To John French
with best regards
Joe Dundovic
1-28-03

John French accepting the last head manufactured by Nortronics from company founder Joe Dundovic.

INDEX

DESIGN DIGEST

Application factors to consider for audio magnetic heads

The theory of magnetic recording is discussed in detail in a number of textbooks on the subject (see bibliography – page 96.) Typical circuits for recording apparatus can also be found in numerous publications, however, there are application factors not always presented that pose questions to the designer. Therefore, in the pages that follow we have listed and discussed briefly those that are most frequently asked of Nortronics. These are listed in two general areas:

MAGNETIC HEAD CONSIDERATIONS AND RECORD/ PLAYBACK CIRCUIT CONSIDERATIONS.

I. MAGNETIC HEAD CONSIDERATIONS

A. RECORD/PLAYBACK HEADS

1. LOW FREQUENCY RESPONSE

All playback heads have a maximum wavelength or minimum low frequency response, sometimes called "contour effect". The low frequency cutoff is determined by three factors as shown in Figure 1:

1. Length of pole across the head face
2. Length of face window
3. Shape of lamination behind head face

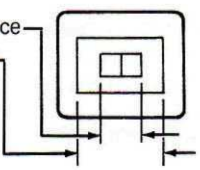

Fig. 1

The longest wavelength the play head can respond to is equal to the mean of the window and pole lengths. High tape speeds such as 15 ips or 30 ips on professional recorders pose severe problems to play head designs since the longest wavelengths may run up to 1-inch, requiring open head faces and very long poles. These are more expensive and also require external magnetic shielding against hum pickup from motors and transformers.

NORTRONICS offers four basic head types to permit optimizing the low frequency performance and hum shielding for a particular tape speed and transport application.

1. **Standard Heads.** Models B2H, B2Q, B1HY, G1H, G1HY, A2H, A1HC, A2Q, A1QC, etc. They have excellent hum shielding and low frequency response suitable for tape speeds of 7.5 ips and below. Low in cost, the standard heads are excellent for general purpose voice applications. Cutoff frequency 50 Hz at 7.5 ips.
2. **Premium Heads.** Models P-B2H, P-B2Q, P-B1HY, P-G1H, P-A2H, P-A2Q, etc. Shielding, hum pickup, and low-frequency cutoff are similar to the Standard Heads. However, pole tips are specially contoured to give smoother response curve for music reproduction, plus finer laminations for better high frequency response. Cutoff is 50 Hz at 7.5 ips or 25 Hz at 3.75 ips.
3. **WP-Series Heads.** Models WP-B2H, WP-B2Q, WP-B1HY. These heads have longer poles and windows for extended and smoother low frequency response. Cutoff is 25 Hz at 7.5 ips and 50 Hz at 15 ips. Fine laminations give excellent high frequency response.
4. **Studio Series and PR Professional Series.** For the ultimate in superb low and high frequency response. Extra long pole pieces and window openings give extremely smooth and extended low frequency performance. Cutoff frequency is 25 Hz at 15 ips and 50 Hz at 30 ips. Supplemental shielding against hum fields is recommended, although the heads do have integral case shields.

Typical low frequency response curves are shown in Figures 2 and 3.

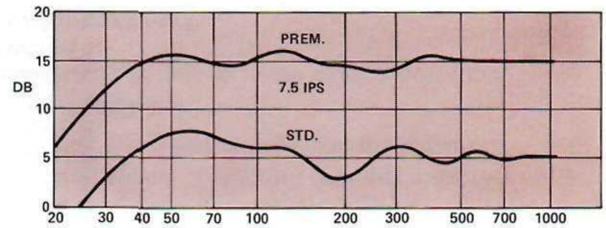

Fig. 2 – Low Frequency playback response, Standard and Premium heads, 7.5 ips.

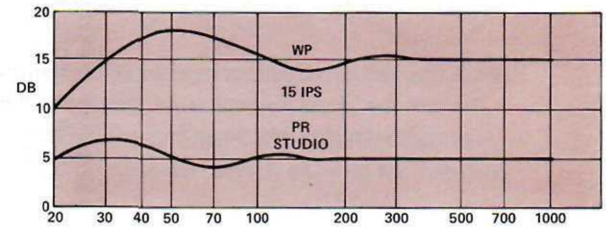

Fig. 3 – Low frequency playback response, WP, PR and Studio Series heads, 15 ips.

2. TAPE WRAP

It is important that a head have sufficient tape wrap around its nose and enough tape tension to insure good oxide-to-gap contact. Hyperbolic face contour is used on most NORTRONICS heads to reduce the tape contact area for a given degree of tape wrap, giving greater unit pressure in grams per cm^2 between the tape surface and head face. Only one head style, the "A-Combo" has a cylindrical face which requires pressure pads or very high tape tension.

Wrap Angle for hyperbolic heads typically can run between 5 and 10 degrees on a side. Figure 4 shows a head with tape wrap included angle of 165° or 7.5° drop back per side. The drawing can be used to make up a card or plastic template to hold against the head to check and adjust the tape wrap.

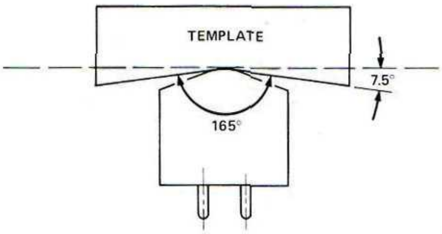

Fig. 4 – Tape wrap angle.

Wear Pattern can be used to verify the actual tape wrap to insure balanced tape wrap on both sides of gap line, and also the Zenith (face parallel to tape guides) which can cause *variation in wrap from top to bottom of contact area. Use* DYKEM™Sheet Metal Layout Blueing obtainable in Aerosol cans from industrial hardware stores. Spray it on a cotton swab and then apply to the head nose. Then run tape or film across head until the dye is worn off. (Do not use your alignment tape!)

3. HIGH FREQUENCY RESPONSE

The high frequency or short-wavelength response of a playback head is determined by the gap length and also by the type of tape. (This assumes the self-resonant frequency is above the highest needed frequency as discussed in the section on *"Self Resonance".*)

A rule of thumb is that the playback gap should be between 1/10 and 1/4 the wavelength of the highest reproduced frequency. The longer gap of 1/4-wavelength will produce a gap loss of no more than 1 dB at the shortest wavelength. A shorter gap than necessary will gain very little in high frequency response, but will reduce the head sensitivity and degrade the signal-to-noise ratio. Typical recommended gap sizes are 200 micro-inches (200-U) for 15 ips, 100-U for 7.5 ips, 50-U for 3.75 ips, and 50-U for 1.875 ips.

Record gap size is not critical, as recording is done with only the "trailing edge" of the gap. Record-only heads have wider gaps to reduce head inductance and improve flux penetration into the tape oxide. Typical record gaps are 500-U for 1/4-inch tape and 200-U for cassettes.

4. AZIMUTH, GAP AND SPACING LOSSES

The high frequency losses from an improperly azimuthed head are proportional to the wavelength of the signal, the track width of the head, and angle of mis-azimuth. A wide track head will be much more critical than one with a narrow track. This is one reason the cassette and 8-track systems with their 20-mil tracks can produce such good high frequency response at slow tape speeds.

To calculate gap, azimuth, and spacing losses the curve and formulae below can be used:

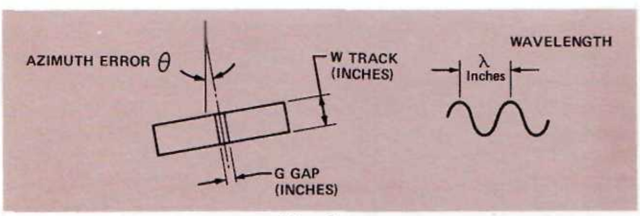

Fig. 5A

CALCULATED GAP LOSSES AT 1-7/8 IPS TAPE SPEED

Gap	1 kHz	5 kHz	10 kHz	15 kHz
100-U	–.1 dB	–1.2 dB	–4.5 dB	–13 dB
80-U	0	–.8 dB	–2.5 dB	–7 dB
50-U	0	–.5 dB	–1.2 dB	–2.5 dB
40-U	0	–.4 dB	–1.0 dB	–1.8 dB

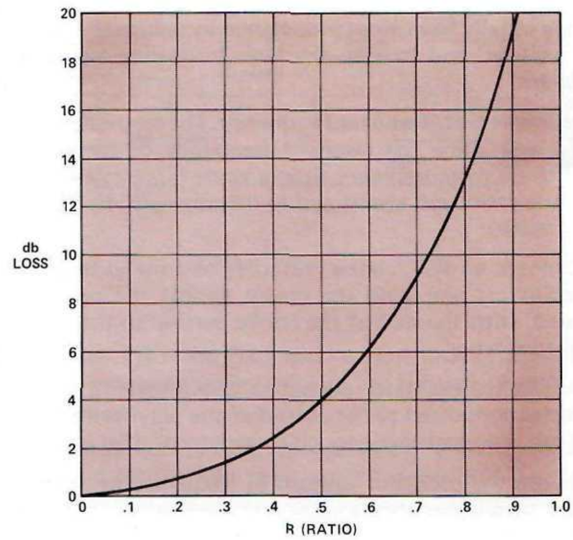

Fig. 5B

1. Gap Loss Calculation:

   $R = \frac{G}{\lambda} \quad \lambda = \frac{IPS}{HZ}$ Wavelength

   "What is the playback gap which gives a 3 dB loss at 10 kHz at a tape speed of 3.75 ips?"

   R = .44 (from graph at 3 dB)

   $\lambda = \frac{3.75}{10{,}000} = .000375$ In.

   $G = R\,\lambda = .44\,\lambda = .000165$ In. (165 micro-in.)

2. Azimuth Loss Calculation:

   $R = \frac{W \tan \theta}{\lambda}$

   "What is the azimuth misalignment which will give a 5 dB loss at 5 kHz at 1 ips with track width of .020?"

   R = .55 *(from graph at 5 dB)*

   $\lambda = \frac{1}{5000} = .0002$ In.

   $\tan \theta = \frac{\lambda R}{W} = \frac{.0002 \times .55}{.020} = .0055$

   $\theta = 19$ MIN

3. Spacing Loss Calculation:

   Spacing loss in db $= 20 \log_{10} \left(e - \frac{2\pi d}{\lambda}\right) = 54.6 \frac{d}{\lambda}$

   where d = spacing between gap and tape

   λ = wavelength

   "What is the playback signal loss in dB on an application with .0001 in. space between gap and tape on a 5 kHz signal at 3.75 ips?"

   wavelength $\lambda = \frac{3.75}{5000} = .00075$

   dB loss $= 54.6 \frac{.0001}{.00075} = 7.3$ dB

5. SELF-RESONANT FREQUENCY

It is very important, for a playback head, to choose a head inductance which, in association with its own distributed capacitance and shunt circuit capacitance, will result in a resonant frequency equal to, or above the maximum playback frequency. Typical top frequencies for various playback head inductances are 15 kHz for 800 mHy, 25 kHz for 200 mHy, 35 kHz for 100 mHy, and 80 kHz for 20 mHy. This is particularly critical for the Master Playback Head on a high speed duplicator where the play frequencies may run 8 or 16 times normal. Record heads are not such a problem,

TM DYKEM Company, 2307 N. 11th St., St. Louis, Mo.

as they usually have a low inductance to reduce the required bias voltage, and to ease the high frequency equalization problems.

Measurement of Resonant Frequency. The method described below will allow the resonant frequency of the playback head to be measured very simply while it is installed on the tape transport and connected to its preamplifier. Procedure is as follows:

1. Connect an R.F. choke (100 uHy to 1 mHy) to an audio oscillator, and hold the choke against the pole of the *head, with the axis of the choke parallel to the direction* of tape travel.
2. Adjust the oscillator output to give a reading on a voltmeter connected to the output of the playback amplifier. Keep the level low enough to avoid amplifier saturation.
3. Sweep the oscillator upward in frequency until the output signal goes thru a peak and then falls off. The peak frequency is resonance.

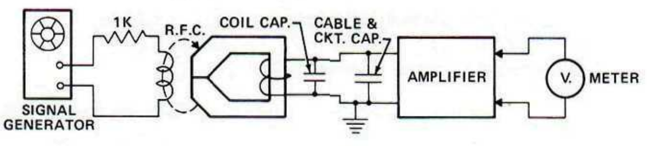

Fig. 6

4. If the peak reading occurs below the maximum operating frequency, change to a play head with lower inductance. Cable capacitance can sometimes be lowered to achieve small changes in resonant frequency.

6. CROSSTALK REJECTION

Crosstalk is the interchannel coupling between adjacent channels of a multichannel tape system. There are several types of Crosstalk:

1. **Transformer Crosstalk.** The figure given in the head specifications is usually called "Transformer Crosstalk Rejection", and is measured at 1 kHz by applying 1.0 volt rms to one coil of the head and measuring the signal picked up by the other coil. Typical rejection ratios run between 50 dB and 60 dB and they will vary somewhat with frequency. Care should be taken to place an electrostatic shield between the terminals and cables at high frequencies during measurements to prevent erroneous poor readings.

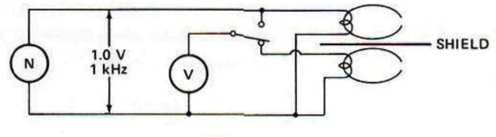

Fig. 7

2. **Record Crosstalk** is the signal recorded by an inactive channel of the record head when the adjacent channel is recording. To check for this, make a saturation level recording on one channel while only bias is being applied to the inactive channel. (Lack of bias will reduce record sensitivity and effectively eliminate the crosstalk.) Playback with a monophonic (single-channel) head on the active and inactive tracks and compare the two signals.
3. **Playback Crosstalk** can be checked by recording a saturation level signal on one channel only, with bias disconnected from the other (inactive) channel. Take playback readings on two channels of the multi-channel play head, and the ratio of active to inactive readings is the Playback Crosstalk Rejection. The input loading on the active track will affect the reading on the inactive track, with maximum reading from a shorted coil and minimum from an open active coil; circulating current in active coil induces additional crosstalk signal in other coil.
4. **Adjacent Channel Crosstalk.** This is a signal picked up directly from a recorded track on the tape by a closely spaced adjacent head channel. It can become troublesome with low-frequency long wavelength signals on stereo or quad systems which have only 12-mils spacing between recorded tracks. Tight-fitting windows in the face shields surrounding the playback head poles keep this crosstalk to an acceptable level.

NOTE: Transformer Crosstalk gives a figure which is very close to the combined worst-state condition of Record and Playback crosstalk. For this reason it is the most commonly used.

7. COIL PHASING AND POLARITY

The coils of record, play, and erase heads are consistently wired to produce a predictable **phase** relationship (A.C. excitation) or **polarity** (D.C. excitation.) For example, the coils of a multichannel head are wired so they produce in-phase magnetic fields on the face poles when the coils are connected in parallel and excited from an A.C. source.

A.C. Phase Check. It is possible to verify the relative phasing of the coils on a multi-channel head by exciting the head pole faces with coil and observing the Lissajous pattern from the exciting and picked up voltages as displayed on an oscilloscope. A reversed coil will flip the pattern 90 degrees. This method does not work well with double-gap erase heads or for specifying absolute phasing between various heads (see Fig. 8).

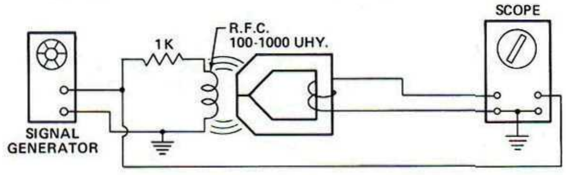

Fig. 8

D.C. Polarity Check. A more versatile test or specification is to apply a D.C. current to the head coil and note the North and South poles on the head face poles, using a magnetic compass. Procedure is as follows:

1. Remove the case from compass needle and cut the dial

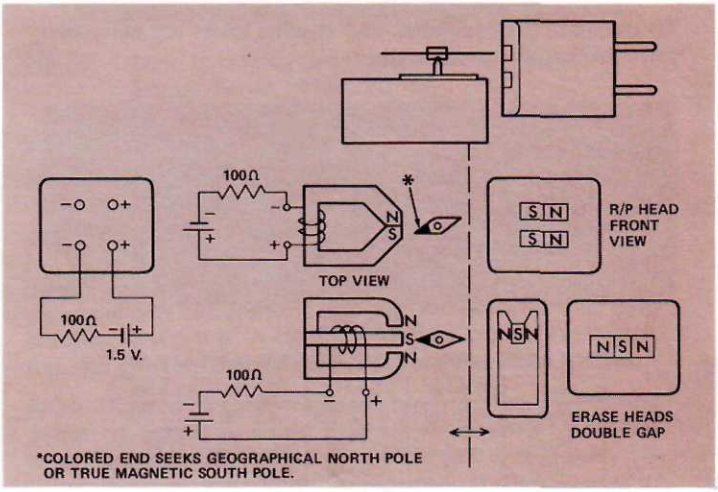

Fig. 9

with a scissors so it is smaller in diameter than the needle. This will allow the point of the needle to be brought up close to the face of a head. Place on a wood or plastic block.

2. Connect a 1.5-volt dry cell to the head pins thru a 100-ohm resistor, with polarity as specified on the head drawing.
3. With the coil excited, move the head face up to the colored (true magnetic South seeking) point of the compass needle, leaving about 1-mm space. The point will move to the South side of the head gap. Double-gap erase heads or Z-Combo heads will have one polarity for the center pole and the other polarity for the two outside poles.

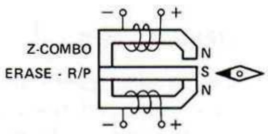

Fig. 10

B. ERASE HEADS

NORTRONICS Erase Heads are of three basic types of core construction:

1. **Metal Core Erase.** Type SEQ, SEH, MEF, B2EH, B1EF, A2H, A2Q, A1HC, etc. for 1/4-inch tape, shown on pages 29, 39, 40, 50, 51, 52, 59, 64. These are low in cost and are available in a variety of case styles and mountings. They have good efficiency up to 60 kHz and can operate at frequencies up to and including 100 kHz, and also with D.C. excitation.
2. **Metal/Ferrite Hybrid Core Erase.** Types PR-B1EF, PR-B2EH, PR-B2EQ and PC-B4-EQ "PRO" series for 1/4-inch tape, shown on pages 28, 32, 60 and 61. STE types for 1/2, 1-inch, and 2-inch tape, shown on pages 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 and 24. These are double-gap erase heads with ferrite center "I" core and laminated Hi-Mu "C" cores, giving the long life and high efficiency of ferrite plus the smooth tape contact surface of polished metal. They are recommended for professional studio recorders which require great depth of erasure and efficient low-power operation at frequencies up to 250 kHz.
3. **Ferrite Core.** Types H805004 and H806036 1-inch full-width ferrite erase. Types W1ER and W2ER single and two-channel erase heads for Cassette recorders. These are extremely efficient erase heads capable of being operated at frequencies as high as 500 kHz for use on high speed duplicators. They are of double-gap all-ferrite construction. See pages 25 and 87.

Application: Metal-Core Erase Heads

Always use a coupling capacitor between the secondary winding of the oscillator transformer and the erase head. If the capacitor is large, about ten times the series-resonance value, it will have little effect upon the erase head voltage, which will then be equal to the transformer voltage. Reducing the capacitance value will begin to increase the erase voltage until a maximum of approximately 1.5 times the transformer voltage is reached at exact resonance. This gives a measure of control of the erase head voltage so it can be set on the recommended nominal value. The head will erase the specified 60 dB at voltages (or currents) 15% above or below the nominal.

The erase voltage will be proportional to the frequency. A head requiring 40 volts at 60 kHz will need 67 volts to produce the same erase current and degree of erasure at 100 kHz. Typical erase circuits are shown in Figure 11.

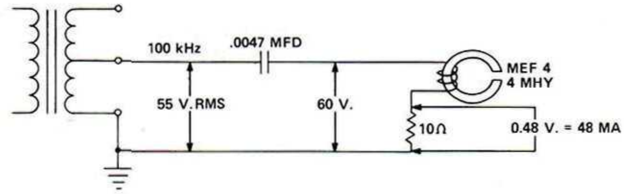

Fig. 11

Application: PR-series Professional erase heads for 1/4-inch tape; STE-series Studio erase heads for 1/2-inch, 1-inch, and 2-inch tape

These superior quality heads are capable of erasing saturated recordings down to the noise level of virgin tape. Dual gap construction and highly efficient core structure require very low power consumption for full erasure.

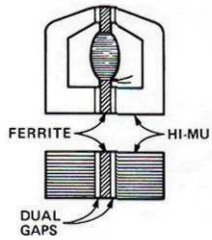

Fig. 12

The hybrid core design features an efficient, long wearing ferrite center I-core and laminated Hi-Mu metal side E-cores for smooth tape contact. The resulting two-material core structure combines the advantages of both ferrite and metal, without the disadvantages.

Excitation. The voltage and current values given in the specification tables are the nominal figures required to produce a minimum erasure of 70 dB from a saturated 400 Hz recording. The heads should be operated within a tolerance range of ± 20% of nominal to insure the 70 dB erasure and prevent saturation of the magnetic core.

Frequency. Because of their high efficiency, these hybrid erase heads may be operated at frequencies up to 250 kHz. Current requirement will remain fixed, but the voltage must be increased proportional to the frequency. Power dissipation will also go up in proportion to frequency.

Power. At 100 kHz the power requirement of the PR-B1EF full-track erase head is approximately 0.7 watts, and the PR-B2EH 2-track and STE Studio erase heads will use about 0.25 watts per channel. To calculate the power, multiply the rms voltage and current (volt-amperes), and then divide by the "Q", which is approximately 7. It is quite important for an energized erase head to be properly "heat-sinked" by securely mounting it to a metal bracket and nest. Also, the movement of tape across the head face serves to carry away the generated heat, reducing temperature rise. These precautions are more important for the multi-track heads operating at higher frequencies.

Saturation. The hybrid erase heads will saturate, causing driving waveform distortion and loading if the head current is increased more than 20% above the nominals given. An ideal way to adjust the drive on a particular head is to increase the voltage until distortion is detected on an oscilloscope, then reduce the drive by 10%.

Coupling. It is recommended that a coupling capacitor be inserted between the erase head and its driver in order to prevent low frequency noise from being coupled to the head and then recorded on the tape, and also to permit a degree of control over the voltage being applied to the head.

The curve (Fig. 13) shows the variation in head voltage, E_h, as a function of the coupling capacitor, C_c. The head voltage reaches a peak of 7 times E_s when the capacitor resonates with the head, at a value of C_{cr}. (A very low value of E_s must be used to run such a curve to keep the head voltage from reaching saturation.)

It is important to stay out of the unstable region, where a transient can flip the head into saturation, thereby lowering its inductance and holding it in the saturation mode. C_c should be chosen to be either **less** than the resonating value, C_{cr}, or greater than 5 times C_{cr}, thereby permitting the head voltage to be adjusted to a value somewhere between the supply voltage and 4 times supply. The voltage regulation of the driver will, of course, have an effect on E_h as C_c is varied. Often E_s will drop sharply as the head current increases near resonance, causing an apparent flattening of the peak on the curve.

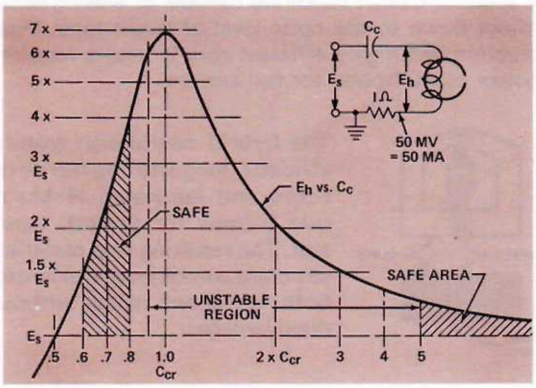

Fig. 13

C. Z COMBO® HEADS

"Z-Combo" heads have combination erase and R/P elements in the same housing. They are sometimes called "Three-in-one" heads. Erase and R/P functions are combined in one core structure with closely spaced erase and R/P gaps. They are available in a number of different track widths, in single or two-channels, and different case sizes. Types are Z-R1LC, Z-W1LC, Z-W1R, Z-W2RK, Z-J2L, and Z-J2H.

Z-Combo heads are particularly suited for use with "extended tip" poles for use against hard surfaces such as film, cards or drums. The close spacing of erase and R/P gaps makes practical the combined functions, where conventional combo or separate heads would not work. It also reduces the time delay or distance between erase and record.

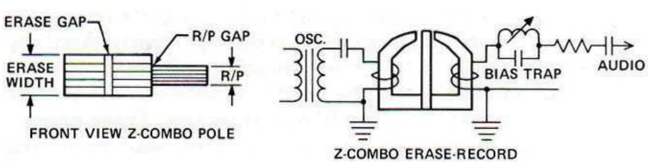

Fig. 14

Construction differs from conventional R/P heads with the addition of a center "I" core which is common to both the erase and R/P functions. The Erase C-core and R/P C-core each have their own coil. When the erase coil is energized with high frequency power from the erase/bias oscillator, enough leakage flux flows to the record side of the head to provide high frequency bias. Erase current is usually adjusted to the value which gives optimum (peak) bias at 1 kHz recording. The single-gap erase head is not as effective as the double-gap heads, limiting the degree of erasure to about 50 dB.

It is sometimes helpful to place a bias trap in the audio driver circuit to cause the R/P coil to look into a high impedance at the bias frequency. This will prevent bias voltages induced in the record coil by the erase coil from causing circulating currents which increase the effective bias flux at the record gap, necessitating a reduction in erase current to prevent overbiasing. In other words, we wish to maintain maximum erase current for good erasure without overbiasing. (D.C. can be used for erase and bias on Z-Combo heads—see section on D.C. BIAS).

Erase/bias voltage may be varied by adjusting the D.C. supply voltage to the oscillator, or by the size of the coupling capacitor to the erase coil. Tuning of the bias trap, if used, will also affect the bias.

D. HIGH SPEED DUPLICATORS

In duplication of tapes at high speeds all of the frequencies on the Master playback tapes and the Slave recorded tapes are increased by exactly the ratio of the duplicator to normal speeds. Equalization of both play and record amplifiers must be shifted up the spectrum in frequency in the same fashion. Fig. 15 below shows the Master Play equalization and the Slave Record equalization for 1 x (100-10,000 Hz), 2 x (200-20,000 Hz), and 4 x (400-40,000 Hz). Response curves are the same, but are changed in location to follow the new frequencies. The shaded areas show the range of adjustment for the equalization controls to compensate for variations in tape, master speed, master quality, etc.

Head Impedances must be scaled down to ease record driving at the higher frequencies, and to keep play head resonance out beyond the highest operating frequency. (See section on **Self Resonant Frequency** for measuring play head resonance.) Record head inductances can be 2, 5, or 10 mhy, and Play head inductances can run 5, 10, or 20 mhy.

Bias Frequency for the duplicator slaves should be at least five times the highest recorded frequency, and typically run 250, 500, or 1000 Hz. T70 series bias oscillator transformers are available for these frequencies.

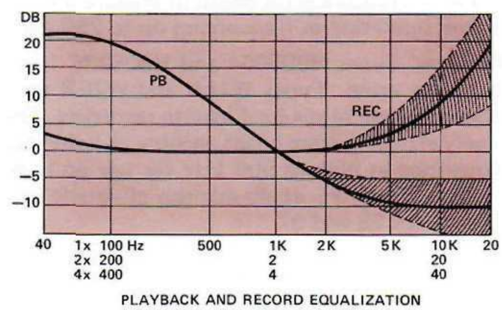

Fig. 15

Basically a duplicator consists of the same units as a conventional recorder, as shown in Fig. 16. The Master Play head feeds an equalized play amplifier which is connected to the recording amplifier. An additional power record driver may be used to drive 10 or more slave heads. The bias oscillator must supply enough power to the common bias buss to drive all the record heads. Sometimes erase heads are also used, placing additional demand on the oscillator.

Individual bias adjustments are recommended to compensate for head differences. Record currents may be individually adjusted also by replacing the fixed series 10K resistor with a variable one.

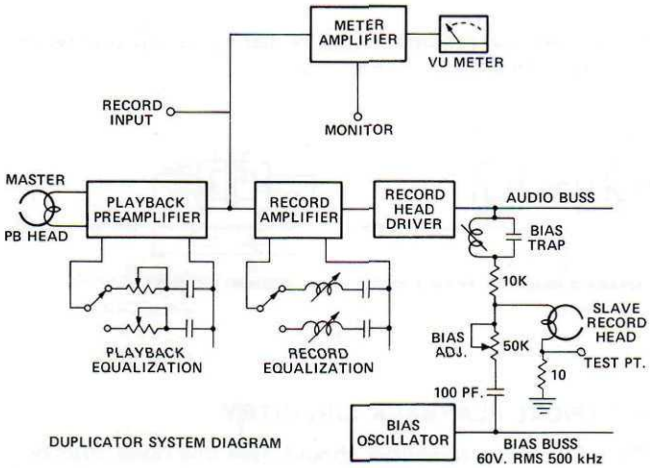

Fig. 16

II. RECORD & PLAYBACK CIRCUIT CONSIDERATIONS

A. TYPICAL RECORD CIRCUITRY

Recording consists of applying the audio signal, intermixed with the high frequency 50 to 100 kHz bias current, to the coil of the record head. Bias current is about ten times the audio current which places a zero-level signal (12 dB below sat.) on the tape. Bias level is adjusted to give maximum record sensitivity for a 1 kHz audio signal.

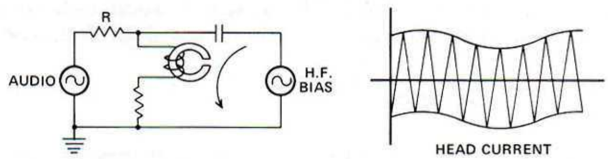

Fig. 17

Typical Record Circuitry is shown in Fig. 18. R1 controls the level of audio current fed to the record head and is adjusted to give a recorded level of zero reference when the VU meter reads zero-VU. Partial high frequency boost is created by C1 shunting R2 loaded by R3. C2 is a short circuit at the high frequencies, but below 100 Hz begins to add impedance to R3 to give a small low frequency boost. C3 and R4 give a degree of adjustment to the amount of high frequency pre-emphasis. C5 shunting R7 helps again to increase the rate of rise on the curve above 10 kHz. Alternately, instead of C5, we can shunt R7 with a series resonant circuit, C10 and L1 to give a greater amount of pre-emphasis and sharper rise. Resonant frequency of C10/L1 can be adjusted by L1 to fall between 10 and 20 kHz. R12 is selected to reduce the Q, if necessary. Tape speeds other than 7.5 ips will require changes in value for C1, C3, C5 and C10. For example, slower speeds need more capacitance.

The output of the transistor amplifier is fed to the record head thru R9 and the bias trap, which keeps the bias from the transistor. C8 serves to bypass the bias, and also to filter out audio frequencies above 20 kHz which might intermodulate with the bias. Bias is coupled to the record head thru the adjustment potentiometer, R10, and C9. R11 in series with the record head permits voltage readings across it to measure the bias and recording currents.

Q1 should be able to deliver at least four times the zero level recording current without distortion. This is not a problem with record heads of 2 to 50 mhy inductance. High impedance R/P heads of 200 or 400 mhy are more difficult to drive because of limited A.C. voltage swing from Q1, especially at the highest frequencies which may be boosted from 15 to 20 dB. A higher d.c. supply voltage may be required, plus holding down the inductance of the R/P head to 100 mhy.

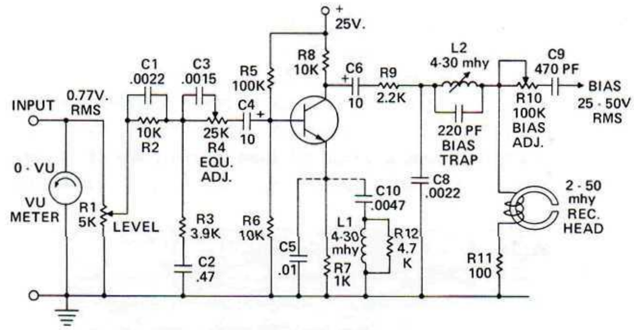

Fig. 18 – Record Equalization and Driver

IC Operational Amplifiers may be used as record head drivers, but are more critical to set up because of stability, gain, feedback, frequency response, power supply and noise considerations. Two references on IC record and play circuits include:

- LM381 Low Noise Dual Preamplifier, NATIONAL SEMICONDUCTOR CORP., AN-64 May, 1972, Byerly & Long. Gives tape head record and playback amplifier circuits.
- PIT FALLS OF THE GENERAL PURPOSE IC OPERATIONAL AMPLIFIER AS APPLIED TO AUDIO SIGNAL PROCESSING. Walter G. Jung, 1972, A.E.S. Preprint No. 893 (F-4), Audio Engineering Society, N.Y.

1. RECORDING LEVEL

The record current values given in the specifications in this catalog will place a 1 kHz signal on the tape 12 dB below tape saturation. This is also the level of the 1 kHz playback signal given in the specifications. To determine these figures follow this procedure:

1. Adjust for peak bias. A separate monitor play head is helpful.
2. Increase record current until playback signal saturates and refuses to increase further.
3. Reduce record current until play signal drops 12 dB from its maximum level. This value of record current is very close to "Zero Reference" and should cause the VU meter to read Zero-VU.

Alignment or Test Tapes have a Zero Reference Level which may be specified as "NAB Standard Reference Level" (150 NanoWebers/Meter), as "Reference Fluxivity" (200 NanoWebers/Meter), "Ampex Operating Level" (185 NanoWebers/Meter), or as "DIN Reference Level" (250 NanoWebers/M for Cassette 1.875 ips).

The above absolute tape levels can be related to each other as dB differences. Depending upon the particular test tape the VU-meter calibration will indicate the record level to produce a playback signal equal to the reference level.

Cassette recorder calibration for Zero-VU is best done at 200 nW/M as this is a safer level for distortion and is also the basis for calibration of the Dolby noise reduction system.

2. BIAS ADJUSTMENT

The bias current of a record or record/play head is normally "peaked" or adjusted to give maximum playback output from a 1 kHz recorded signal. This gives close to minimum distortion, with good high frequency response. **Overbiasing** slightly may substantially reduce the high frequencies while giving a small reduction in distortion. **Underbiasing** will increase the high frequencies at the expense of greater distortion.

Cassette bias at 1-7/8 ips is very critical because of the shorter wavelengths, making it difficult to obtain repeatable results from 1 kHz peak bias adjustments. A superior method is to peak the bias while recording 6.3 kHz, which gives a lower value of bias than the 1 kHz peak. Then increase the bias current until the 6.3 kHz playback signal drops exactly 2.5 dB. This method gives a value of bias current which is very close to peak 1 kHz, and it can be repeated very consistently.

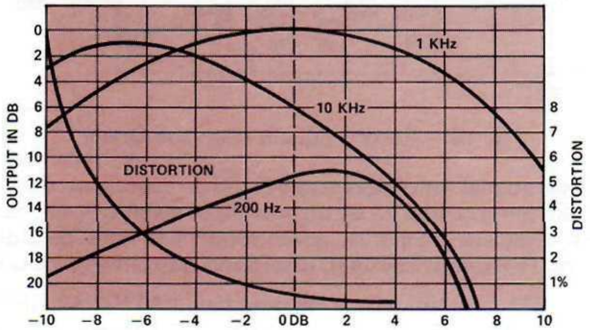

Fig. 19 – Typical 3.75 ips output curves and distortion vs. bias current. (0 dB is 1 kHz peak.)

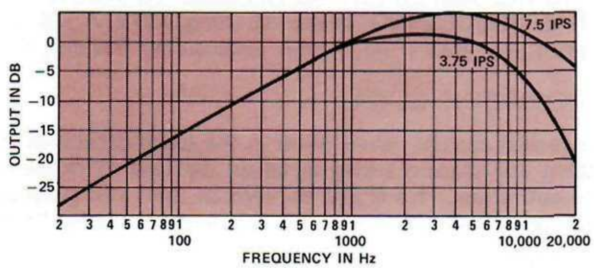

Fig. 20 – Typical constant-current unequalized Record/Play response curves run at peak 1 kHz bias.

The above method of overbiasing at a high frequency for adjusting bias is described for various tape speeds in DIN Standard No. 45512 dated March, 1974, available from USASI, 10 E. 40th St., New York, N.Y. 10016.

Erase/Bias Oscillator. The oscillator to supply erase power and record bias should operate at five or more times the highest audio frequency. Use the NORTRONICS T70-T2 for 50-120 kHz, T70-T5 for 100-250 kHz, and T70-T6 for 250-1000 kHz. The push-pull circuit can deliver more power at minimum distortion. A single-ended (one transistor) oscillator may be adequate for light loads but has more second harmonic distortion in its waveform. A typical circuit is shown on page 89.

D.C. Bias Operation. It is possible to erase and apply bias with D.C. This will reduce cost by eliminating the bias oscillator. Results are inferior to those from A.C. bias and erase, but are often satisfactory for non-critical voice applications such as telephone answering recorders, dictation machines, etc. Background noise and distortion are increased for D.C. bias.

Either Z-Combo or conventional erase and R/P heads can be used with D.C. The erase head is supplied with a D.C. current equal to twice the specified nominal rms A.C. current. This is enough to leave the medium in a saturated condition. Then, D.C. bias is fed to the record coil in a polarity such as to tend to neutralize the residual flux in the medium. This bias is adjusted for peak or optimum 1 kHz recording, or else can be set for minimum hiss or background noise while listening with a monitor play head.

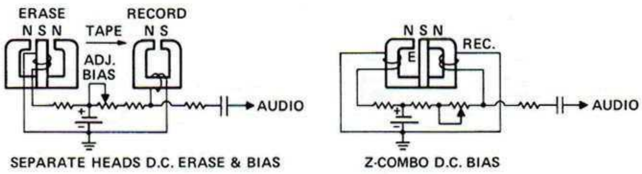

Fig. 21

B. TYPICAL PLAYBACK CIRCUITRY

The playback preamplifier should have low noise components, particularly the input transistor and its collector and emitter resistors. Equalization serves to boost the low frequency response to compensate for the falloff in playback head output as frequency is decreased. Normally the playback equalization is adjusted to give a flat play response from a prerecorded test tape. The circuit below (Fig. 22) is typical for use at 7.5 ips. Other speeds will require changes in the equalization resistance and capacitance to maintain the correct frequency response.

R2 and C2 trap TV and radio interference. C3 and R5 couple high frequency negative feedback from collector of Q2 to emitter of Q1. The impedances of C3 and R5 determine the "break point" or "transition frequency" on the response curve. For example, NAB 7.5 ips specification calls for a time constant of 50 usec. (R x C) or a transition frequency of 3180 Hz $\left(\frac{1}{2\pi RC}\right)$

Therefore, if C is .015 mfd, the value for R may be calculated as:

$$R = \frac{1}{2\pi FC} = \frac{1}{6.3 \times 3180 \times .015 \times 10^6} = 3300 \text{ ohms}$$

$$\text{Alternately, } R = \frac{T_c}{C} = \frac{50 \times 10^6}{.015 \times 10^6} = 3300 \text{ ohms}$$

For a tape speed of 3.75 ips we have 1800 Hz and 90 usec T_c.

$$R = \frac{90}{.015} = 6000 \text{ ohms, well within the range of R5 adjustment.}$$

The curves of Fig. 23 show the 1800 Hz and 3180 Hz transitions for 3.75 and 7.5 ips. The points are located at the intersections of the straight-line extensions of the sloped and horizontal sections on the curves.

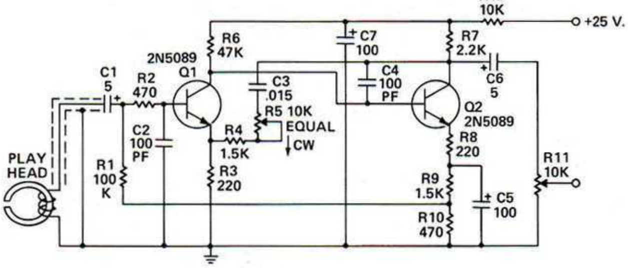

Fig. 22 – Playback Preamplifier

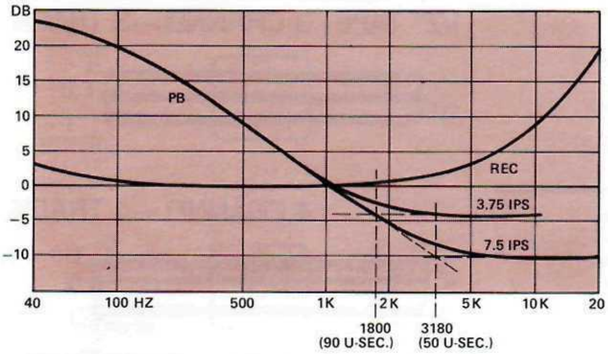

Fig. 23

C. RECORD/PLAYBACK

EQUALIZATION – FREQUENCY RESPONSE

When a record/playback frequency response is run on a magnetic tape head with **no** record or playback equalization (constant-current record, flat playback) the output response curve will look like "CC R/P" in Fig. 24. The rising output in the low frequency region is caused by the typical dø/dt effect of a magnetic transducer. The high frequency falloff is caused by playback gap losses, core losses, and tape demagnetization at shorter wavelengths.

Standard practice to develop a flat R/P response is to **equalize** the playback and record amplifiers by **boosting** the **low** frequencies during playback and **boosting** the **highs** during record. (See the PB and REC curves.) This system gives the best signal-to-noise ratio, dynamic range and frequency response. Since this response condition is caused by the shorter recorded wavelengths at the higher frequencies, the groups of curves are similar for various tape speeds, but are shifted to the right or the left of the frequency spectrum for higher or lower speeds.

A slight boost is usually incorporated in the low frequencies below 100 Hz during recording to compensate for droop in play amplifier equalization.

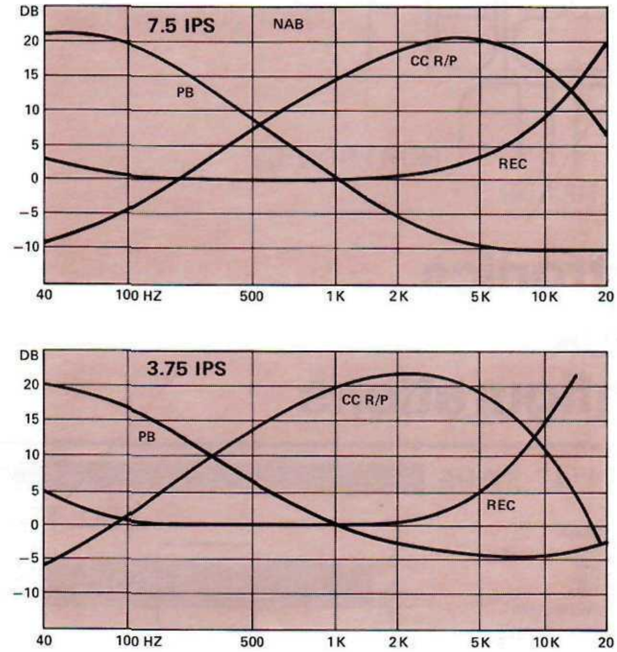

Fig. 24

Adjustments, Playback. Standard alignment or test tapes are available for most tape or film speeds. Practice is to play the test tape and trim the playback equalization until the response is flat over the spectrum. The frequency tones on the test tape have been recorded with the correct record equalization. The additive sum of all three curves on the graph should generate a flat response.

Record Equalization Adjustment. After the playback equalization has been adjusted from the test tape the record equalization is next varied to produce a flat record/play response from an audio oscillator. **Record level** during this procedure should be −10 dB from Standard Reference Level to prevent overloading at the high frequencies and erroneous results.

HOW TO SELECT AND SPECIFY

Selecting the proper head for your application can be accomplished by referring to the information below. Technical data on all Nortronics heads listed in the following index is contained on the individual pages referenced. In determining the part number for your application, please refer to the step-by-step selection guide below.

1	2	3	4	5	6	7	8
DESIGNATE SERIES	**DESIGNATE CASE STYLE**	**NUMBER OF CHANNELS**	**NUMBER OF TRACKS**	**TRACK LOCATION**	**ERASE ELECTRICAL CODE**	**R/P ELECTRICAL CODE**	**MOUNTING STYLE**
P=Premium series XP=Extended tip—Premium PR or WP= Professional series (Standard has no prefix)	List proper letter designation from case outline drawings on each page	1=mono 2=stereo 3=3 channel 4=4 channel	H=2 track (half track) Q=4 track (quarter track) L=8 track	(mono heads only) NONE=Standard stereo offset C=Centered track Y=.020 off center (G1HY) .040 off center (B1HY)	(combo heads only) List code from specification chart	List code from specification chart	List proper mounting code shown on individual pages
EXAMPLE:							
P	A	1	Q	C	4	6K –	SL
series	case style	channels	tracks	track location	erase code	electrical code	mounting

PREMIUM SERIES: "A" case style; 1 channel (mono); 4 track; centered track; combination erase-R/P head; No. 4 erase electrical code; No. 6K R/P electrical code; side mount with erase section to the left.