Erasure of Magnetic Tape*

JOHN G. MCKNIGHT
Ampex Corporation, Audio Division, Sunnyvale, California

A brief look is taken at several parameters of the erasing system of a magnetic tape recorder: head losses, remanence *vs* erasing current, and gap material and size. A re-recording phenomenon is studied, and some measuring problems are discussed.

INTRODUCTION

ONE section of a magnetic recorder which has received little attention is the erasing system. The usual explanation of erasure is very simple: "The principle of ac erasing consists in passing the recorded medium through a decaying alternating magnetic field in which the initial values of the field are great enough to saturate the medium completely and in which subsequent reversals of the field gradually decrease to zero."[1] Some of the practical difficulties of erasure are discussed in *Sound Talk*.[2,3] Many erase heads have been patented[4]—but none with any quantitative theoretical explanation. It seems that the erasing process is considerably less understood than one might suppose from the small number of previous studies.[2,3,5–7]

The erase system is expected to accomplish two things: first, to remove any signals which are on the tape; second, to leave the tape as quiet as possible. A properly designed erasing system using an ordinary ring head will not raise the noise level of a bulk erased tape above the noise which is caused by the bias current in the *recording* head.[8,9] Therefore the principal problem of erasure to be studied here is that of removing the signals which are recorded on the tape. It will also be shown that the very *measurement* of erasure is itself fraught with dangers.

ERASING A SIGNAL RECORDED ON THE TAPE

In erasing as in recording and reproducing, certain effects are dependent only on frequency, and others are dependent only on the recorded wavelength on the tape.[10] In erasing we have one frequency—that of the erasing current. There are, however, two wavelengths of concern: the "wavelength" contributed by the erasing current, and the wavelength of the signal being erased. Each of these effects will be studied.

Finding a criterion for erasure is itself a problem. In these tests almost all data have been taken with heads made from standard Ampex Model 350 cores and windings and the standard erase oscillator.[11] Therefore, head current has been the measure of excitation, rather than power, ampere-turns, or some other factor.

Another problem is that one head may take less current

* Presented October 17, 1962 at the Fourteenth Annual Fall Convention of the Audio Engineering Society, New York.

1. S. J. Begun, *Magnetic Recording,* (Rhinehart Books, New York, 1949), p103.
2. "Time Effects in Erasing Magnetic Recordings" *Sound Talk Bulletin 11* (Minnesota Mining and Mfg. Co., St. Paul, Minn., July, 1949).
3. "AC Erasure of Magnetic Tape," *Sound Talk Bulletin 24* (Minnesota Mining and Mfg. Co., St. Paul, Minn., July, 1953).
4. See Appendix A.
5. R. Herr, B. F. Murphy and W. W. Wetzel: "Some Distinctive Properties of Magnetic Recording Media," *J. Soc. Motion Picture Engrs.* 52, 77 (1949).
6. M. Rettinger, "AC Magnetic Erase Heads," *J. Soc. Motion Picture Engrs.* 56, 407 (1951).
7. D. E. Wiegand and R. E. Zenner, "A Turn-In Gap Erase Head for Magnetic Recorders Providing Intense High-Frequency Fields," *Trans. AIEE.* 67, No. 1 (Communications and Electronics), 507 (1948). Also published as *AIEE Technical Paper 48-76,* (Dec. 1947).
8. See Appendix B.
9. It is possible to design an erase head which leaves the tape nearly as quiet as does bulk erasure, but there is no advantage in doing this since the noise level due to biasing the tape is higher than that due to the erase head.
10. J. G. McKnight, "The Frequency Response of Magnetic Recorders for Audio," *J. Audio Eng. Soc.* 8, 146 (1960).
11. Cores were made from 35 six-mil 4-79 molybdenum permalloy laminations, to form a 270-mil stack; this is wound with 75 turns of No. 28 wire on each leg. The gap structures were modified from those of standard erase heads. A Model 350 erase oscillator was used at 100 kc. Head current was read-in on a meter connected across a 7 ohm series resistor.

than another for a certain amount of erasure, but may take more current for some greater amount of erasure. Therefore, the question of which is the better head may not have a unique answer.

Frequency Effects

Several frequency effects will affect performance: electrical resonance of the erasing head; eddy current loss of core material; stacking factor of the core; erase head gap material; number of cycles of erasure; number of erasures.

The resonant frequency of the head inductance with its self-capacitance and that of the head cable should be well above the erasing frequency, to allow the erasing current

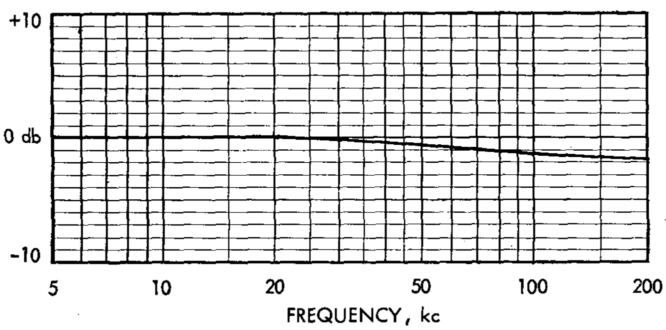


FIG. 1. Head flux *vs* frequency for an Ampex Model 350 erase head when energized from a constant current source at a low flux level.

to flow through the head coil rather than into the cable or winding capacitance. This requirement is met in all of the designs studied here.

Eddy current ("iron") loss was measured, and Fig. 1 shows the head flux *vs* frequency for a standard core energized from a generator giving constant current *vs* frequency.

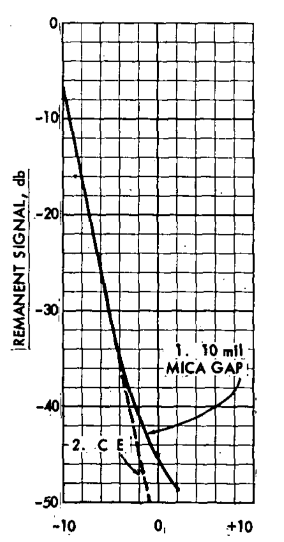


FIG. 2. Remanent signal *vs* erase current: 1. Erase head with a single 10-mil gap spacer. 2. Extrapolation of constant exponent line. Recorded signal: 700 cps at 7½ ips, recorded (with bias) to saturation (+15 db output).

This would indicate that at low flux levels the iron loss of this standard core is only about 1½ db at 100 kc.

The graph of remanence *vs* erase current for a head made from a core as in Fig. 1, with a 10-mil non-conducting (mica) gap, is shown in Fig. 2.[12] This curve is a straight line for most of its length, representing a constant exponential relationship of remanence *vs* erasing current.[13] At the higher erasing currents, however, increasing current does not make proportional increases in erasure. Core saturation was suspected to be a limiting factor. A similar head was made with a core of 4-mil Silectron (4% silicon steel which has a saturation flux level twice that of the usual material). Essentially the same curve as shown in Fig. 2 was found, but this material required 2½ db more current for the same amount of erasure. We concluded that no important

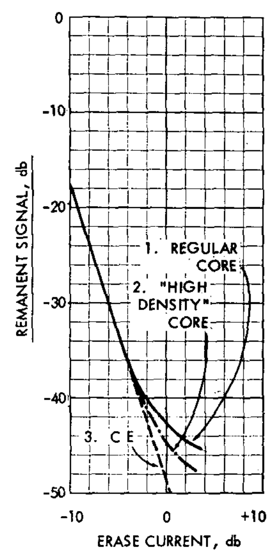


FIG. 3. Remanent signal *vs* erase current, for two erase heads with 10-mil copper gap spacers: 1. Regular core; 2. "High density" core; 3. Extrapolation of constant exponent line. Recorded signal: 700 cps at 7½ ips, recorded (with bias) to saturation (+15 db output).

core saturation effects were occurring. (No difference was found between laminations that were or were not annealed.)

Another possible variable, which is more properly a wavelength effect, is the effect of core stacking factor. A standard and a "high-density" core[14] were compared in heads with nonconducting gaps, and found essentially identical. When a conducting (copper) gap spacer was used, the high-density core showed an improvement. (See Fig. 3.)

12. Throughout this report, the reference level ("zero db") for remanent signal is the "operating level" section of an Ampex 4494 Reproduce Alignment Tape. This was originally determined as that level giving 1% third harmonic distortion, but has since been maintained as a particular flux level. "Saturation output" is the maximum remanent signal obtainable by the use of any magnetizing flux. The "erase current" is as read on the vu meter of an Ampex Model 350 recorder: reference erase current ("zero db") is 110 ma.

13. The graphs are db *vs* db, on linear paper; this is equivalent to a plot on log-log paper, wherein a straight line indicates a constant-exponent relationship.

14. At the time of this work (1957) the "standard" stacking factor was about 70 to 80%. "High density" cores were made with a stacking factor of 90 to 95%. At present (1962) all Ampex cores are "high density".

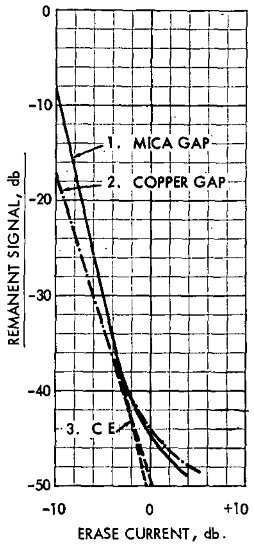


FIG. 4. Remanent signal *vs* erase current, for two erase heads with "high-density" cores: 1. 10-mil mica gap spacer; 2. 10-mil copper gap spacer; 3. Extrapolation of constant exponent line. Recorded signal: 700 cps at 7½ ips, recorded (with bias) to saturation (+15 db output).

A brief look into the effect of the gap material is shown in Fig. 4. The same piece of tape was erased once using

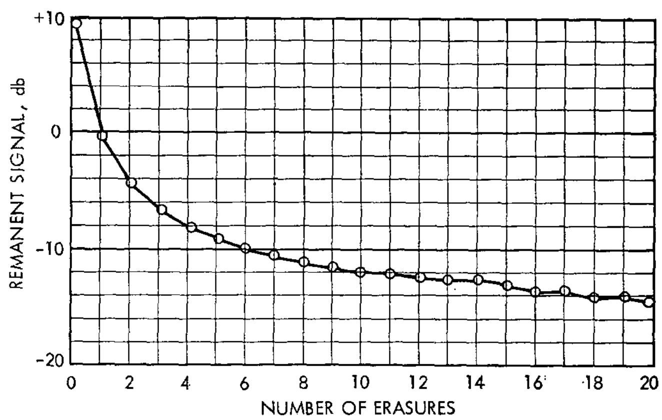


FIG. 5. Remanent signal *vs* number of identical erasures. Erase current set to give 10 db signal reduction on the first pass. Erased with a head having multiple-gap spacers: 2-mil mica gap, 4-mil 4-79 molybdenum permalloy magnetic spacer, and 30-mil mica gap. Recorded signal: 400 cps at 15 ips, recorded (with bias) to +10 db output.

a head with a 10-mil nonconducting (mica) gap spacer, and then with the same head which had the gap spacer replaced with a 10-mil conducting (copper) gap spacer. At lower currents greater erasure was achieved with the conducting gap spacer, but at the higher currents available the conducting gap spacer was slightly poorer.

The operation of the conducting gap spacer involves eddy currents which generate a field that opposes the field in the gap, but aids the field outside the gap. If the conducting material were *perfectly* conducting this type of gap would probably be desirable, but the resistance of the copper causes enough power dissipation to make its use questionable.

An effect which is not clearly related to frequency or wavelength is that of remanence *vs* number of erasures. We wished to find whether, with a given erasing system, an ultimate degree of erasure is achieved if the tape is passed over the erase head many times. Figure 5 shows remanence (in db) *vs* number of erasures (effectively a semi-log plot) for a particular system. Figure 6 shows this same data, but on a log-log plot. It is seen that after the first erasure a constant exponential law is followed. This same erasure

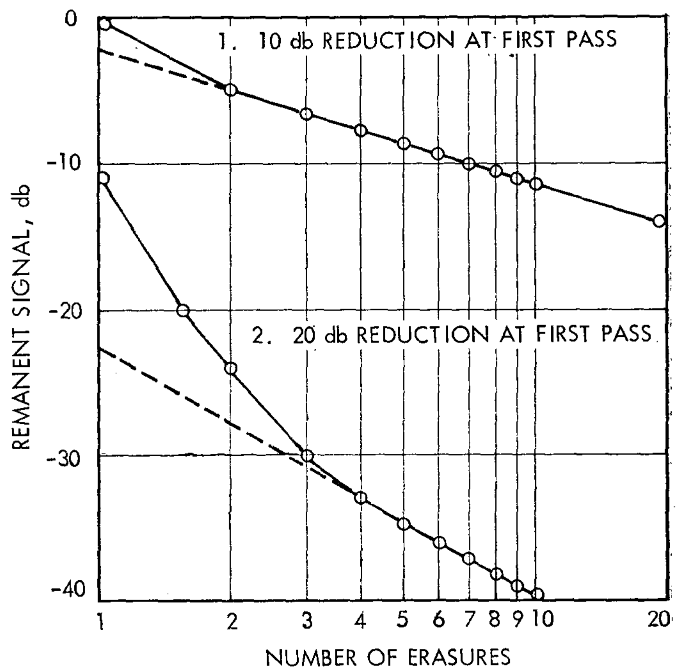


FIG. 6. Remanent signal *vs* number of identical erasures, log-log plot: 1. Erase current set to give 10 db signal reduction on the first pass; 2. Erase current set to give 20 db signal reduction on the first pass. Recorded signal and erase head same as for FIG. 5.

phenomenon held for an erasing frequency of 10 kc or 100 kc (adjustment was made to achieve the same remanence after one pass). For a greater erasing current (Fig. 6) the same general curve is followed, but the constant exponent line is not reached until the fourth pass. This erasure phenomenon may be related to the re-recording process which is discussed further on.

A factor which is largely frequency-dependent is the number of cycles of erasing flux which the tape undergoes in erasure. This should be determined with as few other changes as possible; therefore the speed of the tape was varied during erasure, by driving the reel by hand, with all other conditions unchanged; then (while reproducing at constant speed) the remanence was measured. The erase current had been set for 40 db erasure in order to give sufficient remanence to measure accurately. In reproduction the remanence was seen to vary but little—over a speed range of roughly 2 to 80 ips (a 40 : 1 ratio of number of erasing cycles), the remanence variation was about 6 db (2 : 1 ratio). Therefore, the number of erasing cycles, *per se*, is not critical in this region, and when we discuss the various wavelength effects we can be fairly sure that the effect is

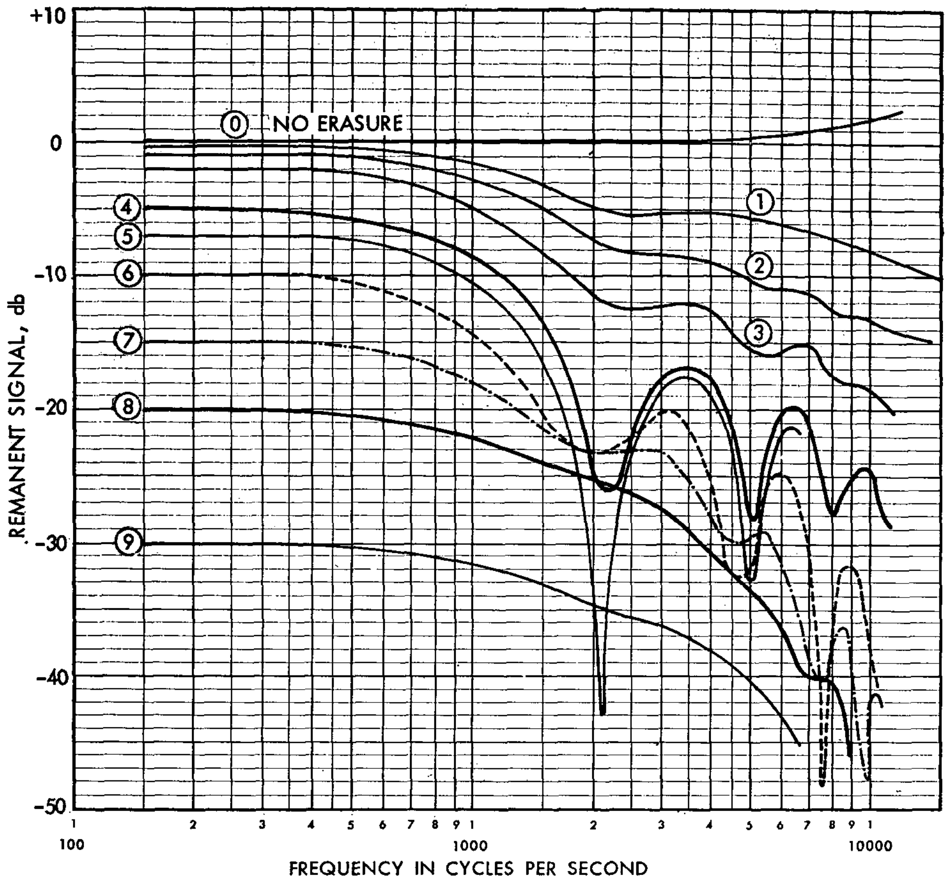


FIG. 7. Remanent signal after erasure *vs* frequency of recorded signal. For one erasure each, with the following erase currents: 0. No erasure; 1. −18½ db; 2. −17½ db; 3. −16½ db; 4. −15¾ db; 5. −15½ db; 6. −14¾ db; 7. −13¾ db; 8. −13 db; 9. −11 db. Erasd with a head having a 4¼-mil mica gap spacer. Recorded signal: frequency sweep at 15 ips, recorded (with bias) to the reference level; standard audio equalization used.

not simply a change in the number of erasing field cycles to which the material is subjected.

Wavelength Effects

To generalize, the shorter the recorded wavelength, the easier it is to erase. We do not yet know relative to what it should be "shorter."

One effect which is indirectly separable is the so-called regeneration effect mentioned in *Sound Talk*.[15] According to this hypothesis, even though a point on the tape has been fully erased while at the center of the erase head gap, when it passes out of the erasing field it must (in going from the saturation erasing field at the center to zero field outside of the erase head) go through a point which has the same magnitude as that of the normal recording bias. Any extraneous fields at this point will be recorded; and the as-yet-unerased tape coming *into* the erase head provides this extraneous field. Therefore the signal is *re-recorded* after having been erased.

The data shown in Fig. 7 corroborate this re-recording hypothesis. The head sequence of an Ampex Model 350 recorder was modified so that the tape would pass first over the recording head, then over the erasing head, and finally over the reproducing head. The upper curve (0) was taken with no erasure and shows the overall response of this system when recording a signal at the reference level; then the response was taken with various amounts of current in the erase head (in all cases bulk-erased tape was used). With an erasing current of −15½ db (Curve 4) the amount of signal which *remains* (due to an insufficient erasing current to erase the signal completely) is equal to the amount of signal which is *re-recorded* across the erasing gap; at a frequency of 2100 cps the two signals are out of phase, so that a null is caused in the response. At lesser erasing currents the signal which has not been erased predominates, and at larger erasing currents the re-recorded signal predominates.

An interesting consequence of this behavior may be seen in Fig. 8, which shows remanence *vs* erasing current at a frequency of 2100 cps. We see that a null occurs sharply at the current −15½ db, and that then the remanence actually *increases* with an increase in erasing current.

15. "AC Erasure of Magnetic Tape," *op. cit.*

SOME MEASURING PROBLEMS

The remanent signal after erasure depends on three parameters: 1. the level of the signal to be erased; 2. the amount of bias which was used in recording; and 3. the wavelength of the recorded signal. These effects will now be examined.

Level of the Signal to be Erased

For any given signal recorded on the tape at a level less than saturation, the amount of erasure with a given erasing system will always be to some particular *fraction* of the original signal, independent of the original signal level. For example, suppose that we record a signal at reference level and find that a given erasing head and current reduce this signal by 50 db; then if we were to record the signal at 10 db below reference level, the erasure would still be 50 db and the signal would be erased to –60 db; or if it had been recorded at +10 db, then the remanence would be –40 db. Therefore, to avoid noise in performing measurements it is usually convenient to record the signal at a level 5 to 10 db above the reference level.

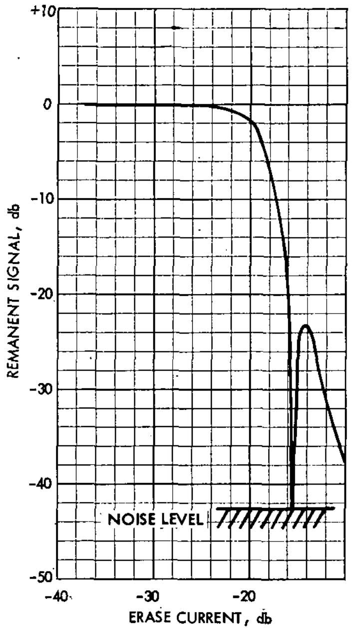


FIG. 8. Remanent signal *vs* erase current, with erase head as for Fig. 7. Recorded signal 2100 cps at 15 ips, recorded (with bias) to refernce level.

Effect of the Amount of Bias used in Recording

Another factor which influences the apparent quality of erasure of an erase head is the amount of bias current used in recording. Herr *et al*[16] show in their Fig. 4 that recordings made with a low bias current are more easily erased than recordings made with the bias set for maximum sensitivity ("peak bias"), and that a further increase of the bias makes the recording even more difficult to erase. We have confirmed this effect in our own measurements. Therefore, all test recordings should be made with the same bias current, preferably the bias current normally used for recording.

16. R. Herr, B. F. Murphy and W. W. Wetzel, *op. cit.*

Effect of the Wavelength of the Recorded Signal

The amount of erasure depends rather critically on the wavelength of the signal which is being erased. Figures 9, 10, and 11 show the reduction of recorded level by erasure *vs* recorded frequency, for three different heads. The first head (Fig. 9) had a single 5-mil nonconducting (mica) gap, and the two curves show the erasure for one pass over the head, and then for a second pass over the head. Figure 10, similarly, is for a standard Ampex "double-gap" erase head (approximately 4 mils of mica gap, a 6-mil 4-79 molybdenum permalloy magnetic piece, and then another 4-mil mica gap); and Fig. 11 shows data for a head with two 5-mil mica gaps with a 50-mil ferrite magnetic piece between them.

In all three cases the amount of erasure for a given erasing current is seen to vary greatly with the recorded wavelength. For Fig. 10 (the standard Ampex erase head), an erase current of –7½ db gives a fairly impressive erasure figure of 60 db erasure at 1600 cps, but at 1200 cps or 2000 cps

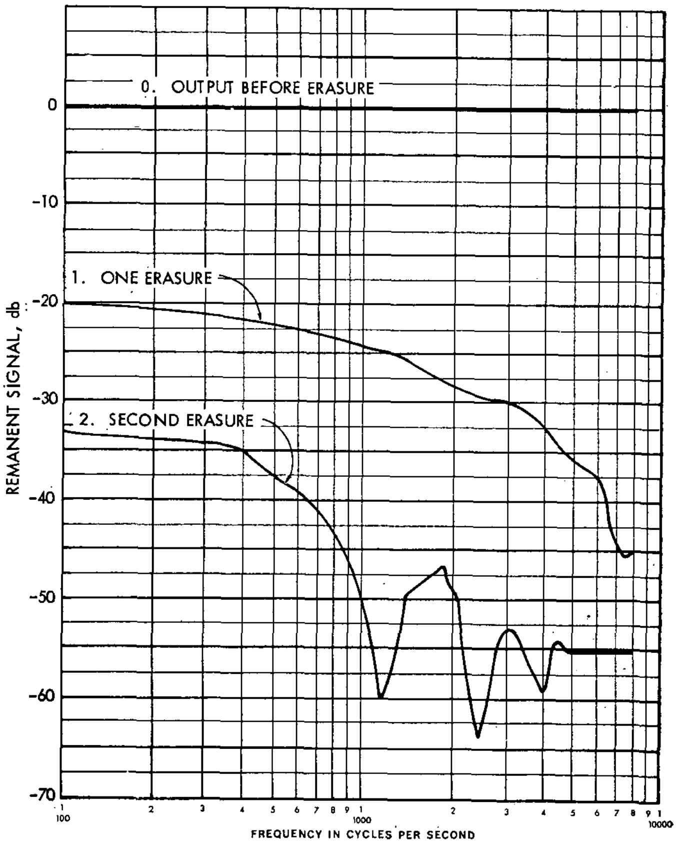


FIG. 9. Remanent signal after erasure *vs* frequency of the recorded signal. 0. Output before erasure; 1. One erasure; 2. Two erasures. Erased with a head having a single 5-mil mica gap spacer; erasing current, –15 db. Recorded signal: frequency sweep at 15 ips, recorded (with bias) to the reference level. Integrating reproduce amplifier, with response equalized in recording. A bandpass filter was used to eliminate extraneous noise.

there is only 45 db of erasure, or 32 db of erasure at 100 cps.

We must conclude that, if measurements are made at only one frequency, and if one is not aware of this difference in erasure at different wavelengths, one may get all sorts of different readings from the same head, or the same readings for greatly different heads.

SUMMARY

We are interested in how well an erasing system removes a signal which has been recorded on a tape, and in how quiet the tape is left after erasure, compared to bulk erasure. Any of the systems evaluated leave the tape adequately quiet, so that the major problem is that of removing the signal recorded on the tape.

Three points must be kept in mind when making measurements on any erase head:

1. For a given erasing system operating at a given erasing current, and erasing a given wavelength, the signal is erased to a certain *percentage* of the original signal; this is almost independent of the original signal level.

2. The ease of erasure of a recorded signal depends greatly on the bias current used to record this signal, all other conditions being constant. The more bias used to make the recording, the more difficult it will be to erase.

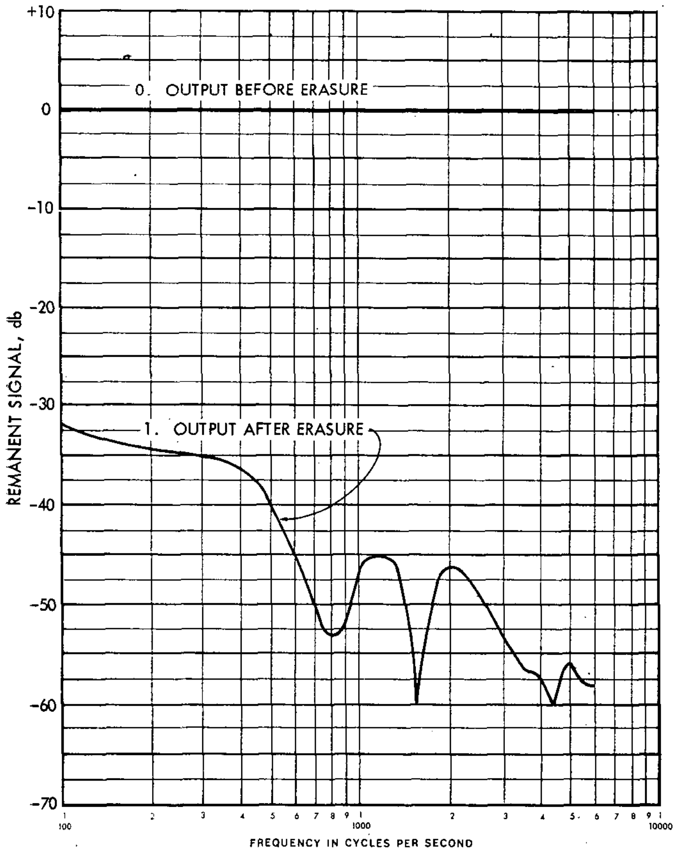


FIG. 10. Remanent signal after erasure *vs* frequency of the recorded signal. 0. Output before erasure; 1. Output after erasure with −7 db erase current, erased with a standard multiple-gap spacer head: 4-mil mica gap, 6-mil 4-79 molybdenum permalloy magnetic spacer, 4-mil mica gap. Recorded signal and reproduce system as for Fig. 9.

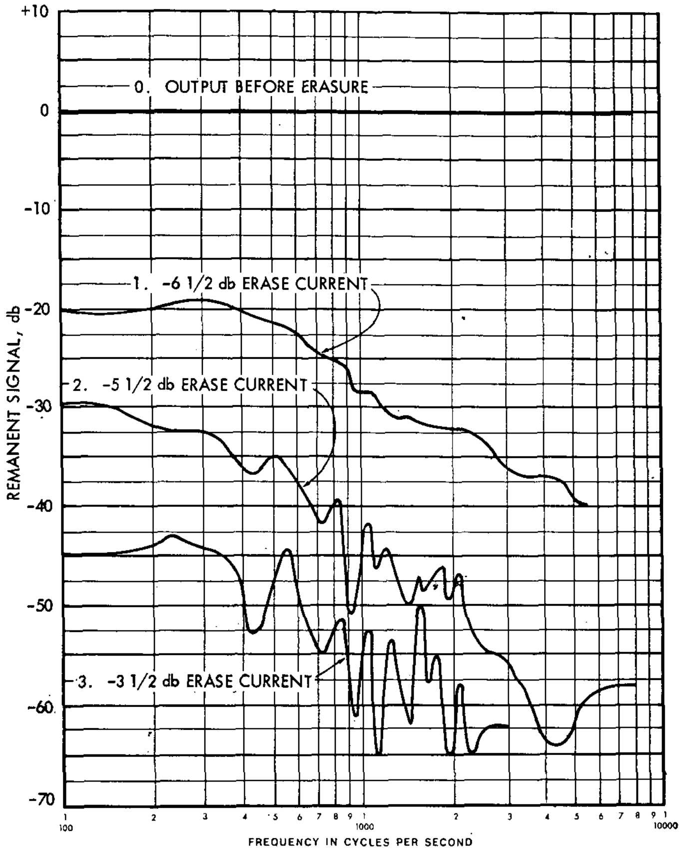


FIG. 11. Remanent signal after erasure *vs* frequency of the recorded signal: 0. Output before erasure; 1. One erasure, −6½ db erase current; 2. One erasure, −5½ db erase current. 3. One erasure, −3½ db erase current. Erased with a multiple-gap spacer head: 4-mil mica gap, 50-mil ferrite magnetic spacer, 4-mil mica gap. Recorded signal and reproduce system as for Fig. 9.

3. The amount of erasure, all else being constant, depends greatly on the wavelength of the signal being erased. In general, the shorter the wavelength of the recorded signal the more easily it is erased, but there will be peaks and dips in the erasure. For example, using a standard Ampex erase head at less than full normal erase current, we had 45 db erasure at 1200 cps and 60 db erasure at 1600 cps.

The most interesting effect found in the erasing process is one whereby the signal is re-recorded across the erase gap. This appears to account for a great deal of the difficulty encountered in attempting a high degree of erasure, since no matter how great the field strength, even though the tape is fully erased at the point where it passes the center of the erase gap, the signal is re-recorded as the tape leaves the gap. This accounts for the fact that with a given current input two separate heads will give much better erasure than one head. A single head with two closely spaced gaps shows the behavior of two gaps at shorter wavelengths only; at longer wavelengths the two-gap effect is largely lost. Better erasure is achieved at longer wavelengths by using either two independent erase heads or one head in which the gaps are spaced very far apart.

And, finally, it was found that a good deal still remains to be learned about the erasure of magnetic tape.

APPENDIX A

Reviews of Patents on Erase Heads for Magnetic Recorders*

1. Systems Employing Alternating dc Fields

2,526,358
5.16m DEMAGNETIZING DEVICE

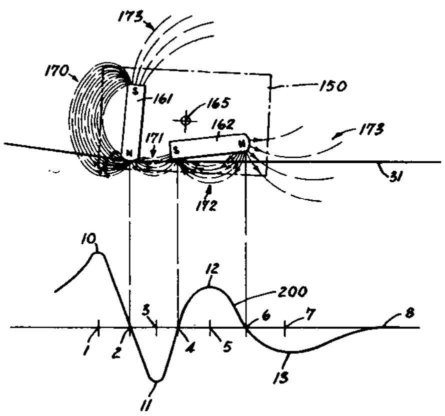
Hugh A. Howell, assignor to the Indiana Steel Products Company. October 17, 1950, 5 Claims (Cl. 179-100.2).

This patent for magnetic recording describes several arrangements of horseshoe and modified horseshoe magnets, together with armatures, for providing first a saturating field, and then a moderate oppositely directed field to a recording tape passing by.—RH

2,535,498
5.16m ERASING HEAD AND APPARATUS FOR MAGNETIC RECORDERS

Otto Kornei, assignor to The Brush Development Company. December 26, 1950, 8 Claims (Cl. 179-100.2).

For erasing magnetic recordings it is sufficient to subject the magnetic medium to a saturating field, but for good results with high frequency bias in recording the medium should also be left in the demag-



netized state. This has commonly dictated the use of an alternating current, usually of high frequency, so as to subject the medium to an alternating field of decreasing magnitude. This patent discloses a design involving permanent magnets *161* and *162* so disposed that the passing medium *31* receives successively alternate magnetizations of opposite polarity and is more nearly demagnetized than by a single magnet. There are included also suitable mechanical devices and interlocks to move the assembly *150* against the tape in the recording process and to remove it at other times.—RH

2,594,934
5.16m ERASING HEAD FOR MAGNETIC RECORD MEMBERS

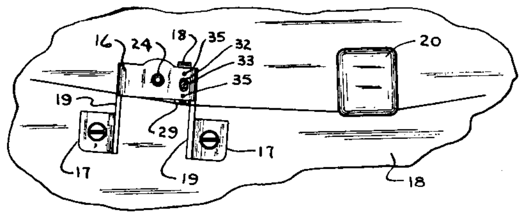
Otto Kornei, assignor to The Brush Development Company. August 31, 1954 (Cl. 179-100.2); filed November 9, 1950.

In some magnetic recorders permanent magnets are used for erasing but if noise is to be held low the tape must experience a succession of gradually reducing, alternating, fields. To obtain these with only one permanent magnet there are clamped to the magnet two plates, each with teeth past which the tape passes. The fields between these intermeshed teeth alternate in the required manner.—RH

2,688,053
5.16m ERASING MAGNET MOUNTING AND ASSEMBLY

Edmund Barany, Harold W. Bauman and Melvin Sackter, assignors to Ampro Corporation. April 29, 1952 (Cl. 179-100.2); filed January 20, 1950.

This mounting is intended to clamp an elongated horseshoe-shaped permanent magnet in the proper position to effect erasure of a magnetic tape as it passes through a magnetic recording machine. The

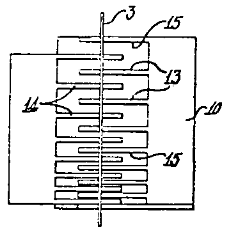


permanent magnet is clamped under the screw *24* and the tape is lifted from the trailing edge of the magnet by the adjustable strip *29*. The residual magnetism in the tape is minimized by demagnetizing action of the opposing field under the trailing pole of the magnet. —RVB

2,784,259
5.16m RECORDING AND ERASE HEAD FOR MAGNETIC RECORDERS

Marvin Camras, assignor to Armour Research Foundation of Illinois Institute of Technology. March 5, 1957 (Cl. 179-100.2); filed December 17, 1952.

Heads with multiple polepieces for erasing and recording purposes are shown in this patent. In one form in which a permanent magnet is utilized, the record *3* travels upwards. Each element of the record



encounters a succession of oppositely directed magnetic fields which become weaker at each gap, until the record emerges in a demagnetized condition. Heads of similar design with three polepieces, two coils, and close-spaced gaps are shown for combination erasing-recording purposes.—MC

2. A System Employing High Frequency ac Fields with Multiple Separate Heads, Each with One Gap

2,730,570
5.16m MAGNETIC SOUND RECORD ERASING METHOD AND HEADS THEREFOR

Michael Rettinger, assignor to Radio Corporation of America. January 10, 1956 (Cl. 179-100.2); filed August 30, 1950.

* Compiled by the author from "Reviews of Acoustical Patents" in the *Journal of the Acoustical Society of America,* and reprinted by their kind permission.

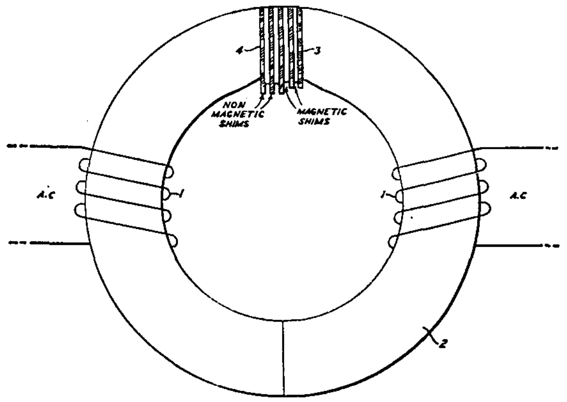
Two or more consecutive independent magnetic fields of super-audible frequency are used for magnetic erasing, separated by at least one-tenth of a second in time, with at least fifteen magnetic reversals within each area of maximum field strength and at least two thousand reversals of diminishing magnetic field adjacent to each gap.—FWK

3. Systems Employing High Frequency ac Fields with a Single Head Having Multiple Gaps

2,535,712
5.16m MULTIPLE GAP ERASE HEAD FOR MAGNETIC RECORDING

Halley Wolfe, assignor to Western Electric Company, Incorporated. December 26, 1950, 5 Claims (Cl. 179-100.2).

A magnetic erasing head is described which uses a number of gaps rather than the more usual single gap. This is claimed to produce more effective erasure than obtainable with a single passage past a



single gap of the same size, and to require a lesser total gap length than is necessary in a single gap, with consequent reduction in power requirements.—RH

2,673,896
5.16m MAGNETIC RECORD ERASING TRANSDUCER

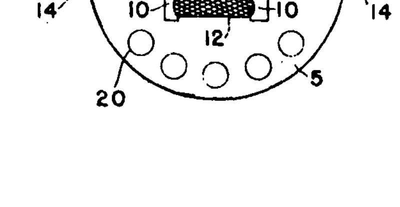
Michael Rettinger, assignor to Radio Corporation of America. March 30, 1954 (Cl. 179-100.2); filed December 29, 1951.

This magnetic tape erasing head contains two similar air gap structures spaced apart along the direction of travel of the tape. This feature is said to increase the efficiency of erasure by eliminating "re-awakening" of the signal. Each air gap structure consists of a central copper strip having a Mu-metal strip laminated to each side and insulated therefrom. The copper strips are connected in parallel to form part of a single turn coil inductively coupled to a high frequency transformer.—RVB

2,655,562
5.16m ERASING HEAD FOR MAGNETIC RECORDING

Donald L. Clark, assignor to Stromberg-Carlson Company. October 13, 1953 (Cl. 179-100.2); filed February 23, 1945.

Increased erasing efficiency is accomplished through the use of an erasing head having multiple air gaps *9* across which the medium *8* passes. The magnetic fields across these air gaps are established from

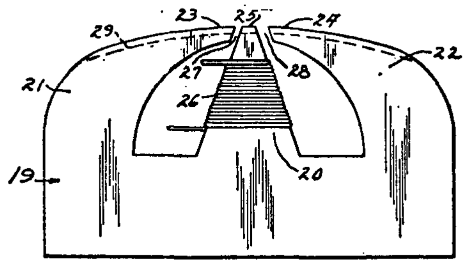


a common magnetic core *5* energized by the high-frequency coil *12*. Holes *20* in the magnetic core aid in dissipating the heat resulting from high-frequency losses.—RVB

2,702,835
5.16m ERASE HEAD FOR MAGNETIC RECORDER

Marvin Camras, assignor to Armour Research Foundation of Illinois Institute of Technology. February 22, 1955 (Cl. 179-100.2); filed August 25, 1945.

This head is particularly adapted for erasing magnetic recording wire, and employs an integral stamped core structure. The erasing efficiency is enhanced by the tapered design of the poles *23, 24,* and *25*

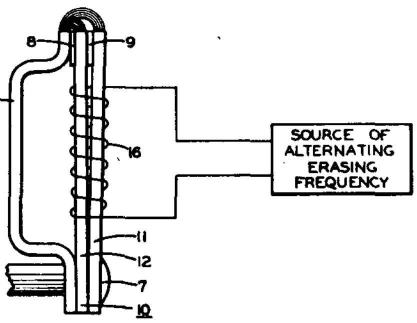


such that the flux density is low in all parts of the core except the pole tips. The efficiency is further enhanced by the double gap construction since the tape encounters two erasing fields in its passage over the head from left to right. The second gap *28* is wider than the first *27*, resulting in a weaker field which reduces the residual noise in the tape.—RVB

2,747,024
5.16m MAGNETIC ERASE HEADS

C. F. Sprosty, assignor to Clevite Corporation. May 22, 1956 (Cl. 179-100.2); filed October 4, 1954.

An erasing head according to this invention has a split pole over which the energizing coil is placed. The additional gap *9* allows a high intensity erasing field between *12* and *13,* followed by a lower



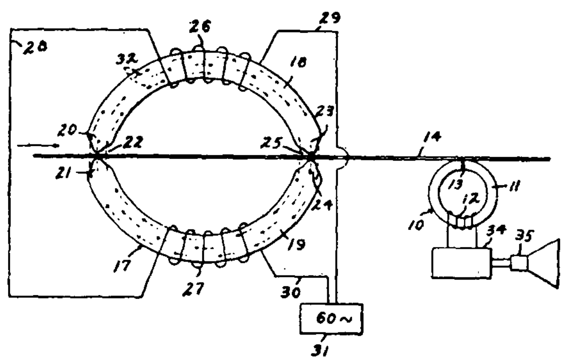
intensity field between *11* and *13.* A table of comparison is given to show that this "multiple sequence" head gave 6 db better erasure with only 75% of the current required in a prior art single gap head. —MC

4. Systems Employing 60 cps ac Fields, with the Tape Passed Between the Ends of the Head Poles

2,498,423
5.16m MEANS FOR DEMAGNETIZING HIGH COERCIVE FORCE MATERIALS

Hugh A. Howell, assignor to The Indiana Steel Products Company. February 21, 1950, 6 Claims (Cl. 179-100.2).

An erasing head consisting of two C-shaped cores so placed that two pairs of pole pieces *20, 21, 23, 24* establish erasing fields through the recording medium is disclosed. The magnetic circuit of the erasing

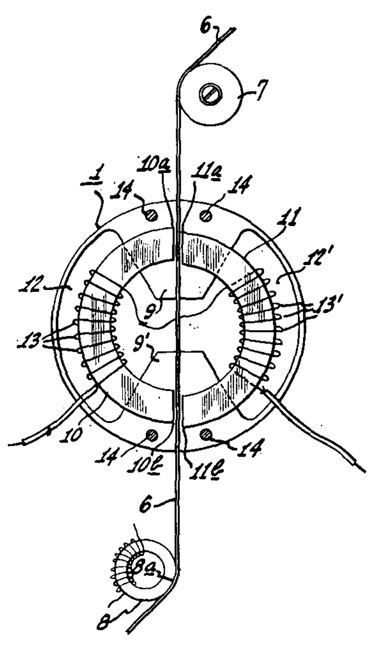


head is energized by a low-frequency power source *31*. In the usual case it has been found impractical to use such low frequencies in erasing heads because of the record which such heads leave on the recording medium. In this case the difficulty may be obviated to some extent in view of the fact that the direction of the erasing field is perpendicular to the direction of the recording field.—LCH

2,550,753
5.16m ERASING HEAD FOR MAGNETIC RECORDERS

Dallas R. Andrews, assignor to Radio Corporation of America. May 1, 1951 (Cl. 179-100.2); application June 22, 1949.

A magnetic tape erasing head is built from two magnetic members *10, 11*, so arranged that the tape *6* may pass between the pole faces *10a, 11a, 10b, 11b* rather than past the comparable gaps of a conven-



tional head. The opposing pole faces are slightly offset in the longitudinal direction. It is contended that this produces a more perfect erasure at less power consumption than the conventional design.—RH

2,604,550
5.16m ERASE HEAD FOR USE WITH COMMERCIAL ALTERNATING CURRENT OR EQUIVALENT

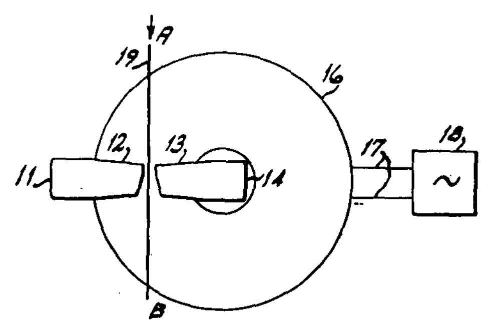
Semi Joseph Begun, assignor to The Brush Development Company. July 22, 1952 (Cl. 179-100.2); filed January 21, 1947.

For simplicity and low cost, it is desirable to demagnetize magnetic recordings with power frequency current rather than the electronically generated high frequency currents usually used. Several head designs are described, characterized in general by magnetic core with non-uniform gap through which the tape is driven. The dimensions are chosen so that at the tape speed used several cycles will occur while the tape moves from one end of the gap to the other, and the tape thereby undergoes a sequence of field reversals of gradually decreasing strength.—RH

2,638,507
5.16m MAGNETIC RECORD ERASER

Eugene H. Lombardi, assignor to General Precision Laboratory, Inc. May 12, 1953 (Cl. 179-100.2); filed August 24, 1950.

An electromagnetic demagnetizer is described consisting of a coil *16* which energizes a core terminating in pole tips *12, 13* between which the record medium *19* passes. These tips have a short portion over

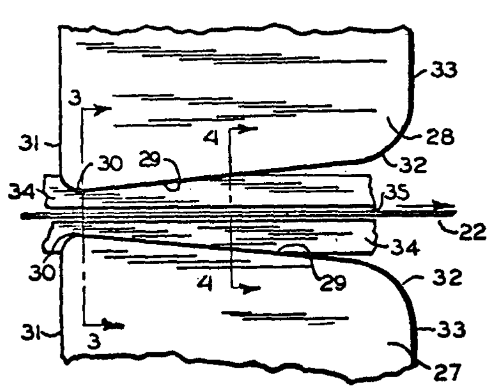


which the faces are parallel, followed by a portion over which they diverge so as to produce in the moving medium a gradually reducing field. The unit is designed to be operated at power frequencies.—RH

2,718,562
5.16m ERASE HEAD

Hugh A. Howell and Harold W. Bauman, assignors to Ampro Corporation. September 20, 1955 (Cl. 179-100.2); filed April 17, 1951.

Magnetic tape records are erased by a 60-cps field. The erasing head polepieces are tapered so that an element of tape encounters about ten cycles of successively decreasing flux as it passes through



the head. Edges are smooth and round to prevent local concentrations of field. Parallel tracks not to be erased are protected by shielding.—MC

5. Miscellaneous

2,429,792
5.16m MAGNETIC RECORDING-REPRODUCING MEANS AND SYSTEM

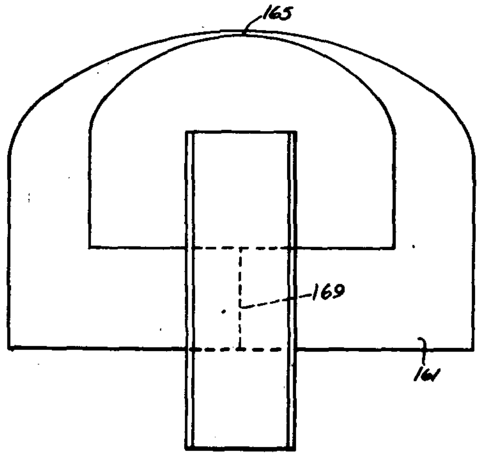
Semi Joseph Begun, assignor to The Brush Development Company. October 28, 1947, 17 Claims (Cl. 179-100.2).

An erasing or obliterating means for magnetic tape recording is disclosed.—LCH

2,535,481
5.16m DEMAGNETIZING APPARATUS FOR MAGNETIC RECORDERS

Semi Joseph Begun, assignor to The Brush Development Company. December 26, 1950, 1 Claim (Cl. 179-100.2).

There is described a magnetic head designed for erasing magnetic recordings on tape or wire which is adapted for use at low frequencies such as 60 cps. The magnetic core *161* is tapered in the region of



contact with the medium and sufficiently large currents are employed in the coil *169* to saturate the core in all but its thickest cross sections. The amount of leakage flux acting upon the tape is greatest at the gap *165* but is appreciable over the entire contact surface. The cross section is so graduated that the field experienced by the medium decreases gradually from the gap *165* to the end of contact, and this distance is made great enough to allow several cycles of field to occur during the passage of a point of the medium.—RH

2,546,927
5.16m POLARIZING HEAD FOR MAGNETIC RECORDERS

Hugh A. Howell, assignor to The Indiana Steel Products Company. March 27, 1951 (Cl. 179-100.2); application September 13, 1947.

This patent describes a permanent magnet head useful chiefly for erasing magnetic records. Assuming that longitudinal recording is used, the tape is first subjected to a saturating field in the longitudinal direction, and subsequently to a preferably saturating field in the transverse direction by a separate set of pole tips.—RH

2,620,403
5.16m WIRE RECORDING AND ERASING MEANS

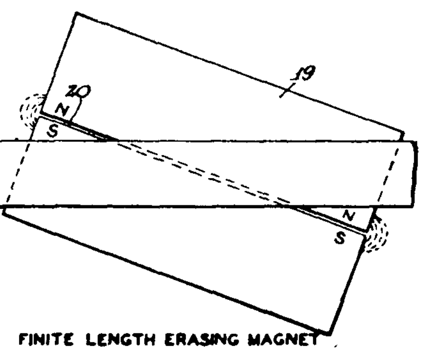
Walter C. Howey.
December 2, 1952 (Cl. 179-100.2); filed July 10, 1948.

A system is described for the magnetic erasure of wire by current pulses of the same polarity plus a small direct current.—RH

2,635,149
5.16m ERASING MEANS FOR MAGNETIC RECORDERS

Robert M. Cain, assignor to Wilcox-Gay Corporation. April 14, 1953 (Cl. 179-100.2); filed December 3, 1949.

This erasing head utilizes a permanent magnet device to obliterate previous signals on the tape. The gap *20* across which the erasing field is established is inclined to the direction of tape travel so that



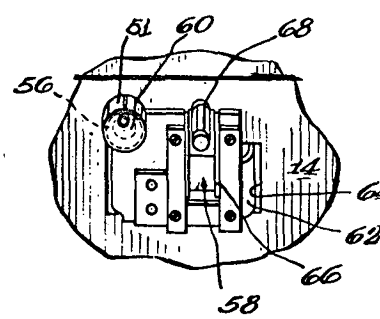
FINITE LENGTH ERASING MAGNET AVOIDING FRINGE FLUX CONDITIONS

the tape is saturated in an almost transverse direction. This reduces the tape noise normally associated with permanent magnet erasing systems. An alternative arrangement suitable for erasing one track of a dual track recording is also detailed.—RVB

2,688,663
5.16m RECORDER-REPRODUCER

David J. Munroe, assignor to Webster Electric Company. September 7, 1954 (Cl. 179-100.2); filed March 4, 1949.

This recorder-reproducer is of conventional design except for the use of a dual erasing system. A circular permanent magnet *56* and an ac erasing head are mounted on a movable slide which advances



to position them in contact with the tape during the recording function. The tape is first saturated by the permanent magnet *56* which obliterates all previous magnetic impulses but leaves the tape in a strongly magnetized condition. The tape then passes through a relatively weak ac field which reduces the steady component of magnetization to a low value. The ac erase head is of the transformer type, the secondary of which is a single heavy turn *68* which excites the core structure containing the erasing airgap. The system is particularly effective in erasing so-called "high flux" magnetic tapes and requires a minimum of ac erasing power.—RVB

2,713,619
5.16m MAGNETIC CONDITIONING DEVICE

Wesley L. Eddy, assignor to Ampro Corporation. July 19, 1955 (Cl. 179-100.2); filed March 27, 1951.

In magnetically saturating a magnetic record tape prior to demagnetizing it for erasing purposes, the saturating flux is confined to a single record track by suitable high-permeability shims properly placed.—FWK

APPENDIX B

Noise Levels from Erasure

The following experiment was performed in order to determine the relative noise of bulk-erased tape, head-erased tape, and biased tape. A standard Ampex Model 350, ¼ in. full-track recorder was adjusted to operate in the normal manner, using NAB equalization, with "Irish 300" tape. Noise was measured with a Hewlett-Packard Model 400-D voltmeter. The broadband measurement used a 20 cps to 20 kc band, limited by an 18 db/octave filter. The weighted measurement used a network giving a response similar to the ASA *A* response. All noise levels are referred to the "operating level" section of an Ampex 15-ips standard tape, No. 4494.

For the weighted response, at 15 ips, the bulk erased tape run over the erase and record heads is −61 db, which is noisier than the −67 db for bulk erased tape only. However, the bulk erased tape run over the record head only is −61 db, which is just as noisy as the bulk erased tape run over the erase head only. (The same relations exist for the other speed and for broadband measurements.) This shows that the additional noise is introduced by the bias in the record head, and *not* by the erase head.

TABLE I. Noise levels from tape as variously erased.

	Broadband		Weighted	
	7½ ips	15 ips	7½ ips	15 ips
1. Reproduce amplifier and head only	−62 db	−62 db	−76 db	−76 db
2. Bulk erased tape	−61 db	−61 db	−68 db	−67 db
3. Bulk erased tape run over erase head only	−60 db	−58 db	−63½ db	−62 db
4. Bulk erased tape run over record head only*	−60 db	−58 db	−63 db	−61 db
5. Bulk erased tape run over erase and record head	−60 db	−58 db	−63 db	−61 db

* Data are the same for unplugging the erase head or for lifting the tape from the erase head.

THE AUTHOR

John G. McKnight was born in Seattle in 1931. He received a B.S. in electrical engineering from Stanford University in 1952.

He has been with Ampex Corporation since 1953, with the exception of the years 1954-56 when he was assigned to the engineering staff of the U. S. Armed Forces Radio Service in New York. The Ampex Corporation appointed him manager of the advanced audio section of the Professional Audio Division in 1959, and staff engineer in the Ampex Audio Division in 1961.

Mr. McKnight's work has been in research and engineering on the dynamics of tape transports as well as on magnetic recording, especially as it concerns the recording of music. He is an amateur musician, and has presented and published papers on energy distribution in music, noise considerations and measurement in magnetic recording, equalization in magnetic recording, stereophonic recording, and transport speed variations (flutter).

He is a governor of the Audio Engineering Society and a member of the Recording and Reproducing Standards Committee of the IEEE and the Magnetic Tape Subcommittee of the NAB Recording and Reproducing Standards Committee, a Fellow of AES and a Senior Member of IEEE.