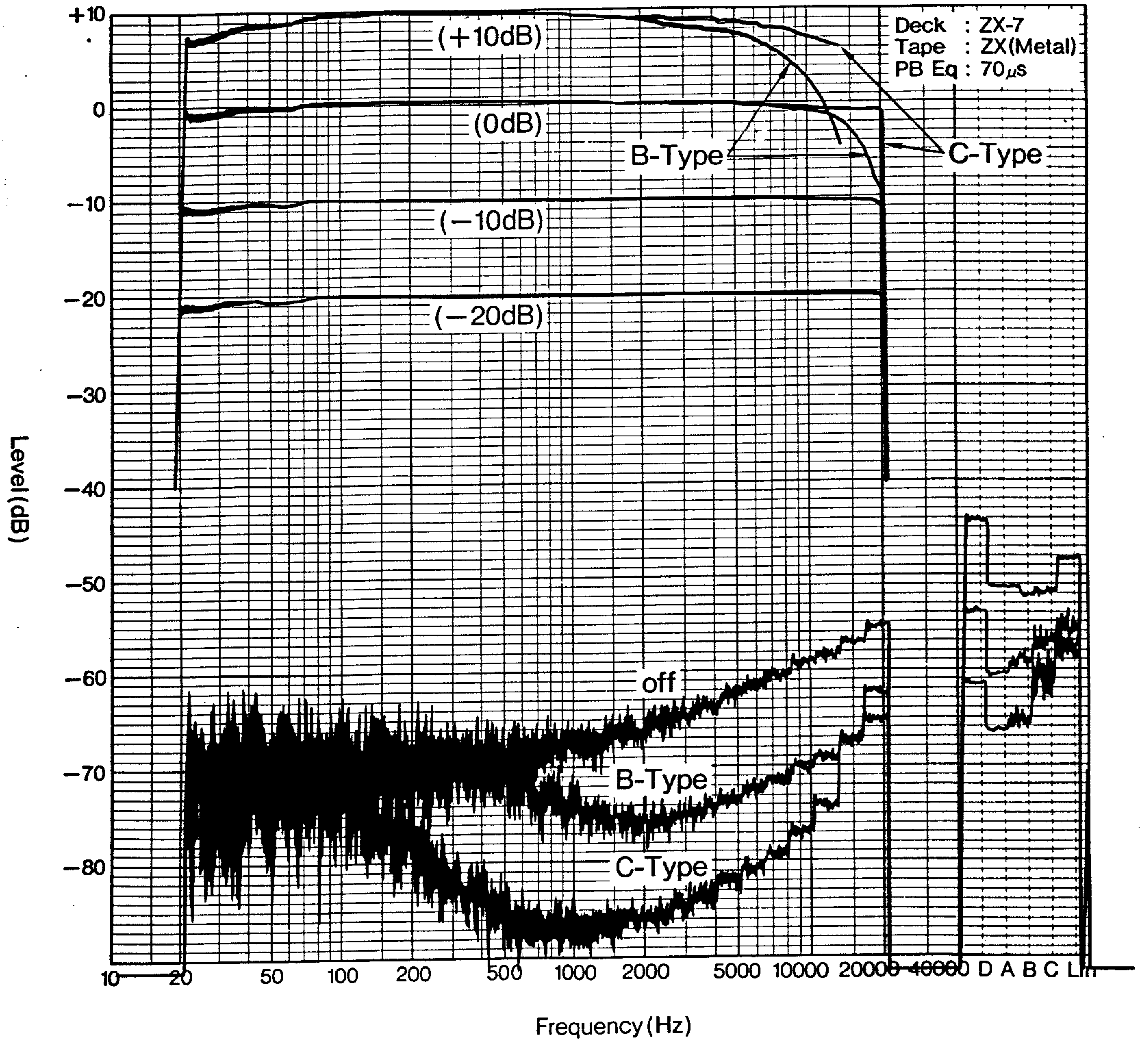
Nakamichi Cassette Equalization: The Standard View

Nakamichi



dat.: najaar 1983

De weergavecorrectie van cassetterecorders

Vanaf het moment dat Eddie Nakamichi aantoonde, dat de Compact Cassette een volwaardige signaalbron voor kwaliteitsweergave kan zijn, heeft in de boezems van pers en industrie een levendige discussie over de weergavecorrectie van cassetterecorders gewoed, die in de loop van 1982 een waardige afsluiting kreeg in de vorm van een interessante briefwisseling in de Amerikaanse vakpers.

De controverse spitst zich steeds weer toe op de verschillen in weergavecorrectie tussen Nakamichi en andere fabrikanten, hoewel die anderen ook onderling sterk afwijkende correcties toepassen, en de norm waarom het eigenlijk gaat, IEC-94, dreigt door de kruitdamp aan het oog onttrokken te worden.

De critici kiezen uit twee standpunten:

1. Nakamichi gebruikte vroeger een afwijkende correctie maar heeft sinds 1978 zijn leven gebeterd (over de rug dus van de eerste gebruikers).
2. Nakamichi gebruikt een verkeerde correctie (want anders zou verder bijna iedereen uit de pas lopen...?).

De eerste stelling is gemakkelijk te ontzenuwen door eenzelfde meetband met Nakamichi's van verschillende ouderdom weer te geven. Dit deden wij in één van de bijlagen met een TT-700 uit 1974, een N-700-II uit 1977 en een gloednieuwe ZX-7 uit 1981.
De klasse II (CrO_2) meetband volgens IEC-94, afgespeeld met de chroomcorrectie (70+3180 μs), levert met alle drie de machines een identieke karakteristiek op, die bovendien ook nog recht is, zodat van een optimale combinatie van weergavekop- en correctie gesproken mag worden.

Voor de goede orde hebben wij dezelfde meetcassette ook nog in deze machines afgespeeld met de klasse I (ijzeroxyde)-correctie, waardoor het verschil tussen beide correcties zichtbaar wordt.
Alle drie machines vertonen in het hoog het verschil tussen de tijdconstanten 70 en 120 μs, terwijl in het laag alleen de TT-700 uit 1974 een afwijkend beeld te zien geeft, omdat deze machine nog is uitgevoerd met een 1590 μs correctie voor de lage tonen.
Pas rond 1975 zijn de laagcorrecties voor ijzeroxyde en chroom beide op 3180 μs vastgelegd.

De afwijkingen tussen de karakteristieken komen precies overeen met de theoretische waarden, hetgeen aantoont, dat ook de ijzer-oxyde-correctie van de Nakamichi's volledig aan de IEC-norm voldoet.

Hiermee is de eerste bewering afdoende ontzenuwd.

Het bestrijden van de tweede stelling was in het verleden minder eenvoudig, omdat in dit geval moet worden aangetoond, dat de berekeningen van Nakamichi in de practijk tot een weergavekarakteristiek overeenkomstig IEC-94 leiden.
Kort na de introductie van de TT-700 in 1973 heeft de fabriek de theorie en de practijk volledig uit de doeken gedaan in een technisch bulletin "Playback equalisation" (bijlage).
Helaas vermocht deze uiteenzetting slecht weinig critici te overtuigen, mede omdat meetcassettes van toonaangevende fabrikanten als BASF en TEAC bij weergave via een Nakamichi een oplopende hoogweergave te zien gaven. Een belangrijk punt hierbij is, dat deze cassettes niet aan de IEC-norm voldeden en dat ook niet pretendeerden. Zij werden gepresenteerd als DIN-normcassettes.
Een voorbeeld hiervan siert onze laatste bijlage: de oude DIN-Cr cassette loopt zelfs bij 12,5 kHz al behoorlijk op, terwijl ook het laag er wat vreemd uitziet, omdat deze cassette de voor CrO_2 afwijkende 1590 µs tijdconstante gebruikt.
Omdat meten nu eenmaal gemakkelijker is dan nadenken werd de meteruitslag door velen hoger aangeslagen dan de goed gedocumenteerde technische verantwoording van Nakamichi.
Sommigen bleven twijfelen en iemand richtte zich in december 1981 tot het amerikaanse tijdschrift Modern Recording met de vraag: Gebruikt Nakamichi een correctie die afwijkt van wat bij andere fabrikanten gebruikelijk is?
De redactie van Modern Recording verzocht Nakamichi hierin stelling te nemen en de woordvoerder van Nakamichi gaf in een uitvoerig antwoord een uiteenzetting van de basisbegrippen en achtergronden. Dit verhaal kon echter niet veel nieuwe elementen bevatten, omdat het uiteindelijk al vanaf het begin van de zeventiger jaren al zo dikwijls als verantwoording voor een ongewijzigd standpunt verteld was.

Wel wees Nakamichi nadrukkelijk op de foute conclusies die men kan trekken uit het gebruik van meetbanden die niet aan de IEC-norm voldoen, waarmee men de handschoen aan de meetband-fabrikanten toewierp.

En gelukkig werd deze opgenomen door de amerikaanse vestiging van BASF, die in het maartnummer (1982) van Modern Recording het standpunt van de meetbandenfabrikant verwoordde.
BASF bevestigde, dat de DIN-meetcassettes die uiteraard volgens DIN-voorschrift gemeten worden, in de loop van de jaren zeventig regelmatig aan de nieuwe inzichten van dit normalisatie-instituut zijn aangepast. En dat is de kern van het probleem.
De door DIN genormaliseerde meetkop anno 1965 beschikte boven 10 kHz over een sterk afnemende nauwkeurigheid, maar dat was in die tijd natuurlijk geen probleem, omdat deze frequentie met de toenmalige cassetterecorders nauwelijks haalbaar was.
Maar normen zijn taai (denk maar aan de z.g. hifi-norm DIN 45500) en lopen in vakgebieden waarin zich een snelle technische ontwikkeling voltrekt maar al te snel achter op de realiteit.
Dit gebeurde ook met de DIN-meetbanden, die tot ver in de zeventiger jaren volgens de oude, beproefde methode werden gemeten, terwijl de industrie inmiddels in staat was koppen te fabriceren die voor de weergave van hoge frequenties onvergelijkbaar veel beter waren.
Deze discrepantie bleef niet geheel onopgemerkt hetgeen in de afgelopen jaren tot een geleidelijke bijstelling van de DIN-voorschriften leidde. Tegelijkertijd werden ook door japanse fabrikanten van meetbanden wijzigingen in hun producten aangebracht, maar door gebrek aan overleg tussen de verschillende normalisatie-instituten liepen deze wijzigingen niet parallel zodat van een internationale normalisatie geen sprake was.
Uiteindelijk vond men elkaar ook voor de normalisatie van meetbanden in de IEC, die uiteindelijk in het grijze verleden de norm voor de weergavecorrectie had geformuleerd, en maakte afspraken ten aanzien van verbeterde meetmethoden, toleranties en uitwisselbaarheid van meetcassettes van verschillende oorsprong, zodat wij tegenwoordig kunnen beschikken over IEC-meetcassettes als toetssteen voor de zorgvuldigheid waarmee cassetterecorderfabrikanten hun weergavekanalen ontwerpen.

./..

De nieuwe meetbanden geven bij afspelen met een Nakamichi, van welk bouwjaar ook, een rechte karakteristiek.

Met de uiteenzetting van BASF is de kring gesloten.
De normalisatie-instituten, de fabrikanten van meetbanden en de industrie, althans Nakamichi en enkele anderen, hebben elkaar gevonden in een eenduidige interpretatie van de IEC-94 norm.

De tweede bewering is definitief naar het rijk der fabelen verwezen.

Inmiddels heeft een onderzoek van een groot aantal cassetterecorders van verschillende merken aangetoond, dat een toenemend aantal fabrikanten naar de IEC-norm toegroeit, hoewel langzaam en niet altijd consequent in al hun modellen.

Deze ontwikkeling zal uiteindelijk leiden tot een betere uitwisselbaarheid van cassettes die met verschillende recorders zijn opgenomen, hoewel het onderzoek ook liet zien, dat de allergrootste weergaveverschillen aan sterk uiteenlopende azimut-instellingen te wijten zijn.
Mits men deze corrigeert kan men de resterende verschillen in hoogweergave meestal met de toonregeling van de voorversterker corrigeren.

Conclusies:

Nakamichi heeft vanaf het prille begin de juiste weergavecorrectie toegepast en houdt zich strikt aan de IEC-94 norm.

De normalisatie-instituten hebben jarenlang verschillende, sterk nationaal gerichte normen gehanteerd en herhaaldelijk gewijzigd.

Cassetterecorders die aan IEC-94 voldoen vormen nog steeds een minderheid.

Naschrift

Navraag bij alle grote fabrikanten van voorbespeelde cassettes leerde ons, dat de karakteristiek van de musicassette in de zeventiger jaren gelijke tred heeft gehouden met de wijzigingen in de DIN-referentie: het niveau van de hoge tonen op de band werd geleidelijk teruggenomen.
In het afgelopen jaar is men vrijwel algemeen overgegaan op de IEC-karakteristiek.

Bijlagen

1. Nakamichi technisch bulletin nr. 2 "Playback equalisation".

2. Brochure "The Standard View" bevattende:
   - -briefwisseling in Modern Recording, december 1981 en maart 1982
   - -artikel "Sound View" uit High Fidelity, februari 1982
   - -artikel "Cassette equalisation: the standard view", uit AudioVideo International, december 1981.

3. TransTec metingen aan Nakamichi recorders:
   - -historisch perspectief met meetband volgens IEC-94
   - -idem, met dezelfde meetband, een oudje volgens DIN 45513/7 en de nieuwe IEC/DIN meetband.

4. Overzicht van weergavecorrectie-metingen aan 24 kwaliteits-recorders, 4 Europese en 20 Japanse, verricht in 1981/82.

   Voor iedere machine is de afwijking ten opzichte van de ideale rechte -ingetekende- karakteristiek aangegeven.
   Eén schaaldeel komt overeen met 1 dB.

   Het azimut van alle recorders werd optimaal afgeregeld en dat was in de helft van de gevallen wel nodig ook.

   Recorders van andere fabrikaten dan Nakamichi zijn met een codenaam aangegeven, omdat dit overzicht beoogt inzicht te geven in de stand van de techniek en geen oordeel wil vellen over producten van derden.

   De meetfrequenties zijn: 400 Hz 0 dB = 200 nWb/m
   400 Hz -20 dB
   15 kHz -20 dB (azimut-instelling)
   -20 dB {
   400-31,5-40-63-125-250-500 Hz
   1-2-4-6,3-8-10-12,5-14-16-18-20 kHz
   400 Hz

20 KHz, it can be ignored for the purposes of this discussion.

The tape deck designer, then, must take into account a multitude of factors before deciding on the final characteristics of his playback EQ amplifier. The job would be simplified if the designer could be sure that his standard playback frequency response test tape contained the proper flux levels as defined by the Philips standard at all frequencies. If this could be guaranteed, all that would be required is to play the test tape with the head to be used and design an EQ amp that would yield flat response. The problem, unfortunately, is that there is no totally accurate and reliable method for measuring the magnetic flux level on the tape, particularly at the shorter wavelengths (higher frequencies). The designer concerned with accuracy, therefore, is required to take a backward route to the solution. A careful calculation of all the losses involved backed up by exhaustive laboratory measurement to confirm theory is thus far the soundest approach to the design of an accurate cassette playback system.

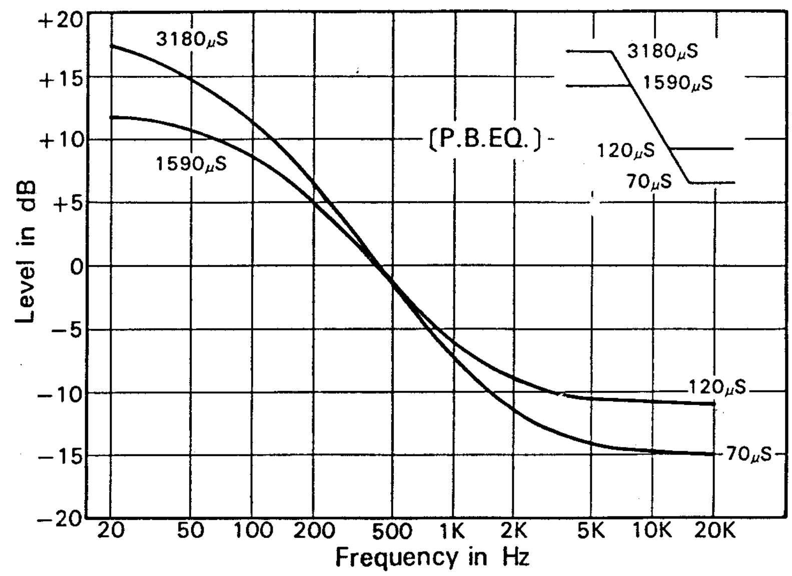


Figure 1 Theoretical Playback Equaligation Curves.

The success of this loss calculation approach largely depends on the ability to accurately measure the head gap width. Although an accurate physical measurement poses no great difficulty, magnetic extension caused by stresses imposed on the material during the manufacture of the head makes accurate calculation extremely difficult. A conventional head (mu-metal, permalloy or ferrite) with a physical gap of 1 micron may exhibit an "effective" gap of 2 microns. Head gap loss is correspondingly increased (see Figure 3), and the designer who does his calculation with the 1 micron figure would end up with a playback system lacking high frequency response. The Nakamichi Crystal Permalloy playback head in the Nakamichi 1000 and 700 cassette decks (a similar head with a slightly wider gap is used in Nakamichi 2-head machines) is manufactured using a highly proprietary low stress process. The discrepancy between physical and effective gap widths is virtually negligible. Figure 4 shows the playback equalization amplifier response for the Nakamichi 1000. Since the playback head has a physical and effective gap width of approximately 1.25 microns (0.9 micron gap spacer with 0.1 – 0.2 micron clearance on either side), the amount of correction required is determined almost solely by the head gap loss curve for 1.25 microns. Adding the 1.25 micron curve of Figure 3 to the response curves of Figure 4, in fact, yields almost exactly the theoretical curves of Figure 1.

Keeping this in mind, one proceeds to "measure" various commercially available test tapes using a Nakamichi 1000. Figure 5 is the result of such a

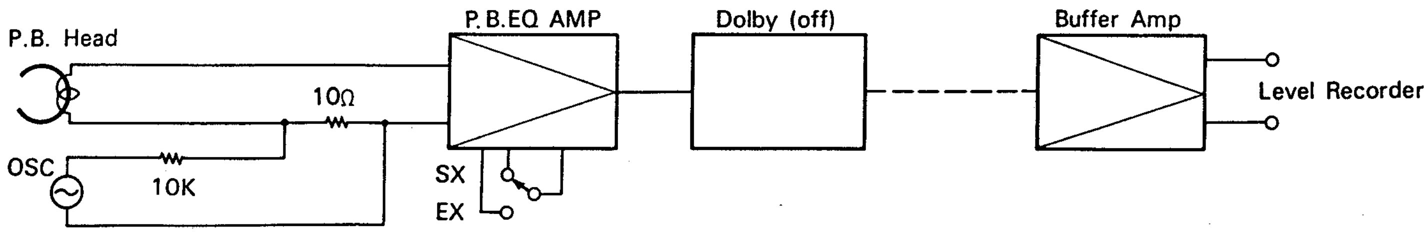


Figure 2 Method for Measuring EQ. Amp Response.

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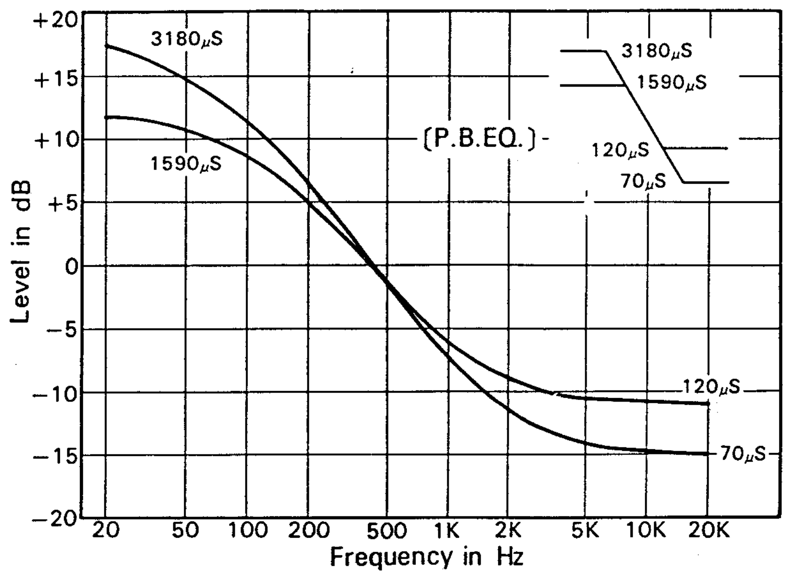

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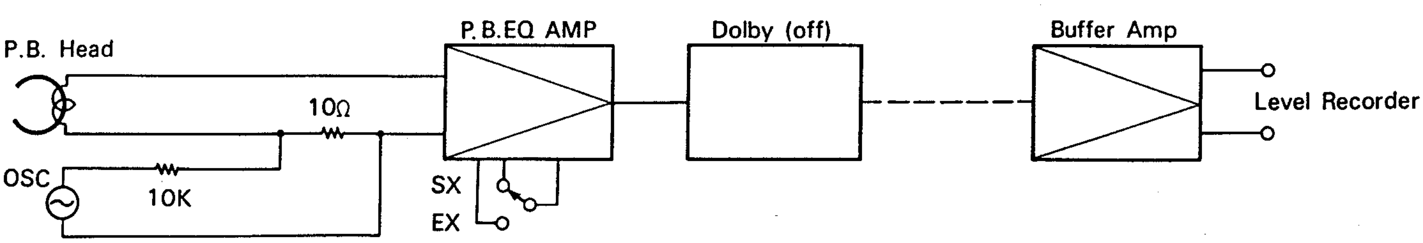

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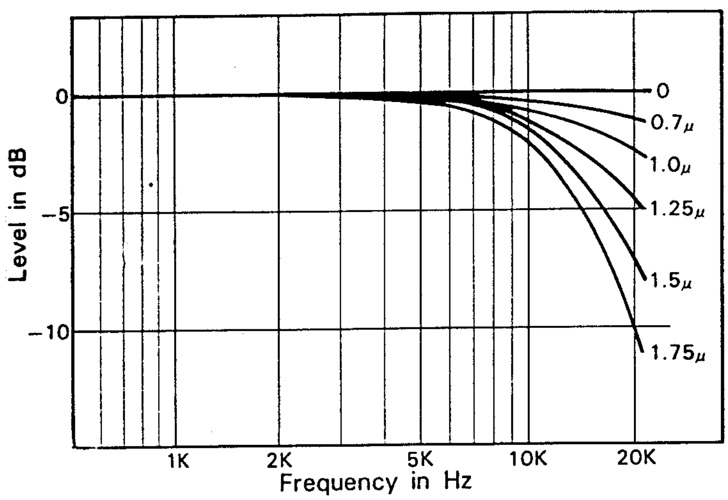

Figure 3 Head Gap Loss.

measurement. A popular test tape, claiming to represent Philips standard, was played on a Nakamichi 1000 known to have particularly close-to-theoretical playback characteristics. It can be readily observed that the response is 1 dB high at 4,000 Hz and 2 dB high at 10 KHz. A cassette recorder designed to this "standard" tape would yield dull sounding reproductions of tapes recorded to the correct Philips specifications. Conversely, a tape recorded on such a machine would sound bright when played on a correctly designed cassette deck.

Our further tests have shown that a large number of cassette decks on the market are adjusted to test tapes with rising responses. This is not difficult to understand. Test tapes exhibiting a rising high end with respect to the Philips standard work in favor of the cassette deck designer who is restricted to the use of inferior magnetic heads. For all intents and purposes, these test tape allow the designer to ignore the discrepancy between physical and effective gap widths because the characteristics of the test tape will cover up the lack of loss compensation in the playback EQ amplifier. This allows the designer to boost highs a bit more during record and thereby gain a few dB of signal-to-noise ratio, albeit at the expense of recording headroom.

To put the icing on the cake, another measurement was performed, this time with a Nakamichi 1000 whose playback EQ amp had been modified so that no loss compensation took place. The frequency response of this modified EQ amplifier is shown in Figure 6. As a comparison with Figure 1 will verify, the modified EQ amplifier's characteristics are an extremely close approximation of the theoretical playback EQ curves, which is as it should be since all loss compensation was removed. The measurement of the same test tape yielded results almost identical to those of Figure 5. Not only is this strong evidence that the test tape is incorrect; it points to the fact that at this writing the Nakamichi Crystal Permalloy head is virtually *ideal* (that is to say, loss-free) to 10 KHz, a rather remarkable achievement by any standard.

Although the playback equalization problem does not concern the cassette deck user who does all his recording and subsequent playing on a single machine, users with multiple decks or those who regularly exchange cassette recordings with others could conceivably run into serious compartibility problems. In worst cases, we have measured a playback EQ discrepancy of as much as 8 dB at 10 KHz between a Nakamichi deck and a cassette

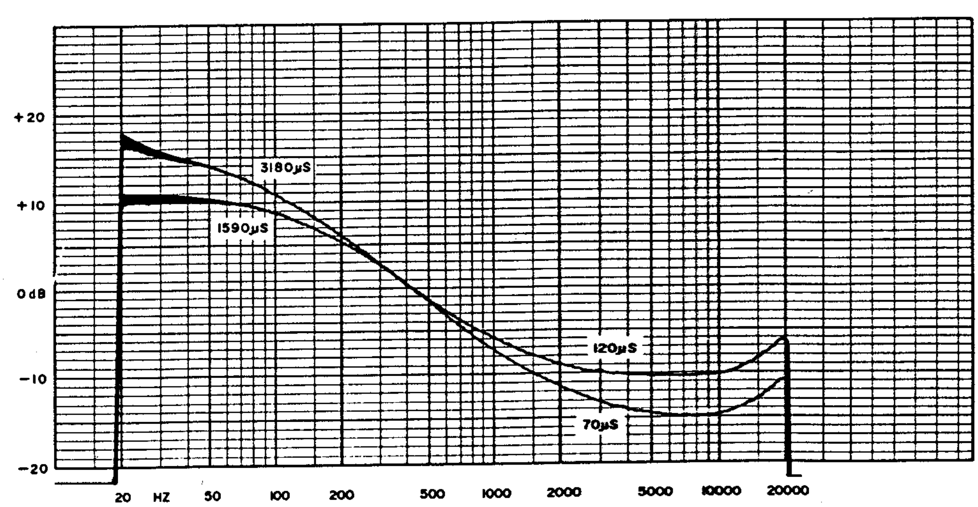

Figure 4 Frequency Response of Nakamichi1000 Playback EQ. Amp.

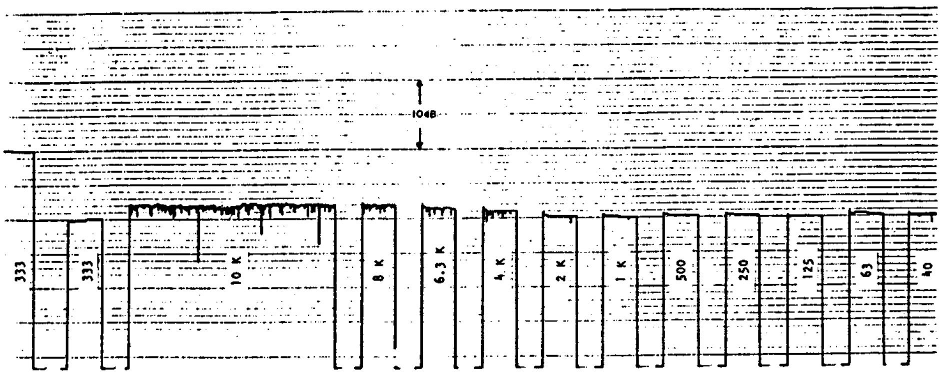

Figure 5 Output of a Popular Test Tape

deck of another well known brand. Improvements in magnetic heads will undoubtedly help reduce the number of non-standard test tapes and cassette decks, but it would seem that the industry is in need of stronger enforcement of standards.

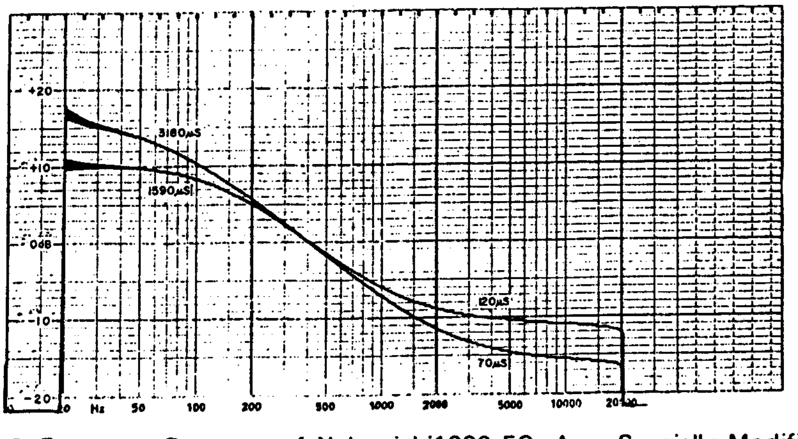

Figure 6 Frequency Response of Nakamichi1000 EQ. Amp Specially Modified for Test Purposes.

When we introduced the Nakamichi 1000 in 1973, we took the audiophile world by surprise. No one had believed that a "three-head" cassette deck was feasible; no one had envisioned a cassette recorder capable of such extraordinary bandwidth. Shortly thereafter, a rumor began to spread that Nakamichi acheived its remarkable results by adopting a "non-standard" equalization—that cassettes recorded on a Nakamichi deck were "incompatible" with those recorded on competing equipment.

To correct this misconception, Nakamichi issued *Technical Bulletin 2* on the subject of Playback Equalization. In that paper, we demonstrated quite clearly that Nakamichi decks adhered precisely to the Philips standard (4th revision, October 1968) and that the majority of test tapes then on the market, in fact, failed to meet the requirements of the standard. (Reprints of this Technical Bulletin are available upon request.) Despite this effort to "clear the air," many audiophiles persisted in the erroneous assumption that Nakamichi cassette recorders were "non-standard."

Recently, several excellent articles have appeared on the subject of "standard" cassette equalization, and we have reprinted two of these in this brochure. But the impetus for the brochure came from a Letter to the Editor of *Modern Recording & Music* from a reader concerned about the compatibility of Nakamichi recorders. We were graciously offered a chance to reply, a reprint of which also is included herein. Interestingly, we soon received a copy of a letter from a leading tape manufacturer independently substantiating the points we had made and confirming our contention regarding early test tapes. This too is included in the brochure.

We hope that a careful perusal of the articles and letters reprinted herein will establish once and for all that Nakamichi recorders are now, and always have been, in perfect compliance with international cassette-equalization standards, that tapes recorded on a Nakamichi deck are playback compatible on any other deck adhering to international standards, and that tapes created on any "standard" recorder will be reproduced perfectly on a Nakamichi deck.

MODERN RECORDING & MUSIC

TALK BACK

Reprinted from January 1982

"Talkback" questions are answered by professional engineers, many of whose names you have probably seen listed on the credits of major pop albums. Their techniques are their own and might very well differ from another's. Thus, an answer in "Talkback" is certainly not necessarily the last word.

We welcome all questions on the subject of recording, although the large volume of questions received precludes our being able to answer them all. If you feel that we are skirting any issues, fire a letter off to the editor right away. "Talkback" is the Modern Recording & Music *reader's technical forum.*

The Flux is the Crux

I have heard that Nakamichi uses a different type of equalization for recording than other deck manufacturers, and therefore tapes made on their machines are not entirely compatible with other machines. To the best of your knowledge, is this true?

—Steve Riley
Pocatello, Idaho

Thank you for this opportunity to clarify a common misconception regarding Nakamichi's adherence to standards. The question of what constitutes "standard equalization" is really quite simple—one carefully reads and adheres to published standards. The IEC (International Electrotechnical Commission) publications are *the* accepted standards throughout the world; the one that applies to cassette recording is Publication 94.

Publication 94 specifies the standard *recording* curve in terms of the short-circuit flux on tape as a function of frequency. In theory, the short-circuit flux can be determined by measuring the voltage developed across the terminals of an *ideal* playback head. Please note that it is the *recorded flux level* that is specified—not the playback equalization—for here is the crux of the misunderstanding.

If the ideal playback head existed, it would only be necessary to provide electrical equalization with a low-frequency break point of 3180 μs and a high-frequency break point of 120 μs (for Type-I tape) and 70 μs (for Type-II, III, or IV tape). Unfortunately, the ideal playback head does *not* exist. The main differences between a "real" and an "ideal" playback head stem from the finite polepiece length and the finite gap length of the real head, the magnetic losses in the core and the electrical ones in the windings, and the less-than-perfect contact between polepiece and tape.

Polepiece length affects response primarily at very low frequencies; it produces the so-called "contour effect" otherwise known as "head bumps." The other differences between the real and the ideal affect the high-frequency portion of the spectrum. The head's surface finish has a major impact on "spacing loss" which is most severe at short wavelengths (high frequencies). "Gap loss" comes into play as the recorded wavelength begins to approach the effective magnetic length of the gap. Similarly, the losses caused by the head's finite electrical inductance are most severe at high frequencies, and, in general, magnetic losses in the core also increase with frequency. Fortunately, it is possible to either calculate or empirically determine many of these losses. For example, core and winding losses are easily determined by forcing an appropriate current through the windings with the head connected to the playback amplifier. The difference between the ideal response and the measured response establishes the losses involved. Gap and spacing losses are readily calculated *if* one knows the true magnetic gap length and the actual tape-to-head separation. Since "work hardening" of the magnetic material prevents the true magnetic pole from being actually at the surface of the head, it is imperative that the head be fabricated in such a way as to minimize damaging the magnetic material and thus losing control over where the effective magnetic pole is located.

Play-head losses can be determined quite accurately if proper care is taken in the fabrication of the head. Knowing the losses, one can compensate for them in the playback electronics and so produce the same effect as if one had started with the ideal head specified by the standard. In fact, to be in compliance with the standard, *one must compensate for the playback head losses* for the standard specifies *recorded flux as seen by an ideal playback head.* It does *not* specify playback equalization. If you think about it, this makes a great deal of sense. It is the magnetic recording that is taken from machine to machine, and therefore it is the *recording* that must be standardized. Playback equalizers do not hop from deck to deck and it would be rather foolish to standardize them independently from the playback head with which they are used.

Compensating for play-head losses requires substantial additional circuitry; it also requires carefully controlled head fabrication so that the compensation works. Thus it is not surprising that many less expensive decks avoid this complexity. It is not difficult to convince oneself that one is in compliance with standards merely by adopting a 70 or 120 microsend *electrical* playback equalization, and one can find test tapes whose high frequencies are boosted beyond standard level to confirm one's delusion. On such tapes, a properly equalized deck such as a Nakamichi will appear to have too hot a high end. On a tape recorded in accordance with IEC standards, a Nakamichi will have a flat response.

We are very sensitive to this point because some have suggested that Nakamichi recorders are "non-standard" and implied that we have in some way "cheated" in order to achieve the response for which we are famous. Quite the contrary; we have always adhered to the letter of the standard. Actually, as play-head technology improves, we find several competitive decks meet IEC standards at least to as high a frequency as typical test tapes extend.

—Ken Ohba
Marketing Manager
Nakamichi U.S.A. Corp.,
1101 Colorado Ave.,
Santa Monica, CA 90401

[Mr. Ohba also included a copy of Nakamichi Technical Bulletin, No. 2, which deals with the topic of Playback Equalization in detail. We, of course, were unable to reprint it here, but copies of the Technical Bulletin are available free of charge from Nakamichi. Write for Bulletin No. 2 to Nakamichi, 1101 Colorado Ave., Santa Monica, California 90401, or call 213-451-5901.]

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December 16, 1981

Ms. Pam Highton, Managing Editor
Modern Recording and Music
14 Vanderventer Avenue
Port Washington, NY 11050

Dear Pam,

I read the letter in the December "Talk Back" column written by Mr. Ohba of Nakamichi Research, and I thought that I could shed some light on the playback equalization controversy. I spoke to Mr. Ohba about this matter, and we both agreed that information from a calibration tape manufacturer might clarify the issue.

Mr. Ohba's thorough description of the equalization process is accurate in every detail. An interesting point that might not be clear, however, is that the only way to measure magnetic flux on a tape is to measure the voltage induced across a head. When the German DIN standards established the 120-µs calibration tape standard, BASF and Philips used the best ferrite heads available at the time (mid-60's) as reference heads. It is always an uncomfortable fact that the time for initial standards is also the time when little information is available and equipment is relatively crude.

When the cassette came of age, vastly improved heads, especially the Nakamichi crystalloy head with its incredibly small gap, showed how accurate the original reference head was. The calibration standard had too much high frequency compensation added. The new heads could better resolve the short wavelength flux and produced a rising high frequency response. In 1974 DIN decided to reduce the level of short wavelength flux on the calibration tapes but remain close to the original but technically "wrong" standard in order to maintain compatibility. DIN also made several other minor changes over the years, but Japan was never fully informed about what was happening in Europe. A great deal of confusion and misunderstanding arose from the lack of technical communication.

What everyone needed was communication and cooperation on an international basis. The IEC (International Electrotechnical Commission) was established to provide a forum and to set "the accepted standards throughout the world," as Mr. Ohba points out. BASF and TEAC worked together on the question of calibration accuracy and compatibility, and both companies manufacture the IEC calibration tapes used to align the heads and playback amplifiers of cassette recorders for flat frequency response at both 120-µs and 70-µs equalization.

Playback EQ can be a complicated matter because mechanical azimuth misalignment can easily disguise the electrical accuracy of the tape and the amplifier. Nakamichi's ability to resolve incredibly short wavelengths for extended high frequency response is due to the design and finish of heads with extremely small playback gaps and not to "tricks" with equalization. The IEC calibration standard manufactured by BASF will show flat frequency response on all Nakamichi recorders produced for the last few years. This compatibility assures complete compatibility with all other recorders adhering to international standards.

Cordially,

Terence D. O'Kelly

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TDOK:sem

cc K. Ohba, Nakamichi Corporation

HIGH FIDELITY Reprinted from February 1982

AUDIO

Sound Views

Opinion and comment on the changing audio scene by Robert Long

The High Price of Progress

EVERY TIME I HEAR the statistician's term "standard deviation" it strikes me afresh that there's something vaguely absurd about it. If deviation is a departure from some sort of standard course or condition, how can a deviation be standard? A sophistry, perhaps, but disturbingly similar to the situation in which the cassette medium finds itself, where some standards are honored more in the deviation than in the adherence and others suffer from a multiplicity of references, each deviating from the other.

We have, for example, received a few letters citing what the writers called the "nonstandardness" of Nakamichi decks and pointing to the International Electrotechnical Commission standards and to playback-response test tapes based on those standards to "prove" their point. And if you measure an old Nakamichi deck with an old test tape, you may well find that the response curve turns upward at the extreme high end. Why? Because Nakamichi followed the IEC standard, that's why.

How can this be, you ask. Well, the IEC wrote its primary specification in terms of flux density on the tape and playback-equalization time-constants. So far so good. But because there was no way of measuring flux densities directly (and still isn't for practical purposes), the IEC specified elsewhere what heads would be considered standard for playing back (and thus measuring indirectly) recorded flux densities. And in order to be "standard," test tapes were devised to give flat results with the existing heads. Meanwhile, however, Nakamichi had calculated head behavior for the standard flux densities and time-constants and was producing decks whose performance was flat on that basis. Because the calculations took head-gap losses into account and the progression by which the test tapes were arrived at didn't, there was a discrepancy between the end results. Yet each was "standard!"

There's actually a lot more to it than this résumé suggests. Addenda to the original IEC documents tend to confound any attempt to derive a clear picture of what the standards say, and time has made nonsense of some of their specifics. (In fact, a tape-test standard is largely complete.) The IEC's standard heads, in particular, have become obsolete, and so have the tapes based on them. If you measure a current Nakamichi deck with a current test tape, you'll probably find a perfectly flat high end. That's because today's narrow-gap playback heads (including Nakamichi's) display little if any high-frequency loss within the audio band, so neither the deck's electronics nor the test tape need compensate substantially for such losses; both used to compensate for the *same* loss and thus turned it into a gain—which explains the rising high end in the measured response of early Nakamichi decks.

> Improvement and standardization of the cassette medium are necessary but inhibit each other.

One more example of how standards can trip us up, and then I'll get down to my real point. If you look at a lot of our cassette-deck playback-response curves, you've surely noticed many that turn down instead of up at the high-frequency end. The reason usually is a "disagreement" over cassette head azimuth. In fact, if the response begins to sag at frequencies below 8 or 10 kHz in any deck that is above the budget-price level, you can be fairly certain that its azimuth does not match that of the test tape; if the record/play response curves all stand up well to higher frequencies, the point can be considered proven.

Azimuth is the effective perpendicularity of the head gap to the tape path. If the playback head is rotated out of perpendicularity, one edge of the gap will read the recorded signal a little ahead of the other; as recorded frequency rises—and recorded wavelength consequently shrinks—some frequency eventually will be reached where the trough of the waveform is being read at one edge of the track while the peak is being read at the other, cancelling each other and reducing output. It sounds as though the cure is simple: Just make sure that all head gaps are perfectly perpendicular to the tape path. But it's not that easy. Depending on the drive mechanics, the tape doesn't necessarily pass the heads in a perfectly straight line between tape guides, and its "bending" can introduce azimuth skew. Nor is the magnetic azimuth of a tape head necessarily dead straight along the centerline of the gap. So achieving perpendicularity is rather like trying to draw a square box with no aids except a rubber T-square and a French curve.

HIGH FIDELITY used to measure playback response—and, indirectly, azimuth—with Philips test tapes. We found them (like all brands, to some extent) a little inconsistent from sample to sample. But when we changed to the TDK test tape to get its greater reach into the high-frequency range and its modern bass equalization (the Philips tapes follow an older standard and hence represent yet another example of "standard deviation"), we found still larger inconsistencies between results with the two brands than we had with our various samples of the Philips tapes. And other tests suggested that neither brand would match the results with a Teac test tape. Of course, we might have come to different conclusions with different samples of these same test-tape brands, but the point remains that there is no unanimity of azimuth among quality brands and hence no standard—de jure or de facto—for azimuth adjustment!

All of which may sound like an elaborate way of introducing a plea for comprehensive, comprehensible, cast-iron standards for the cassette medium. Well, yes and no. In the scant decade that has passed since the cassette became a serious contender for grace in the high fidelity firmament, there have been many calls for more (or more useful) standards. There have also been complaints that the restrictions Philips incorporated into its licensing agreement were barriers to progress in the cassette format. Would the immense changes that have taken place in the last ten years have been possible with more comprehensive standards? I tend to think not—not entirely, at least. Yet obviously standards are needed and, in some areas, even overdue.

This dichotomy between the radical and the conservative is a fascinating paradox. Extremism in either direction exacts a heavy toll; improvement and standardization inhibit each other, yet each is a necessity to a healthy and viable cassette medium. The industry must continue to try to write "perfect" standards, but while one hand is codifying the past the other must always be reaching for the future. HF

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Cassette equalization: the standard view

Technical Side

With audio as a world wide business, the interchangeability of cassettes is ever more vital

By Ed Foster

Considering the number of years cassettes have been around, it might be surprising to hear that cassette equalization is not as straightforward a proposition as meets the eye. It would be easy to explain the confusion on an East-vs.-West basis, in that the cassette was originally a European development (invented by Philips of the Netherlands). But that would be a rather simplistic view; Japanese manufacturers do not all agree with each other, much less with the Europeans. One might also point out that the cassette was originally envisioned as a dictation means, and for that purpose, standardization of equalization is less important than in its present use as a high-fidelity music medium. But, again, that explanation is weak, for seldom has any company ruled its licensees more thoroughly than has Philips in such things as tape speed, track width and location, and the physical characteristics of the cassette itself. In the final analysis, it is not important *why* there are differences but only that the differences exist.

Alphabet standards

There are many organizations whose purpose it is to standardize either methods of measurement or performance (or both), or to establish means by which compatibility among equipment is ensured. Most major countries have national standards organizations, such as ANSI in this country, DIN in Germany, and the CCIR in France. Then there are manufacturers' organizations and engineering institutes that promulgate standards — the IEEE and EIA (into which the old IHF has been merged) in the U.S., and the EIAJ in Japan. Last, but certainly not least, there is the IEC — the International Electrotechnical Committee — which has representatives from both Western and Communist countries and seeks to establish *international* norms. Considering the world-wide popularity of the cassette recorder, it would appear that this is the organization to turn to at least insofar as interchangeability of software is concerned.

The establishment of an equalization standard is simply a means of insuring interchangeability of cassettes. As long as a cassette is recorded and reproduced on the same machine, it really makes no difference which equalization is used. For that matter, track width, track placement, and azimuth need only be standardized so that a tape recorded on one machine can be played properly on another. But in order to insure interchangeability of software, the reproducer must have heads whose track width, placement, and azimuth angle match those of the deck on which the tape was recorded. Similarly, to reproduce the tape with the correct frequency response, the playback equalization must complement the recording equalization so that, together, they compensate for recording and playback losses.

What are those losses? Ignoring the loss due to azimuth misalignment (which, at least theoretically, shouldn't occur if both record and playback heads are properly aligned), the main playback losses are caused by the finite length of the play head gap, the unavoidable separation between the tape and the play head poletips, the magnetic losses in the play head core, and whatever electrical losses might occur in the interface between the inductive head winding and the preamplifier. There are two other play head peculiarities: the so-called "contour effect" produced by the finite polepiece length used in the play head (and resulting in "head bumps" or irregularities in low-frequency response); and the 6dB/octave rising response (for constant flux level on tape) that is characteristic of all rate-of-change-of-flux-sensitive devices such as the normal playback head.

On the recording side of the ledger, there are core losses and separation losses too. The size and shape of the gap also plays a role in establishing how deeply into the magnetic coating the tape is recorded and how sharply defined the "critical recording zone" is. In conjunction with the tape formulation itself and the choice of bias level, these determine the relative strength of short-wavelength (high-frequency) information compared with long-wavelength (low-frequency) information.

Record or playback equalization?

Insofar as the playback losses are, in the main, caused by imperfections in the playback head and its interface with the playback electronics, it would seem logical that compensation for these losses should take place in the *playback* electronics and the losses should not be "pre-compensated" for in the recording equalization. Similarly, it would seem sensible to correct for *recording* losses in the recording equalization so that, despite imperfections in the recording head, each recorder produces as theoretically perfect a recording as is possible. In this way, a designer could choose whatever bias field he deemed most appropriate and use whatever recording preemphasis is required to create a "proper" response with a theoretically perfect playback system. Only in this way is true tape interchangeability assured; every recorder would assume that the tape would be reproduced on an ideal playback system, and every playback system would assume it was reproducing a theoretically ideal recording.

Of course, there has to be some *generalized* equalization implied. Here is where the curves come in: the so-called "120-microsecond" (for Type-I — ferric) and "70-microsecond" (for Types II, III, and IV — chrome, ferrichrome, and metal respectively). The purpose of these curves (and the 3180-microsecond low-frequency break now standard for *all* tapes) is to make a "first cut" at correcting for the 6dB/octave rising response of the typical playback head, the energy distribution of music, and the basic high-frequency losses common to all recording systems.

The nut of the question is whether these "standard playback equalizations" apply to the playback *electronics* or to the playback *system*. That is, should one simply dial these fixed equalization parameters into the playback electronics and then juggle the recording equalization to compensate for other playback losses, or should one instead use the "standard playback equalizations" as a *starting* point and modify them for the playback losses peculiar to that deck? It would seem sensible to adopt the latter approach, and, indeed, a careful reading of the IEC standard (Publication 94 is the one that applies) would imply that this is the "correct" technique.

The first amendment to IEC Publication 94 defines the "short-circuit flux" of a magnetic tape as "The flux which flows through the core of a reproducing head which has a zero reluctance (read, no core losses) and is in intimate contact with the surface of the tape (read, no spacing loss) over an infinite length (read, no contour effect)." It then goes on to specify the *recorded tape flux characteristic* in terms of the *short-circuit tape flux versus frequency* as the result of the combination of two curves, i.e. the 3180 and 120 (or 70) microsecond curves that we have always used. Clearly, this seems to indicate that the playback system is assumed to be "ideal," and that playback losses should be compensated for in the playback electronics so that the "real" system is as close to ideal as is feasible.

Pre-equalized test-tapes

I may seem to be belaboring the obvious, but the point seems to have escaped most designers. More often than not, cassette decks are engineered *without* correction for playback losses in the playback equalizer, which simply contains the composite of the two curves (3180 and 70 or 120 microseconds). All additional losses are corrected in the *recording* equalization. Nakamichi, the one company that, practically from time immemorial, has compensated for playback losses in the playback equalizer, has frequently been accused of "non-standard equalization" when, in fact, its approach seems to be in precise adherence to IEC standards.

This peculiar state of affairs is attributable, in large measure, to the propensity of test tape manufacturers to pre-equalize their frequency response tapes for a presumed playback gap length and spacing loss. Insofar as the losses in a playback head match the presumption on which the test tape was created, it will appear to yield flat response *without* additional correction. A deck that has correction for playback loss built into the playback equalizer — and thus, *as a system*, appears ideal — will exhibit a rising high-end when tested with a tape whose high-end has been boosted to "correct" for presumed playback losses.

This idea of generating a test tape based upon the presumption of certain playback losses is not a new one; it goes back to the early days of open reel. At that time, Ampex was probably the leading tape deck manufacturer and, for internal use, created a frequency response test tape. Early Ampex recorders used a playback head with a 250 microinch gap, and its test tape was designed to compensate for that playback gap. Ampex then was induced to sell these tapes.

Everything went swimmingly until Ampex adopted narrower playback gaps (100 microinches) in order to extend the bandwidth of the deck. Tested with the old tape, the new decks had a rising high-end. Little by little, the test tapes were deemphasized to show flat response on the newer and better players.

The NAB standard, which was in general acceptance at that time, was written in terms of a *playback* equalization rather than a recorded flux characteristic, and that, in a sense, blessed a rather questionable practice. For that matter, there may be some cassette standards extant today that follow the same philosophy. My only point is that IEC Publication 94 does not seem to be one of them, and that, both from the point of view of its international recognition and from the point of view of common sense, it seems to be the one to follow. Recent indications are that tape deck manufacturers other than Nakamichi also seem to be adopting this posture, and are compensating for playback losses in the playback equalizer. Common sense and good engineering practice may yet win out. **AVI**

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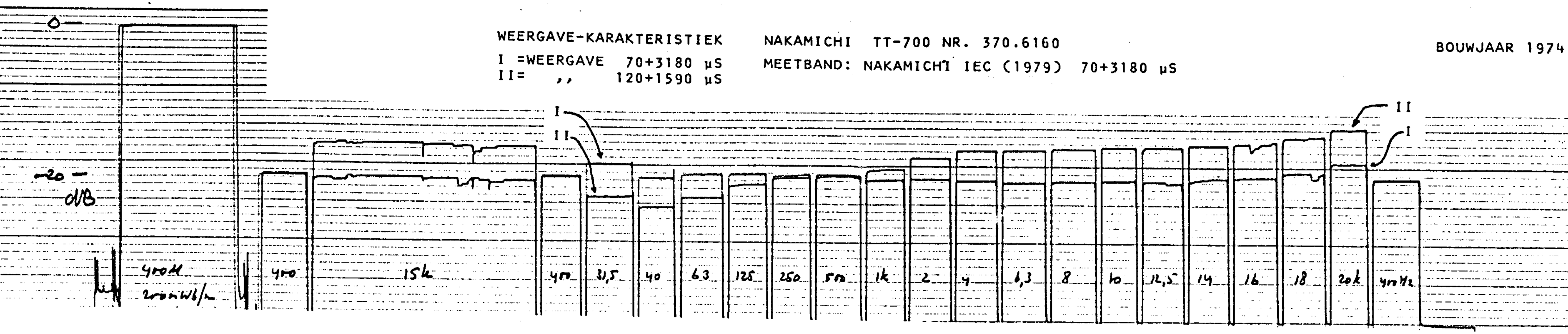
WEERGAVE-KARAKTERISTIEK NAKAMICHI TT-700 NR. 370.6160 BOUWJAAR 1974

I =WEERGAVE 70+3180 µS
II= ,, 120+1590 µS

MEETBAND: NAKAMICHI IEC (1979) 70+3180 µS



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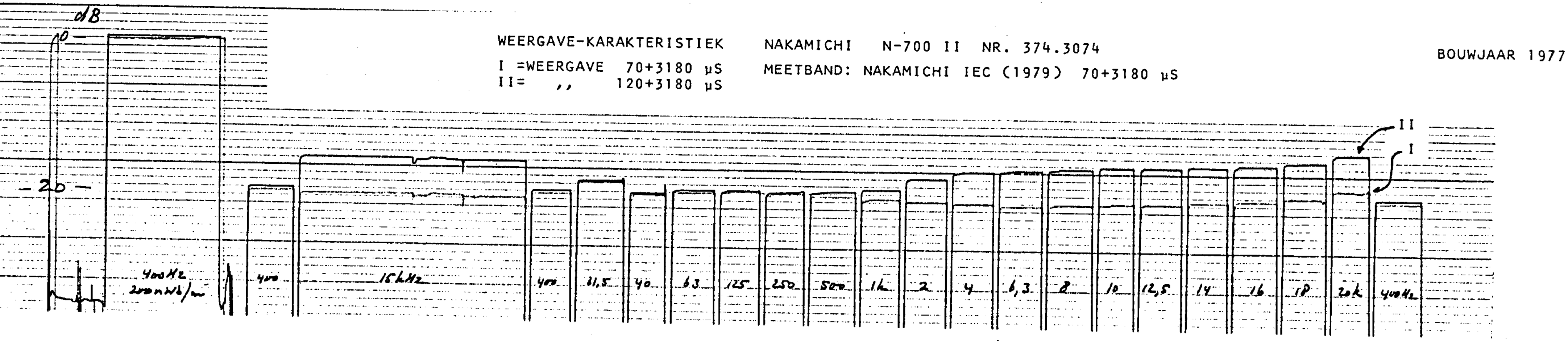
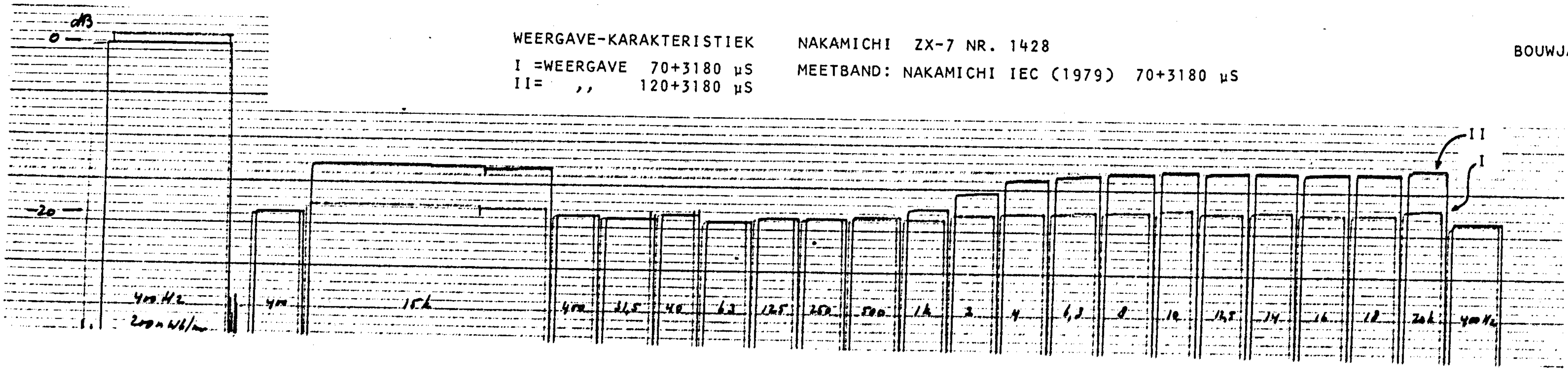
MEETBAND: NAKAMICHI IEC (1979) 70+3180 µS



WEERGAVE-KARAKTERISTIEK NAKAMICHI ZX-7 NR. 1428 BOUWJAAR 1981

I =WEERGAVE 70+3180 µS
II= ,, 120+3180 µS

MEETBAND: NAKAMICHI IEC (1979) 70+3180 µS



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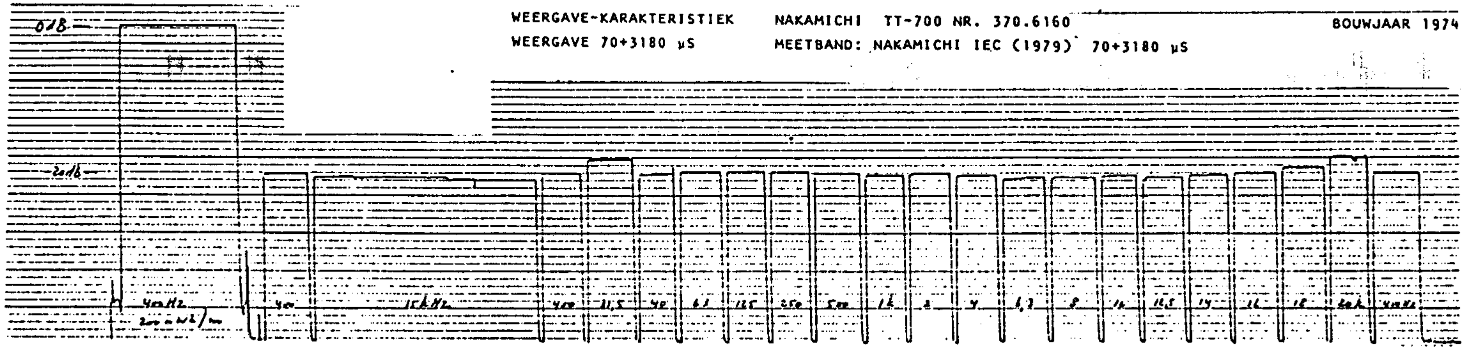

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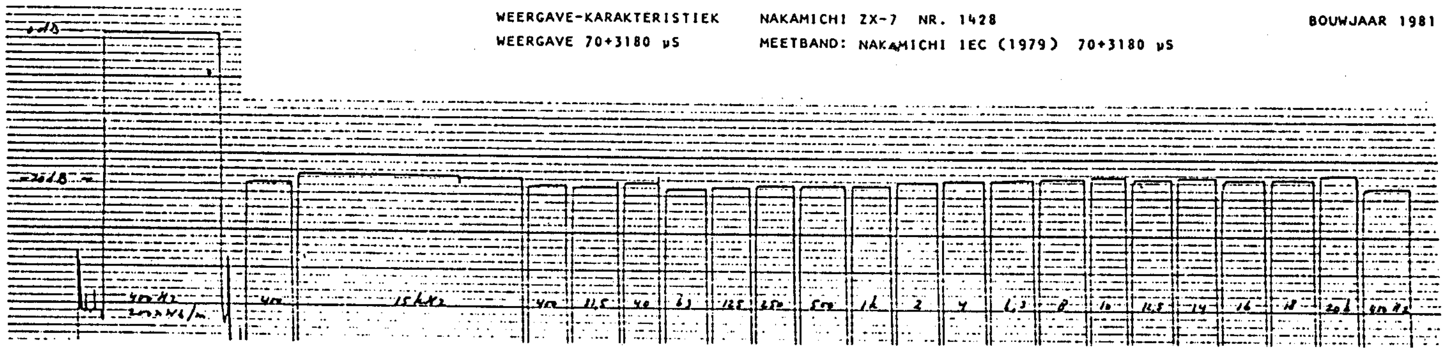
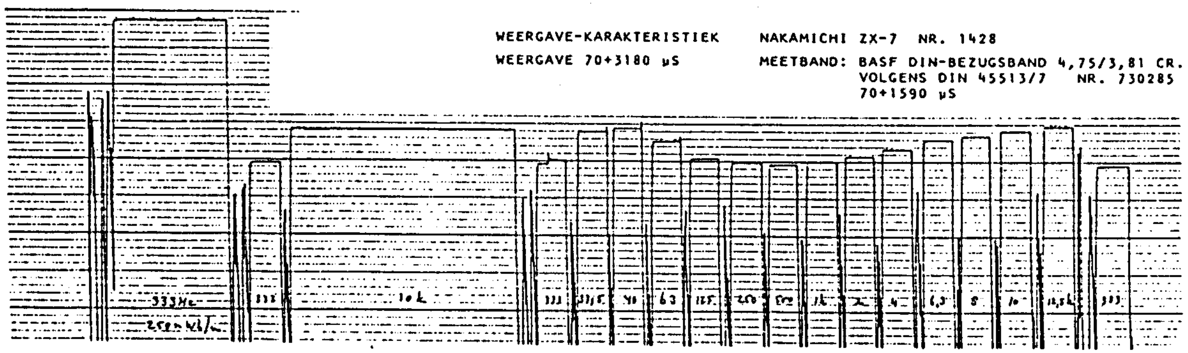
WEERGAVE 70+3180 µS MEETBAND: NAKAMICHI IEC (1979) 70+3180 µS



WEERGAVE-KARAKTERISTIEK NAKAMICHI ZX-7 NR. 1428 BOUWJAAR 1981
WEERGAVE 70+3180 µS MEETBAND: BASF DIN-BEZUGSBAND 4,75/3,81 CR. (1973)
VOLGENS DIN 45513/7 NR. 730285
70+1590 µS



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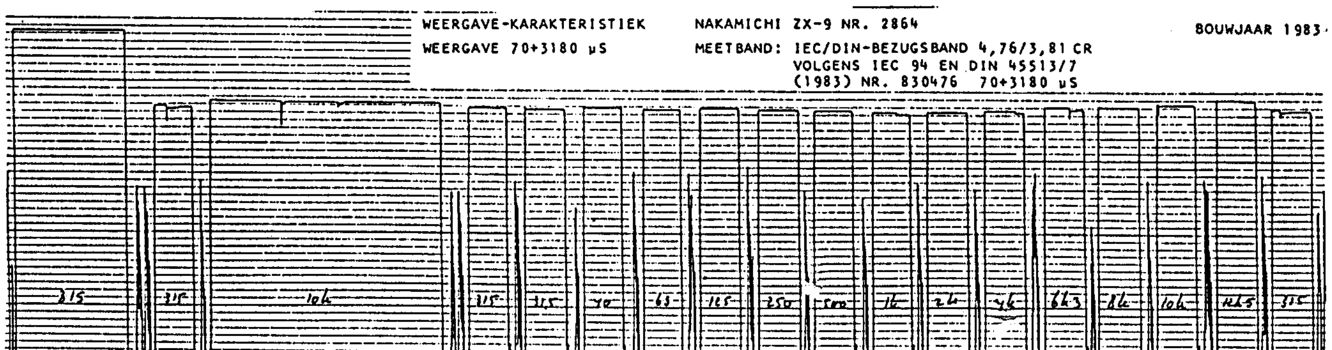
(1983) NR. 830476 70+3180 µS



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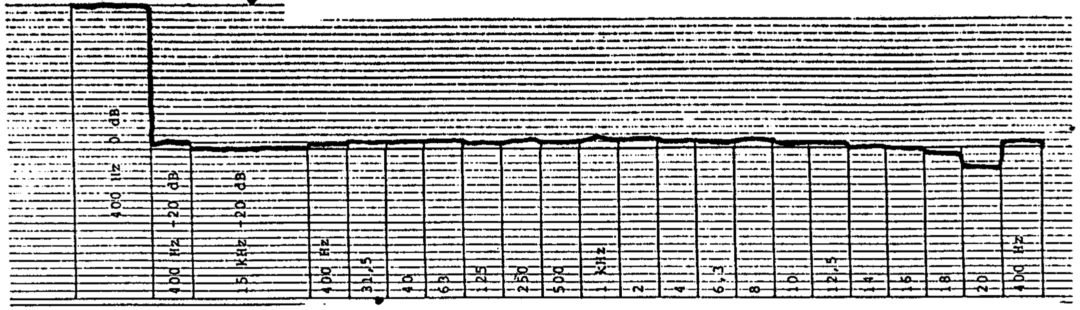

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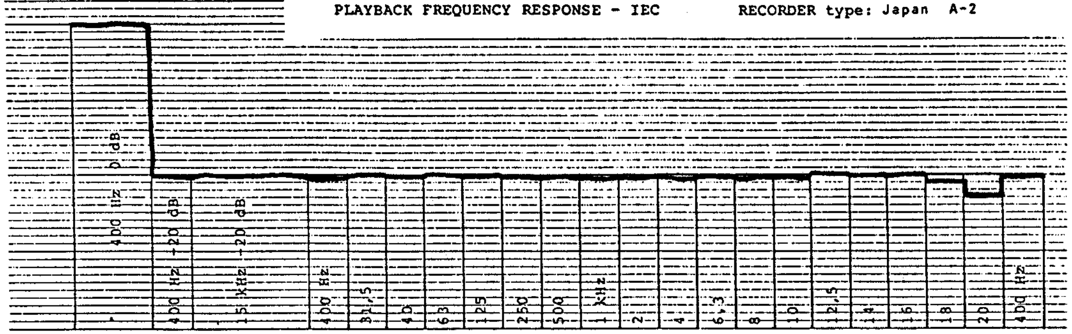

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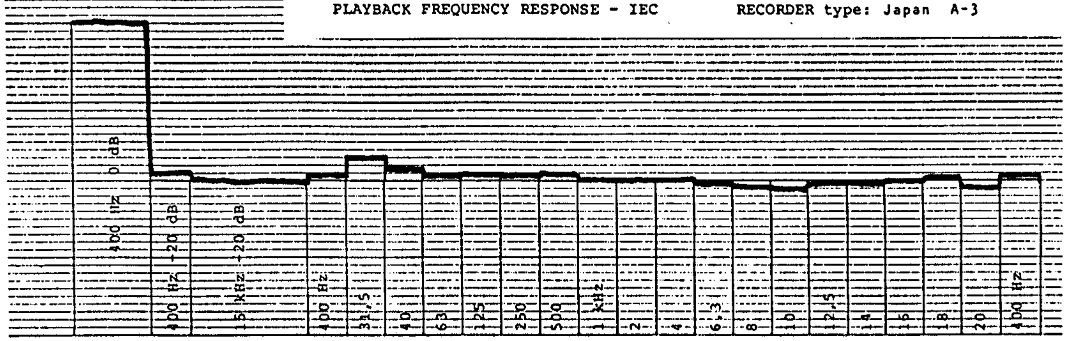

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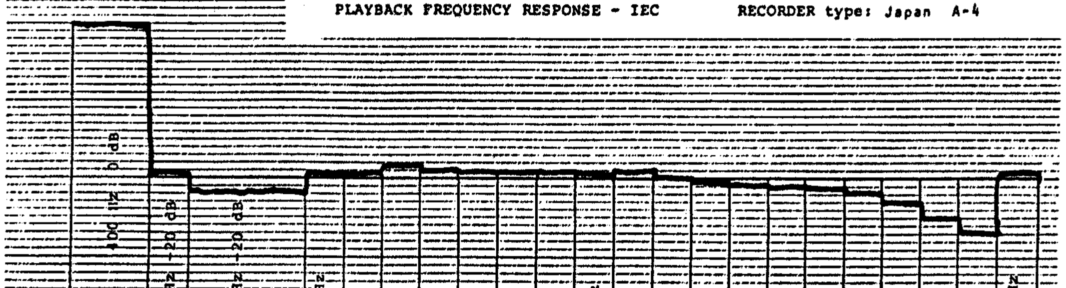

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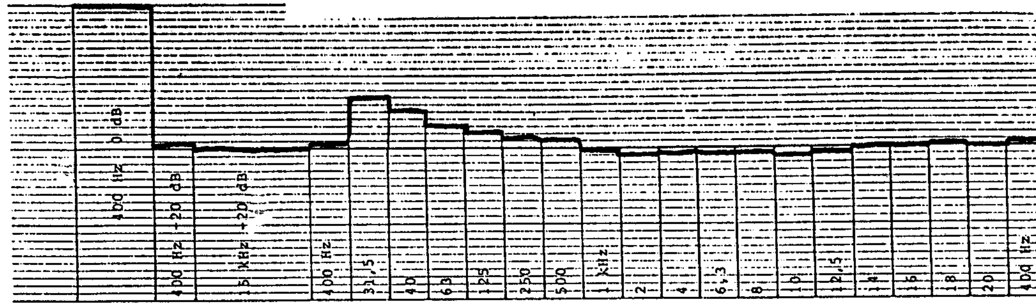

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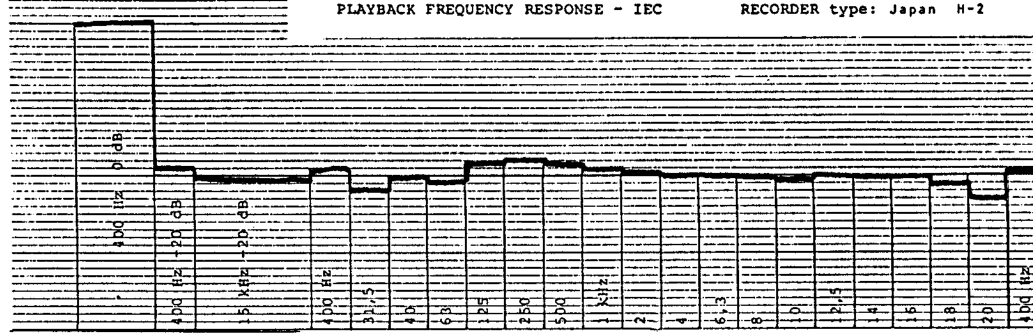

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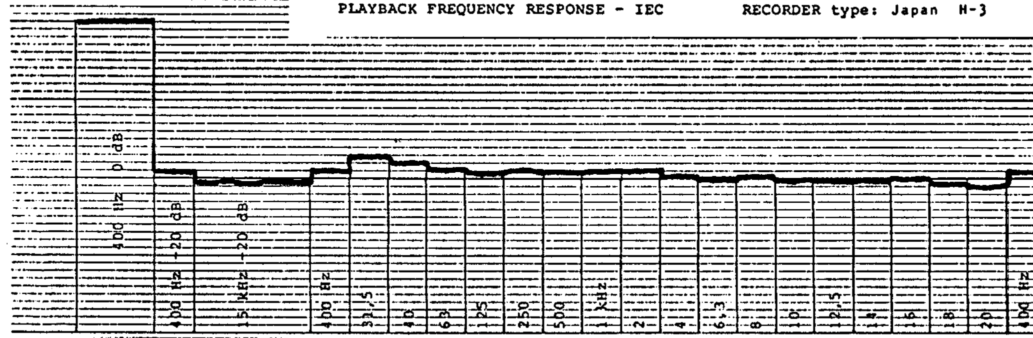

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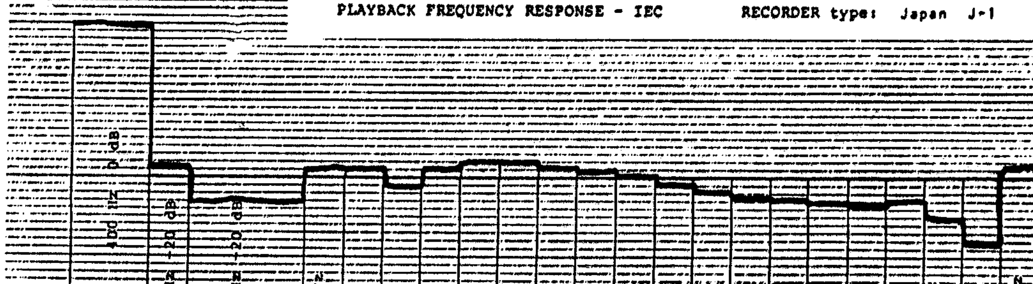

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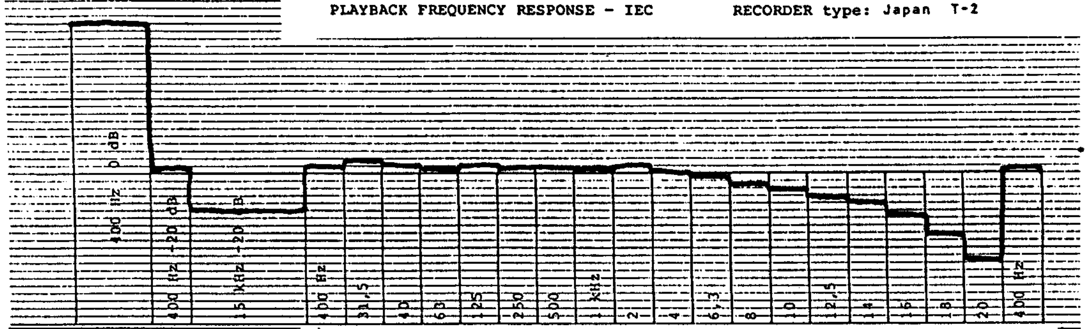

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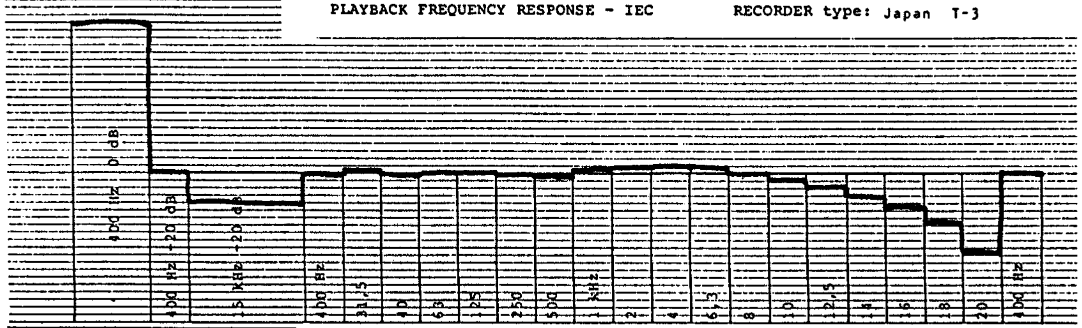

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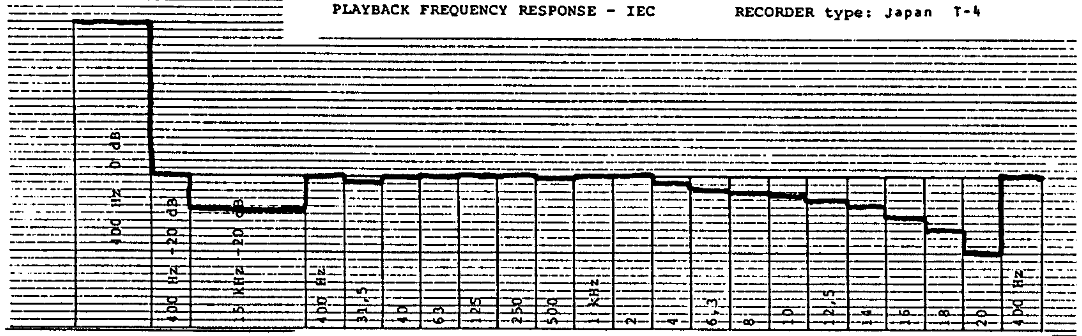

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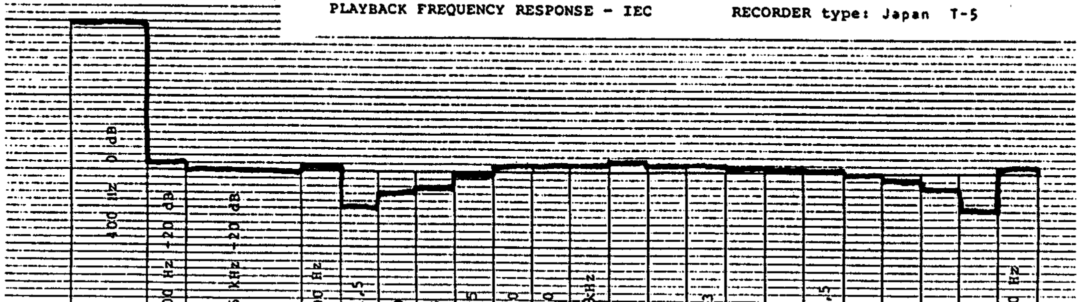

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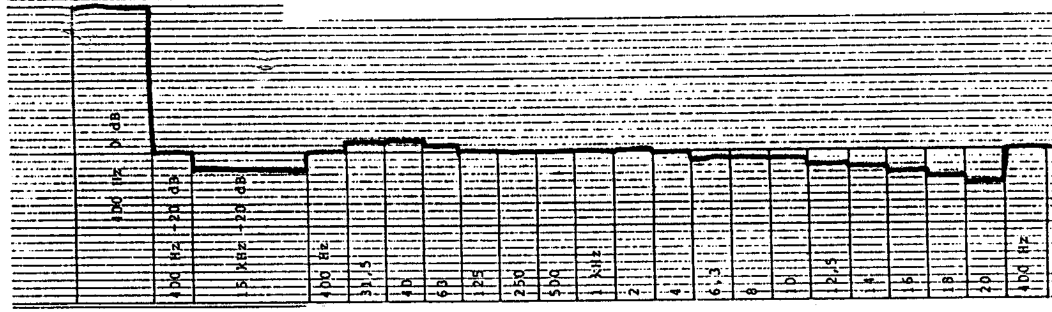

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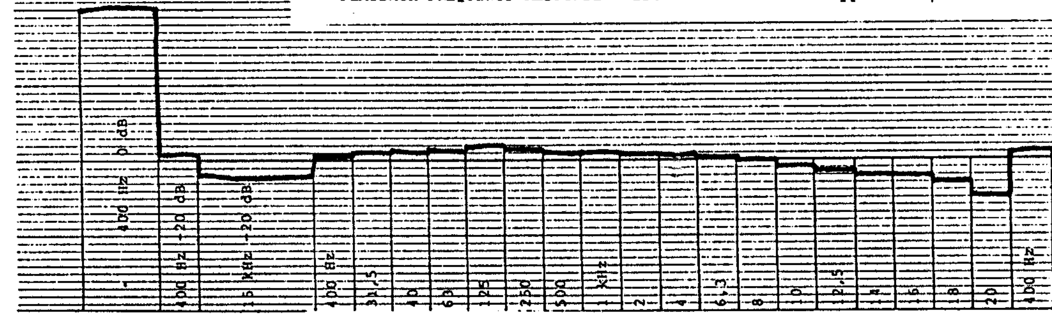

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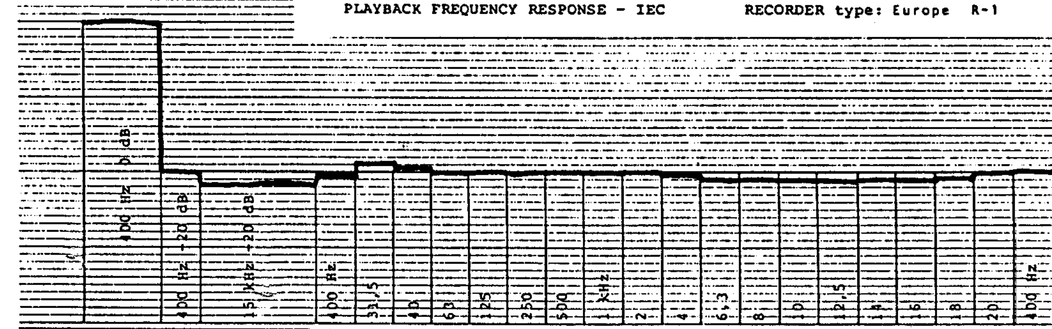

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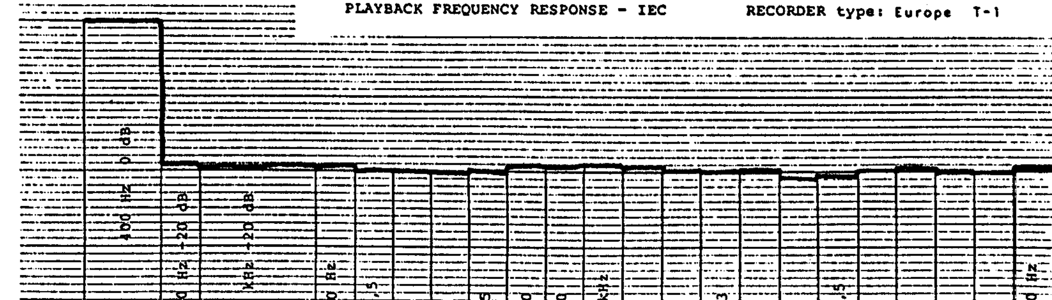

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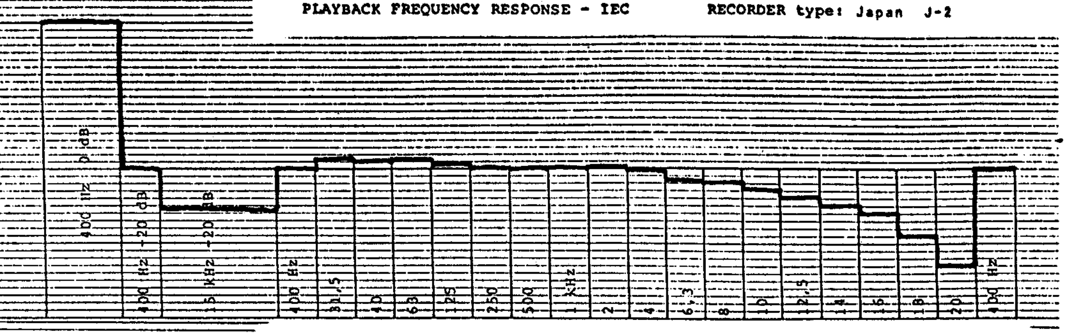

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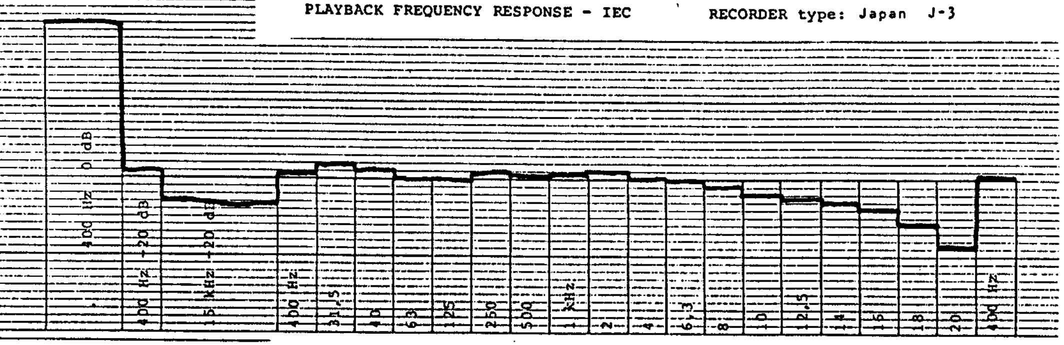

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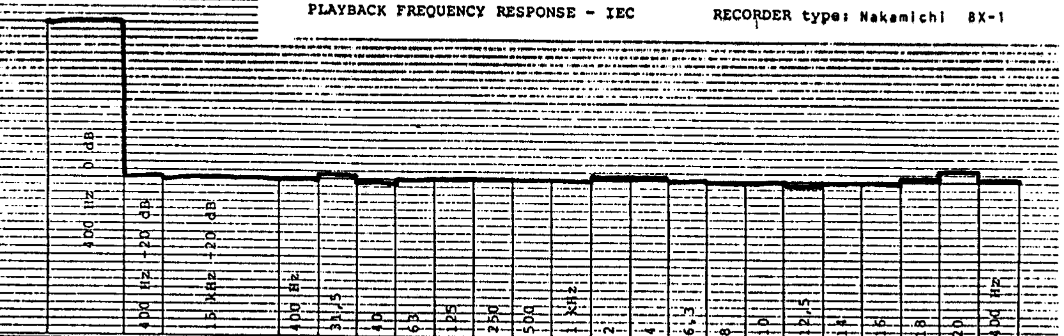

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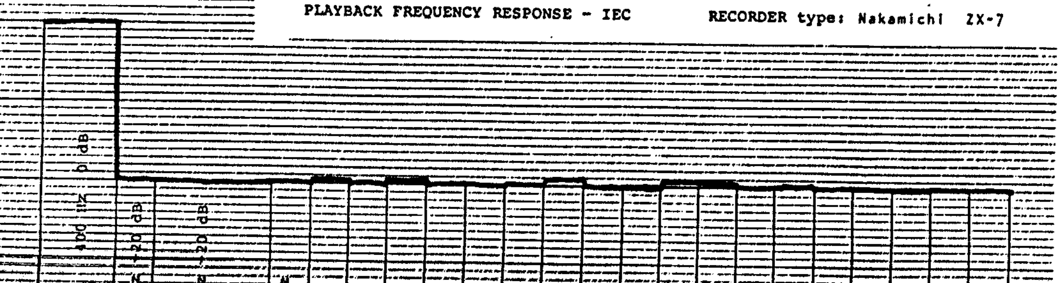

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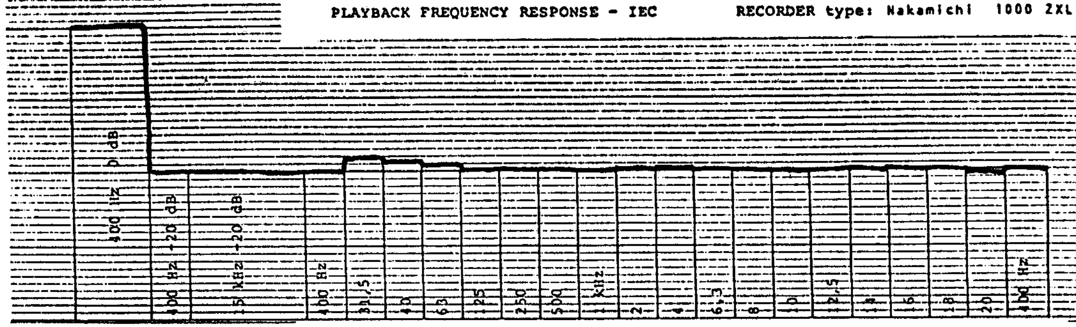
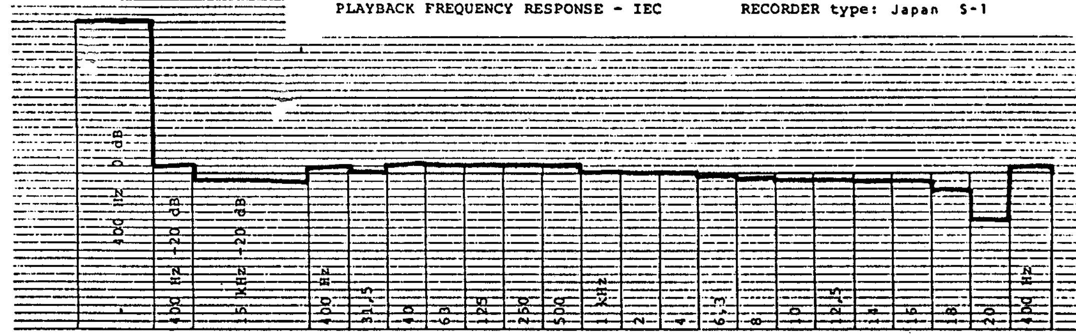


PLAYBACK FREQUENCY RESPONSE - IEC RECORDER type: Japan S-1



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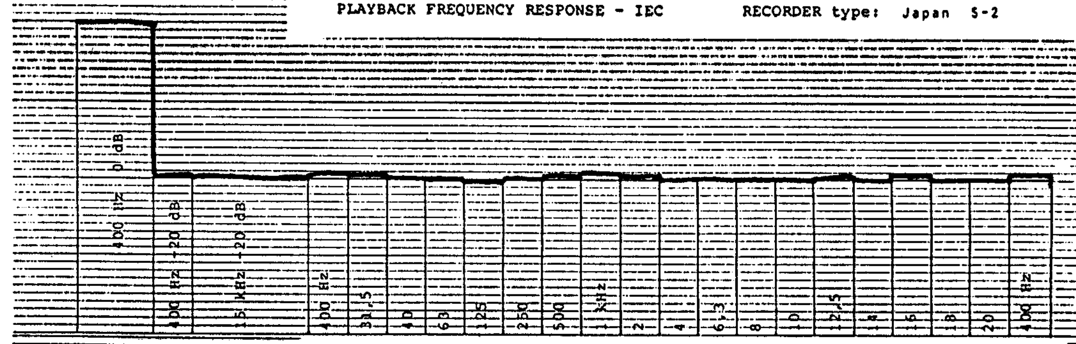

PLAYBACK FREQUENCY RESPONSE - IEC RECORDER type: Japan T-1