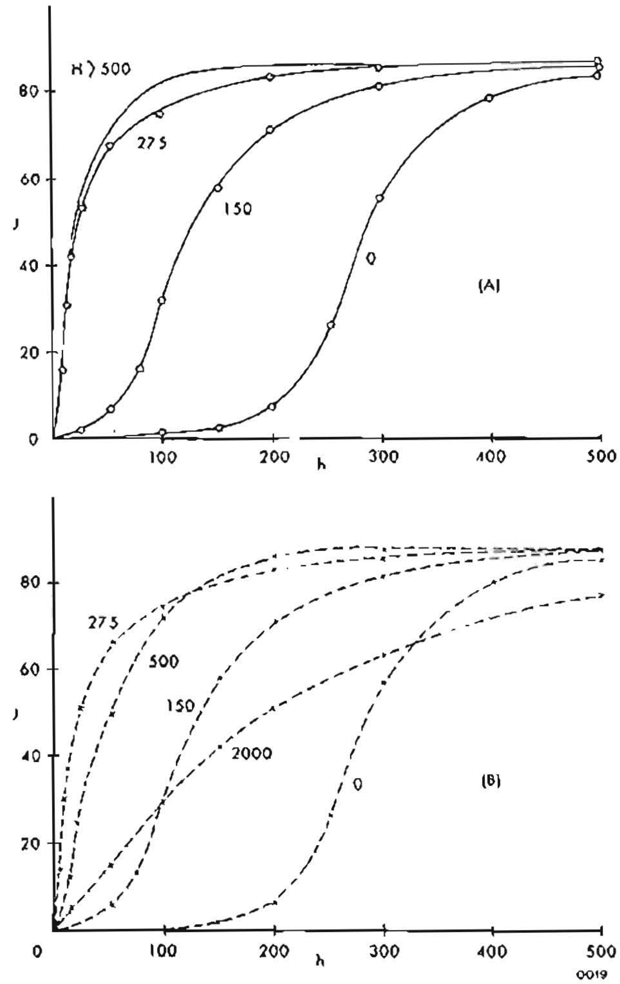
A-C Bias

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*

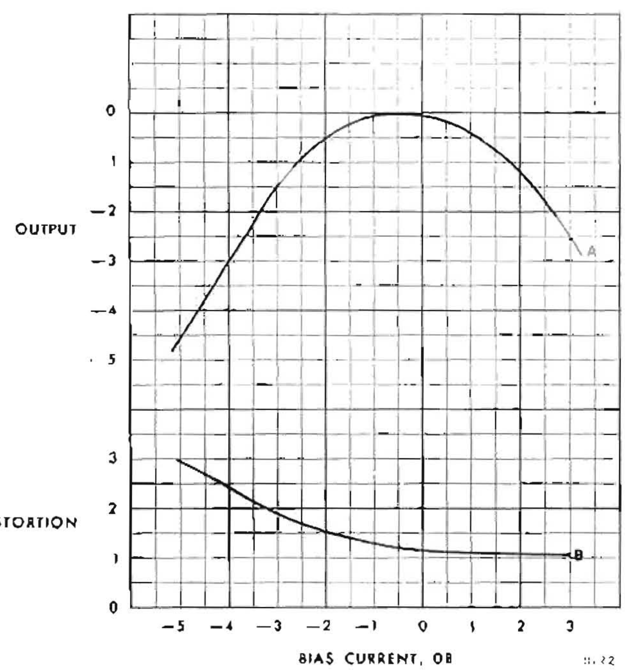


Anhysteretic intensity of magnetization (J) is plotted against the unidirectional field strength (h) for various amplitudes of a-c bias in this chart. In (A) the bias field was reduced while holding the unidirectional field constant. In (B) both fields were reduced simultaneously. Note in (B) that increasing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

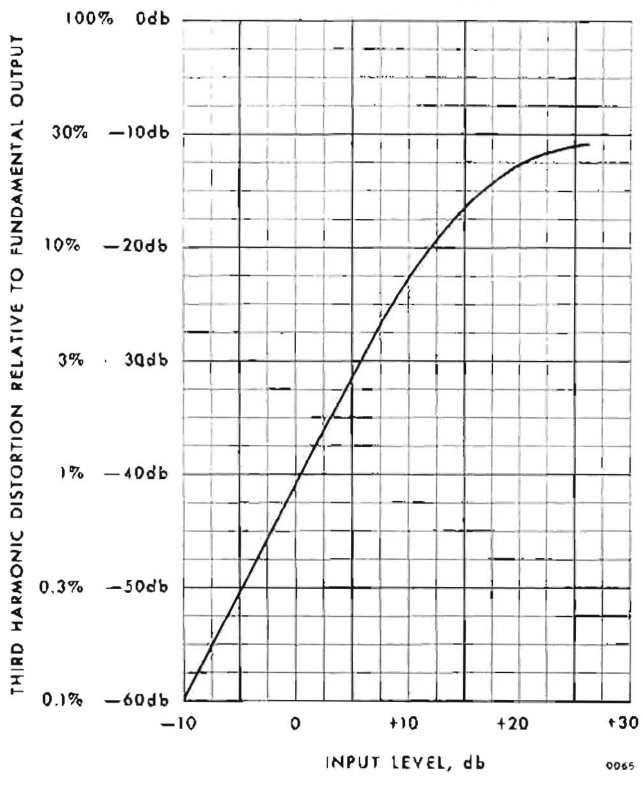
Preliminary amplification of the signal induced in the reproduce head is accomplished in the reproduce (or "playback") preamplifier. You will recall that the output of a reproduce head rises directly with frequency. This increasing output is at an approximate six db per octave rate (a very technical 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.

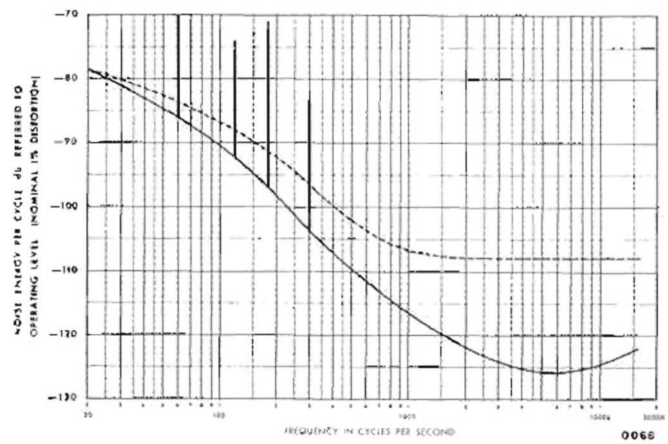
First is the tendency of both studios and "hi-fi" fans to reproduce music at a greater volume than that of the original source. This, of course, also increases the audible noise level.

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.

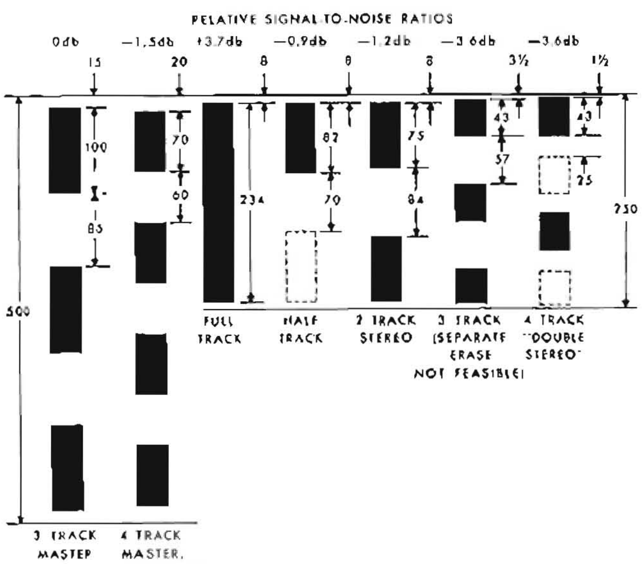
If the signal-to-noise ratio is determined by the medium itself, (the tape noise is at least 8 to 10 db above the equipment noise) then the signal-to-noise of the system is proportional to the square root of the track width.

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.)

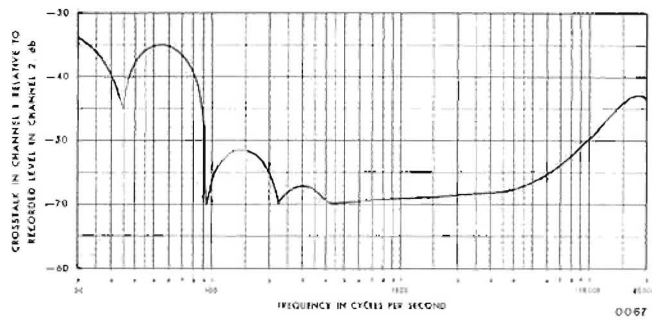
Remembering our practical economic considerations, we can put three 100 mil tracks, separated by 85 mils, on ½-inch tape (or six tracks on 1-inch tape) The three track, ½-inch, equipment is widely used in recording master tapes, and has been accepted as the best compromise between tape utilization and 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

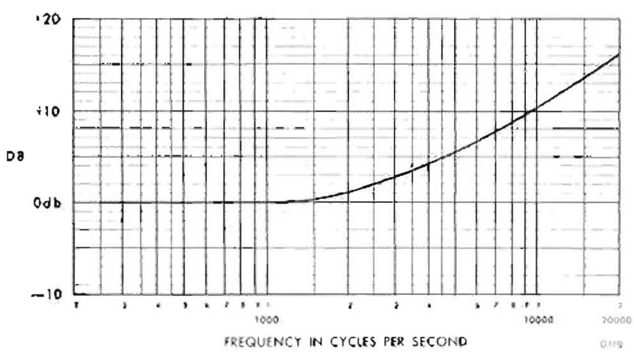
Two crosstalk effects are known to occur At long wavelengths magnetic coupling occurs in reproduce between the signal recorded on one track and the reproduce head of the other track. At high frequencies, the mutual inductance and capacitance between the two record heads causes the signal from one record 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.



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.



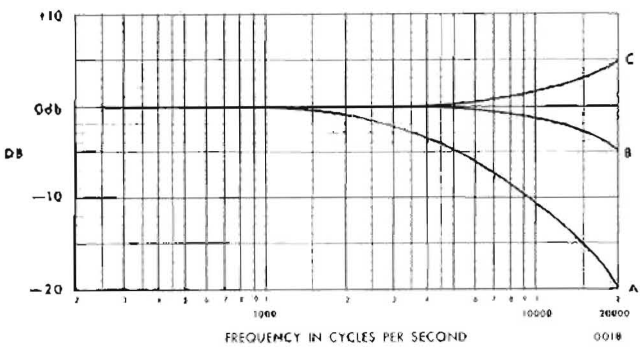
Standard NAB post-emphasis curve for 15 ips.

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

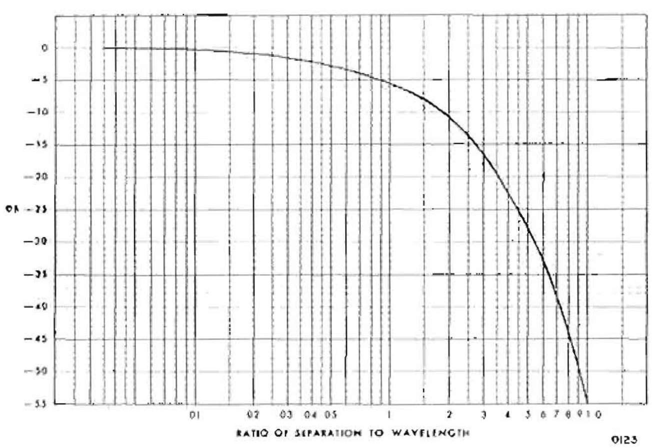


This graph shows how a flat overall frequency response is achieved. Curve A is an "ideal" record-reproduce response. Curve B is the result of adding the standard NAB post-emphasis to the ideal response. Curve C indicates the amount of record pre-emphasis needed to achieve flat response. As the post-emphasis 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.

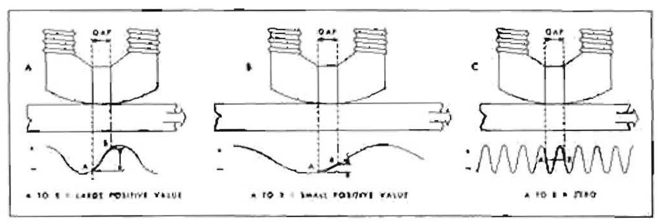
High Frequency Response

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

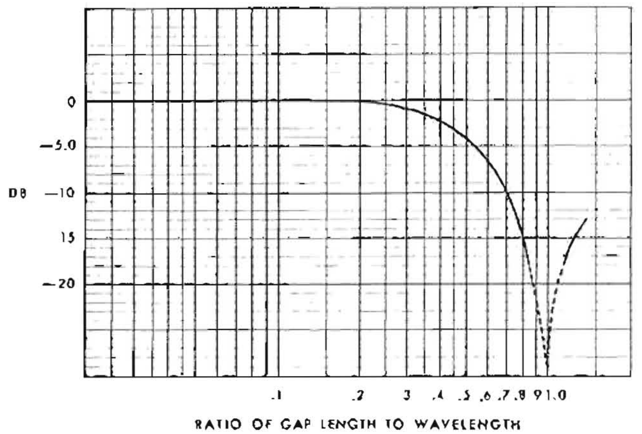
As shown on the accompanying diagram, when the recorded frequency rises to a degree where the reproduce head gap intercepts a complete wavelength of the signal on the tape, there can be no difference in flux magnitude across the gap, and the head output will be reduced to zero. Practically, this will 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

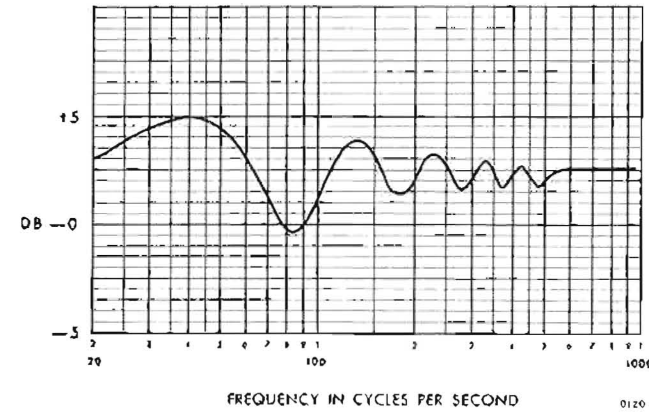
The coils of the heads are inductances which will resonate with lumped or distributed capacity in the circuit. At the resonant frequency of the reproduce head there is an increased output, but a sharp drop of approximately 12 db per octave occurs directly after this point. Thus the resonant frequency 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.

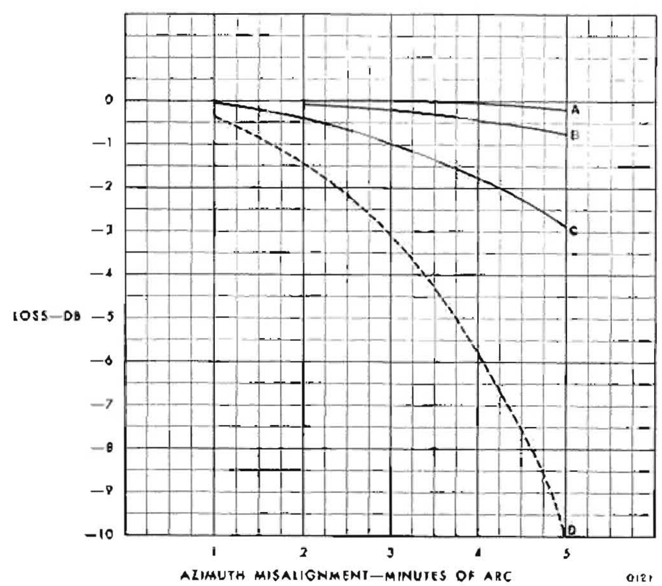
The introduction of cast type heads, with tolerances held by mechancial considerations, has alleviated this problem — but only recently. Today we should be able to play back tape from any recorder on any other comparable equipment, and do it within quoted specifications

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.

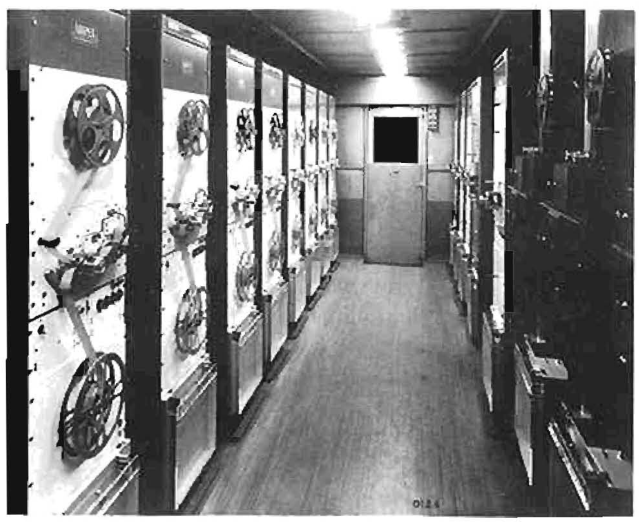
When we use a push-pull oscillator we can balance out any asymmetry by using a variable cathode resistor common to each tube in the circuit. This resistor is adjusted for a minimum noise as read at the output of the equipment.

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

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Section 6 TAPE TRANSPORT MECHANISM

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TAPE TRANSPORT MECHANISM

GENERAL

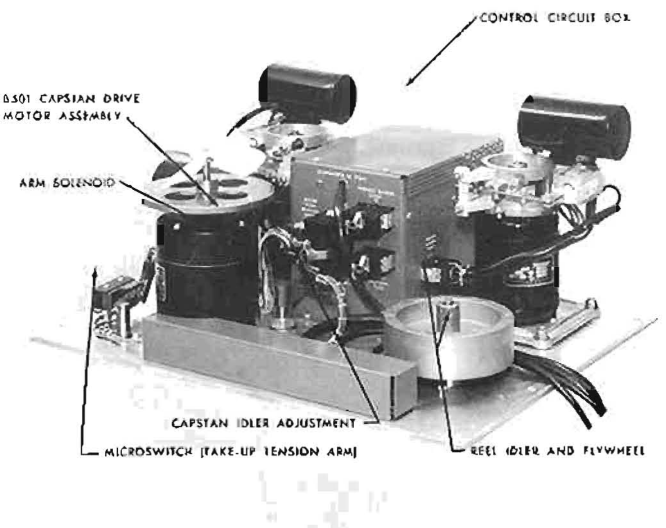
The tape transport mechanism provides tape motion for all modes of operation. Interaction of four basic assemblies and their associated components—the tape supply system, the tape take-up system, the tape drive system, and the control circuit—insures smooth, positive movement of the tape across the head assembly, and proper tape tension. All tape motion controls, a reel size selector, a safety microswitch and the head assembly are located on the tape transport.

TAPE SUPPLY AND TAKE-UP SYSTEMS

From the supply reel, on the left side of the tape transport as the operator faces the equipment, tape is delivered to the take-up reel when the PLAY or FAST FORWARD buttons are pressed, tape is rewound onto the supply reel when the REWIND button is pressed. Proper tape tensioning is maintained during all modes by means of two induction torque motors.

The reel idler assembly on the supply side of the tape transport is composed of a pulley, a spring-pivot-mounted arm and a flywheel for smoothing out transient speed variations in the supply turntable assembly.

On the take-up side of the tape transport, the tension arm assembly with a spring-pivot-mounted arm performs two main functions. The first function of this assembly is to provide a small tape storage loop which prevents tape breakage during the starting and stopping of tape motion. Secondly, this arm is used to stop



Component and assembly callouts

the machine if tension is lost due to tape breakage at the end of the tape or other failure. Near the base of the shaft on which the tension arm is mounted, a drive-lock pin actuates the safety switch (S501).

Both the tape supply and take-up assemblies are composed of induction torque motors (B503 supply-rewind, B502 take-up), a turntable mounted directly on each motor shaft, a brake housing assembly and a flange for mounting the entire assembly. Because the brake housings are mirror images of each other, these assemblies are not interchangeable although the motors are identical. The brakes are solenoid operated, remaining in the braking position until the brake solenoids K505 and K506 are energized at which time the brakes are released.

During all operating modes, the two induction torque motors B502 and B503 act as tensioning devices and in the fast forward and rewind modes the motors respond to the commands from either pushbutton by alternately operating each motor at maximum torque in the selected function.

The supply (rewind) and take-up induction torque motors are so connected that when power is applied with no tape threaded, the turntables, fixed to their shafts, will rotate in opposite directions. The tape supply turntable will rotate clockwise and the tape take-up turntable, counterclockwise.

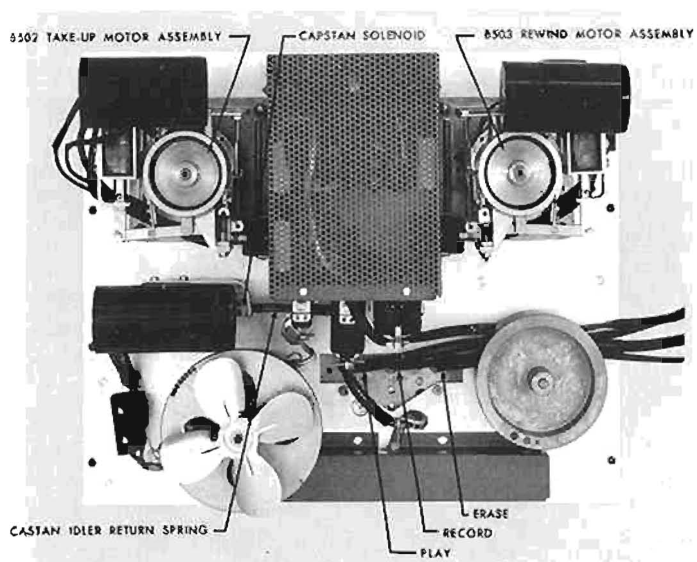
Motor torque in the reproduce and record modes is adjusted to equality by the tensioning adjustment resistors (R503 TAKE-UP and R503 HOLDBACK) in series with each motor. In the fast forward mode, the torque of the supply (rewind) motor is reduced considerably by introduction of a series resistance (R504). In the rewind mode, R504 is in series with the take-up motor. Basic tape tensioning operation is shown in the illustrations.

In the fast forward mode, the take-up motor operates at full torque, the supply motor at reduced torque, and the tape is pulled from the tape supply reel. Because the torque of the tape supply turntable motor (rewind motor) is applied in the opposite direction to the turntable rotation, the tape is held under continuous tension as it is pulled from the reel.

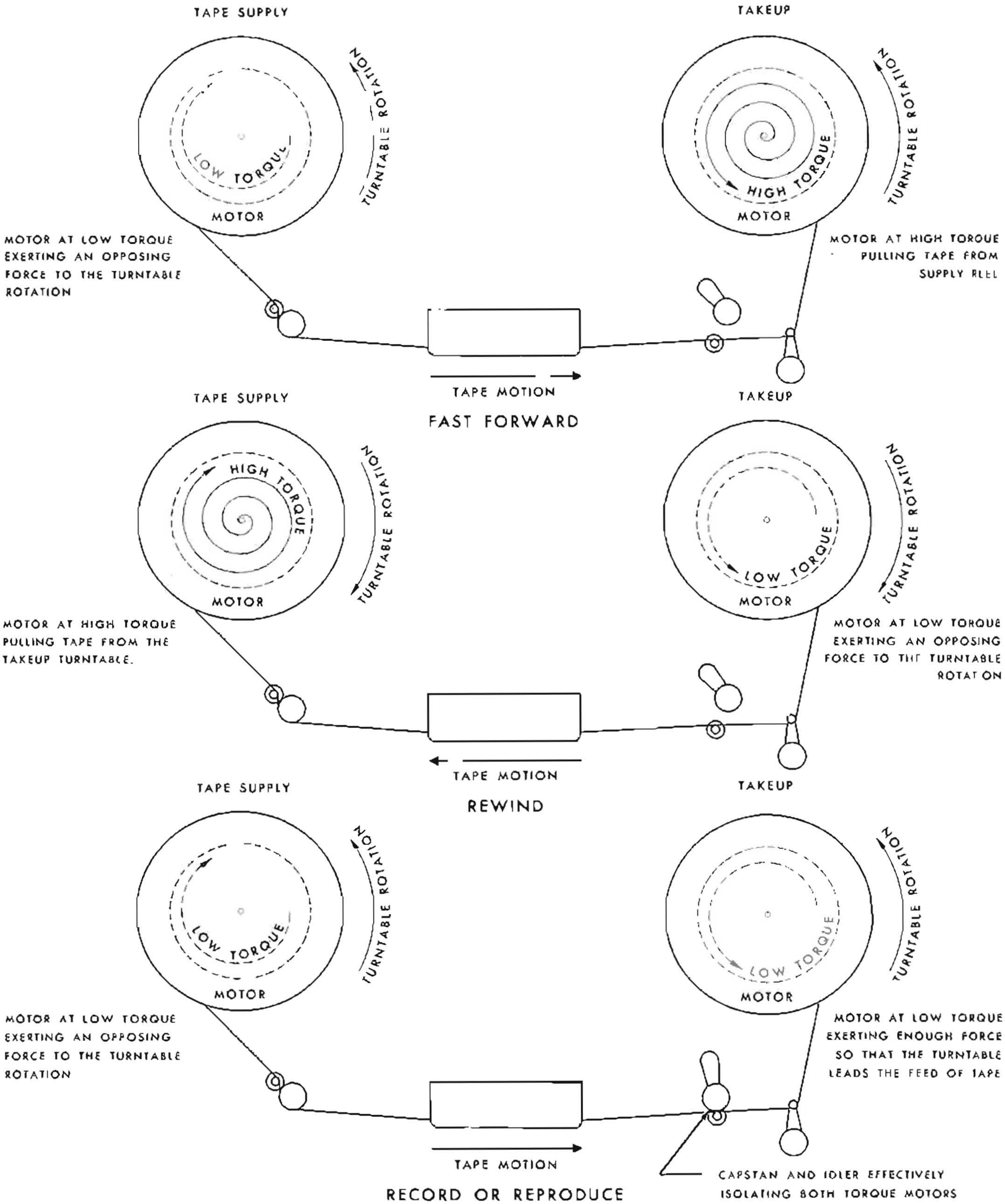
In the rewind mode, the supply motor operates at full torque and the take-up motor holds the tape under continuous tension by its opposite and reduced torque.

In the reproduce or record modes, both torque motors operate at the same value of reduced torque. The tape drive capstan and the capstan idler, between which the tape is clamped, then determines the tape speed, and the tensioning system supplies tape or takes it up as metered by the capstan drive.

From the point of view of the tape supply turntable, the capstan and idler action exerts sufficient pull on the tape to overcome the opposing torque of the supply motor, which constitutes the hold back tension. From the point



Component and assembly callouts



Tape tensioning

of view of the tape take-up turntable, the capstan and idler action is feeding the tape to it. The tape is held under tension here, because the take-up rate exceeds the feed rate (a tape loop will be thrown on the right side of the capstan whenever any malfunction causes the feed rate to exceed the take-up rate).

If a tape loop is thrown, or the tape breaks, the take-up tension arm will actuate the safety switch S501 and stop the equipment. The take-up tension arm is not a part of the tape tension system. Its function is to takeup tape slack, especially when starting, and to operate the safety switch.

The reel idler assembly smooths out transients in the supply reel system. For example, when starting the tape in the reproduce mode, the momentary strain transmitted through the tape to the tape supply turntable when the capstan idler forces the tape against the capstan is considerable. Under some circumstances, this impulse tends to stretch or break the tape. A momentary decrease in holdback tension might be sufficient to start a transient oscillation in the tape tension system which would be reflected as a periodic variation in the distance of the tape from the heads. This variation might be of sufficient magnitude to appear as an undesirable fluctuation in the signal level at the start of recording or reproduction. The reel idler arm absorbs most of the starting strain, and prevents or minimizes this type of oscillation. The reel idler pulley and flywheel provide additional stability in the tape tension system, by smoothing out such transients as motor torque fluctuations and irregularities due to faulty tape wrap on the supply reel. This is accomplished because the high inertia of the reel idler pulley and flywheel effectively isolate the reel assembly from the heads.

TAPE DRIVE SYSTEM

The tape drive system is composed of the drive motor, the extended shaft of which forms the capstan, the capstan idler arm and idler, and the tape guides at the tape entrance and exit within the head assembly.

The purpose of the tape drive system is to transport the tape across the heads at a uniform speed during the record and reproduce processes. By means of a hysteresis synchronous capstan drive motor (B501) and a capstan idler, the magnetic tape is driven at a constant speed after power has been applied to the equipment and the PLAY button is pressed. (The drive motor has two sets of windings to provide two tape speeds, either of which can be selected at TAPE SPEED toggle switch S503).

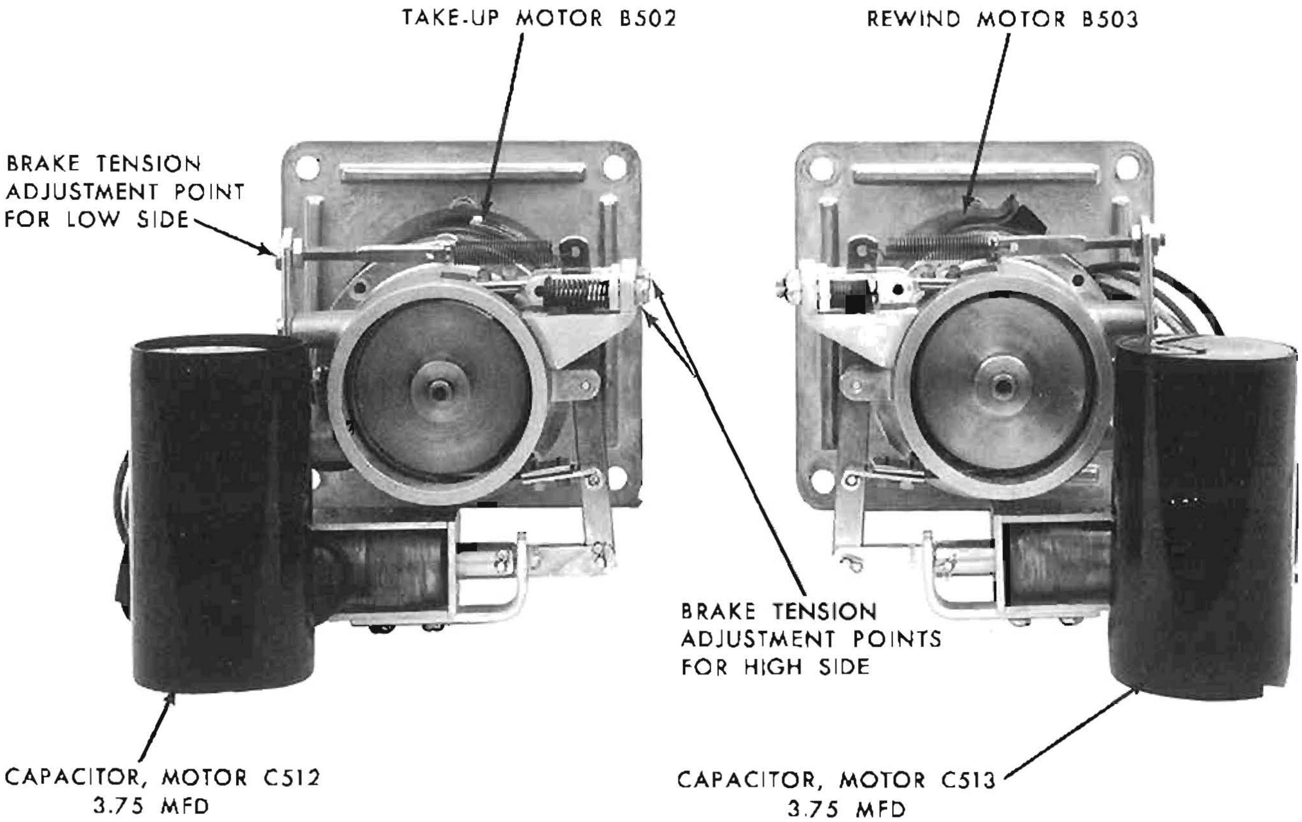
After the POWER switch at the electronic assembly has been placed in the ON position and the tape is threaded actuating the safety switch, the drive motor operates continuously, its capstan awaiting the PLAY command (the RECORD function is selected at the amplifier). When the PLAY button is pressed, the capstan solenoid (K501) and the brake solenoids (K505 and K506—releasing brake pressure) are energized. The capstan solenoid pulls the rubber tired capstan idler wheel, which is mounted on a swivel type arm, against the tape, causing the tape to make firm positive contact with the capstan. The tape is then driven at a constant speed across the head assembly.

BRAKE OPERATION

Smooth brake operation is extremely important in maintaining proper tape tension when stopping the tape. Because the holdback tension, supplied by the trailing turntable motor torque, is lost after the STOP button is pressed, maintenance of tape tension then becomes a function of brake operation. The braking force acting on the turntable from which the tape is being pulled (trailing turntable) in any of the modes of operation must exceed the braking force acting on the turntable taking up the tape (the leading turntable) to prevent tape loops forming.

One end of the brake band is fixed to the cross head by a roll pin and two socket head cap screws which is attached to the anchor mounted on the brake housing. The other end is linked to the brake lever by a drivelock pin and is free to move. When the brake solenoid is de-energized, the brake tension spring acting on the brake lever draws the brake band against the brake drum.

If the brake drum of the supply motor, as viewed from the brake housing end, is rotating clockwise when the brake band is applied, the frictional force will cause the band to wrap



Take-up and rewind motor assemblies

itself tightly around the brake drum as the brake lever end of the band moves to the right, increasing braking force. When the drum is rotating counterclockwise, the process is reversed, causing the band to tend to pull away from the drum, decreasing the braking force.

The ratio of the braking force in one direction to the braking force in the other — the brake differential — is approximately two to one on this equipment.

In all modes of operation, the greater braking force always acts on the trailing turntable, maintaining the proper tape tension as the system is stopped.

CONTROL CIRCUIT

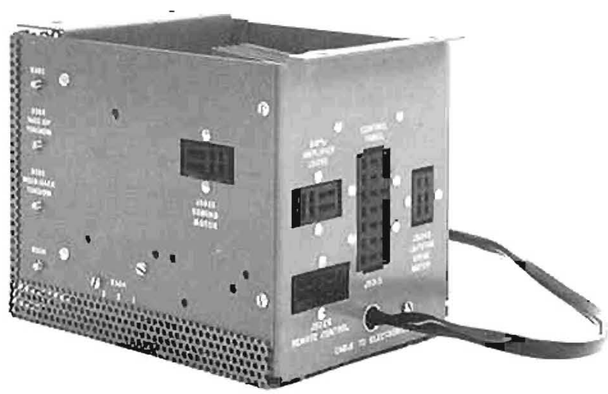
(Refer to schematic diagram—Tape Transport Control Circuits)

Located in the control circuit box underneath the tape transport are all relays, the tension adjustment resistors, and electronic components such as the capacitors and resistors shown in the foldout illustration, Tape Transport Control Circuits, with the exception of the three motor starting capacitors, the capstan solenoid, the brake solenoids and the safety microswitch (which are mounted adjacent to the assemblies they serve).

On the outside of the control circuit box receptacles are available for cables from the drive motor, supply motor, take-up motor and control cluster. Female receptacles and plugs (cables not supplied) are also available for interconnecting the tape transport and accessory units such as remote control panels and a precision frequency source when furnished.

NOTE

The special connector jumper plugs supplied for receptacles J503S 60 CYCLE AMPLIFIER and J502S REMOTE CONTROL must be plugged into their receptacles when these accessory units are not used because jumpers in these plugs complete the necessary circuits in the system for proper operation.



Control circuit box

All functional control of the tape transport, with one exception, takes place at the control circuit switch assembly comprising four push-buttons: REWIND, FAST FORWARD, STOP and PLAY. Two toggle switches REEL SIZE and TAPE SPEED are mounted at either end of the control cluster. The exception is the RECORD function which is controlled at the amplifier. The safety switch (not an operating control) is mounted under the tape transport.

Play

When PLAY button S505 is pressed, play relay K502 is energized. Capstan solenoid K501 is energized through K502-1. Contact sets K502-1, K503-1, K504-3, and the normally closed STOP button S502 form a holding circuit. Power is connected to the turntable reel motors through contact K502-2. Through contact K502-3, D.C. voltage is applied to the brake solenoids K505 and K506. The reel motors are powered and the brakes are released simultaneously, causing the equipment to operate in the reproduce mode at the speed selected by TAPE SPEED SWITCH S503.

Rewind

When REWIND button S507 is pressed, rewind relay K504 is energized and held in this condition by relay contact sets K504-1, K503-3 and the normally closed STOP button S502. Contact set K504-2 connects the full a-c power directly to the rewind (supply) motor, and places R504 in the a-c circuit to the take-up motor. The rewind motor thus operates at full torque and the take-up motor at reduced torque, and tape is pulled at a maximum speed from the take-up to the rewind reel. Contact set K504-3 completes the d-c circuit to the brake solenoids at each reel assembly, thus releasing the brakes.

Fast Forward

When FAST FORWARD button S506 is pressed, fast forward relay K503 is energized and held through contacts K503-1, K504-3 and the normally closed STOP button S502. Contact set K503-2 connects the full a-c power to the take-up motor, and places R504 in the circuit to the rewind motor. The take-up motor now operates at full torque and the rewind motor at reduced torque, causing the tape to be pulled at a maximum speed from the rewind to the take-up reel.

Stop

When the tape is moving in any mode and the STOP button (S502) is pressed, the brake solenoids and all relays are de-energized. The brakes are applied to both turntable motors. The capstan drive motor will continue to operate so long as the tape remains properly threaded.

NOTE

The record mode is not a tape motion control function, but it is interlocked and dependent on the PLAY button, which must be pressed before the record mode can be energized at the amplifier.

Safety Interlocks

When the tape is moving in either of the high speed modes (fast forward or rewind) it is impossible to switch to the play mode without first pushing the STOP button. In fast forward, contact K503-1 interlocks the play relay and capstan solenoid. In rewind, K504-3 is the interlock.

CAUTION

If the STOP and PLAY buttons are pressed in too rapid a sequence when the tape is in either fast winding mode, tape will almost invariably be broken or deformed. Always allow *time for the tape to stop completely when switching from either of the fast modes to play.*

Reel Size Switch

Selection of proper holdback tension, depending on reel hub size, is made at the two position toggle switch labeled LARGE-SMALL. Holdback tension is not a constant in any mode of operation, varying directly as a function of the trailing turntable motor torque, and inversely as a function of the effective trailing reel hub diameter (hub meter includes the tape wound on the hub). For a given torque on the trailing motor, the holdback tension will increase as the effective hub diameter of the trailing reel decreases. Reducing the torque on the trailing turntable motor will decrease the holdback tension.

The holdback tension resistors for adjustment of take-up and rewind motor torques are factory-set for NAB 10½ inch reels. If the smaller (7 or 5 inch) EIA (formerly RETMA) reels are used, compensation for the overall increase in holdback tension must be made by placing the switch in the SMALL position. This places resistor R502 in series with the take-up and rewind motors, thus reducing the torque of both motors in any mode of operation when the EIA reels are used. If it is desired to accelerate faster in the rewind or fast forward modes, the switch may be placed in the LARGE position during these modes. The REEL SIZE switch is a SPST switch placed across the resistor R502. It is closed when the LARGE position for 10½ inch diameter NAB is selected; and open (resistor R502 in the torque motor circuits) when the SMALL position is selected.

NOTE

In the LARGE reel position both the rewind and take-up reels must be NAB type and in the SMALL reel position both reels must be EIA.

NOTE

The Catalog Number 5700 tape transports used on earlier models changed PLAY tension only when in the SMALL reel position.

ROUTINE MAINTENANCE

Carefully follow the routine maintenance program outlined below if proper performance is to be expected of the equipment at all times. It is recommended that an Operation and Maintenance Log be kept.

Cleaning

Clean the capstan, the head faces and tape guides daily. Clean the capstan idler wheel weekly. Great care must be taken to see that oil does not reach the rubber tire. Avoid, as much as possible, touching the tire with the fingers.

The agent for cleaning AMPEX head assemblies is a mixture of Xylene and 0.1% Aerosol, and is available in 4 oz. bottles (AMPEX AUDIO Part No. 823). Other solvents can have detrimental effects on these precision parts.

To clean any head assembly, wind a clean, lintless cloth on a wooden swab-stick and moisten with this mixture. Swab the heads periodically to remove all dirt and accumulated oxide deposited from some tapes.

CAUTION

Do not use any other solvents as there are some which may damage the laminations of the head assembly. Do not use metal swab-sticks.

Cleanliness of all parts of the tape drive mechanism is required for consistent optimum performance. Clean all parts except the head assembly using a lintless cloth moistened with Iso-Propyl alcohol (easily obtained). This cleaning is of particular importance because most tape manufacturers lubricate their tapes, and the lubricant will gradually form a coating on the components in the tape threading path which will result in a loss of positive drive at the capstan, flutter and wow, drop-outs or poor high frequency response.

NOTE

It is imperative that Iso-Propyl alcohol be used on the cleaning of the capstan idler wheel (rubber) and not the recommended Xylene cleaner for heads.

Lubrication

The following parts of the tape transport mechanism require lubrication every three months, or after every thousand hours of operation, whichever occurs first.

CAPSTAN DRIVE MOTOR LUBRICATION

Lubricate the upper sleeve bearing of the capstan drive motor with this oil or its equivalent:

Caloil OC-11 (AMPEX AUDIO Part No. 827), Standard Oil Company of California, San Francisco, California. Class "C"

Medium turbine oil, petroleum base with inhibitor additives to increase oxidization and corrosion preventive properties. Essential characteristics are as follows:

Characteristics	*Required (Limit)*
Viscosity in Centistrokes at 130° F	40.0-48.0
Pour Point	25° F (Max.)
Flash Point	370° F (Min.) ± 20° F

There are two ways to lubricate the drive motor, the first of which requires its removal. The second, and simpler method, does not require removal of the motor. See alternate method. To remove the drive motor proceed as follows:

Step 1: Unplug the motor connector P504P from its receptacle J504S at the control circuit box.

Step 2: Remove the capstan idler by loosening the Allen head screw on the idler arm and gently pulling the idler assembly away (the capstan idler must be removed because one of the mount-screws is beneath it).

Step 3: Support the motor in one hand and remove the four mounting screws that hold it to the tape transport.

Step 4: Now pull the motor free.

Step 5: Locate the oil hole which will be on the top or the side of the motor end bell.

Step 6: Place not more than four drops of a recommended lubricant in the oil hole (OC-11).

CAUTION

Do not over-lubricate. Wipe off excess oil.

Step 7: Replace the motor.

Step 8. Replace the capstan idler.

CAUTION

The capstan idler must be properly placed in relation to the tape. Thread tape on the equipment along the prescribed tape thread-path, and set the idler so that the tape travel is centered on the tire. Placement is not critical and visual alignment is adequate.

Step 9: Readjust the capstan idler pressure if necessary (see *Capstan Idler Pressure*).

The alternate method for drive motor lubrication is:

Step 1: Gently pry up and remove the capstan dust cap.

Step 2: Before activating the safety switch, apply not more than four drops of lubricant (OC-11) to the exposed bearing surface.

Step 3: Replace the capstan dust cap.

Step 4: Start the drive motor by placing the POWER switch in the ON position, activate the safety switch and allow the motor to warm up (requires about 15 minutes).

Step 5. Turn off the equipment when the warm-up period is complete.

Step 6: If the bearing appears dry after the motor has cooled, repeat the above procedure.

Step 7: Wipe the capstan dry of any excess oil that may have been applied accidentally.

CAPSTAN IDLER LUBRICATION

Gently pry the dust cap from the wheel hub (a knife blade can be used) and oil with not more than 3 drops of OC-11, on the felt washer. Failure to perform capstan idler lubrication can result in the felt washer becoming completely dry, and a dragging idler can contribute to flutter.

CAUTION

DO NOT OVER-LUBRICATE or the wheel will throw oil in operation. If oil spills on the rubber tire, clean it immediately with Iso-Propyl. Oil will deteriorate the rubber wheel.

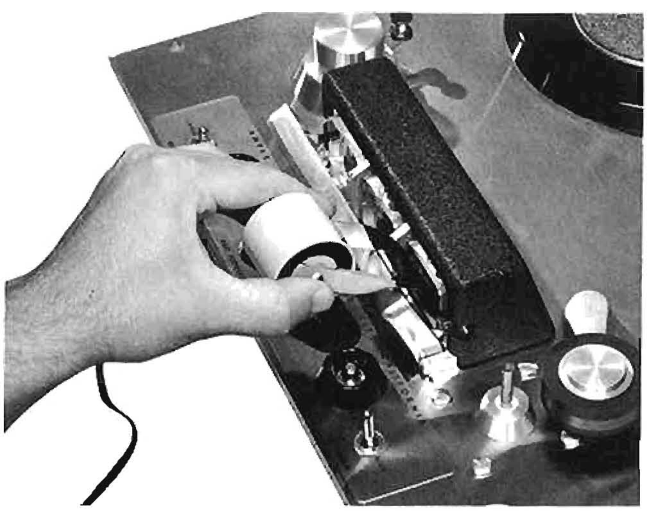
NOTE

The reel idler assembly, the take-up tension arm assembly and the take-up and rewind motors contain permanently lubricated bearings, and require no lubrication.

Head Demagnetization

Occasionally, the heads may become permanently magnetized through electrical faults in the amplifiers, improper use of the equipment, or by contact with magnetized objects. Magnetized heads may cause an increase of 5 to 10 db in background noise level, and can impair good recordings by partially erasing high frequencies. The full dynamic range of the equipment cannot be realized if the heads are magnetized.

Any phenomena that tend to put large unbalanced pulses through the record head will magnetize it. Observe these precautions and no difficulty should be experienced. Do not remove any tube from the record amplifier while the equipment is recording. Do not connect or disconnect the input leads or the head leads while recording.



Demagnetizating the heads

Do not saturate the record amplifiers with abnormally high input signals. Such signals would be 10 db greater than tape saturation or approximately 30 db greater than normal operating level.

If it becomes necessary to test the heads with an ohmmeter, they must be demagnetized afterwards.

If the heads become magnetized, proceed as follows using a head demagnetizer (AMPEX AUDIO Part No. 820):

Step 1: Place the equipment power switch in the OFF position.

Step 2: Plug the demagnetizer into a 117-volt a-c source.

NOTE

If the plastic coating wears off, place one layer of electrical friction tape on the demagnetizer tips. Scratching the heads will then be prevented.

Step 3: Bring the tips of the demagnetizer to within approximately ⅛-inch (if the demagnetizer tips are taped or covered, contact with the heads can be made) of the record head core stack, straddle the head gap and draw the demagnetizer tips up and down the length of the core stack three or four times.

Step 4: Remove the demagnetizer slowly from the head stack to a distance of 3 or 4 feet, thus allowing its a-c field to diminish gradually. This slow removal is extremely important.

CAUTION

Do not unplug the demagnetizer while it is near the heads; the collapse of its magnetic field may re-magnetize the head.

Step 5: Repeat Steps 3 and 4 at the reproduce and erase heads.

Step 6: If necessary, repeat the process till complete demagnetization is effected in each case.

NOTE

The erase head, under certain conditions, is susceptible to magnetization by spurious sources and can require demagnetization.

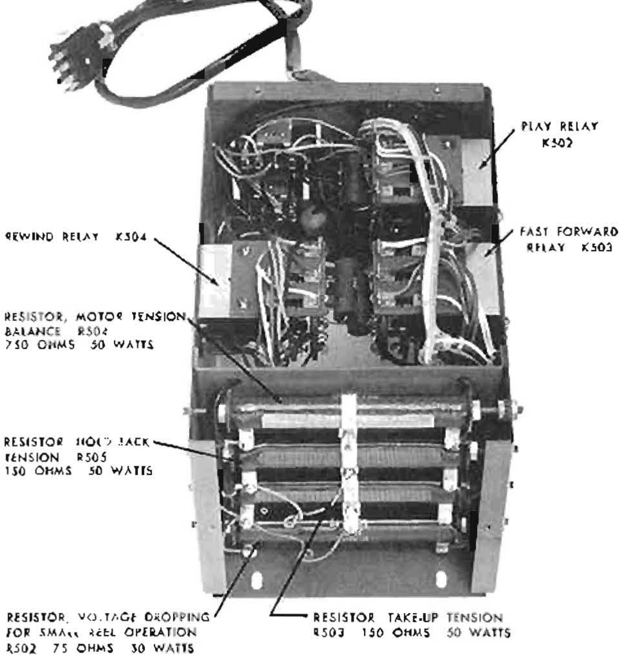
If the capstan, tape guides or other metal parts be come magnetized, a few passes of the demagnetizer along their lengths and the slow withdrawing technique should be adequate.

ADJUSTMENTS

The mechanical assembly is shipped from the factory with all adjustments set for correct performance. It should be unnecessary to change any adjustment before putting the equipment into service, unless shipping damage has occurred. In the course of wear in normal service, or in the event of component failure, and replacement of parts, some readjustments may be necessary.

Equipment Required:

- Spring Scale 0-16 oz.
- Spring Scale 0-80 oz.
- 3/8-inch Nut Driver
- 3/16-inch Screwdriver
- Nylon Lacing Twine or Strong String
- 7/16-inch Socket Wrench
- 5/64-inch Allen Wrench



Control circuit box callouts

Take-up and Supply (Rewind) Tension

Take-up and supply tensions are determined by the positioning of the sliders on resistors R503 and R505 located in the tape transport control circuit box. The torque of both the rewind and take-up motors must be adjusted to between 5½ and 6 ounces as read on the 16 oz. spring scale at NAB reel hub diameter. Checking techniques are not difficult and should be performed carefully.

Step 1: Place an empty 10½ inch NAB reel on the tape supply turntable.

Step 2. Place the POWER switch in the ON position.

Step 3: Place the REEL SIZE switch in the LARGE position.

Step 4: Hold the take-up tension arm so that the safety switch is activated (a rubber band or piece of masking tape will hold the arm as though tape were threaded on the equipment).

Step 5: Make small loops at both ends of a thirty inch piece of nylon lacing twine.

Step 6: Attach one loop to the tape anchor on the reel hub and the other to a 0 to 16 oz. spring scale.

Step 7: Press the PLAY button and allow the clockwise motion of the supply reel (torque motor tension) to draw a turn of twine onto the hub.

Step 8: Make certain that the twine is now parallel to the plane of the top of the tape transport and that the twine is centered and not touching either reel flange.

Step 9: Now, let the torque motor pull the twine slowly onto the hub by following the torque motor force with the scale.

Step 10: Using this "following" technique, observe the readings on the scale until a constant reading is obtained.

Step 11: If necessary, adjust the slide on resistor R505 in the control circuit box until a scale reading between 5½ and 6 ounces is achieved.

Step 12: A good check consists in placing the REEL SIZE switch in the SMALL position, then checking the torque using the same procedure as above. The scale should indicate tape tension as 1½-3 ounces.

Step 13: Use the procedures in the preceding steps to check and adjust the take-up tension which is set at R503 (note that the reel on this side will move counterclockwise).

Brake Adjustment

Brake adjustment is made (*with no power applied to the equipment*) at the point shown in the illustration.

Step 1: Place an empty 10½ NAB reel on the tape supply turntable.

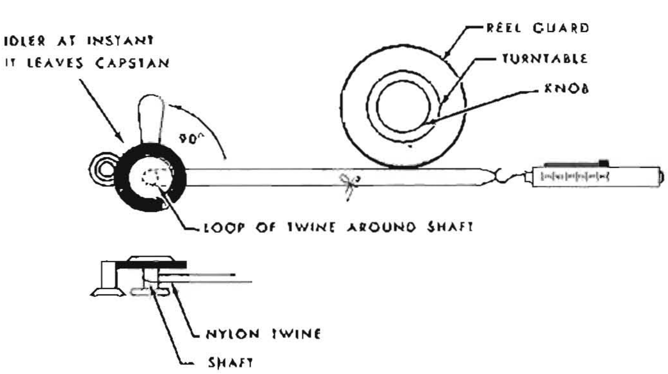
Step 2: Make small loops at both ends of a thirty inch piece of nylon lacing twine.

Step 3: Attach one loop to the tape anchor on the reel hub and the other to a 0-16 oz. spring scale.

Step 4: Manually rotate the reel clockwise to wind several turns of twine onto the hub.

Step 5: Pull the scale, making certain that the twine does not touch either flange of the reel. The turntable will rotate counterclockwise. Take a reading only when the turntable is in steady motion, because the force required to overcome the static friction will produce a false and excessively high initial reading.

Step 6: Adjust the supply and takeup motors' brakes for scale readings listed below. Points of adjustment are shown by illustration.



Capstan idler pressure measurement

Step 7: Now wind the twine on the hub by rotating the reel counterclockwise; pull, and take a reading. The turntable will rotate clockwise.

Step 8: Repeat the entire process on the takeup turntable.

SPRING SCALE READING

Tape Width	*Direction of Most Resistance Supply Counterclockwise Takeup Clockwise*	*Direction of Least Resistance—Supply Clockwise—Takeup Counterclockwise*
¼ inch	12 to 17 ounces	2:1 ratio ±1 ounce in accordance with High Side

Capstan Idler Pressure

The capstan idler is forced against the capstan by the action of capstan solenoid K501. Idler pressure is supplied by the capstan idler pressure spring, and is adjusted by a lock nut on the capstan solenoid spade bolt. See the illustration. Tightening the lock nut increases idler pressure until a point is reached where the solenoid will not bottom. At this point, idler pressure drops to a value which is inadequate to permit the capstan to drive the tape, and slippage will occur unless the nut is backed off. Excessive pressure also throws an unnecessary load on the upper sleeve bearing of the drive motor. The recommended procedure for adjusting idler pressure is as follows.

Step 1: Hold the take-up arm so that the safety switch is activated.

Step 2: With the POWER switch in the ON position, press the PLAY button, and note whether the capstan solenoid is bottomed. (The capstan idler can be pushed off the capstan easily by pushing on the idler arm, if the solenoid is not bottomed). If necessary, back off the lock nut until the solenoid does bottom at 90 volts a-c when cold, or 105 volts when warm (after ½ hour running). The pressure ("dig") against the capstan shaft should be approximately 5 pounds.

NOTE

In the course of normal operation in the reproduce or record modes, the *temperature of the capstan solenoid will rise, and its d-c resistance will increase. Therefore, the minimum line voltage required to bottom the solenoid when it is hot will be greater than that required when it is cold. If the equipment is operating on unusually low line voltage (below 100 to 105v), sometimes encountered in areas where regulation is poor, the solenoid may fail to bottom after it has reached normal operating temperature. It is advisable, therefore, to allow the equipment to operate in the reproduce mode for about half an hour before making any necessary solenoid adjustments. This will allow the widest margin of safety with respect to line voltage variations. The solenoid is factory-adjusted to bottom at 90 line volts cold and 105 line volts hot.*

Step 3: If it is desired to measure capstan dig, press the STOP button at this point and select a piece of nylon lacing twine about 30 inches long and tie the ends together.

Step 4: Slip the twine loop just formed between the idler and idler arm so that the nylon rests against the idler shaft.

Step 5: Attach the other side of the loop to a 0 to 80 oz. scale, letting the nylon twine remain slack.

Step 6: Press the PLAY pushbutton, causing the capstan idler to clamp against the capstan.

Step 7: Pull the scale away so that the nylon twine is taut and makes a 90 degree angle with the idler arm.

Step 8: Now, slowly pull the scale away with sufficient power to cause the capstan idler to leave the capstan, reading the scale at the instant the capstan idler leaves the capstan. The scale reading should be 5 lbs ±½ lb. If necessary, adjust the capstan dig at the point shown in the illustration.

Replacement of Parts

All sub-assemblies of the tape transport mechanism can be easily dismounted with the use of a screwdriver and a few small socket-head screw keys.

CAUTION

Do not attempt complete disassembly of any of the sub-assemblies. The list of individually replaceable parts under each assembly listing in the parts list should be used as a guide to disassembly limits. Replacement of parts other than those listed calls for precision work which should not be attempted in the field. Assemblies with defects in parts other than those listed as replaceable should be returned to the factory or to an Ampex Authorized Service Center for repair or replacement.

Write the Service Department for a proper authorized equipment return tag. Do NOT ship unidentified parts to factory; Ampex can assume no responsibility for their proper care or return under such circumstances.

BRAKE BAND REPLACEMENT

NOTE

Brake Bands may be replaced without removing motor from tape transport on rackmount machines and deleting the first three steps.

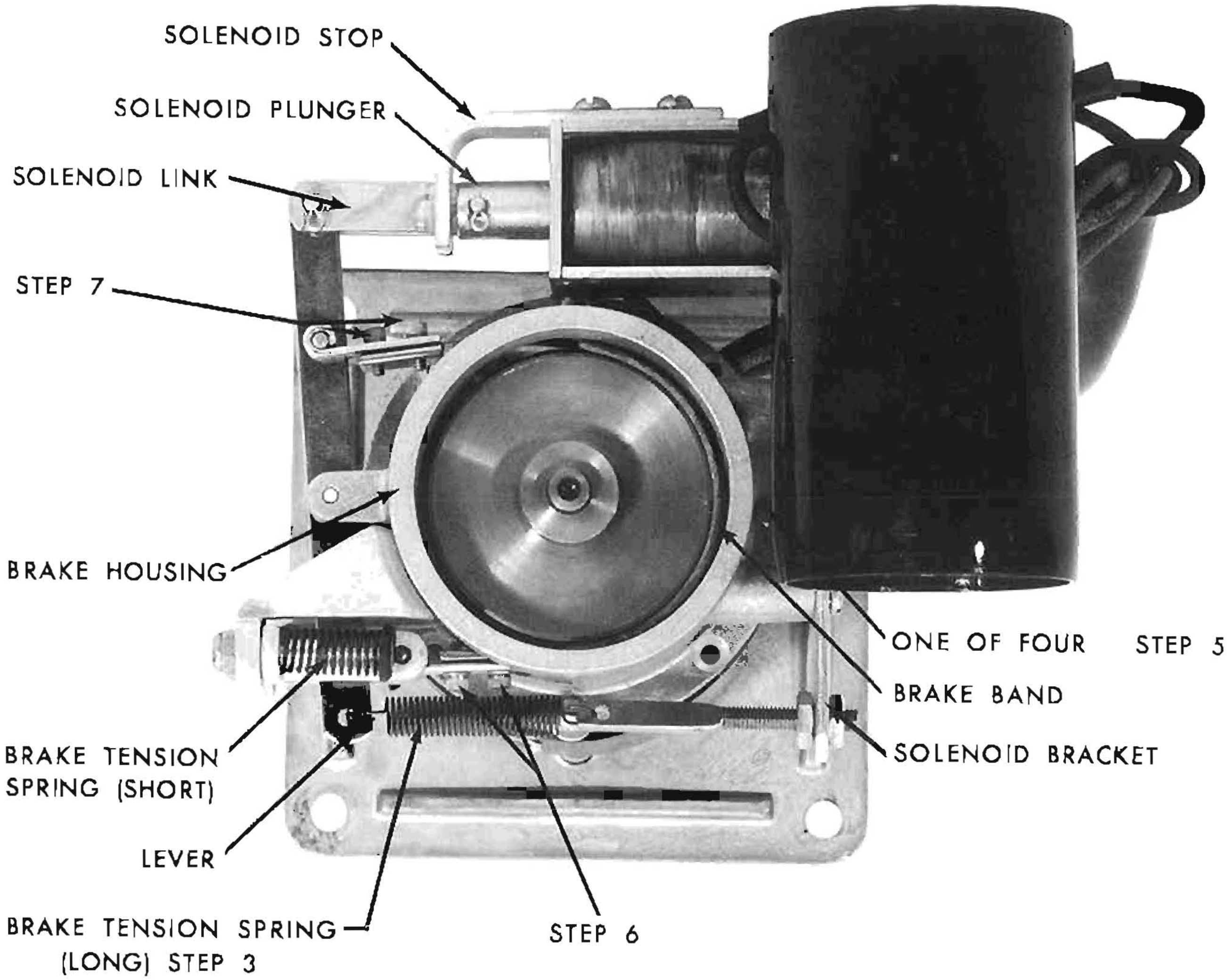
The most convenient method for changing the brake band is first to remove the entire motor assembly.

Step 1: With a 7/16-inch socket wrench remove the four mounting nuts and washers at the motor mounting plate, carefully holding the motor with one hand to prevent it from falling. The turntable will remain attached to the motor assembly.

Step 2: Take the motor to a convenient work area.

Step 3: Unhook the brake tension spring from the brake lever.

Step 4: Remove the two screws holding the capacitor. Disconnect the capacitor wires at the knife disconnects and free the capacitor from the bracket.



Brake band replacement

Step 5: Remove the screws that hold the brake housing to the motor, noting the positioning of the washers, and spacers, and remove the entire housing.

Step 6: Remove the two cap screws holding one end of the brake band between the brake lever spring and the housing using a 5/64-inch Allen wrench.

Step 7: Loosen (do not remove) the two cap screws at the end of the brake band next to the solenoid.

Step 8: The brake band may now be removed taking caution not to lose the band leaf on the solenoid side. There is only one band leaf per assembly.

Step 9: Position the new brake band through the hole in the housing and place between the clamp and tighten the two cap screws loosened in Step 8.

Step 10: Replace the brake housing, making certain that the spacers, the housing, the washers and the screws are replaced in that order, and tighten the screws.

Step 11: Insert the brake band between the band link and band link clamp. Replace the two cap screws but DO NOT TIGHTEN.

Step 12: Push the solenoid in until it bottoms. Adjust the depth of insertion of the brake band between the link and clamp so that the brake drum rotates freely with no drag; then tighten the screws.

CAUTION

If the band is set too far forward in the link, it will buckle slightly when the solenoid plunger is bottomed by hand. If this condition exists the plunger may not bottom when the solenoid is energized. The purpose of the band leaf is to keep the band from splitting when it buckles at the band clamp.

Step 13: Interconnect the wires at the knife disconnects and replace the capacitor to the bracket with the two screws removed in Step 5.

Step 14: Hook the brake spring to the brake lever. Step 4.

Step 15: Replace the motor assembly tightening the four screws that were removed in Step 1.

PACKING PRECAUTIONS FOR MOTORS

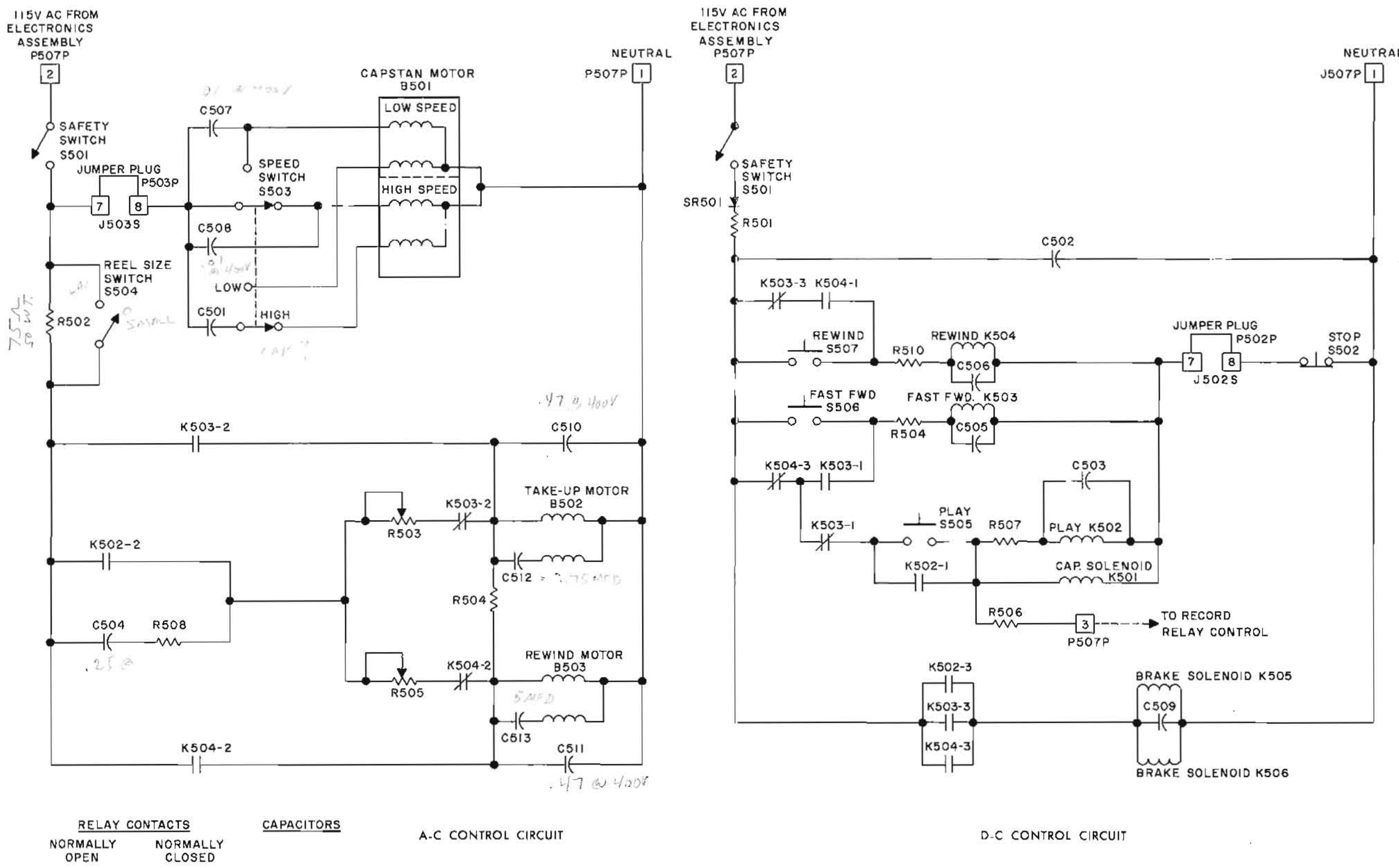
In packing motors for return to the factory, take particular care to prevent the bending of their shafts in transit.

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	TAPE TRANSPORT ASSEMBLY, 7-1/2 - 15 ips: 60 cps; Catalog No. 02-30970-01	
	TAPE TRANSPORT ASSEMBLY, 7-1/2 - 15 ips: 50 cps, Catalog No. 02-30970-02	
	TAPE TRANSPORT ASSEMBLY, 3-3/4 - 7-1/2 ips: 60 cps; Catalog No. 02-30970-03	
	TAPE TRANSPORT ASSEMBLY, 3-3/4 - 7-1/2 ips: 50 cps, Catalog No. 02-30970-04	
B501	MOTOR ASSEMBLY, Drive: 7-1/2 - 15 ips; 60 cps	31210-01
B501	MOTOR ASSEMBLY, Drive: 7-1/2 - 15 ips; 50 cps	31210-02
B501	MOTOR ASSEMBLY, Drive: 3-3/4 - 7-1/2 ips; 50 cps	31210-03
B501	MOTOR ASSEMBLY, Drive: 3-3/4 - 7-1/2 ips; 60 cps	31210-04
C501	CAPACITOR, Motor	9487-02
	FLYWHEEL, Bodine motor	981-00
	FLYWHEEL, Ashland motor	2212-01
P504P	CONNECTOR, Plug: male; 6 contacts; Jones Part No. P-306-CCT-L	145-012
	FAN, Motor	591-001
	TAKEUP ASSEMBLY	9451-04
B502	MOTOR ASSEMBLY, Takeup	6768-03
	TURNTABLE	61462-01
	PAD, Turntable	958-00
P505P	CONNECTOR, Plug: 8 contact	17313-01
C512	CAPACITOR, Motor: 3.75 mfd	035-111
	BRAKE ASSEMBLY	17327-01
	HOUSING, Brake	17614-01
	BAND, Brake	17612-01
	LEAF, Brake Band; 1-1/8" long	61460-01
	SPRING, Brake Tension: long	322-01
	SPRING, Brake Tension: short	17323-01
	BOLT, Eye	69517-06
	CROSSHEAD	17324-01
	ANCHOR	17325-01
	SPACER	17322-01
	PIN, Roll: 1/8 in. dia. by 3/4 in. lg.	406-005
	SCREW, Machine: Cap; socket head, 4-40 by 1/4 in. lg.	470-008
	LINK, Brake Band	69528-01
	CLAMP, Brake Band	69529-01
	LEVER, Brake	69530-01
	PIN, Drivelock: 1/8 in. dia. by 1/2 in. lg.	403-008
	PIN, Cotter: 1/16 in. dia. by 1/2 in. lg.	401-005
	PIN, Clevis: 1/8 in. dia. by 9/32 in. lg.	400-002
K505	SOLENOID, Brake	69532-01
	STOP, Solenoid	17326-01
	BRACKET, Solenoid	69527-01
	LINK, Solenoid	69531-01
	CONNECTOR, Solderless: disconnect splice	171-008
	REWIND ASSEMBLY	9452-04
B503	MOTOR ASSEMBLY, Rewind	6768-03
	TURNTABLE	61462-01
	PAD, Turntable	958-00
P506P	CONNECTOR, Plug: 8 contact	17313-01
C513	CAPACITOR, Motor: 3.75 mfd	035-111
C513	CAPACITOR, Motor: 5 mfd	035-117
	BRAKE ASSEMBLY	17327-02
	HOUSING, Brake	17614-01
	BAND, Brake	17612-01

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	LEAF, Brake Band: 1-1/8 in. long	61460-01
	SPRING, Brake Tension: long	322-01
	SPRING, Brake Tension: short	17323-01
	BOLT, Eye	69517-06
	CROSSHEAD	17324-01
	ANCHOR	17325-01
	SPACER	17322-01
	PIN, Roll: 1/8 in. dia. by 3/4 in. lg.	406-005
	SCREW, Machine cap; socket head; 4-40 by 1/4 in. lg.	470-008
	LINK, Brake Band	69528-01
	CLAMP, Brake Band	69529-01
	LEVER, Brake	69530-01
	PIN, Drivelock: 1/8 in. dia. by 1/2 in. lg.	403-008
	PIN, Cotter: 1/16 in. dia. by 1/2 in. lg.	401-005
	PIN, Clevis: 1/8 in. dia. by 9/32 in. lg.	400-002
K506	SOLENOID, Brake	69532-01
	STOP, Solenoid	17326-01
	BRACKET, Solenoid	69527-01
	LINK, Solenoid	69531-01
	CONNECTOR, Solderless disconnect splice	171-008
	ARM ASSEMBLY, Takeup tension	425-00
	SPRING, Takeup tension arm	30946-01
	GUIDE, Tape: 1/4 in.	675-00
	HOOK, Tape Guide	69542-01
	REEL IDLER ASSEMBLY: 7-1/2 - 15 ips	4459-00
	REEL IDLER ASSEMBLY: 3-3/4 - 7-1/2 ips	4459-03
	GUIDE, Tape	257-00
	PULLEY ASSEMBLY: 7-1/2 - 15 ips	5893-00
	PULLEY ASSEMBLY: 3-3/4 - 7-1/2 ips	5893-01
	BASE, Reel Idler	30840-01
	FLYWHEEL, Reel Idler	636-01
	WHEEL ASSEMBLY, Capstan Idler: 7-1/2 - 15 ips	30945-01
	WHEEL ASSEMBLY, Capstan Idler: 3-3/4 - 7-1/2 ips	30945-07
	CAP	5770-00
	RING, Retaining: external; for 0.250 in. dia. shaft, Truarc Part No. 5100-25-S	430-004
	RING, Lock	5772-00
	WASHER, Cambric	9482-01
	WASHER, Shim: brass; 0.250 in. ID by 0.437 in. OD by 0.002 in. thk.	501-049
	WASHER, Felt	5771-00
	ARM, Capstan Idler	372-01
	BUSHING, Capstan Idler Arm	5755-00
	DUST CAP, Capstan: 7-1/2 - 15 ips	3506-00
	DUST CAP, Capstan. 3-3/4 - 7-1/2 ips	3506-01
	WASHER, Felt	3583-02
	RING, Retaining: rubber; Plastic and Rubber Products Co. Part No. PRP6227-14, 209-70	432-007
	SOLENOID ASSEMBLY, Capstan Idler	5783-01
K501	SOLENOID, Capstan	670-00
	BOLT, Eye Capstan solenoid	396-03
	STOP, Capstan Solenoid	388-00
	WASHER, Felt; 1/4 in. thk.	503-015
	SPRING, Solenoid pressure	676-01
	SPRING, Solenoid Return	5757-00
	GUARD, Pushbutton	361-00
	GUARD, Reel	5708-00

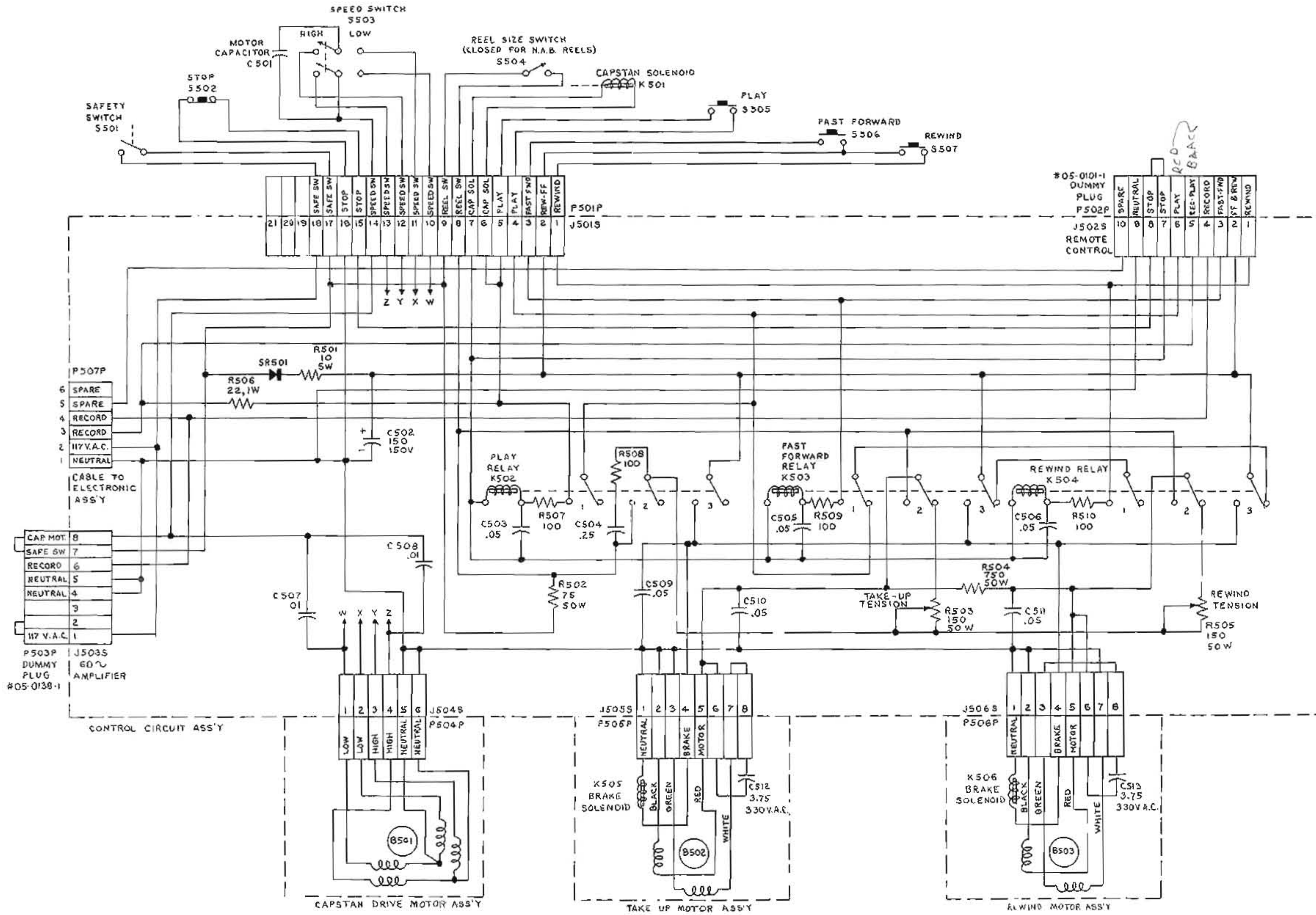
REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	HARNESS ASSEMBLY, Switch	5782-01
	CONNECTOR, Plug: male; 21 contact	145-022
	SWITCH ASSEMBLY, Safety	6582-00
	SHIELD, Microswitch	5730-00
	SWITCH, Normally closed (STOP)	120-014
	SWITCH, Normally open (PLAY, FAST FORWARD, REWIND)	120-013
	SWITCH, DPST (TAPE SPEED)	120-004
	SWITCH, SPST (REEL SIZE)	120-005
	CONTROL BOX ASSEMBLY	5703-03
C502	CAPACITOR, Fixed: electrolytic; 150 mfd; 150 vdcw; Cornell-Dubilier Part No. 15015	031-045
C503	CAPACITOR, Fixed: Mylar; 0.047 mfd; ±10%; 400 vdcw; Sprague Type 160P	033-234
C504	CAPACITOR, Fixed: paper; 0.25 mfd; ±20%; 400 vdcw; Astron Part No. ML-4-25	033-008
C505	(Same as C503)	033-234
C506	(Same as C503)	033-234
C507	CAPACITOR, Fixed: paper, 0.01 mfd; ±20%; 400 vdcw; Astron Part No. ML-4-01	033-005
C508	(Same as C507)	033-005
C509	(Same as C503)	033-234
C510	(Same as C503)	033-234
C511	(Same as C503)	033-234
J501S	CONNECTOR, Receptacle: female; 21 contacts; Jones Part No. S-321-AB	146-057
J502S	CONNECTOR, Receptacle: female; 10 contacts; Jones Part No. S-310-AB	146-018
J503S	CONNECTOR, Receptacle: female; 8 contacts; Jones Part No. S-308-AB	146-003
J504S	CONNECTOR, Receptacle: female; 6 contacts; Jones Part No. S-306-AB	146-004
J505S	(Same as J503S)	146-003
J506S	(Same as J503S)	146-003
K502	RELAY, 3PDT: 115 vdc coil; 10 amp contacts; Philtrol Part No. 33QA (PLAY)	020-006
K503	(Same as K502) (FAST FORWARD)	020-006
K504	(Same as K502) (REWIND)	020-006
P501P	CONNECTOR, Plug: male; 21 contacts; Jones Part No. P-321-CCT-L	145-022
P502P	CONNECTOR, Plug (REMOTE DUMMY PLUG)	3461-00
P503P	CONNECTOR, Plug (60 CYCLE DUMMY PLUG)	567-01
P504P	CONNECTOR, Plug: male; 6 contacts; Jones Part No. P-306-CCT-L	145-012
P505P	CONNECTOR, Plug: male; 8 contacts; Jones Part No. P-308-CCT-L	145-013
P506P	(Same as P505P)	145-013
P507P	(Same as P505P)	145-013
R501	RESISTOR, Fixed: wirewound; 10 ohm; ±10%; 5 watt; Tru-Ohm Type FRL-5	043-156
R502	RESISTOR, Fixed: wirewound; 75 ohm; ±5%; 50 watt; Tru-Ohm Type FR-50	043-002
R503	RESISTOR, Adjustable: wirewound; 150 ohm; ±5%; 50 watt; Tru-Ohm Type AR-50	040-011
R504	RESISTOR, Adjustable: wirewound; 750 ohm; ±5%; 50 watt; Tru-Ohm Type AR-50	040-007
R505	(Same as R503)	040-011

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
R506	RESISTOR, Fixed: composition; 22 ohm; ±10%; 1 watt; MIL-R-11A:RC32GF220K	041-132
R507	RESISTOR, Fixed: composition; 100 ohm; ±10%; 1/2 watt, MIL-R-11A:RC20GF101K	041-038
R508	(Same as R507)	041-038
R509	(Same as R507)	041-038
R510	(Same as R507)	041-038
SR501	RECTIFIER, Selenium: single phase; half wave; General Electric Part No. 6RS25PH6ATD1	582-016



SIMPLIFIED CONTROL CIRCUIT SCHEMATIC

SCHEMATIC DIAGRAM
TAPE TRANSPORT
CONTROL CIRCUITS



NOTES:
1. ALL RESISTORS IN OHMS & RATED 1/2 WATT UNLESS OTHERWISE SPECIFIED
2. ALL CAPACITORS IN MICROFARADS AND RATED 400V UNLESS OTHERWISE SPECIFIED

Section 7 HEAD ASSEMBLY

Section 7 HEAD ASSEMBLY

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, a tape recorder head assembly is a simple device. In practice however, building a head assembly is a complicated task requiring extremely precise manufacturing techniques. There are three head stacks in an assembly–erase, record and playback. 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 playback, the magnetic flux in the *moving* tape induces a voltage in the playback head.

The design and construction of these heads is extremely critical. Their surfaces are lapped to finishes so smooth that variations are measured in wave lengths of light. In typical playback heads the gap is .00025 inch, which give 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.

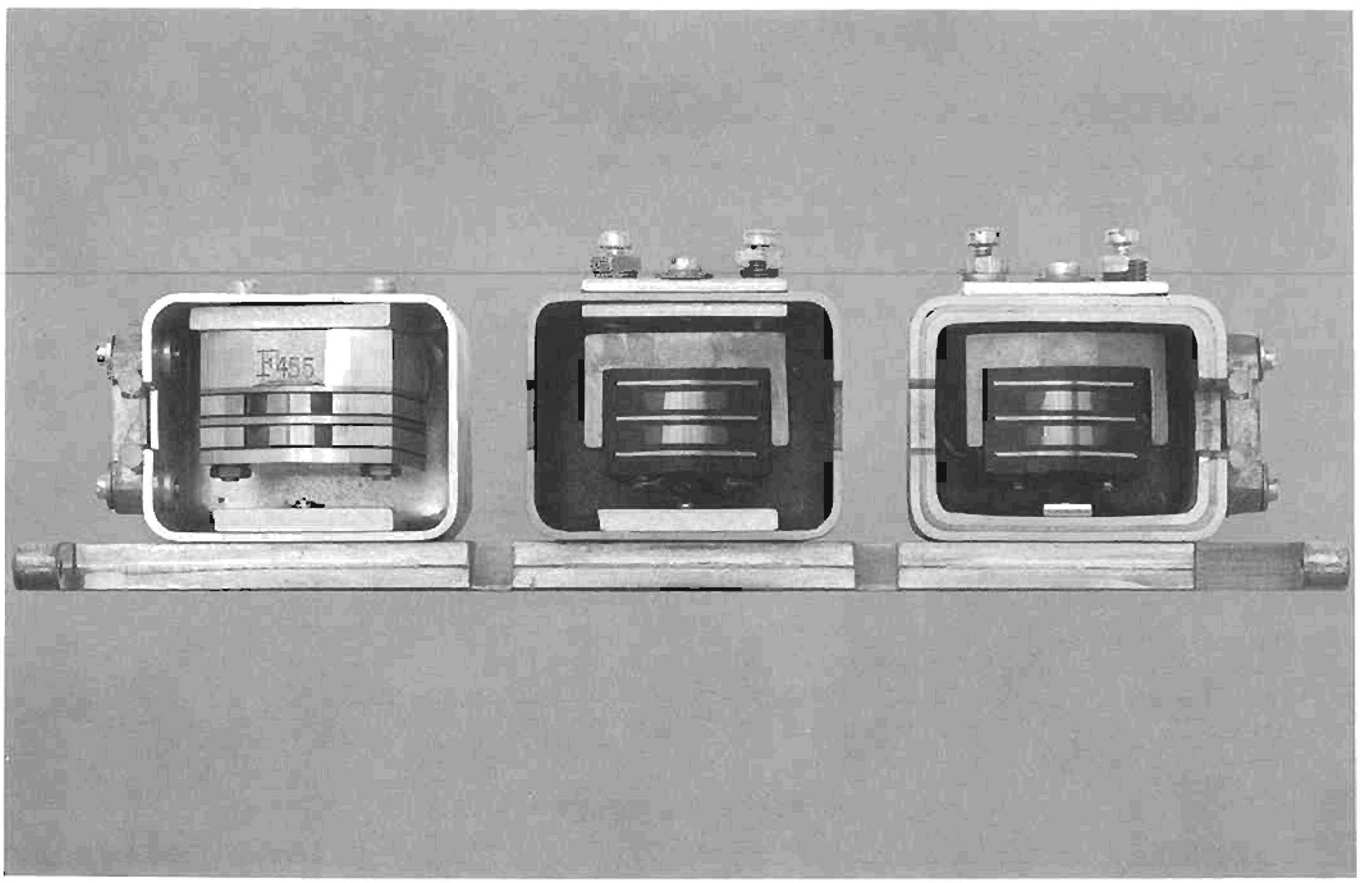
The superb design, engineering and manufacturing care built into Ampex head assemblies assures dependable long life and economical operation at the lowest cost per operating hours.

Head Assembly

The head assembly is housed in a die cast housing and contains three heads used in the operating process. The heads are respectively erase, record and playback as viewed from left to right when facing the machine. The gate on the assembly holds the playback and record shield covers and the tape-lifting fingers. The function of the tape lifting fingers is to remove the tape from the heads when the gate is open during the REWIND and FAST FORWARD operation. The tape may leave a deposit on the heads if allowed to contact them at high speeds. Such a deposit will seriously impair the performance of the machine and should be guarded against by always opening the gate in the FAST FORWARD and REWIND modes. If a deposit is left, it may be removed by xylene on a soft cloth or tissue. Never use metal of any kind to touch the head surfaces. The gates should never be allowed to spring shut, but should be closed gently.

INDIVIDUAL REPLACEABLE HEAD PARTS

Part Description	*Ampex Part Number*
Gate spring, two required	27-0166-01
Gate pin, two required	16-0113
Glass rod, tape guide, 1/2-inch long, four required	21-0190-00
Gate assembly (1/4-inch tape)	→03-0110-00
Housing (1/4-inch tape)	29-0288-01
Screw, cover	40-0373
Screw, alignment	40-0377
Nut	42-0113



Two-track head assembly

Section 8 ELECTRONIC ASSEMBLY

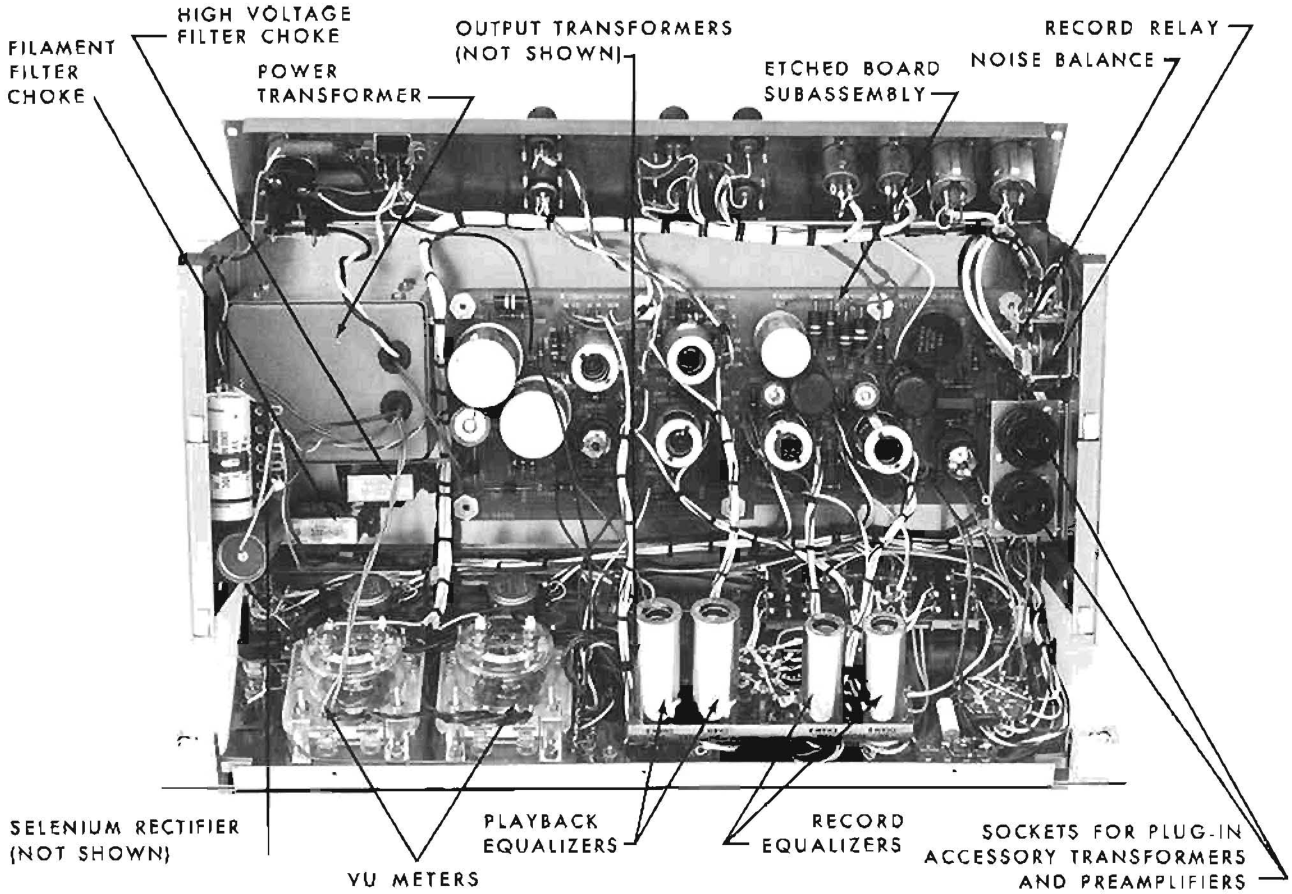
Section 8 ELECTRONIC ASSEMBLY

ELECTRONIC ASSEMBLY

GENERAL

The electronic assembly consists of a single chassis on which is mounted an etched board subassembly containing two record amplifiers, two reproduce amplifiers, a bias and erase oscillator, and the power supply. On the face panel, facilities are available for setting record levels, selecting high or low speed equalization circuitry, and switching output circuitry. Visual monitoring of reproduce and record levels is provided by the two vu meters on the face panel. Two phone jacks for aural monitoring are provided on the face panel. Power on-off is controlled at the front of the assembly. A control for the record function, signified by accompanying indicator lights, and a record channel selector completes the front panel arrangement.

On the back panel of the electronic assembly chassis are all connecting and inter-connecting provisions for power input, line input, line output, power to the tape transport, and head connections. Two screw-type fuse posts are also provided on the chassis back panel.

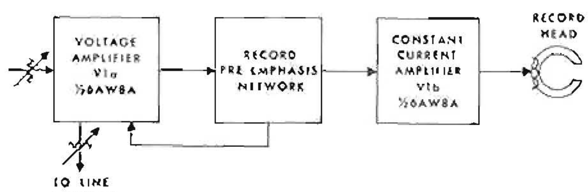


Location of electronic subassemblies

RECORD AMPLIFIER

The two record sections of the electronic assembly each consist of a two stage, high gain, resistance coupled amplifier. Two triode-pentrodes, V1 and V2 and their associated circuitry, form the stages of amplification for both channels. To simplify the discussion, only channel "A", V1 and its related circuitry, will be described. Channel "B" is identical except for reference symbol numbers.

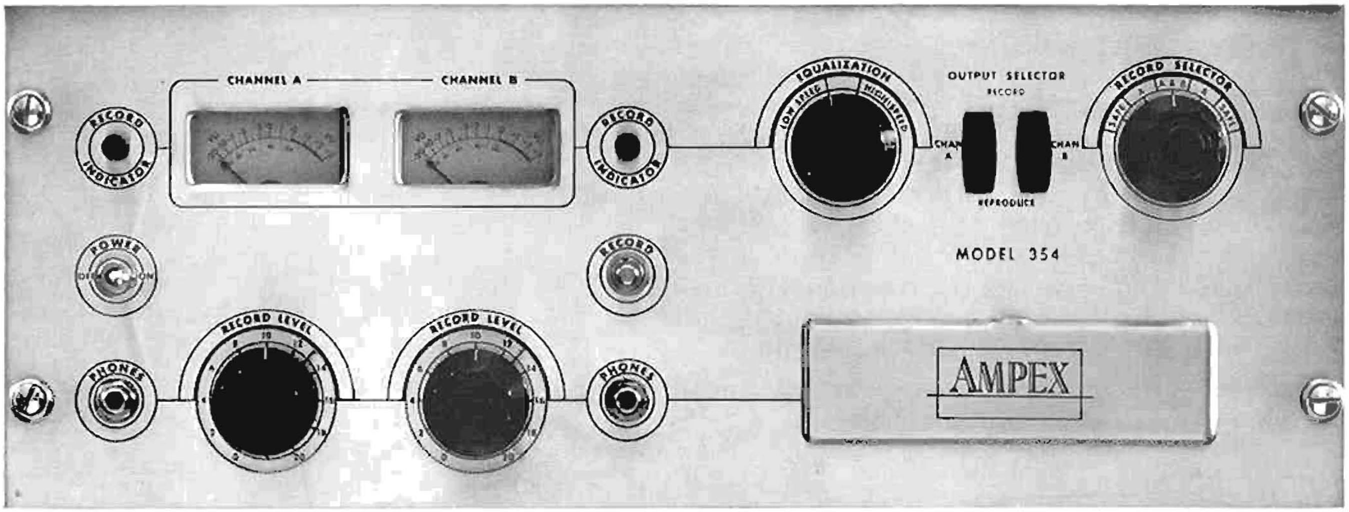
When using an unbalanced-bridging line input, the signal from J1 appears at the grid of tube V1a through transformer socket J15, dummy plug P15, potentiometer R1, and resistor R3. Potentiometer R1 provides a means of setting RECORD LEVEL. Bias is attained by unbypassed resistor R5. Capacitor C1a and resistor R51 form a plate decoupling network for the first stage of both channels. Capacitor C2, resistor R11 and potentiometer R13 (RECord CALIBrate) provide record calibration circuitry. Resistors R3 and R7 establish negative feedback around V1a. Capacitor C2 in conjunction with resistors R7, R11 and potentiometer R13 provides low frequency pre-emphasis.



Block diagram, record circuit

NOTE

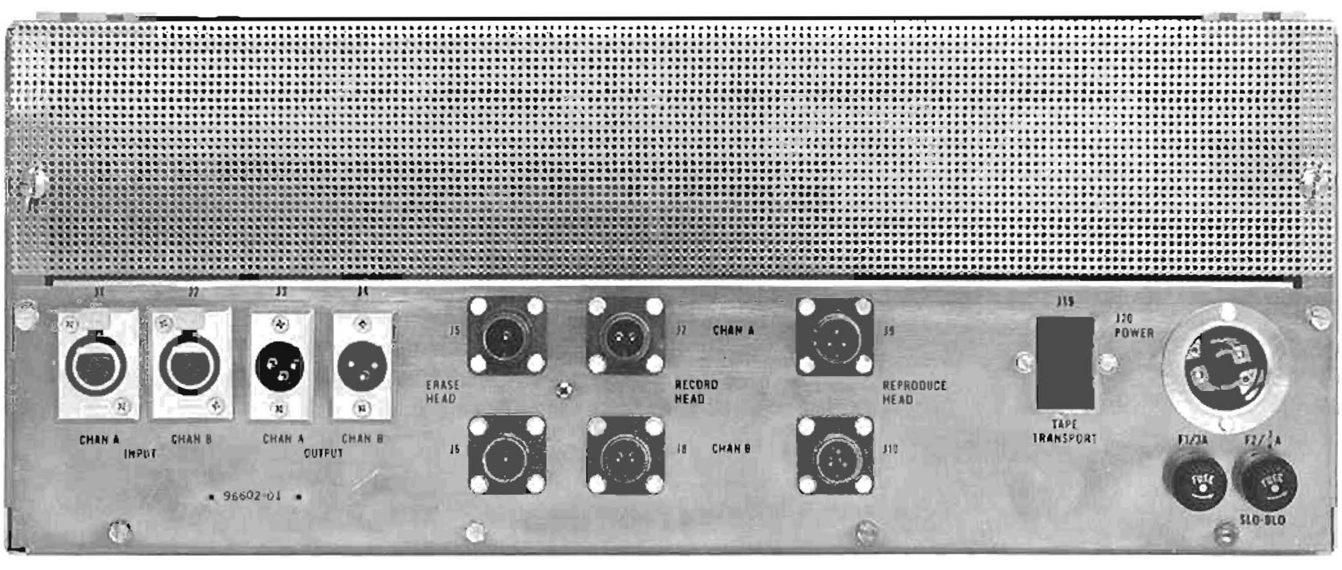
When reading vu meter indications with the OUTPUT SELECTOR switch



Amplifier chassis, front panel

in the RECORD 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 V1b through capacitor C4, the plug-in pre-emphasis network, and resistor R17. Negative feedback is provided through unbypassed resistor R19. Bias for tube V1b is provided by the difference in voltages developed across resistor R5 and resistor R19 by returning the control grid of V1b to the cathode of V1a through a resistance in the plug-in pre-emphasis network. The plug-in pre-emphasis circuitry for high and low tape speeds provide the necessary high frequency pre-emphasis to the control grid of tube V1b. Tube V1b delivers an audio signal current



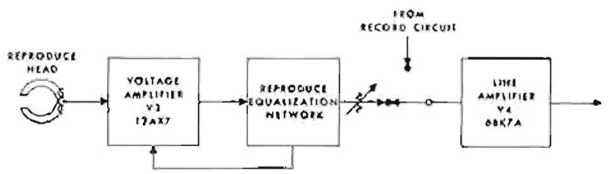
Amplifier chassis, rear view

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 C14.

In the balanced-bridging line input arrangement, operation is identical to that for unbalanced-bridging input except that an accessory plug-in transformer is used in place of dummy plug P15 so that one side of the signal input line will not be connected to chassis ground. When a microphone is used with the equipment an accessory plug-in transistorized preamplifier is used in place of the dummy plug.

REPRODUCE AMPLIFIER

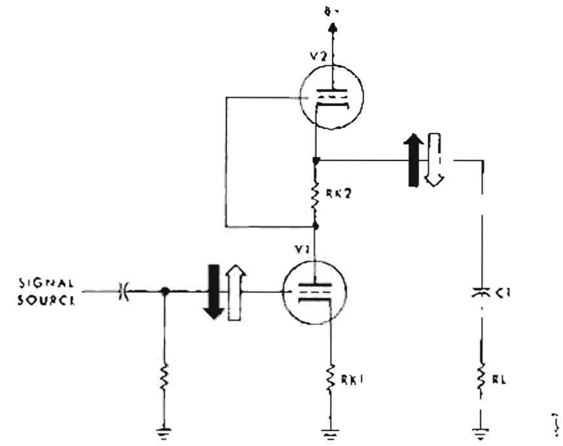
The reproduce section of the electronic assembly is a resistance coupled audio amplifier. Two dual triodes are used to provide two stages of amplification and a single-ended push-pull output for each channel.



Block diagram, reproduce circuit

Signals on the moving magnetic tape induce voltages in the reproduce head. This induced voltage appears across resistor R37 and then the grid of tube V3a. Bias on this first stage is derived from the voltage divider network consisting of resistors R49, R47 and R45. The amplifier output of this first stage is coupled to the second stage grid through capacitor C24. Contact bias is used on V3b. Capacitor C23a and resistor R52 form a plate decoupling network for the first two stages. Reproduce equalization is achieved by means of the plug-in equalizer network.

The signal is now delivered to the push-pull output amplifier V4, the tube receiving the signal through coupling capacitor C26, PlayBack LEVEL potentiometer R54 and OUTPUT SELECTOR switch S2 when the switch is in the REPRODUCE position.



Simplified Schematic, Line Output Amplifier

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 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 foldout schematic diagram, resistor 1R62 corresponds to RK1, resistor 1R60 corresponds to RK2, tube 1V4a corresponds to V1, tube 1V4b corresponds to V2, capacitor 3C30 corresponds to C1, and transformer 3T2 corresponds to RL.

When the output of transformer 3T2 is terminated in its characteristic impedance (i.e. 600 ohms), the output level would drop by 6 db if the basic circuit were used. To partially compensate for this affect, 7 db of negative voltage feedback is applied to the grid circuit from the primary of transformer 3T2 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 1C28 compensates the output stage for flat high frequency response.

BIAS AND ERASE OSCILLATOR

A dual triode tube V7, 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 taps on the oscillator transformer primary. 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 tube 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 T4 and the effective capacity across the primary.

The oscillator output is fed through RECORD SELECTOR switch S4 and through capacitors C21 (for channel A) and C22 (for channel B) to the two-channel erase head. The oscillator ouput is also fed to BIAS ADJ*ust* variable capacitors C14 (for channel A) and C15 (for channel B) where record bias current adjustments take place. The bias signals are then mixed with the record signals and delivered to the two-channel record head. Plate voltage is supplied to the center tap of oscillator transformer T4 through relay contact K1B only when the equipment is in the record mode.

NOISE BALANCE control, potentiometer R31, in the oscillator cathode circuits is adjusted to correct for any asymmetry in the waveform, which would cause random noise during reproduction and distortion while recording.

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 as well as the RECORD INDICATOR lights DS1 and DS2. Selenium rectifier CR3 is connected as a conventional full wave center tap rectifier to provide dc filament voltage for all tubes except V7.

The center tap of the V5 tube filament provides a ground for the dc filaments. Even though this tube is only used for the reproduction of channel two, it must be in its socket for proper operation of all functions. Ac power input is connected at J20 POWER receptacle and is controlled by POWER switch S6. The power is fed through fuse F2 and impressed across the primary of power transformer T1 and also through fuse F1 to the tape transport.

There are three secondary windings on the power transformer — two for filament supply and one for high voltage. One filament winding serves oscillator tube V7 and the panel lights, the second filament winding provides 12.6 volts dc after rectification, and the other winding furnishes high voltages for the plate supply. The plate supply ripple is filtered by a capacitance-input choke filter formed by choke L1, capacitors C16b, C16c, and C35; additional filtering is supplied by the decoupling capacitors.

High voltage is applied to the bias oscillator through record relay K1b. Whenever the PLAY button on the tape transport is pressed, approximately 150 volts dc is available at pin 3 of J19. When the RECORD SELECTOR switch S4 is in the "A", "A&B" or "B" position and when the RECORD button S5 is pressed, the dc voltage is applied to the record relay coil. As long as the dc voltage is available at pin 3 of J19 and as long as the RECORD SELECTOR switch is in one of the positions mentioned above, contact K1a holds the record relay energized. When the STOP button on the tape transport is pressed or when the RECORD SELECTOR switch is turned to one of the SAFE positions, the dc voltage no longer reaches the relay coil, the relay is de-energized and drops out.

NOTE

The RECORD SELECTOR switch can be turned from one position to another during the recording process provided that it is not turned to one of the SAFE positions. However, for click-free performance it is preferable to pre-select the setting of the RECORD SELECTOR for the mode of operation desired.

ALIGNMENT AND PERFORMANCE CHECKS

General:

In the following alignment and performance checks, each channel should be treated separately except where noted. In cases where, in the middle of a procedure, the second channel must be checked simultaneously with the first channel, all steps preceding should be performed on both channels.

Equipment Required:

AMPEX Standard Alignment Tape, Catalog No. 01-31323-01. (See "Accessories" section.)

Ac Vacuum Tube Voltmeter capable of indicating rms voltages of 0.004 or less.

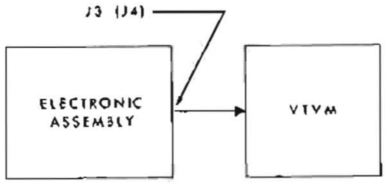
Audio Oscillator with stable output from 50 cps to 15 kc.

Earphones or Speaker - Amplifier for aural monitoring.

Nutdriver, number 8 (¼ inch).

Reel of unrecorded tape.

Small screwdriver.



Block diagram, reproduce alignment connections

Reproduce Alignment:

CAUTION

The standard alignment tape used in the following procedures may be partially erased if the record and reproduce heads are permanently magnetized. Demagnetize the heads before proceeding.

Step 1: Take off the head cover.

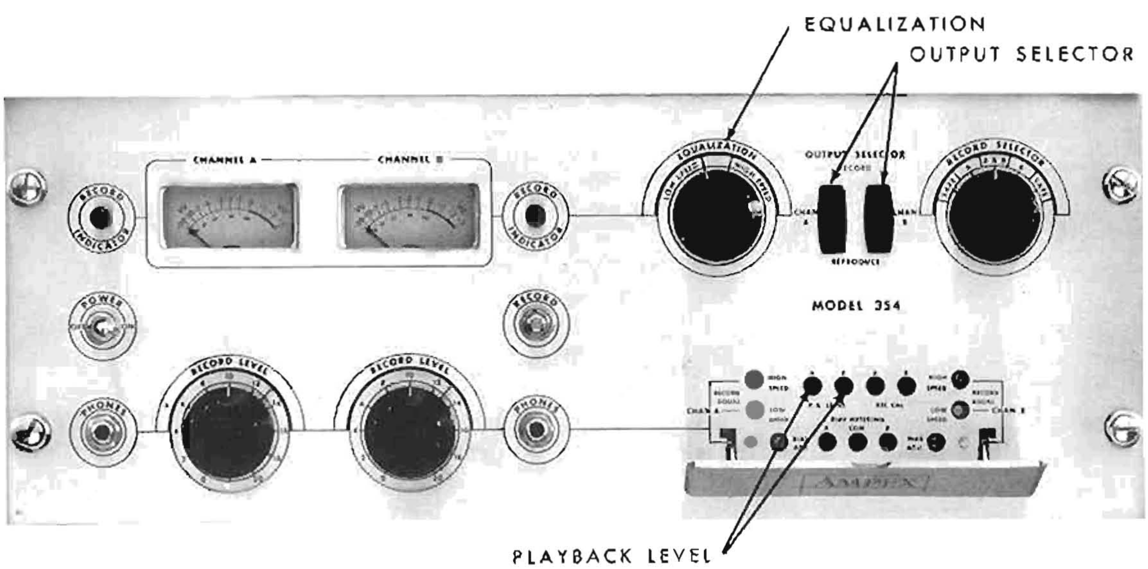
Step 2: With the equipment connected as shown and all power switches in the ON position, thread the appropriate AMPEX standard alignment tape along the prescribed path.

Step 3: Set the EQUALIZATION switch to the desired speed.

Step 4: Place the OUTPUT SELECTOR switch in the REPRODUCE position.

Step 5: Start the standard tape. The first tone on all standard tapes is a reference level, 700 cycles for 7½ and 15 inches per second, and 500 cycles for 3¾ inches per second. Adjust the *PlayBack* LEVEL control to a convenient meter reading for checking alignment and response.

Step 6: The next tone will be 15,000 cycles at 7½ and 15 inches per second, and 7500 cycles at 3¾ inches per second for adjusting reproduce head alignment. Take the number 8 nut driver and adjust the left hand stop nut on the reproduce head for maximum output on VU meter or VTVM. If the peak is broad adjust for minimum output variation. Because there are two heads in the head stack, make the azimuth adjustment for an average maximum meter indication, ad-



Reproduce alignment controls

justing first one head and then the other, and finally adjusting for the average maximum meter indication.

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 peaks.

Step 7: Depending on tape speed, tones from 15,000 cycles to 30 cycles now will be reproduced from the standard tape. High frequency response (above 300 cycles) should not vary more than 2 db from the standard curve.

NOTE

When reproducing AMPEX *standard alignment tapes on multitrack equipment, 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 standard 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 8: The next tone to be heard on the 3¾ and 7½ inch per second standard tapes is a reference tone at operating level. (For 15 inches per second, rewind the standard tape to the first tone.) Adjust the P*layB*ack LEVEL control to obtain a zero reading on the vu meter or a +4 dbm output on a VTVM.

NOTE

Do not change this playback level setting for the remainder of the adjustments. Remove the standard tape upon completion of the reproduce alignment.

Reproduce Amplifier Noise Measurement:

Step 1: After performing the reproduce alignment checks, stop the tape motion.

Step 2. Read the noise level on the VTVM. Noise should be below the level specified in the performance characteristics. 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.

Record Amplifier Bias Adjustment:

NOTE

This adjustment should be made using the brand and type of tape that normally will be used on the equipment.

Step 1: Place the OUTPUT SELECTOR switch in the REPRODUCE position.

Step 2: Place the equipment in the record mode at 7½ ips tape speed.

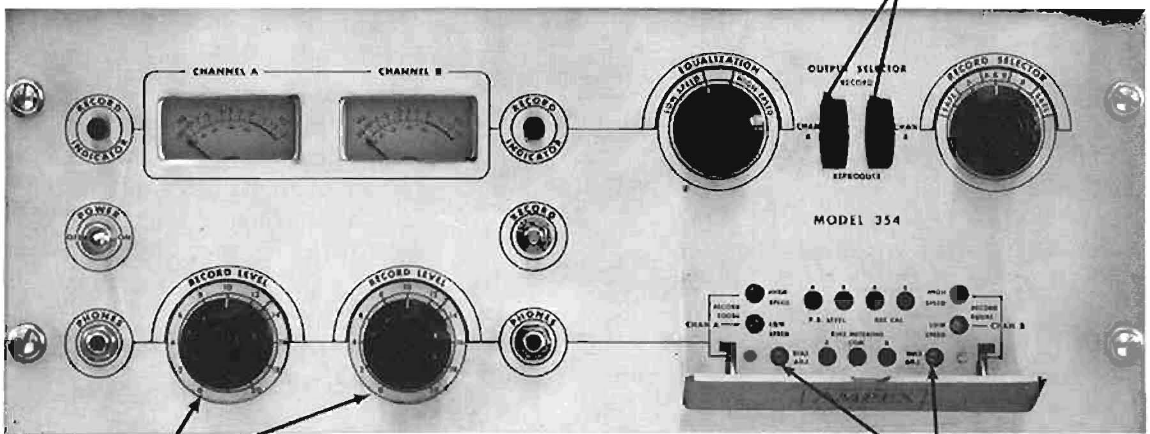
Step 3: Set the oscillator frequency at 500 cycles per second (cps) with an output of approximately 1 volt.

NOTE

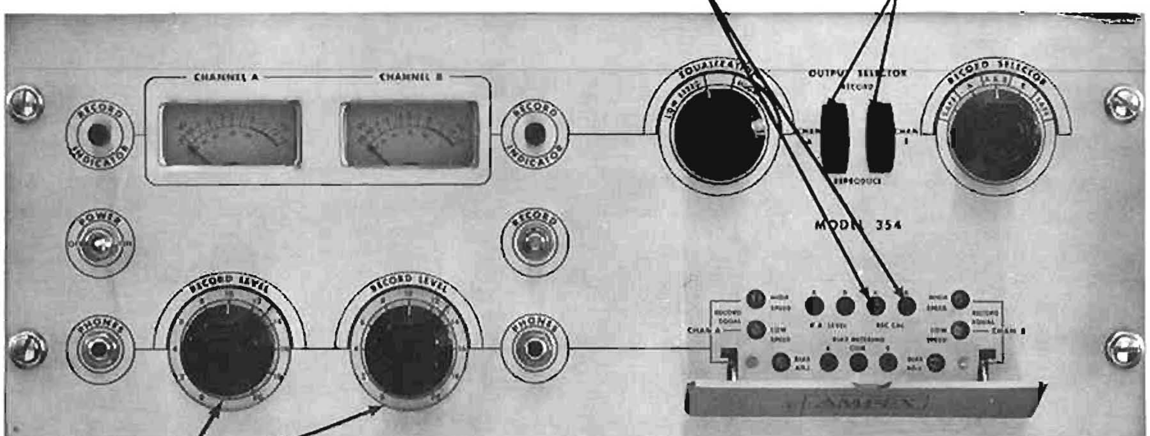
Bias is set at a specific wavelength. If it is desired to set bias at 15 inch tape speed, use a frequency of 1000 cps.

Step 4: Set the RECORD LEVEL control at 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. Then adjust the trimmer clockwise until the vu meter reading drops ½ db. Measure the bias current with a VTVM connected between the BIAS METERING test point for the appropriate channel (test points are labeled A and B) and COM*mom* (ground) (current = voltage on meter ÷ 100). Readjust the trimmer counterclockwise until the vu meter reading again drops ½ db. Measure the bias current. Set the trimmer at the median of the two bias current readings.



Record Amplifier bias adjustment controls



Record level calibration controls

NOTE

Provided that the head assembly and the type of tape is not changed, the median bias current reading found in step 5 may be used to reset the bias current whenever the units is recalibrated.

Record Level Calibration:

NOTE

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

Step 1: Set the audio oscillator to 500 cps. Leave the OUTPUT SELECTOR switch in the REPRODUCE position.

Step 2: Place the equipment in the record mode at 7½ ips tape speed.

Step 3: Set the RECORD LEVEL control at a position that will obtain a zero reading on the vu meter.

Step 4: Place the OUTPUT SELECTOR switch in the RECORD position.

Step 5: Adjust the RECord CALIBrate potentiometer for a zero vu reading.

Record Azimuth Adjustment:

Step 1: Set the audio oscillator at 500 cps.

Step 2: Place the OUTPUT SELECTOR switch in the RECORD position.

Step 3: Set the RECORD LEVEL control to obtain a vu meter reading of approximately −20 (−16 dbm on VTVM).

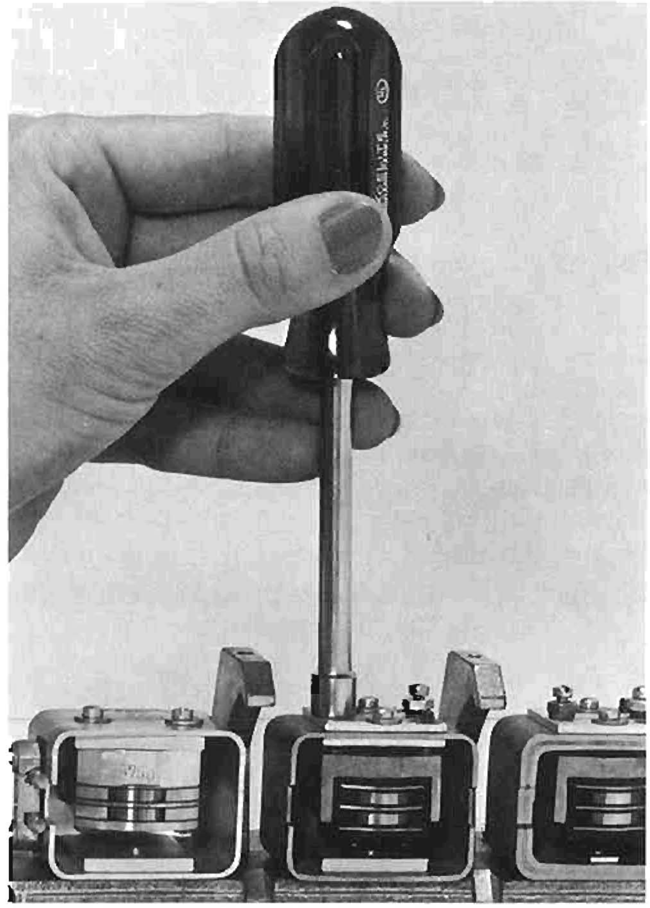
Step 4: Place the OUTPUT SELECTOR switch in the REPRODUCE position.

Step 5: Set the audio oscillator to 7500 cps for 3¾ ips, 15 kc for 7½ or 15 ips.

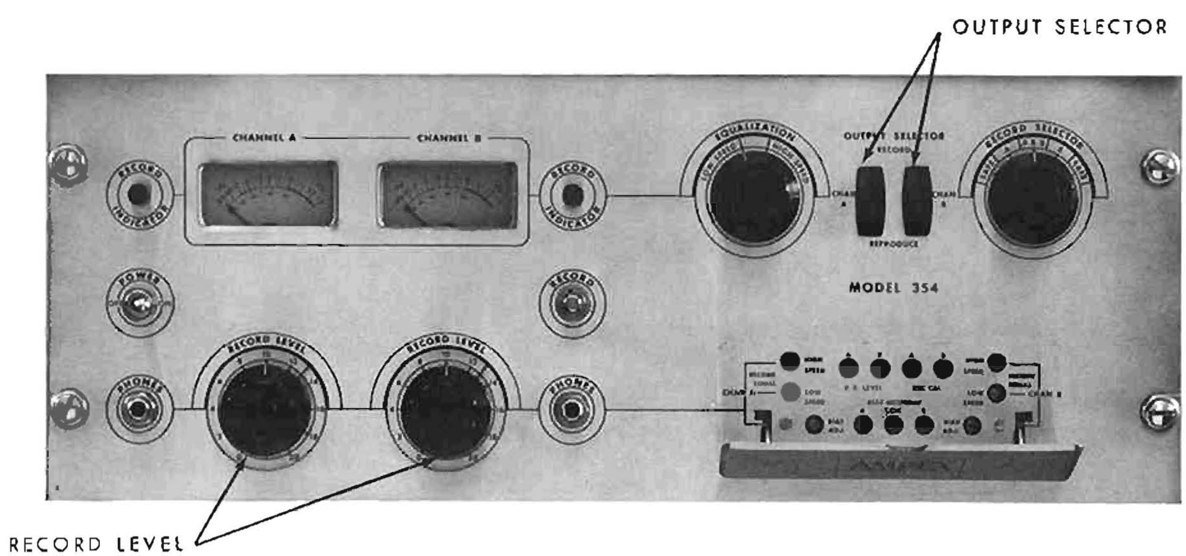
Step 6: With the nut driver, rotate the adjustment nut on the left side of the record head (as the user faces the front of the equipment) to obtain a maximum VTVM reading. Several peaks may appear, but the maximum peak is obvious because it is much greater than the minor peaks.

CAUTION

The right hand nuts are factory set. DO NOT ADJUST THEM.



Record head azimuth adjustment



Record head azimuth controls

NOTE

If it is desired to make this azimuth adjustment using the VU meter instead of the VTVM, place the PLAYBACK LEVEL control in the full clockwise position and adjust the azimuth nut to obtain a maximum VU meter reading.

Overall Frequency Response:

To avoid tape compression, frequency response measurements at 15 ips tape speed should be made at least 10 db below operating level (−6 dbm), at 3¾ and 7½ ips at least 20 db below operating level (−16 dbm). The standard alignment tapes are recorded at a higher level to facilitate reproduce measurements only on the vu meter.

Step 1: Place the OUTPUT SELECTOR switch in the RECORD position.

Step 2: Set the audio oscillator at 500 cycles and adjust the RECORD LEVEL control to obtain a VTVM reading of approximately −16 dbm.

Step 3: Place the OUTPUT SELECTOR switch in the REPRODUCE position.

Step 4: Place the equipment in the record mode at the desired operating speed.

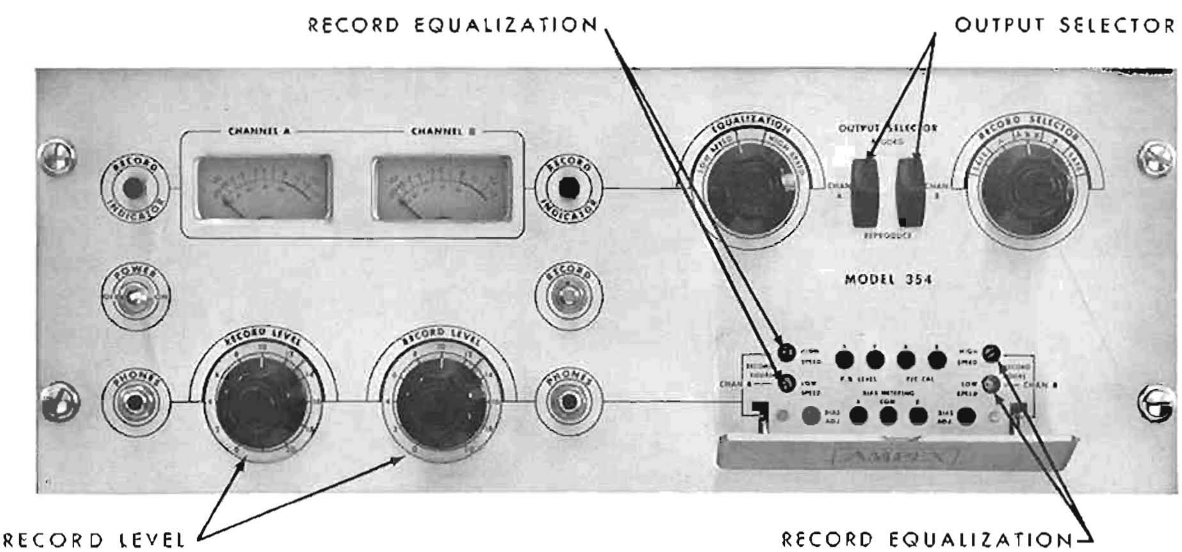
Step 5: Make a frequency response check by using at least ten discrete frequencies between 50 and 15,000 cycles. The high frequency response may vary with tapes of different manufacturers. This machine was adjusted at the factory to give optimum performance within specifications with an average tape. The RECord EQUALizer controls may be re-adjusted to give the flattest possible response with the tape you intend to use. The bias setting will also change the high frequency response, especially at the lower tape speeds (3¾ and 7½ ips). Before adjusting the RECord EQUALizers be certain that the bias has been correctly adjusted as previously described.

CAUTION

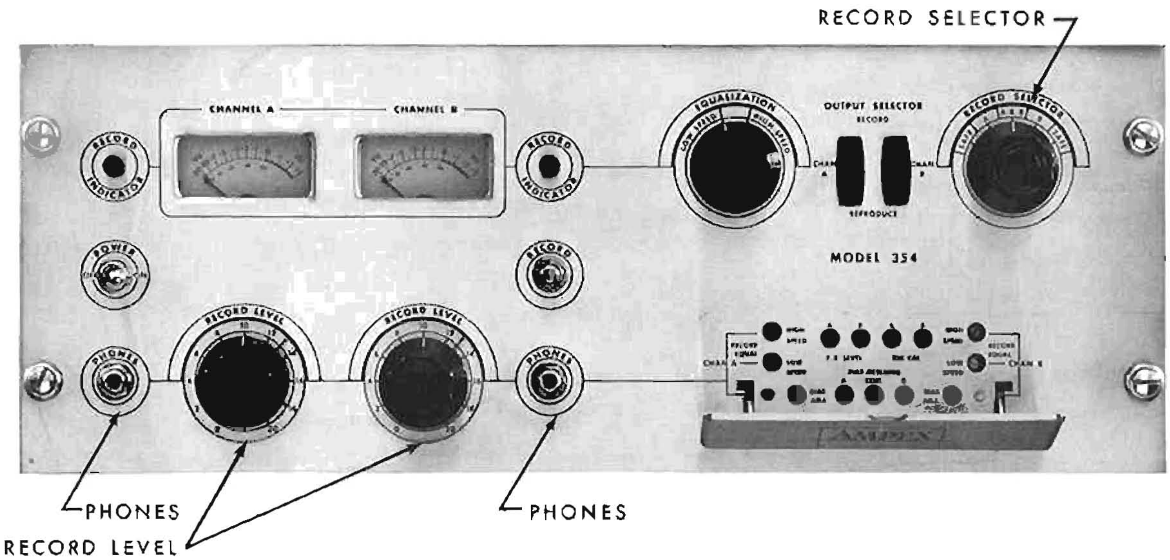
Changing bias may change the RECord level CALIBration which may require re-adjustment as described earlier in this section.

Record Noise Balance Adjustment:

Step 1. Position the RECORD LEVEL control for channel one completely counterclockwise.



Frequency response adjustment controls



Noise balance adjustment controls

Step 2: Disconnect all inputs.

Step 3: Place the RECORD SELECTOR switch in the "A" position.

Step 4: Place the equipment in the record mode.

Step 5: Plug a set of headphones into the monitor jack for channel one and listen for the minimum noise location while adjusting the noise balance control. Note the position of the slot on the noise balance control.

Step 6: Stop the recorder.

Step 7: Perform steps 1 through 6 for channel "B".

Step 8: Set the noise balance control to the position midway between the positions found in step 5. The control slot should be within 45 degrees of a line paralleling the face panel of the chassis.

NOTE

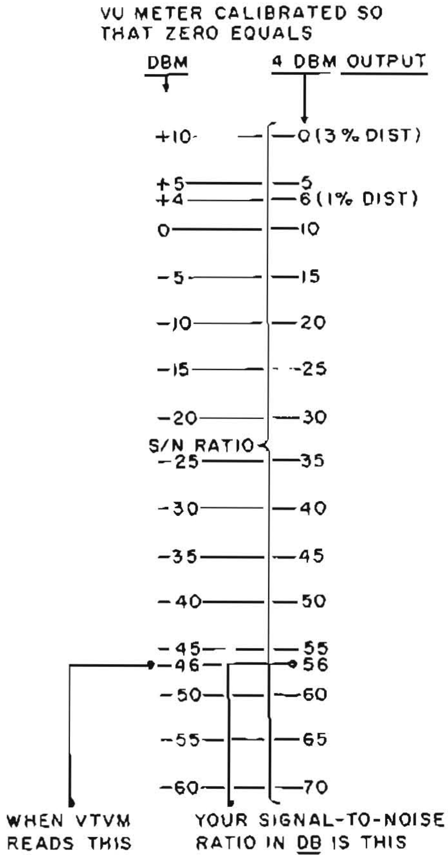
This adjustment is not critical and noise will normally not be heard. This adjustment can, however, be used to balance out second harmonic distortion in the oscillator using a wave analyzer. If noise is present and cannot be nulled in either steps 5 or 8, it indicates excessive leakage in capacitor C12 or C13, trouble in the oscillator circuitry, or magnetized heads and troubleshooting is indicated.

Record Noise Measurement:

To translate VTVM readings into specific signal-to-noise ratios when the vu meter is so calibrated that zero vu corresponds to +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 4 dbm normal level and 6 dbm to the 3% distortion level)
−50 (dbm, vtvm reading)
60 db signal-to-noise ratio

Any reading below −50 dbm meets performance characteristics specifications of 60 db signal-to-noise and satisfies the signal-to-noise ratio definition.



Signal-to-noise ratio computations

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 the band from 30 to 15,000 cycles, which exists in reproduction under the same gain conditions.

AMPEX audio instruments normally are 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 due to the approach of 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.

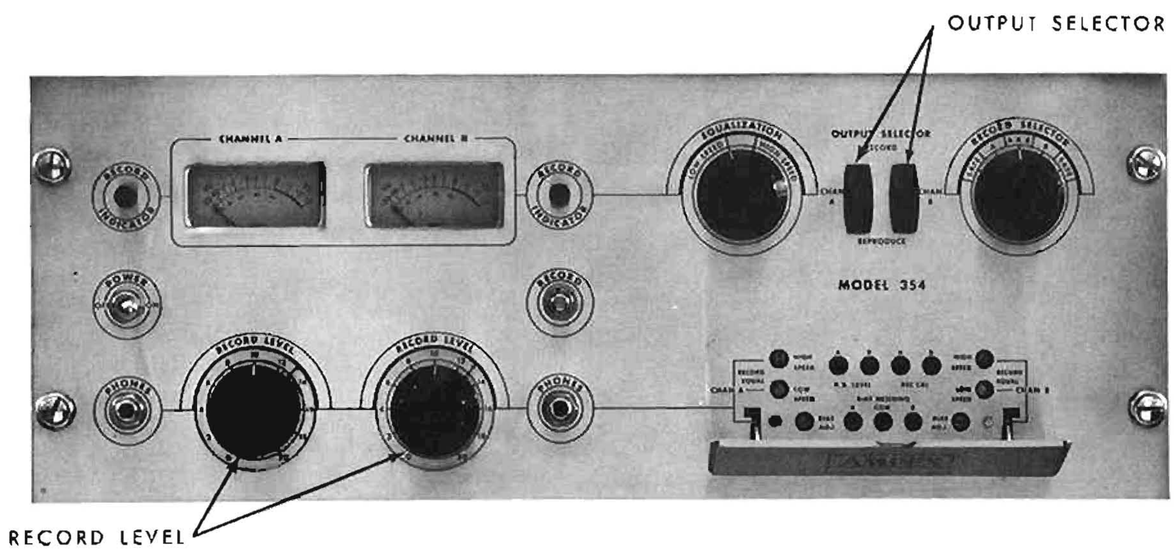
Step 1: Place the OUTPUT SELECTOR switch in the RECORD position.

Step 2: Set the audio oscillator at 400 cps.

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

Step 4: Record the 400 cps on a section of tape, noting where the recording begins for later reference.

Step 5: Disconnect the oscillator.



Noise measurement controls

Step 6: Set the RECORD LEVEL control to zero (fully counterclockwise).

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

Step 8: Erase the tape by recording with no input signal.

Step 9: Rewind again to the beginning of the recording.

Step 10: Place the OUTPUT SELECTOR switch in the REPRODUCE position.

Step 11: Reproduce the tape, reading the VTVM, and checking the reading against the table.

MAINTENANCE AND TROUBLESHOOTING

General Maintenance Information

Faithful adherence to the recommended ROUTINE MAINTENANCE found in SECTION 6 TAPE TRANSPORT MECHANISM and careful performance checks will insure excellent equipment operation. When the cleaning, lubricating and demagnetizing 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.

When the user suspects faults, the above information should be considered, and, if satisfied that the cause is in the amplifier, he then can begin troubleshooting.

Progressive Maintenance of the Amplifiers

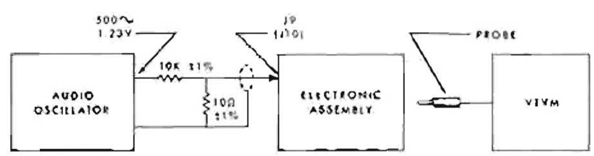
Check B+ voltage at junction of filter choke L1 and capacitor C16b; voltages measured will vary with line voltage, the voltages indicated on the schematic diagram were measured with a 117 volt line voltage. Check all tubes using a tube tester. Make certain that tubes are returned to same socket from which they were removed. Check dc filament voltage to note aging of CR3. Clean the relay contacts by inserting a burnishing tool between contacts and pull it back and forth several times.

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, PARTS LOCATION PRINTED CIRCUIT BOARD SUB-ASSEMBLY, and fold out SCHEMATIC DIAGRAM—ELECTRONIC ASSEMBLY).

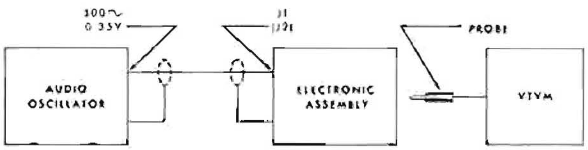


Troubleshooting the reproduce amplifier

Disconnect the head cable at J9 (or J10) 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 foldout 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, PARTS LOCATION PRINTED CIRCUIT BOARD SUBASSEMBLY, and foldout SCHEMATIC DIAGRAM — ELECTRONIC ASSEMBLY).



Troubleshooting the record amplifier

Proceed as in troubleshooting the reproduce amplifier. Typical voltage readings are shown on the foldout 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 the record relay energized.

Servicing and Repairing Printed Circuits

Because of the uniform wiring layout and translucent boards, printed circuits can be traced more easily than conventional circuits, troubleshooting is less difficult, and any qualified person will be able to service and repair the equipment including replacement of components by following the instructions, suggestions and procedures in this section The translucency of the board makes locating connections and test points easier if a light bulb is placed underneath the circuit to be traced. Continuity checks and measurement of resistors, coils and some types of capacitors can be made at the component side of the etched board. Very small breaks in wiring can be located by means of a magnifying glass. The parts location illustrations and the schematic diagram in this section can be used to advantage when tracing circuitry, especially where tube sockets are concerned. Pin numbers are plainly marked.

Precautions

Be careful when removing components from the board to avoid damaging the components themselves or the copper foil wiring. If damage occurs, small breaks can be joined with solder, new foil can be cut to simulate the damaged sections, and large breaks can be repaired with hook-up wire. When applying new foil, first remove all coatings such as flux, grease and wax from the damaged portion and place the adhesive side of the foil toward the board. With the tip of the smooth wedge-shaped soldering iron heat the new foil, sliding the tip slowly along the copper surface for about a minute to cure the bond.

Excessive pressure can crack the boards. Access to certain components may not be possible when the boards are in the chassis To remove the board from the chassis, remove the four mounting nuts carefully. When disconnecting the edge-on harness connectors, make certain that the diagonal pliers grasping the individual connector will not strike and break an adjacent component. To prevent this type of damage, insert a screw driver or similar protective device between the diagonal pliers and the vulnerable component. A vise with protected jaws can be used to hold the boards while servicing. Avoid excessive pressure against the boards when using the vise.

Another source of damage can come from overheating during the soldering process. Excessive heat can cause breaks in the bond between the board and foil, necessitating costly repair of the foil connections. Use 60/40 resin core solder, the melting point of which is 375 degrees F. Some soldering irons are available with tip temperature of 650 degrees F., but the more skilled repair man can speed up the soldering process by using an iron with a tip temperature in the neighborhood of 750 degrees F.

Equipment and Tools Required

Diagonal cutters
Long-nosed pliers
Pocket knife
¼-inch nut driver
Solder pick
Small wire brush
Pencil soldering iron
60/40 resin core solder

Removing a Resistor

A convenient method of removing resistors is to clip the leads with cutters, leaving sufficient wire at each point so that wiring terminals remain. New components can be soldered to these remnant leads.

Replacing the Resistor

Make mechanical joints by wrapping a turn of each new resistor wire around the remnant wires left from the old component. Perform the soldering quickly and efficiently.

Solder Method of Removing and Replacing Components

On the wiring side of the board at the component to be replaced, heat the connections with an iron until the solder melts. Quickly remove the iron and brush away the solder using the wire brush. Two or more heating passes may be required; but take special care to avoid excessive heat.

Now the mechanical joint will be revealed. Insert a knife blade between the board and the exposed wire, and carefully raise the wire until it is perpendicular to the board and will come free in the next step. Again apply the soldering iron to the connection point while simultaneously moving the lead back and forth until it breaks free of the molten solder.

Take the replacement component, cut the leads to the desired length, insert them into the holes, bending the leads against the board to make mechanical connections, and solder the connections.

Replacing Electrolytic Capacitors, Relays and Coils

The replacement of these types of components can be accomplished as follows:

Step 1: With the soldering iron, heat each connection and brush away melted solder. Some parts may require prying the mounting lugs perpendicular to the board in order to brush away the melted solder.

Step 2: Trim the lugs as close as possible to the board.

Step 3: Again apply the soldering iron to the connections, brush away the melted solder.

Step 4. Insert replacement component and solder the connections.

Replacing of Tube Sockets

Step 1: With soldering iron, heat each contion and brush away melted solder. If the connections do not come free on the first pass, repeat the heating process until connections are broken.

Step 2: With a pen knife inserted between the socket lug and wiring foil, bend each lug upward — except the grounding lug.

Step 3: When all socket lugs have been freed from the wiring foil, heat the grounding lug until the solder melts and slowly pull the socket away from the board.

ORDERING PARTS

The purpose of the parts list is to aid you in ordering replacement parts. Ampex can offer fast and efficient service in providing normally replaceable parts of the components in the system when proper information is furnished. Parts listed according to the schematic reference symbol, a description of the part and the Ampex part number. The Ampex Corporation offers some replacement parts that are not necessarily exact replicas of those used on the original version of the equipment; but these parts are interchangeable with the original parts. 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, CAPACITOR, fixed: ceramic, .02 uf + 80%-20%, 500 vdcw; Sprague Part No. 36C205 will always bear the Ampex catalog 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 Serial Number, Ampex Part Number, Description of Part. Example: 4 ea. 54-0265 capacitors for Series 354.

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	ELECTRONIC ASSEMBLY, 7-1/2 ips NAB - 15 ips NAB: Catalog No. 02-96601-01	
	ELECTRONIC ASSEMBLY, 7-1/2 ips CCIR - 15 ips CCIR: Catalog No. 02-96601-02	
	ELECTRONIC ASSEMBLY, 3-3/4 ips 120usec - 7-1/2 ips NAB: Catalog No. 02-96601-03	
	ELECTRONIC ASSEMBLY, 7-1/2 ips NAB - 15 ips AME: Catalog No. 02-96601-04	
	ELECTRONIC SUBASSEMBLY	05-0131-01
1C1	CAPACITOR, Fixed: electrolytic, 3 x 15 mfd; 450 vdcw	30770-03
1C2	CAPACITOR, Fixed: ceramic; 0.05 mfd: +80 -20%; 500 vdcw; Sprague Part No. 5HK-S5	030-066
1C3	(Same as 1C2)	030-066
1C4	CAPACITOR, Fixed: paper; 0.068 mfd; ±10%; 400 vdcw; Sprague Part No. 89P68394	035-299
1C5	(Same as 1C4)	035-299
3C6	CAPACITOR, Variable: trimmer; 50-240 pfd, 175 vdcw; Arco Part No. 584	038-998
3C7	(Same as 3C6)	038-998
3C8	CAPACITOR, Variable: trimmer; 19-160 pfd, 175 vdcw; Arco Part No. 583	038-999
3C9	(Same as 3C8)	038-999
1C10	CAPACITOR, Fixed: electrolytic; 2 mfd; +80 -10%; 450 vdcw; Sprague Type DEE	031-991
1C11	(Same as 1C10)	031-991
1C12	CAPACITOR, Fixed: mylar; 0.47 mfd; ±20%; 400 vdcw; Goodall Type 600UPE	035-997
1C13	(Same as 1C12)	035-997
3C14	(Same as 3C8)	038-999
3C15	(Same as 3C8)	038-999
1C16	CAPACITOR, Fixed electrolytic; 40 mfd; 450 vdcw; 10 mfd; 450 vdcw; 40 mfd; 250 vdcw	30769-05
1C17	CAPACITOR, Fixed: ceramic, 2000 pfd; ±20%; 1000 vdcw; Sprague Part No. 33C12A2	030-995
1C18	(Same as 1C17)	030-995
1C19	CAPACITOR, Fixed: mica; 300 pfd; ±5%; 2000 vdcw, Cornell Dubilier Part No. 1AP20T3	034-990
3C20	CAPACITOR, Fixed: mica; 1270 pfd; ±5%; 2000 vdcw; Elmenco Type DM20	034-964
3C21	(Same as 3C20)	034-964
C22	Not Used	---
1C23	CAPACITOR, Fixed: electrolytic; 60-60 mfd, 300 vdcw; 40-40 mfd; 400 vdcw	30769-07
1C24	CAPACITOR, Fixed: ceramic; 0.02 mfd; +80 -20%; 50 vdcw; Sprague Part No. 36C205	030-059
1C25	(Same as 1C24)	030-059
3C26	CAPACITOR, Fixed: mylar; 0.1 mfd; ±10%; 400 vdcw; Cornell-Dubilier Part No. WMF4P1E	035-999
3C27	(Same as 3C26)	035-999
1C28	CAPACITOR, Fixed: ceramic; 56 pfd; ±5%; 500 vdcw; Erie Type 831	54-0294
1C29	(Same as 1C28)	54-0294
1C30	CAPACITOR, Fixed: electrolytic; 4 mfd; 150 vdcw, Cornell-Dubilier Part No. NLP361	55-0066
1C31	(Same as 1C30)	55-0066
1C32	CAPACITOR, Fixed: electrolytic; 25 mfd; +100 -10%; 10 vdcw; Cornell-Dubilier Part No. NLP259	55-0065

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
1C33	(Same as 1C32)	55-0065
3C34	CAPACITOR, Fixed: ceramic; 0.01 mfd; GMV; 500 vdcw; Erie Part No. 811-.01	030-002
1C35	CAPACITOR, Fixed: electrolytic; 40 mfd, +80 -10%; 250 vdcw, Sprague Type DEE	031-996
C36 thru C40	Not Used	---
4C41	CAPACITOR, Fixed: electrolytic, 1000 mfd; +250 -10%; 15 vdcw; Cornell Dubilier Part No. BRHM-1510	031-034
4C42	CAPACITOR, Fixed: electrolytic; 2000 mfd; 15 vdcw	96147-01
2C43	CAPACITOR, Fixed: paper; 0.0047 mfd; ±20%; 600 vdcw; Sprague Part No. 73P47206	035-028
2C44	(Same as 2C43)	035-028
3C45	CAPACITOR, Fixed: paper; 0.047 mfd; ±20%; 400 vdcw; Cornell-Dubilier Part No. WMF4S47E	035-985
3C46	(Same as 3C45)	035-985
3C47	(Same as 3C45)	035-985
4C48	CAPACITOR, Fixed: ceramic; 0.02 mfd; GMV; 500 vdcw, Erie Part No. 841-.02	030-001
3C49	CAPACITOR, Fixed: electrolytic; 25 mfd; 6 vdcw, Sprague Part No. 30D131A1	031-140
3C50	(Same as 3C49)	031-140
4C51	CAPACITOR, Fixed: electrolytic; 4 mfd; +50 -10%; 450 vdcw; Sangamo Part No. MT-4504	031-009
4C52	(Same as 4C51)	031-009
3C53	(Same as 3C34)	030-002
3C54	(Same as 3C34)	030-002
1C55	(Same as 3C34)	030-002
1C56	(Same as 3C34)	030-002
1C57	CAPACITOR, Fixed: Mylar, 0.018 mfd; ±10%, 100 vdcw; Cornell-Dubilier Type WMF	54-0291
1C58	(Same as 1C57)	54-0291
1CR1	DIODE, Silicon: 600 PIV; RCA Type 1N2864	57-0012
1CR2	(Same as 1CR1)	57-0012
4CR3	DIODE, Silicon: 50 PIV; GE Type 1N607	57-0060
4CR4	(Same as 4CR3)	57-0060
3DS1	LAMP, Neon: miniature; red, Eldema Part No. 1B9-6271	61-0071
3DS2	(Same as 3DS1)	61-0071
3DS3	LAMP, Incandescent: miniature; 6.3 vac; 2 pin; GE Type 12	060-041
3DS4	(Same as 3DS3)	060-041
2F1	FUSE, Cartridge: 3 amp; 250 v; fast blow; Littelfuse Part No. 312003	070-001
2F2	FUSE, Cartridge: 0.75 amp; 125 v; slow blow; Littelfuse Part No. 313.750	070-048
2J1	CONNECTOR, Receptacle: female; 3 contact; Cannon Part No. XLR-3-31	146-998
2J2	(Same as 2J1)	146-998
2J3	CONNECTOR, Receptacle: male; 3 contact; Cannon Part No. XLR-3-32	147-999
2J4	(Same as 2J3)	147-999
2J5	CONNECTOR, Receptacle: male; 2 contact; MS3102A-12S-3P	143-010
2J6	(Same as 2J5)	143-010
2J7	CONNECTOR, Receptacle: male; 2 contact, MS3102A-10SL-4P	143-009

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
2J8	(Same as 2J7)	143-009
2J9	CONNECTOR, Receptacle: male; 3 contact, MS3102A-10S-3P	143-008
2J10	(Same as 2J9)	143-008
3J11	SOCKET, Tube: miniature; 7 pin; mica filled; Cinch Part No. 7XM	150-021
3J12	(Same as 3J11)	150-021
3J13	SOCKET, Tube: miniature; 9 pin; mica filled; Cinch Part No. 53F12621	150-020
3J14	(Same as 3J13)	150-020
4J15	SOCKET, Tube: octal: mica filled; Cinch Part No. 12272 8 AM	150-010
4J16	(Same as 4J15)	150-010
3J17	JACK, Phone: 3 conductor; single closed circuit; Carter Part No. J4	148-024
3J18	(Same as 3J17)	148-024
2J19	CONNECTOR, Receptacle: female; 6 contact; Jones Part No. S-306-AB	146-004
2J20	CONNECTOR, Receptacle: male; 2 contact; 10 amp; 250 v; Hubbell Part No. 7466	147-013
4K1	RELAY, 3 pole double throw	96133-01
4L1	CHOKE, 5.5 henry	96135-01
4L2	CHOKE, 15 millihenry	96126-01
3M1	METER, VU	96130-01
3M2	(Same as 3M1)	96130-01
3R1	RESISTOR, Variable composition; 100K ohm, ±10%; 2 watt, Allen Bradley Part No. JA1N056S104AZ	044-015
3R2	(Same as 3R1)	044-015
1R3	RESISTOR, Fixed: composition; 47K ohm; ±10%; 1/2 watt; MIL-R-11A:RC20GF473K	041-068
1R4	(Same as 1R3)	041-068
1R5	RESISTOR, Fixed: composition; 2.2K ohm; ±10%; 1/2 watt; MIL-R-11A:RC20GF222K	041-052
1R6	(Same as 1R5)	041-052
1R7	RESISTOR, Fixed: composition; 1 megohm; ±5%; 1/2 watt; MIL-R-11A RC20GF105J	041-031
1R8	(Same as 1R7)	041-031
1R9	RESISTOR, Fixed: composition, 68K ohm; ±10%; 1/2 watt; MIL-R-11A:RC20GF683K	041-070
1R10	(Same as 1R9)	041-070
3R11	RESISTOR, Fixed: 100K (Part of 52-0138-01)	---
3R12	RESISTOR, Fixed: 100K (Part of 52-0138-01)	---
3R13	RESISTOR, Variable: 400K (Part of 52-0138-01)	---
3R14	RESISTOR, Variable: 400K (Part of 52-0138-01)	---
R15	Not Used	---
R16	Not Used	---
1R17	RESISTOR, Fixed: composition; 1K ohm, ±10%; 1/4 watt; Allen Bradley Type C-B	041-979
1R18	(Same as 1R17)	041-979
1R19	RESISTOR, Fixed: composition; 560 ohm, ±10%; 1/2 watt; MIL-R-11A:RC30GF561K	041-045
1R20	(Same as 1R19)	041-045
1R21	RESISTOR, Fixed: composition; 22K ohm; ±10%; 2 watt; MIL-R-11A:RC42GF223K	041-216
1R22	(Same as 1R21)	041-216
1R23	RESISTOR, Fixed: composition 8.2K ohm; ±10%, 1 watt; MIL-R-11A:RC32GF822K	041-157
1R24	(Same as 1R23)	041-157

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
3R25	RESISTOR, Fixed: composition; 180K ohm; ±10%; 1 watt, MIL-R-11A:RC32GF184K	041-173
3R26	(Same as 3R25)	041-173
1R27	RESISTOR, Fixed: composition; 150K ohm; ±10%; 2 watt; MIL-R-11A.RC42GF154K	041-226
1R28	(Same as 1R27)	041-226
3R29	RESISTOR, Fixed: composition; 100 ohm; ±5%; 1/2 watt; MIL-R-11A:RC20GF101J	041-003
3R30	(Same as 3R29)	041-003
1R31	RESISTOR, Variable: composition, 1K ohm; ±20%; 3 watt; Chicago Telephone Supply Type UPE-200	044-995
1R32	RESISTOR, Fixed: composition; 22K ohm; ±5%; 1/2 watt; MIL-R-11A:RC20GF223J	041-016
1R33	(Same as 1R32)	041-016
1R34	(Same as 1R17)	041-979
1R35	(Same as 1R17)	041-979
1R36	RESISTOR, Fixed: composition; 470 ohm; ±10%; 1 watt; MIL-R-11A:RC32GF471K	041-1[illegible]1
1R37	RESISTOR, Fixed. composition; 330K ohm; ±5%, 1/2 watt; MIL-R-11A:RC20GF334J	041-028
1R38	(Same as 1R37)	041-028
1R39	RESISTOR, Fixed: wirewound; 330K ohm; ±2%; 1/2 watt; Cinema Type CE516E	043-995
1R40	(Same as 1R39)	043-995
1R41	RESISTOR, Fixed: composition, 10 megohm; ±10%, 1/2 watt, MIL-R-11A:RC20GF106K	041-090
1R42	(Same as 1R41)	041-090
1R43	RESISTOR, Fixed: composition; 220K ohm; ±10%; 1/2 watt, MIL-R-11A:RC20GF224K	041-076
1R44	(Same as 1R43)	041-076
1R45	RESISTOR, Fixed: wirewound; 2[illegible] ohm; [illegible]; 1/2 watt, International Resistance Corp Type BW-1/2	043-996
1R46	(Same as 1R45)	043-996
1R47	RESISTOR, Fixed: wirewound; 820 ohm; ±5%; 1/2 watt, International Resistance Corp Type BW-1/2	043-997
1R48	(Same as 1R47)	043-997
1R49	RESISTOR, Fixed: composition; 120K ohm; ±10%; 1/2 watt; MIL-R-11A:RC20GF124K	041-073
1R50	(Same as 1R49)	041-073
1R51	RESISTOR, Fixed: composition, 4.7K ohm; ±10%; 1/2 watt; MIL-R-11A RC20GF472K	041-056
1R52	(Same as 1R3)	041-068
1R53	(Same as 1R3)	041-068
3R54	RESISTOR, Variable: 250K (Part of 52-0138-01)	---
3R55	RESISTOR, Variable: 250K (Part of 52-0138-01)	---
1R56	RESISTOR, Fixed: composition; 270K ohm, ±10%; 1/2 watt; MIL-R-11A:RC20GF274K	041-077
1R57	(Same as 1R56)	041-077
1R58	RESISTOR, Fixed: composition; 3.3 megohm, ±10%; 1/4 watt; Allen Bradley Type C-B	041-937
1R59	(Same as 1R58)	041-937
1R60	RESISTOR, Fixed: composition; 750 ohm; ±5%; 1/2 watt; MIL-R-11A:RC20GF751J	041-007
1R61	RESISTOR, Fixed: composition; 470 ohm; ±10%; 1/2 watt; MIL-R-11A:RC20GF471K	041-044
1R62	(Same as 1R61)	041-044
1R63	(Same as 1R60)	041-007
R64	Not Used	---

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
R65	Not Used	---
1R66	RESISTOR, Fixed: composition; 6.8K ohm; ±10%; 1 watt; MIL-R-11A:RC32GF682K	041-156
1R67	(Same as 1R66)	041-156
3R68	RESISTOR, Fixed: composition; 12K ohm; ±10%; 1/2 watt; MIL-R-11A:RC20GF123K	041-061
3R69	(Same as 3R68)	041-061
3R70	(Same as 3R68)	041-061
3R71	(Same as 3R68)	041-061
1R72	RESISTOR, Fixed: composition; 2.2K ohm; ±10%; 1 watt; MIL-R-11A:RC32HG222K	041-150
1R73	(Same as 1R36)	041-141
R74	Not Used	---
1R75	RESISTOR, Fixed: composition; 1 megohm; ±10%; 1/4 watt; Allen Bradley Type C-B	041-968
1R76	(Same as 1R75)	041-968
1R77	(Same as 1R61)	041-044
3R78	RESISTOR, Fixed: composition; 100 ohm; ±10%; 1/2 watt; MIL-R-11A:RC20GF101K	041-038
3R79	(Same as 3R78)	041-038
3R80	(Same as 3R78)	041-038
2R81	(Same as 3R78)	041-038
4R82	RESISTOR, Fixed: composition; 100K ohm; ±10%; 1 watt; MIL-R-11A:RC32GF104K	041-170
4R83	(Same as 4R82)	041-170
3S1	SWITCH, Equalization	96138-01
3S2	SWITCH, Output Selector	62-0147-01
3S3	(Same as 3S2)	62-0147-01
3S4	SWITCH, Record Selector	96109-01
3S5	SWITCH, Pushbutton: SPST; normally open; momentary contact; Arrow H and H Part No. 3391 EPA	120-013
3S6	SWITCH, Toggle: SPST, 6 amp; 125 v; Circle F Part No. 1887-L2P	62-0142
4T1	TRANSFORMER, Power	96144-01
3T2	TRANSFORMER, Output	96137-01
3T3	(Same as 3T2)	96137-01
1T4	TRANSFORMER, Oscillator	58-0115-01
3TP1	JACK, Tip: red; E. F. Johnson Part No. 105-802	148-999
3TP2	(Same as 3TP1)	148-999
3TP3	JACK, Tip: black; E. F. Johnson Part No. 105-803	148-998
1V1	TUBE, Electron: Type 6AW8A	012-099
1V2	(Same as 1V1)	012-099
1V3	TUBE, Electron: Type 12AX7	012-024
1V4	TUBE, Electron: Type 6DJ8	56-0077
1V5	(Same as 1V3)	012-024
1V6	(Same as 1V4)	56-0077
1V7	TUBE, Electron: Type 12BH7	012-065
	BRACKET ASSEMBLY, Equalization (with sockets J11, J12, J13 and J14)	96092-01
	BRACKET ASSEMBLY, Plug-in input (with sockets J15 and J16)	96094-01
	NUT, Sleeve	21078-01
	BOARD ASSEMBLY (includes all items with prefix 1)	96057-01
	PLUG ASSEMBLY, Input (Dummy)	17420-01
	FUSEPOST, Cartridge; Littelfuse Part No. 342012	085-001
	HOLDER, Pilot Light	96140-01
	KNOB, Skirted	230-003

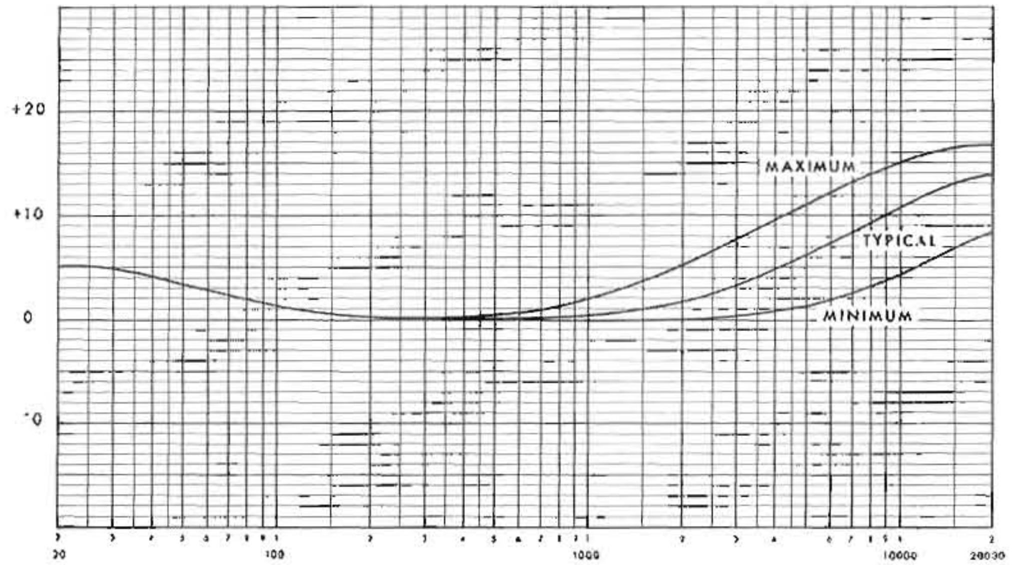
REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	INDICATOR ASSEMBLY, Reset	50735-02
	SOCKET, Tube: 9 pin	30818-01
	SOCKET, Tube: octal	150-078
	SHIELD, Tube: 9 pin; 2-3/8 in. high	160-020
	SHIELD, Tube: 7 pin; 2-1/2 in. high	160-999
	SHIELD, Tube: 9 pin; 1-15/16 in. high	160-012
	SHIELD, Tube: 9 pin; ventilated	160-998
	3.75 (120 usec)/7.5 NAB REPRODUCE EQUALIZER, Fixed: Catalog No. 96110-02	
	CAPACITOR, Fixed: mica; 750 pfd; ±5%; 500 vdcw; Elmenco Part No. CM20C751J	034-144
	PLUG AND SHIELD: 9 pin: Vector Part No. G2.1-8F	099-006
	RESISTOR, Fixed: composition; 68K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-088
	RESISTOR, Fixed: composition; 160K ohms; ±1%; 1/2 watt: Electra Type DS-1/2	042-993
	RESISTOR, Fixed: composition; 6.2 megohm; ±5%; 1/2 watt: Allen Bradley Type EB	041-965
	3.75 (120 usec)/7.5 NAB REPRODUCE EQUALIZER, Variable: Catalog No. 96110-03	
	CAPACITOR, Fixed: mica; 750 pfd; ±5%; 300 vdcw; C-D type DC-15	034-966
	RESISTOR, Variable: composition; 50K ohms; ±20%; 1/10 watt: Centralab Type 1	044-989
	RESISTOR, Fixed: composition; 47K ohms; ±5%; 1/4 watt: MIL-R-11:RC07GF473J	041-411
	RESISTOR, Fixed: composition; 120K ohms; ±5%; 1/4 watt: Allen Bradley Type CB	041-929
	RESISTOR, Fixed: composition; 6.2 megohm; ±5%; 1/2 watt: Allen Bradley Type EB	041-965
	RESISTOR, Variable: composition; 100K ohms; ±20%; 1/10 watt: Centralab Type 1	044-988
	3.75 (200 usec)/7.5 NAB REPRODUCE EQUALIZER, Fixed: Catalog No. 96114-02	
	CAPACITOR, Fixed: mica; 750 pfd; ±5%; 500 vdcw: Elmenco Part No. CM20C751J	034-144
	PLUG AND SHIELD: 9 pin: Vector Part No. G2.1-8F	099-006
	RESISTOR, Fixed: composition; 68K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-088
	RESISTOR, Fixed: composition; 270K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-098
	RESISTOR, Fixed: composition; 6.2 megohm; ±5%; 1/2 watt: Allen Bradley Type EB	041-965
	3.75 (200 usec)/7.5 NAB REPRODUCE EQUALIZER, Variable: Catalog No. 96114-03	
	CAPACITOR, Fixed: mica, 750 pfd; ±5%; 300 vdcw: C-D Type DC-15	034-966
	RESISTOR, Variable: composition; 50K ohms; ±20%; 1/10 watt: Centralab Type 1	044-989
	RESISTOR, Fixed: composition; 47K ohms; ±5%; 1/4 watt: MIL-R-11:RC07GF473J	041-411
	RESISTOR, Fixed: composition; 220K ohms; ±5%, 1/4 watt: Allen Bradley Type CB	041-930
	RESISTOR, Variable: composition; 100K ohms; ±20%; 1/10 watt: Centralab Type 1	044-988
	RESISTOR, Fixed: composition; 6.2 megohm; ±5%; 1/2 watt: Allen Bradley Type EB	041-965

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	3.75/7.5 NAB RECORD EQUALIZER- Catalog No. 96120-01	
	CAPACITOR, Fixed: paper; 0.082 mfd; ±10%; 100 vdcw: Goodall Type 663UW	035-977
	PLUG AND SHIELD, 7 pin, Vector Part No. G2.2-8F	099-005
	RESISTOR, Fixed: composition; 47K ohms; ±5%; 1/2 watt: MIL-R-11:RC20GF473J	041-020
	RESISTOR, Fixed: composition; 120K ohms; ±5%; 1/2 watt: MIL-R-11:RC30GF124J	041-318
	RESISTOR, Fixed: composition; 500K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-102
	7.5/15 NAB REPRODUCE EQUALIZER, Fixed: Catalog No. 96111-02	
	CAPACITOR, Fixed: mica; 750 pfd; ±5%; 500 vdcw; Elmenco Part No. CM20C751J	034-144
	PLUG AND SHIELD: 9 pin, Vector Part No. G2.1-8F	099-006
	RESISTOR, Fixed: composition; 68K ohms, ±1%; 1/2 watt: Electra Type DC-1/2	042-088
	RESISTOR, Fixed: composition; 3.3 megohm; ±5%, 1/2 watt: MIL-R-11:RC20GF335J	041-464
	RESISTOR, Fixed: composition; 6.2 megohm; ±5%; 1/2 watt: Allen Bradley Type EB	041-965
	7.5/15 NAB REPRODUCE EQUALIZER, Variable: Catalog No. 96111-03	
	CAPACITOR, Fixed: mica; 750 pfd; ±5%, 300 vdcw: C-C Type DC-15	034-966
	RESISTOR, Fixed: composition; 3.3 megohm; ±5%; 1/2 watt: MIL-R-11: RC20GF335J	041-464
	RESISTOR, Fixed. composition; 6.2 megohm; ±5%; 1/2 watt: Allen Bradley Type EB	041-965
	RESISTOR, Fixed: composition; 47K ohms; ±5%; 1/4 watt: MIL-R-11:RC07GF473J	041-411
	RESISTOR, Variable: composition; 50K ohms; ±20%; 1/10 watt: Centralab Type 1	041-989
	7.5/15 NAB RECORD EQUALIZER: Catalog No. 96121-01	
	CAPACITOR, Fixed: paper; 0.12 mfd; ±10%; 100 vdcw; Goodall Type 663UW	035-978
	PLUG AND SHIELD: 7 pin: Vector Part No. G2.2-8F	099-005
	RESISTOR, Fixed: composition; 68K ohms; ±5%; 1/2 watt: MIL-R-11:RC20GF683J	041-022
	RESISTOR, Fixed: composition; 30K ohms; ±5%; 1/2 watt: Allen Bradley Type EB	041-951
	RESISTOR, Fixed: composition; 75K ohms; ±5%; 1/2 watt. Allen Bradley Type EB	041-949
	RESISTOR, Fixed: composition; 270K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-098
	7.5 NAB/15 AME REPRODUCE EQUALIZER, Fixed: Catalog No. 96112-02	
	CAPACITOR, Fixed: mica, 750 pfd, ±5%, 500 vdcw. Elmenco Part No. CM20C751J	034-144
	CAPACITOR, Fixed: paper; 4700 pfd; ±2%; 200 vdcw: Goodall Type 663UW	035-992
	CAPACITOR, Fixed: paper; 1000 pfd; ±2%; 200 vdcw: Goodall Type 663UW	035-993
	PLUG AND SHIELD: 9 pin: Vector Part No. G2.1-8F	099-006
	RESISTOR, Fixed: composition; 3.3 megohm; ±5%; 1/2 watt: MIL-R-11:RC20GF335J	041-464
	RESISTOR, Fixed: composition; 47K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-086

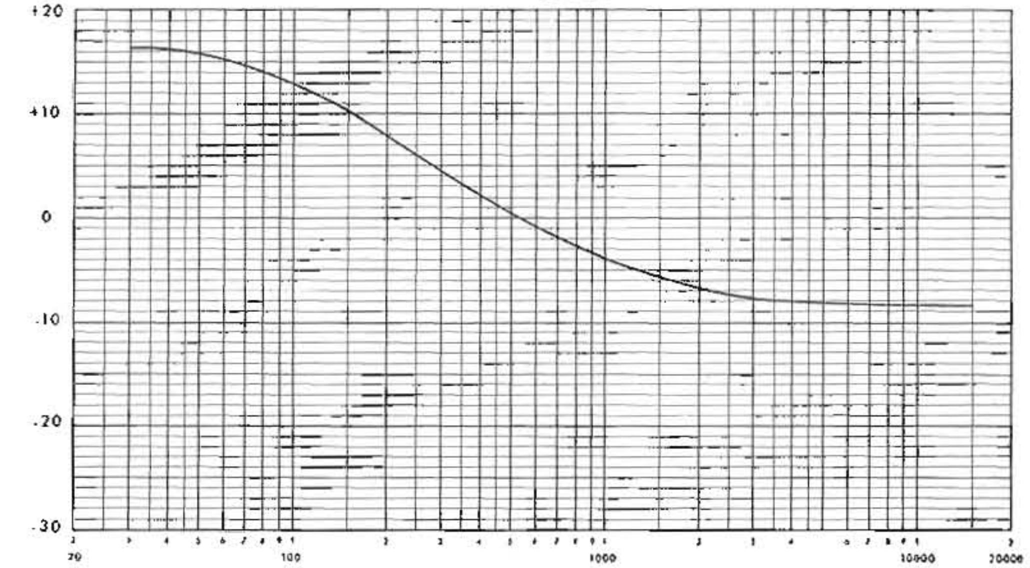
REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	RESISTOR, Fixed: composition; 68K ohms; ±1%; 1/2 watt: MIL-R-10509A:RN15X6802F	042-136
	RESISTOR, Fixed: composition; 12K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-990
	7.5 NAB/15 AME REPRODUCE EQUALIZER, Variable: Catalog No. 96112-03	
	CAPACITOR, Fixed: mica; 750 pfd; ±5%; 300 vdcw: C-D Type DC-15	034-966
	CAPACITOR, Fixed: paper; 4700 pfd; ±2%; 200 vdcw: Goodall Type 663UW	035-992
	CAPACITOR, Fixed: paper; 1000 pfd; ±2%; 200 vdcw: Goodall Type 663UW	035-993
	RESISTOR, Fixed: composition; 47K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-086
	RESISTOR, Fixed: composition; 12K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-990
	RESISTOR, Fixed: composition; 3.3 megohm; ±5%; 1/2 watt: MIL-R-11:RC20GF335J	041-464
	RESISTOR, Variable: composition; 50K ohms; ±20%; 1/10 watt: Centralab Type 1	044-989
	RESISTOR, Fixed: composition; 47K ohms, ±5%, 1/4 watt: MIL-R-11:RC07GF473J	041-411
	7.5 NAB/15 AME RECORD EQUALIZER: Catalog No. 96122-01	
	CAPACITOR, Fixed: mica; 680 pfd; ±2%; 500 vdcw Elmenco Type CM15	034-125
	CAPACITOR, Fixed: paper; 0.12 mfd; ±10%; 100 vdcw: Goodall Type 663UW	035-978
	PLUG AND SHIELD: 7 pin Vector Part No. G2.2-8F	099-005
	RESISTOR, Fixed: composition; 150K ohms; ±5%; 1/4 watt: Allen Bradley Type CB	041-934
	RESISTOR, Fixed: composition; 100K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-092
	RESISTOR, Fixed: composition; 75K ohms; ±5%; 1/4 watt: Allen Bradley Type CB	041-935
	RESISTOR, Fixed composition; 30K ohms; ±5%; 1/4 watt: Allen Bradley Type CB	041-933
	RESISTOR, Fixed: composition, 330K ohms; ±1%; 1/2 watt:Electra Type DC-1/2	042-100
	7.5/15 CCIR REPRODUCE EQUALIZER, Fixed: Catalog No. 96113-02	
	CAPACITOR, Fixed: mica; 750 pfd; ±5%; 500 vdcw: Elmenco Part No. CM20C751J	034-144
	PLUG AND SHIELD: 9 pin: Vector Part No. G2.1-8F	099-006
	RESISTOR, Fixed: composition; 47K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-086
	RESISTOR, Fixed: composition; 120K ohms; ±1%; 1/2 watt: MIL-R-10509A.RN15R1203F	042-117
	RESISTOR, Fixed: composition; 8.2 megohm, ±5%; 1/2 watt: MIL-R-11:RC20GF825J	041-423
	7.5/15 CCIR REPRODUCE EQUALIZER, Variable: Catalog No. 96113-03	
	CAPACITOR, Fixed: mica; 750 pfd: ±5%; 300 vdcw: C-D Type CD-15	034-966
	RESISTOR, Fixed: composition; 82K ohms; ±5%; 1/4 watt: Allen Bradley Type CB	041-927
	RESISTOR, Variable: composition; 50K ohms; ±20%; 1/10 watt: Centralab Type 1	044-989

REF. NO.	PART DESCRIPTION	AMPEX PART NO.
	RESISTOR, Variable: composition; 100K ohms; ±20%; 1/10 watt: Centralab Type 1	044-988
	RESISTOR, Fixed: composition; 33K ohms; ±5%; 1/4 watt: Allen Bradley Type CB	041-926
	RESISTOR, Fixed: composition; 8.2 megohm; ±5%; 1/2 watt: MIL-R-11:RC20GF825J	041-423
	7.5/15 CCIR RECORD EQUALIZER: Catalog No. 96123-01	
	CAPACITOR, Fixed: mica; 50 pfd; ±5%; 500 vdcw: Elmenco Part No. CM20C500J	034-046
	PLUG AND SHIELD: 7 pin: Vector Part No. G2.2-8F	099-005
	RESISTOR, Fixed: composition; 16K ohms; ±5%; 1/2 watt: Allen Bradley Type EB	041-950
	RESISTOR, Fixed: composition; 180K ohms; ±1%; 1/2 watt: Electra Type DC-1/2	042-096

RECORD

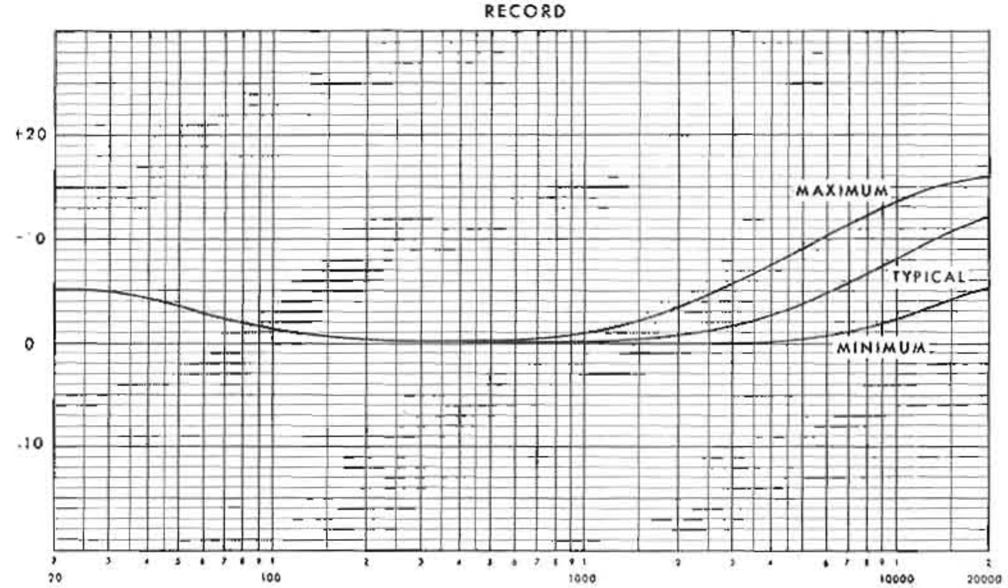


REPRODUCE

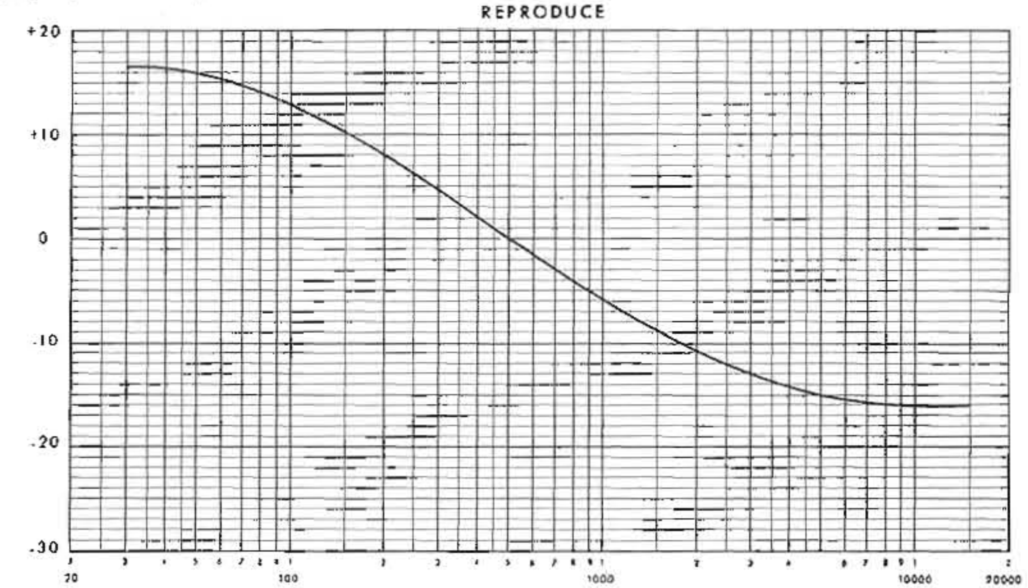


7½ips NAB (SEE NOTE 2)

RECORD

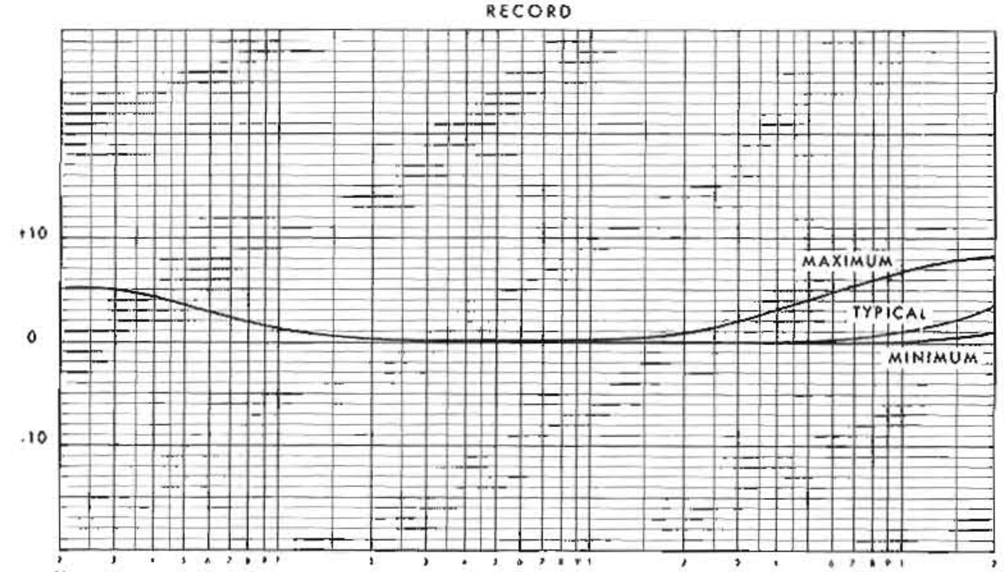


REPRODUCE

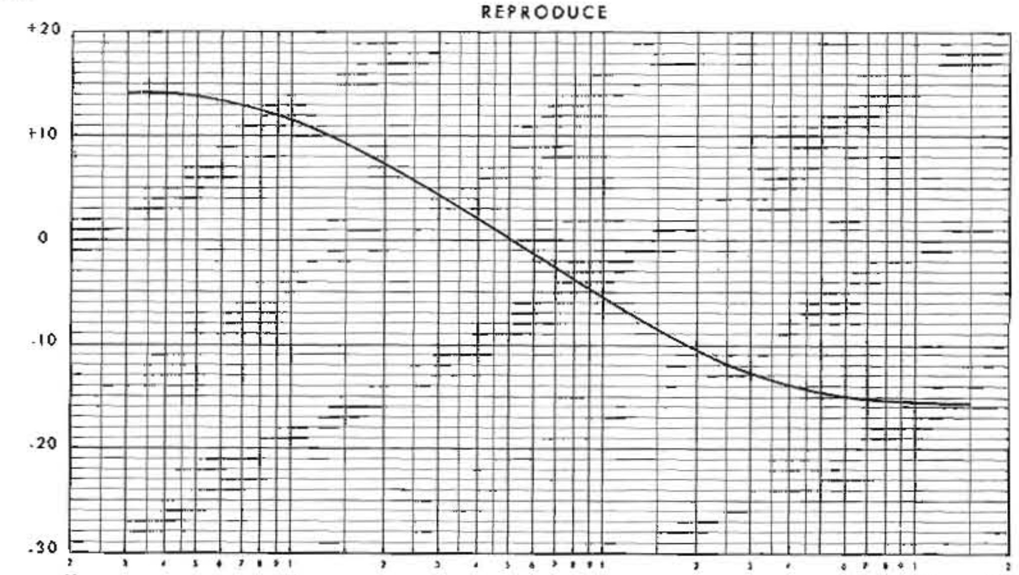


15ips NAB

RECORD



REPRODUCE



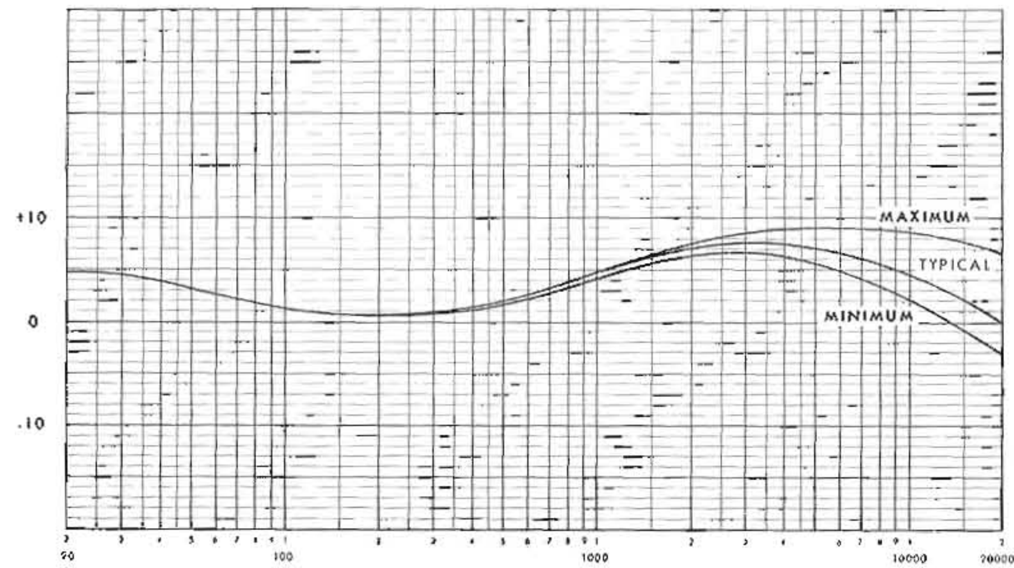
NOTE 1
RECORD CURVES SHOWN ARE APPROXIMATE AND WILL VARY WITH TAPE TO MAINTAIN FLAT OVERALL RESPONSE.

NOTE 2
USE THE 7½ NAB REPRODUCE CURVE FOR THE 3¾ (120 µ sec)/7½ NAB AND THE 7½ NAB/15 NAB EQUALIZERS. FOR THE 7½ NAB/15 AME EQUALIZERS USE THE 15 NAB REPRODUCE CURVE.

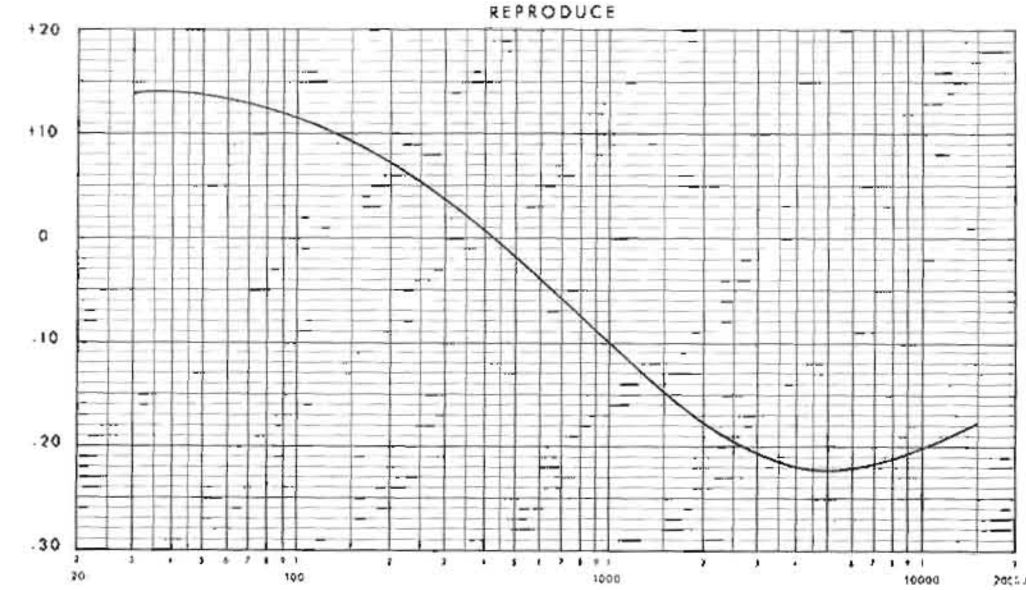
APPLICABLE RESPONSE CURVES (SHEET 1)

15ips AME

RECORD

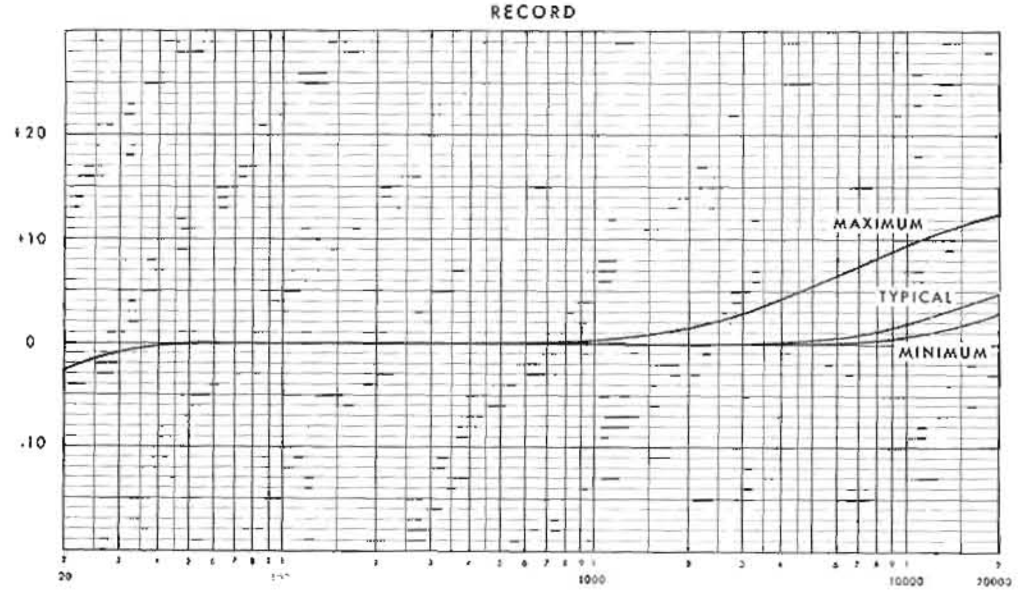


REPRODUCE

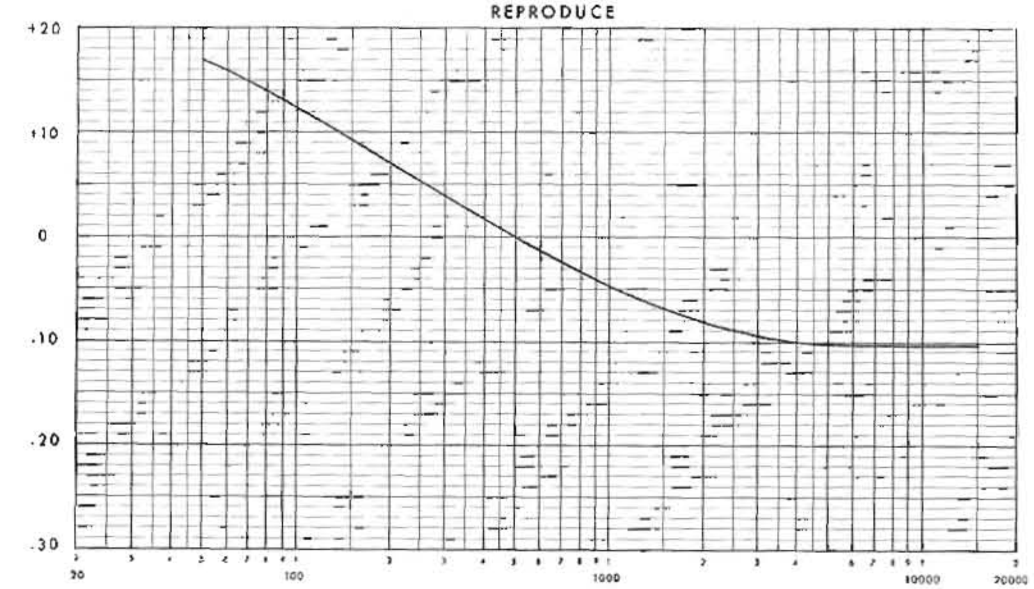


7½ips CCIR

RECORD

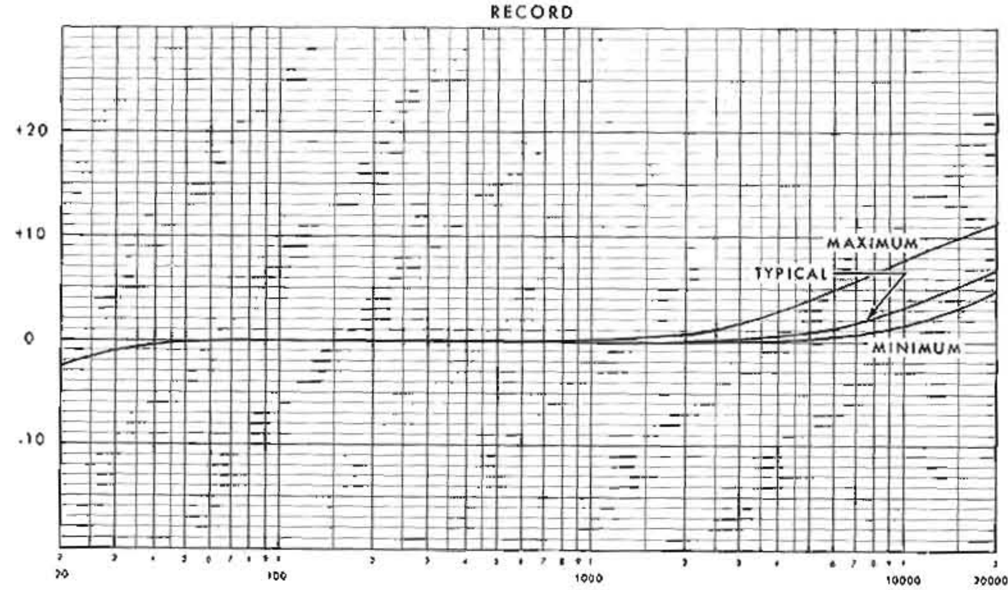


REPRODUCE

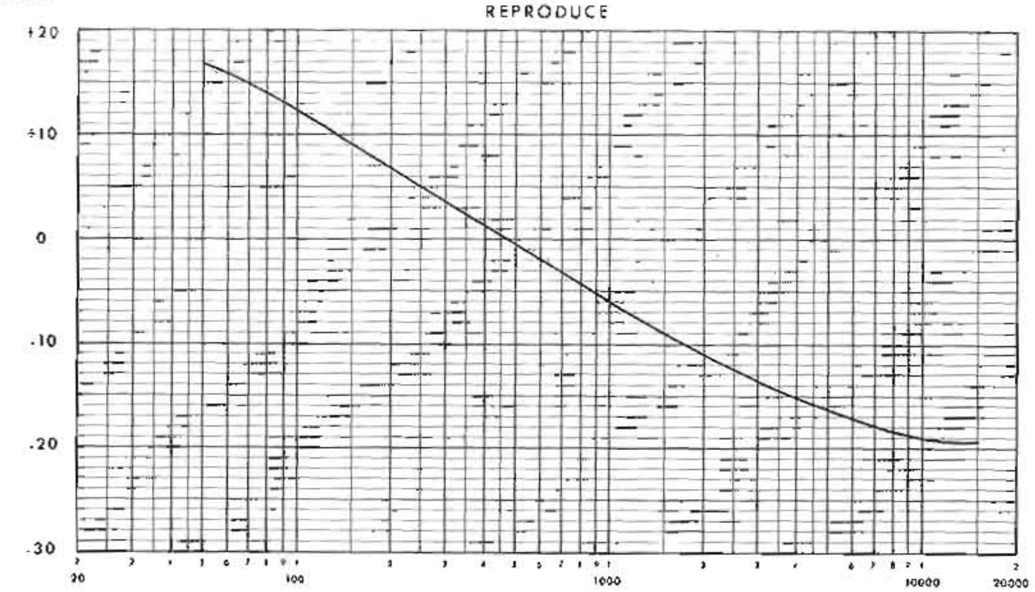


15ips CCIR

RECORD



REPRODUCE



NOTES:
(SEE SHEET 1)

APPLICABLE RESPONSE CURVES (SHEET 2)

SCHEMATIC DIAGRAM
354 ELECTRONIC ASSEMBLY
(Sheet 1 of 2)

CIRCUIT CONDITIONS

1. EQUALIZATION SWITCH 3S1 IN LOW SPEED POSITION WITH 7.5/ 15 NAB RECORD AND PLAYBACK PLUG-IN EQUILIZER CANS INSTALLED.
2. 500 CYCLE SIGNAL INPUT.
3. RECORD LEVEL CONTROLS 3R1 AND 3R2 SET AT FULL CLOCKWISE ROTATION.
4. LINE OUTPUTS 2J3 AND 2J4 TERMINATED ∤ NOMINAL 600 OHMS.
5. 1000 OHM RESISTOR SUBSTITUTED FOR RECORD HEAD.
6. RECORD SELECTOR SWITCH 3S4 IN CH A & 1 POSITION AND RECORD RELAY 4K1 ENERGIZED.
7. ERASE HEADS PLUGGED INTO 2J5 AND 2J6.
8. RESISTORS 3R11,12,13,14,54, AND 55 ARE MOUNTED ON CERAMIC WAFER.

NOTES

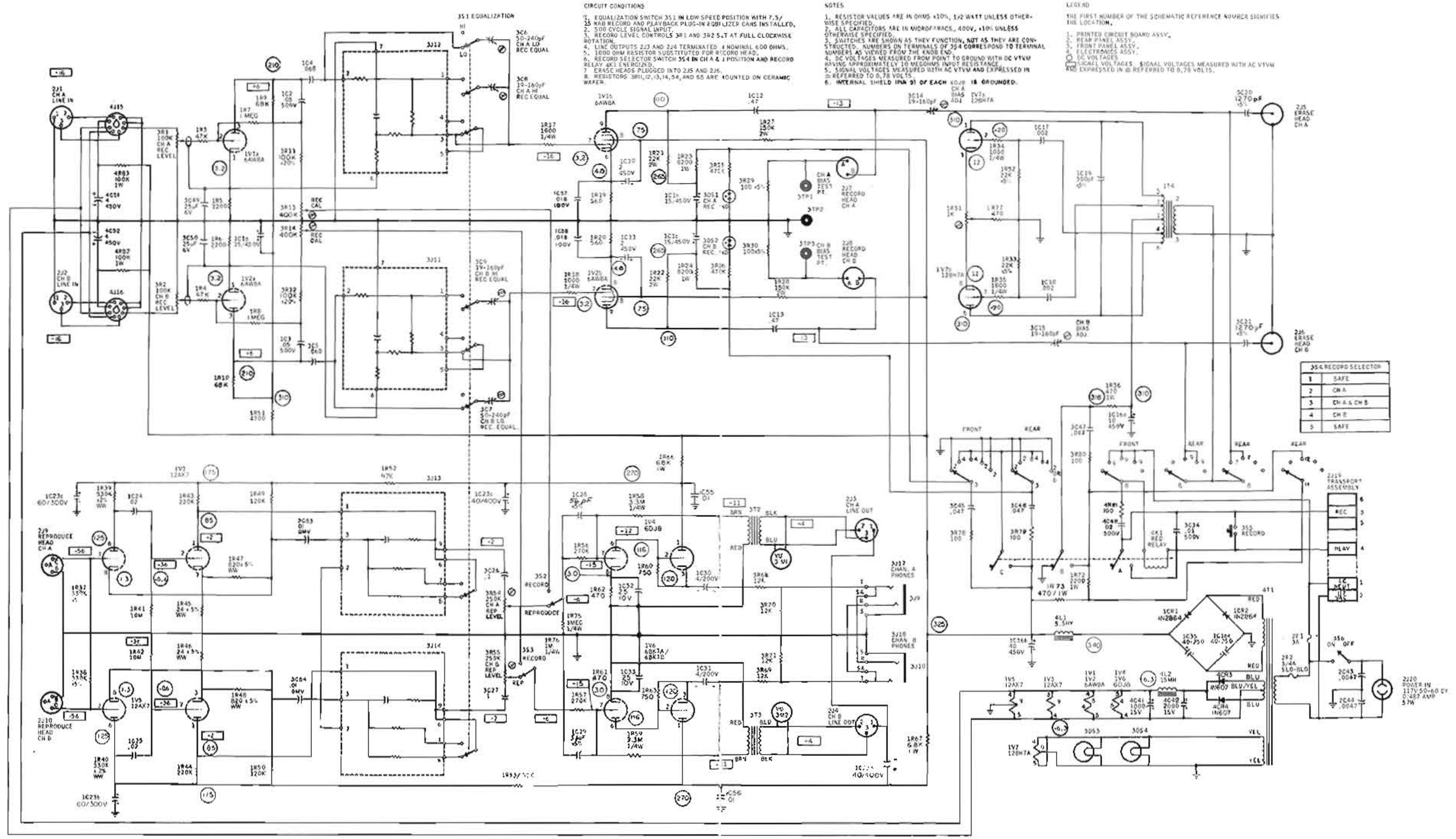
1. RESISTOR VALUES ARE IN OHMS ±10%, 1/2 WATT UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITORS ARE IN MICROFARADS, 400V, ±10% UNLESS OTHERWISE SPECIFIED.
3. SWITCHES ARE SHOWN AS THEY FUNCTION, NOT AS THEY ARE CONSTRUCTED. NUMBERS ON TERMINALS OF 3S4 CORRESPOND TO TERMINAL NUMBERS AS VIEWED FROM THE KNOB END.
4. DC VOLTAGES MEASURED FROM POINT TO GROUND WITH DC VTVM HAVING APPROXIMATELY 10 MEGOHMS INPUT RESISTANCE.
5. SIGNAL VOLTAGES MEASURED WITH AC VTVM AND EXPRESSED IN db REFERRED TO 0.78 VOLTS.
6. INTERNAL SHIELD (PIN 9) OF EACH 6DJ8 IS GROUNDED.

LEGEND

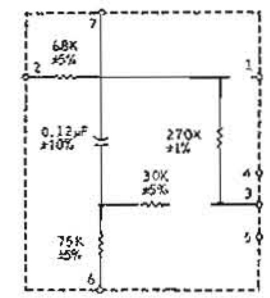
THE FIRST NUMBER OF THE SCHEMATIC REFERENCE NUMBER SIGNIFIES THE LOCATION.

1. PRINTED CIRCUIT BOARD ASSY.
2. REAR PANEL ASSY.
3. FRONT PANEL ASSY.
4. ELECTRONICS ASSY.

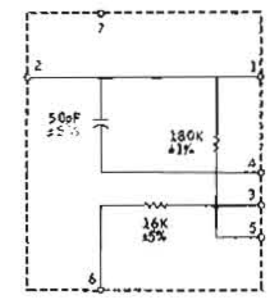
○ DC VOLTAGES
▭ SIGNAL VOLTAGES. SIGNAL VOLTAGES MEASURED WITH AC VTVM AND EXPRESSED IN db REFERRED TO 0.78 VOLTS.



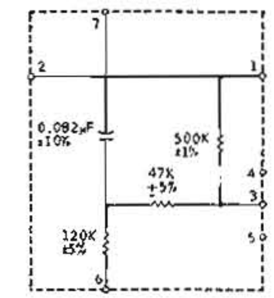
SCHEMATIC DIAGRAM
354 ELECTRONIC ASSEMBLY
(Sheet 2 of 2)



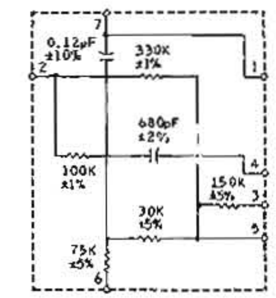
7.5 NAB/15 NAB
RECORD EQUALIZER
02-96121



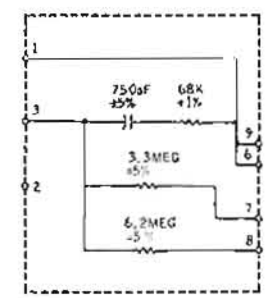
7.5 CCIR/15 CCIR
RECORD EQUALIZER
02-96123



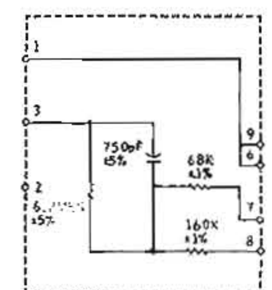
3.75-7.5 NAB
RECORD EQUALIZER
96120



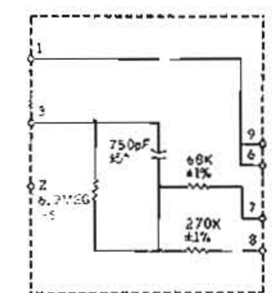
7.5 NAB-15 AME
RECORD EQUALIZER
02-96122



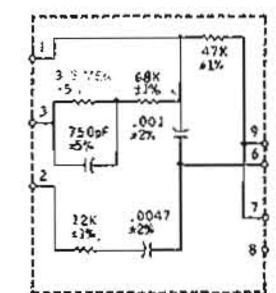
7.5NAB/15NAB
REPRODUCE EQUALIZER
96111-02



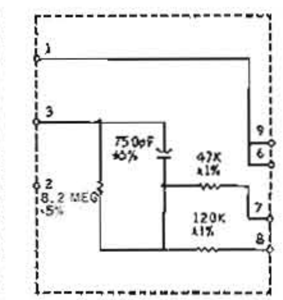
3.75 (120μSEC.)7.5NAB
REPRODUCE EQUALIZER
02-96110-02



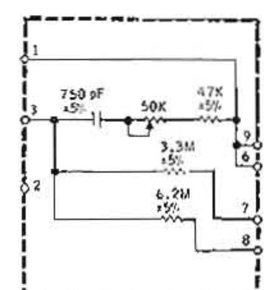
3.75(200μSEC.)/7.5NAB
REPRODUCE EQUALIZER
96114-02



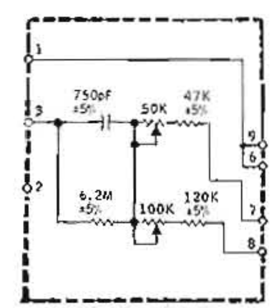
7.5NAB/15AME
REPRODUCE EQUALIZER
02-96112-02



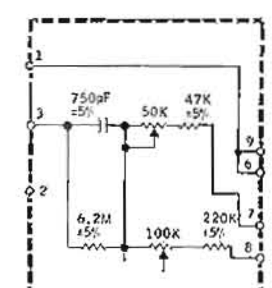
7.5CCIR/15CCIR
REPRODUCE EQUALIZER
02-96113-02



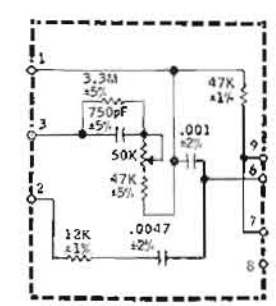
7.5 NAB/15NAB
REPRODUCE EQUALIZER
96111-03



3.75 (120μSEC.) 7.5 NAB
REPRODUCE EQUALIZER
96110-03



3.75 (200μSEC.) 7.5 NAB
REPRODUCE EQUALIZER
96114-03



7.5 NAB/15 AME
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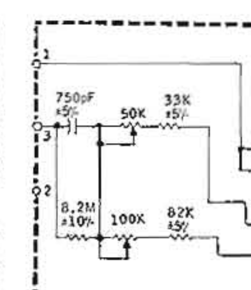
96112-03



7.5 CCIR/15CCIR
REPRODUCE EQUALIZER
96113-03

Section 9 ACCESSORIES

Section 9 ACCESSORIES

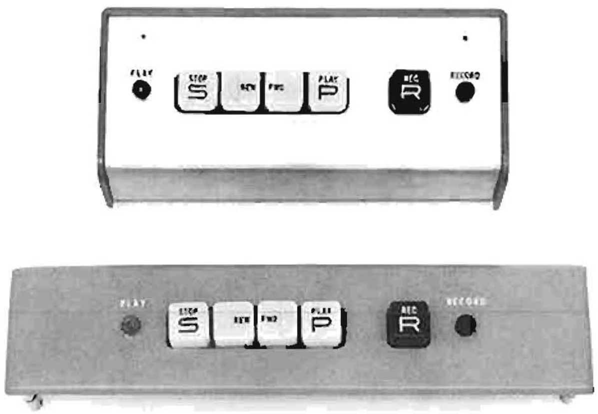
ACCESSORIES

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.

REMOTE CONTROL UNIT

The operation of the tape transport mechanism can be remotely controlled by a Remote Control Unit. The Catalog No. 01-96510-01 unit is supplied in a metal case, completely wired (includes a 30 foot interconnecting cable) and ready to plug into the remote control connector, J116S, on the transport. The Catalog No. 01-96520-01 unit is mounted on a flat plate for installation in studio consoles. The unit is completely wired but does not include the interconnecting cable.



0101

Remote Control Unit

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.

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.

MIXER ASSEMBLY

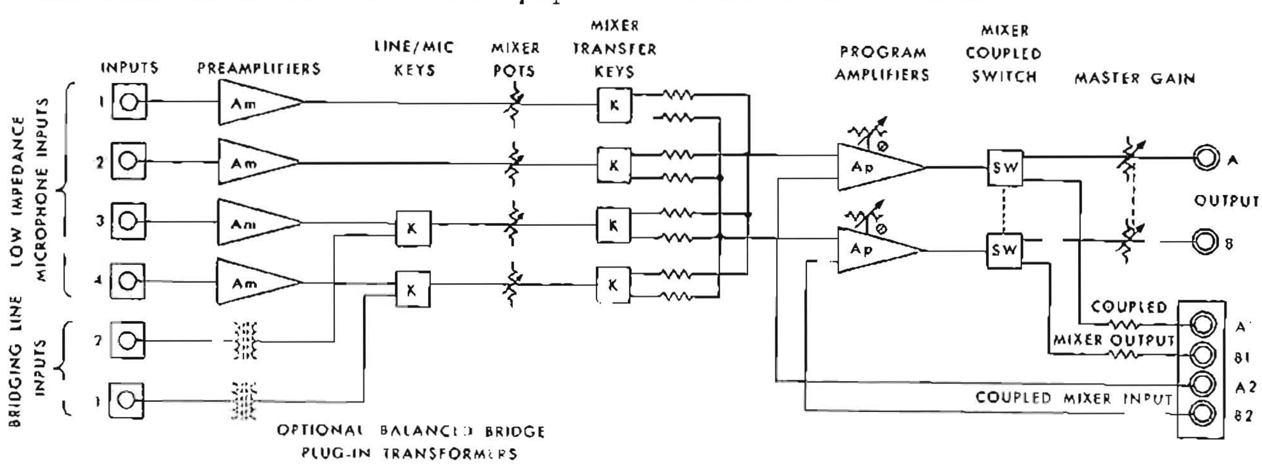
The MX-35 mixer assembly (Catalog No. 01-96910-01) is a compact four position, two channel mixer with unique switching facilities found only in expensive custom designed studio consoles. Special coupling connectors are provided to give additional facilities where up to four MX-35's can be coupled together with overall master gain controlled by the last unit in the system. Each mixer position has a reset indicator which permits return to a previous level and is supplied with a key switch which feeds channels "A" or "B" or BOTH. In the latter position, this permits feeding the solo mike (as in the case of stereo recording) equally to both left and right channels while other mikes are feeding either the left or right channels. Above mixer positions No. 3 and No. 4 are two additional keys to select mike or line input from appropriate receptacles located on the back of the unit. All switching regardless of combination maintains proper balance and isolation between channels.

The MX-35 operates from four low impedance microphone inputs and two unbalanced line inputs: (balanced input when using No. 58-0116-01 plug-in transformer), feeding two independent program amplifiers controlled by a two gang master gain control. Advanced design amplifier circuitry permits very high input and output levels without distortion. Power supply is self-contained and all heaters are fed by a dc supply. Conservatively rated components maintain quality and long operating life without need for service or repair.

Although designed primarily to feed AMPEX Professional recorders, this unit can be used with other audio recorders and sound equipment such as speech input systems, public address or sound systems where unique control facilities of the MX-35 make it a flexible audio tool.

Rack layout (shown with Ampex 354 tape recorder)

The operating instructions for the MX-35 Mixer Assembly are contained in Ampex instruction manual TM-2010.



Block diagram, MX-35 mixer

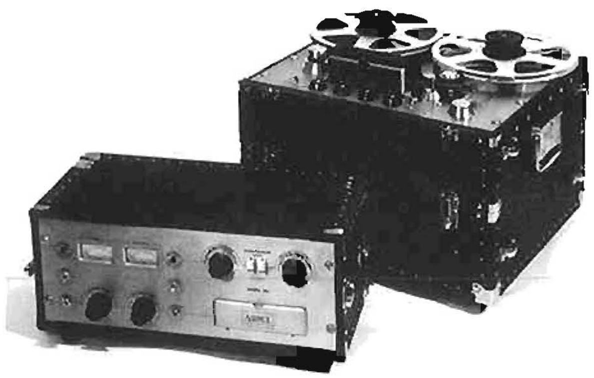
Specifications

Input	Four microphone level inputs and two line high level inputs incorporating high level mixing.
Input Impedance	Microphone; 200 ohm non-terminating; line: 100 k ohms bridging. (With optional plug-in balance line transformer 20,000 ohms.)
Outputs	Two, 1 volt normal; 30 volts maximum unbalanced to feed bridging input of recorder.
Gain	With internal and external control settings at maximum, −67 dbm on any mic channel or −27 dbm on any line channel will produce 1 volt output. 1 volt input to the PR-10 electronics corresponds to 0 vu.
Frequency Response	±1 db 40 to 15,000 cycles
Noise	65 db below signal for inputs of −55 dbm. This represents a noise equivalent to an input signal of −120 dbm.
Distortion	At 500 cycles, less than 0.3% with −43 dbm mic input level, 1v output level; less than 1% with −29 dbm mic input level, 25v output level.
Crosstalk Rejection	65 db at 500 cycles, 50 db at 10 kc.
Controls	Four Allen-Bradley pots (calibrated step type available on special order); master gain (two gang) pot; key switches for selection of mic or line on two input positions; key switches for channel A, both or Channel B on each mixer position; AC line switch; mixer coupling switch (located on the back of the chassis).
Connectors	Rugged "XL" type on all inputs and outputs except mixer coupling strip.
Power Input	105-125 volts, 50-60 cycles, 30 watts.
Tubes	Six EF86's and one 12AU7
Dimensions	5-7/32" H, 19" L, 5-3/16" D (for 5¼" rack space or portable case).
Finish	Brushed stainless steel with grey knobs.
Accessories	Plug-in balanced bridging line input transformer (Cat. No. 58-0116-01), and plug-in balanced matching line input transformer (Cat. No. 58-0116-02).

CARRYING CASES AND CONSOLES

Tape Transport Carrying Case

The portable tape transport carrying case, Catalog No. 03-0154-01, is specially designed to house the 354 tape transport. A special door on the side of the case is provided for all necessary interconnections between the tape transport and the electronic assembly and allows the tape transport to be operated in either a horizontal or vertical position. Special ducting in the case is designed to provide adequate ventilation. Air circulation within the case is such that the equipment actually runs cooler in the case than in free air.



Carrying Cases

Electronic Assembly Carrying Case

The portable electronic assembly carrying case, Catalog No. 15-0211-00, is specially designed to house the 354 electronic assembly. All necessary interconnections are provided for by removing the rear panel from the case.

Console

Console Assembly

The console assembly, Catalog No. 15-0214-00, is designed to house the 354 tape transport and electronic assembly as a complete and easy-to-operate unit. Facilities for easy maintenance of the equipment are provided.

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Section 10 INDEX

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