Georg Neumann GmbH | Berlin

The Dummy Head – Theory and Practice

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KU 100 bottom side with connection panel

The Dummy Head: A Condenser Stereo Microphone

The KU 100 dummy head is a replication of the human head, equipped with microphones within the "ears". Listening to the dummy head signals through good-quality headphones, the listener receives an impression which is almost completely identical to that which he would have if he kept its head stationary at the location of the dummy head, i.e. the illusion of physical presence at the scene of the performance.

If reproduced through loudspeakers, the sound impressions are almost identical to those obtained by means of conventional stereo microphone techniques with an increased sense of "depth" of the sound-stage.

For artistic recordings, the KU 100 is equally suited for creative radio drama recordings and for music presentations, the advantage of the KU 100 over conventional stereo recording techniques being a more realistic representation of the acoustic conditions in the recording environment. In industrial applications, the KU 100 can be utilized to assess noise influences at different workplaces under realistic conditions. The sound field is received in a physiologically proper manner and can be recorded for subsequent evaluation by different test subjects under the same listening conditions.

The KU 100 represents the third generation of the Neumann artificial head stereo microphone systems (dummy head). The original KU 80 was replaced by the KU 81 which marked the transition from "free-field" equalization to "diffuse-field" equalization. This yielded compatibility of the dummy head signals with stereo loudspeaker reproduction. The KU 100 replaces the KU 81 and offers the following advancements:

Acoustic Improvements

- Revised design of the outer ears for precise symmetry of the left/right characteristics
- Improved approximation of the ideal "smooth diffuse-field frequency response"
- Adjusted ear coordinates, thereby avoiding vertical displacements of sound sources (artificial elevations) in the listening event

Improved Circuitry

- Transformerless "fet 100" circuit
- Sensitivity increased by 5 dB
- Dynamic range increased by 5 dB

Improved Flexibility

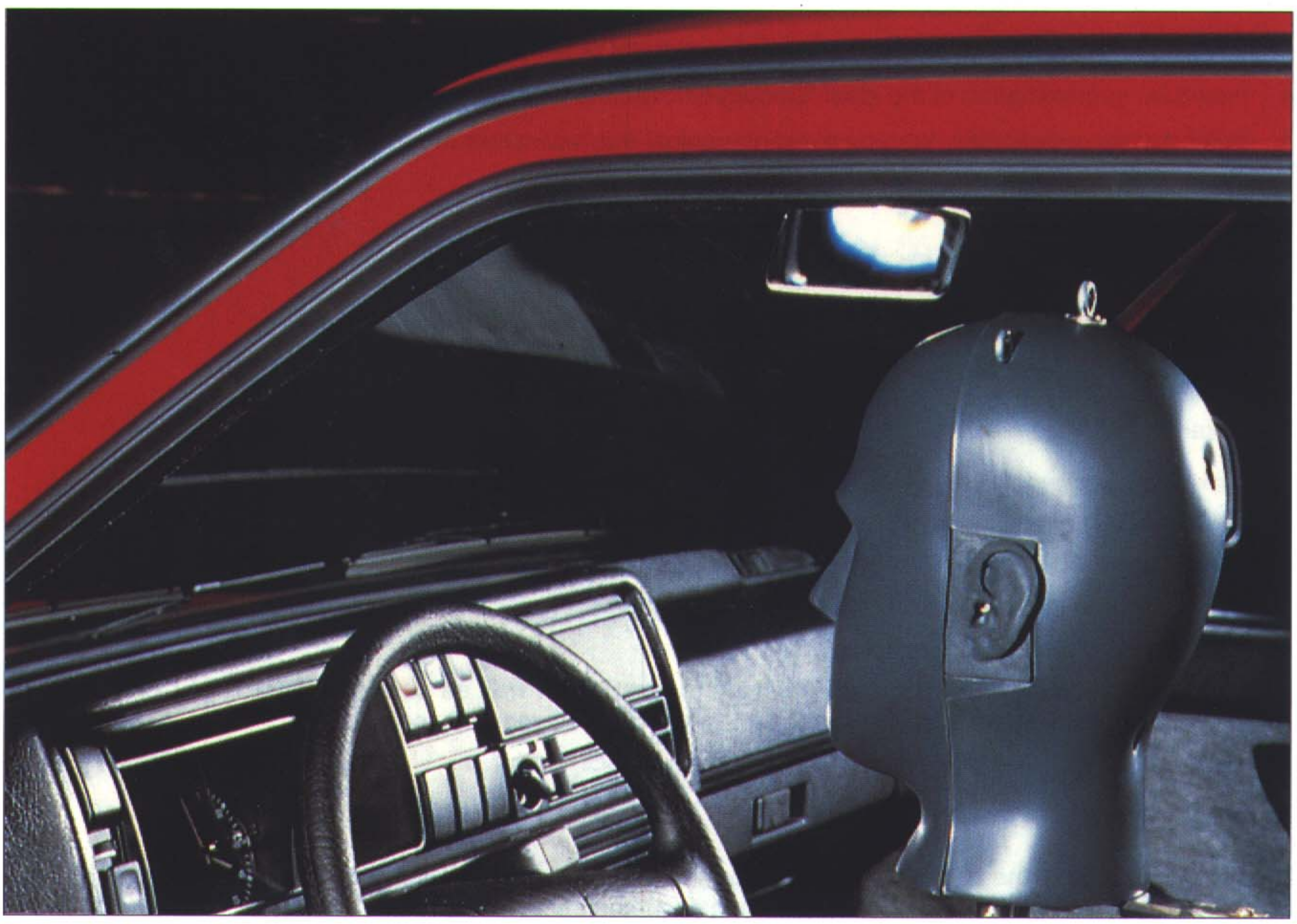
- Flexible power supply configurations:
  - Integrated battery supply with LED "low battery power"
  - external P 48 phantom powering via 5-pin XLR connection
  - powering via supplied external power supply unit
- Flexible output connector configurations:
  - Integrated, balanced XLR outputs for studio-operation as well as separate Left/Right BNC outputs for unbalanced measuring, data processing and data storage devices
- Switchable high-pass filter (150 Hz, 40 Hz and linear)
- Switchable 10 dB attenuation

Especially because of the above-mentioned improvements, the general publications concerning the use of the dummy head, which are compiled in the following documentation, remain in full effect.

Their purpose is to describe applications in which the dummy head as a recording system and measuring instrument has been successfully used so far, and why it is sometimes more suitable than "normal" stereo microphone arrangements or measuring microphones for the applications described below:

- Radio Drama/Feature Productions
- Recording of concerts and live broadcasts in the areas of classical music, jazz, pop music, and entertainment shows
- Stereo recordings with relatively simple means in acoustically very complex environments (i.e. churches, etc.)
- Documentation of animal voices and natural sounds, conferences, theater and opera performances
- Monitoring of the effect of P.A. Systems in halls, theaters, and auditoriums
- Documentation and assessment of the audibility conditions of rooms (i.e. concert halls)
- Documentation and assessment of musical instruments
- Documentation and assessment of electroacoustic P.A. Systems in rooms and/or in automobiles (i.e. evaluation of automotive loudspeakers)
- Measurement of speech intellegibility
- Documentation and assessment of noise nuisance in industry, at workplaces or in traffic
- Measurement of (open) headphones

The dummy head is the first link of the transmission chain in "Head-Related Stereophony". High-quality, diffuse-field equalized headphones should be on the other end. This is why the following literature also refers to the subject of optimal headphone equalization as well as suitable designed headphones.



Documentation and assessment of noise nuisance in industry, at workplaces or in traffic

The Importance of Diffuse-field Equalization for Stereophonic Recording and Reproduction

by Günther Theile, IRT Munich

1. The Problem of Compatibility

Typical stereophonic recordings aim for "loudspeaker stereophony". The sound engineer makes use of widely varying microphone and mixing techniques to create a sound image which satisfies his requirements for realism (naturalness) and aesthetics. The result is typically heard in the control room via loudspeakers.

For some time now, a completely different recording method has been available to sound engineers: Dummy Head stereophony. In contrast to loudspeaker stereophony which strives for acceptable reproduction of acoustic events in the listening room, dummy head stereophony creates the illusion that the listener is in the recording room.

Loudspeaker and dummy head stereophony are completely disparate methods of sound transmission, which can be used alternatively. However, there are problems of compatibility.

1) **Technical Compatibility**
The complicated polar pattern of the microphone termed the "dummy head" is very different from that of more familiar microphones. Therefore, to avoid coloration errors in loudspeaker reproduction, the studio Dummy Head KU 81, which has been specially developed for radio broadcasting purposes, is provided with "diffuse-field equalization". In the same way, on the reproduction side, the corresponding diffuse-field equalization of the headphone is optimally adapted for the reproduction of the loudspeaker stereophony signals. The result of all this is that the diffuse-field equalization on both the recording and reproduction side achieves technical compatibility; more detailed reference to this will be made in this contribution.

2) **Artistic Compatibility**
Unaffected by the solution of the technical compatibility problem are questions relating to "artistic compatibility", which arise when a dummy head production is heard via a loudspeaker or a loudspeaker production is heard via a headphone. For example, there are questions about the positioning of the dummy head (a dummy head position which might be ideal for dummy head stereophony is mostly not optimum for the position of the microphone for loudspeaker stereophony).
There are also problems of modulation, backup technique, reverberation balance, the effect of reflections and extraneous noises in the recording studios, etc.
Conversely, in the headphone reproduction of loudspeaker stereophony recordings, the in-the-head orientation leads to large perceptual changes, for instance concerning depth gradations, and the original reflections are no longer present. Problems of this nature are purposely ignored in this contribution.

The problems associated with technical compatibility are considered in greater detail and illustrated in Fig. 1.

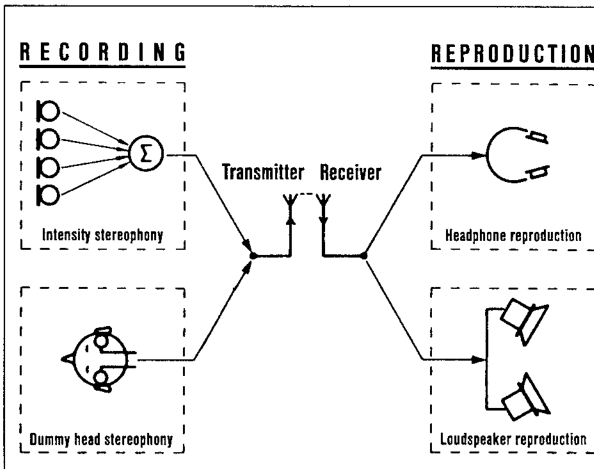


Fig. 1: Compatibility scheme

On both the recording and reproduction side, there are a space-related system and a head-related system (definitions of these terms, see [1]).
The diagonal methods "loudspeaker stereophony - loudspeaker reproduction" (space-related method) and "dummy head stereophony - headphone reproduction" (head-related method) are compatible by definition. The method of equalization at the interface recording/reproduction is in principle a matter of choice.

Incompatible by contrast are the methods "loudspeaker stereophony - headphone reproduction" and - equally so - "dummy head stereophony - loudspeaker reproduction". In either case, the recording/reproduction chain is a composite of space-related and head-related methods. Incompatibility [1] derives from the association model in general; it results from an adaptive processing of the signal received by the ear in the orientation stage of the hearing sense.

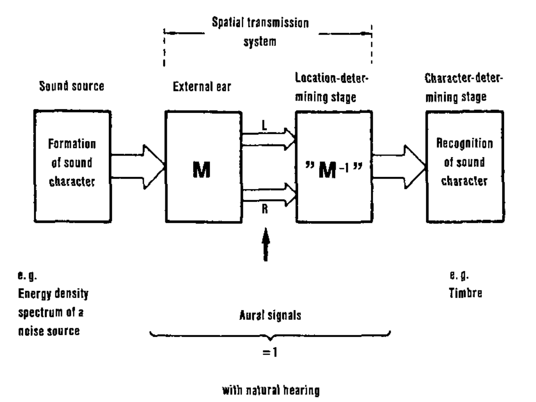


Fig. 2: How the ear functions with natural hearing

Fig. 2 depicts the function of the hearing sense with normal hearing.

The signals received by the ear are influenced by the effects of the head and the pinnae in the sound field. This happens in a way which is dependent solely on the location of the sound source.
In the model, this influence is represented as the encoding of spatial information *M*. In the orientation stage, the spatial information *M* is "recognized" by the development of cross- and auto-correlations and comparison of the actual correlation pattern with memorized patterns [2]. This is followed by spatial decoding with the aid of an adaptive filter "M^{-1}".
Consequently, the signals are "freed" again from the characteristics of the sound source by the effect of the orientation stage . They are only then forwarded to the higher-placed "character-determining" stage, the directional and distance information obtained by this process being separately rerouted.

The timbre is relevant for the determination of optimum equalization for head-related systems. If the above mentioned mode of operation is applied to the shaping of the timbre, a phenomenon which we take for granted but is nevertheless astounding, finds its explanation: The angle of incidence of a sound source is altered by rotating the head. The spectra of the aural signal are caused to change according to the directional characteristics of the ear. However, the listener does not perceive this spectral change as an alteration of the timbre. The sense of hearing offsets the changes in the aural signal against changes in the direction of the aural event.

The effect of the directional characteristics of the external ear on the spectra of the aural signals has no influence on the timbre, because the location-dependent filter "M^{-1}" comes into play ("timbre invariance" [3]) before the hearing sense defines the timbre. Thus it is not the stimulation of the timpani which determines the timbre; it is the sense of hearing which "identifies the timbre and the location of the sound source".

This elementary property of the sense of hearing is represented in the model by the product $M \times M^{-1} = 1$. The spatial transmission system does not influence the timbre of the aural event as far as the spatial information *M* can be interpreted by the hearing sense. This is the case with natural hearing.

If the transmission cases "loudspeaker stereophony - headphone reproduction" and "dummy head stereophony - loudspeaker reproduction" are analyzed from this standpoint (Fig. 1), it is shown that:

- Spatial information *M* is not present in the headphone reproduction of space-related signals.
- The spatial information *M* contained in the dummy head signal cannot be interpreted by the sense of hearing through loudspeaker reproduction.

In either case, timbre problems arise because the location-determining stage interprets the wrong spatial features or none at all. The spectral features of the aural signal generated by the dummy head or headphone arrive without any "offsetting" at the character-determining stage of the hearing sense, and consequently affect the timbre.

It can be derived in general from [1] that for the equalization of dummy heads and headphones it is not permissible to lay down a single reference direction; the basis must be the integral of all the transmission functions of the external ear as a "neutral reference", to ensure a minimum of timbre falsifications.
In terms of measurement technique, this means that it is not any definite free-field sensitivity which must show a flat frequency response, but the diffuse-field sensitivity of dummy heads and headphones.

2. Reproduction of Dummy Head Recordings via Loudspeaker

Fig. 3 depicts the function of the ear when the electroacoustic transmission takes place via dummy head and loudspeaker.
The orientation stage recognizes the location of the two loudspeakers via the effect of the external ear ($M \cdot M^{-1} = 1$).
Depending on the correlation of the loudspeaker signals, phantom sound sources are constructed [2].

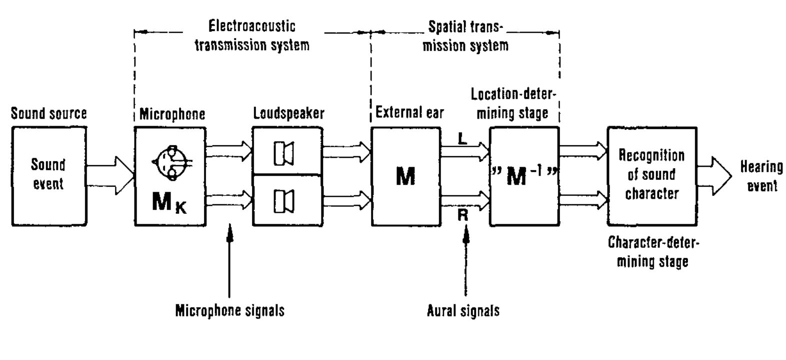


Fig. 3: How the ear functions with loudspeaker reproduction of head-related signals

The spectral features of dummy head signals do not function here as orientation features; they merely influence the timbre of the phantom sound source. The diffuse-field equalization of the dummy head results in the influence of the directional characteristic on the timbre being held to a minimum: The sum of all direction-specific linear distortions is equalized.

The Practical Significance of Diffuse-field Equalization

Therefore, with loudspeaker reproduction, the dummy head has the effect of a normal stereo microphone. *It is imperative for equalization of the dummy head to approach it as a standard studio microphone.*

The following aspects lend a special significance to diffuse-field equalization:

Sometimes the recording is made in a concert hall or studio with a relatively long reverberation time. Then, not only the free-field frequency response of the microphone determines the sound image or timbre, but also the diffuse-field frequency response. This is true even with a relatively short distance between microphone and sound source. This is based on wide experience in microphone practice:

1. Studio microphones are required to have a free-field and diffuse-field sensitivity which is almost independent of frequency.
   This is not possible with microphones which function as pure pressure transducers (spherical polar pattern); the free-field and diffuse-field frequency responses seldom coincide, as is well known. Here, the significance of the diffuse-field sensitivity is considered by making the response as flat as possible and accepting in exchange an increase in free-field sensitivity at high frequencies. (See Fig. 4).

   (This of course does not apply to special microphones which are used predominantly for close-proximity work or are required to produce some "special" sound).

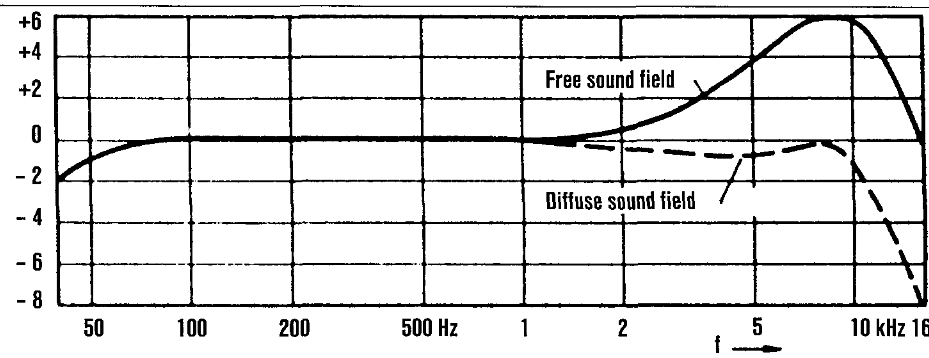


Fig. 4:

Transmission parameters of a pressure microphone

2. Usually, microphones are preferred with a flat diffuse-field response if the microphone is stationed in the diffuse field. Especially for the dummy head, where the distance from the sound source is greater in practice than that in polymicrophony, a flat diffuse-field response is the decisive criterion if a loudspeaker reproduction is to be achieved which does justice to the timbre.

Fig. 5 depicts the diffuse-field sensitivity of several studio microphones. More over, the diffuse-field sensitivity of the Neumann dummy head KU 81 and that of a dummy head developed by the Institute of Electrical Communications (IENT) at the TH Aachen for experimental purposes [4].

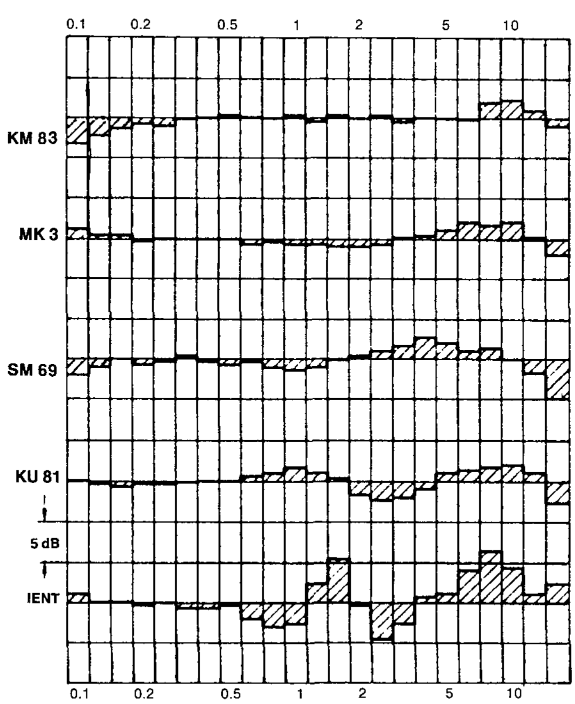


Fig. 5: Diffuse-field sensitivities of omnidirectional microphones and dummy heads

Unlike the radio broadcasting dummy head KU 81 with diffuse-field equalization, the IENT dummy head has free-field equalization which results in a correspondingly poor diffuse-field sensitivity (Fig. 5). This dummy head was compared with the KU 81 and with other microphones as shown in Fig. 5. It produced a sound image which in listening tests was rejected by almost all sound engineers and knowledgeable listeners.
Because the directional characteristics of both heads are very similar [5], the cause for the rejection of the IENT dummy head must be due to its different diffuse-field sensitivity.

Neither does the KU 81 show a perfectly flat diffuse-field response (Fig. 5).
True, a slight trough in the 1 kHz region (approx. 3 dB) may sometimes cause some improvement of the timbre, but this correction is not desirable in all recordings.

To compare the timbre of the various microphone types, appropriate recordings were made in three concert halls (Alte Oper - Frankfurt, Herkulessaal - Munich, Grosser Sendesaal - SFB, Berlin). The signals of various microphones were recorded in parallel on a multitrack machine (16-track-telcom and/or 24-track-digital) to serve as test material for the formulation of various questions.

No special listening tests to evaluate this voluminous material for sound image or "timbre" have yet been carried out. However, it could already be established that especially deviations from the microphone diffuse-field sensitivity alter the character of a musical performance.

It is well known that the frequency of the reverberation time [6] characterizes to a large extent the sound impression obtained in a concert hall. A doubling of the reverberation time raises the energy density level by 4 dB (constant room volume assumed). A specific frequency-dependent curve of the reverberation time in the region of T = 1...3 s thus results in a specific sound character; the spectrum of the indirect sound component corresponds here to the curve of the reverberation time in the region of $\pm$ 2 dB. No precise analysis in this respect has yet been made, especially concerning the significance of diffuse-field sensitivity. At this stage, it can be said:

- Up to the present there have been no investigations of the extent to which the indirect sound component in comparison with the direct sound component determines timbre.
  Experience gained with omnidirectional microphones, the Jecklin disc and the KU 81 show that the diffuse-field component - at least with serious music recordings - dominates. This is especially shown by the listening comparison of the IENT dummy head with free-field equalization and the KU 81 with diffuse-field equalization.

- The diffuse-field response should be as flat as possible when high-fidelity reproduction of the sound image characteristic of the recording venue is wished. Slight deviations of $\pm$ 2 dB may have a falsifying effect, but can be tolerated, varying as they do within the framework of diverse energy density spectra of different concert halls. Tonal inadequacies of the recording room are enabled within this framework to be compensated or amplified as required.

3. Headphone Reproduction of Space-related Recordings

Fig. 6 illustrates the function of the ear when the electroacoustic transmission occurs with standard space-related techniques and reproduced via headphones.

The orientation stage is not able to recognize spatial features *M*, as the directional characteristics of the external ear are nullified by putting on the headphones. Neither do the microphone signals deliver any spatial ear signal features, not being dummy

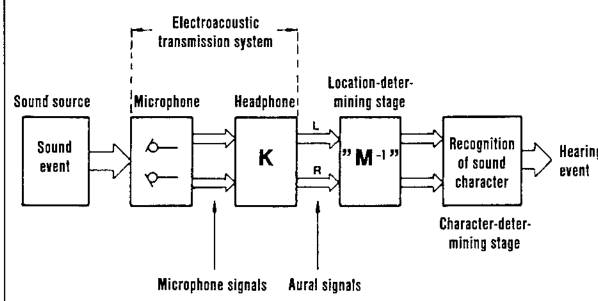


Fig. 6: How the ear functions with headphone reproduction of space-related signals

head signals. The location-dependent transmission function *M* is superseded by the location-independent headphone transmission function *K*.

What frequency response must *K* have to avoid tonal falsification?

The notion of "free-field equalization" appears to be formally correct: If the headphones are equalized in such a manner that they duplicate the free-field sensitivity function M_O (frontal sound incidence), then "M^{-1}" can adapt to M_O; we then have $M_O \cdot M^{-1} = 1$, i.e. the microphone signal reaches the character-determining stage without any linear distortion.
However, this can be successful with a mono signal only if the free-field equalization of the headphones $K = M_O$ is performed individually and precisely [7]. $M_O \cdot M^{-1} = 1$ applies only if the aural event occurs at the point of reference of the equalization (2 meters in front of the listener's head). No adequately precise equalization for mass-production headphones is feasible.

For stereophonic signals, free-field equalization is also from the theoretical point of view wrong. The "external ear substitute" $K = M_O$ interprets all the components of space-related signals equally. This behaviour is independent of the location of the sound sources participating in the recording and independent of ΔL and Δt of the microphone signals. A sound source in the recording room thus generates audio signals via headphone reproduction which contain no natural spatial features. Therefore, the orientation stage "recognizes" nothing more than the two headphone capsules at the left and right ears. This is easily confirmed by the in-head orientation: The stereophonic sound image is characterized by "phantom sound sources in the head" [2] - we have $M^{-1} = 1$.

What the above means is that the spectral features of the aural signals delivered by free-field equalized headphones take effect not in the orientation stage, but in the character-determining stage.
Here it is $M_O \cdot M^{-1} = M_O$; the filtering effect inversely to M_O does not occur, and timbre falsification occurs due to M_O.
A free-field equalized headphone causes "linear distortion".

Linear Distortion with Headphone Reproduction

Obviously timbre falsifications can be avoided only if the equalization of the headphone is $K = 1$. Only in this way can distortion-free transmission $K \cdot M^{-1} = 1$ be achieved. It is the aim to show in the following that this condition is also physically definable.

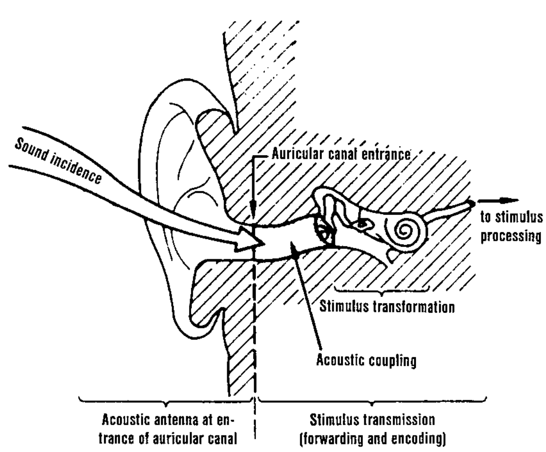


Fig. 7a: The ear in the sound field

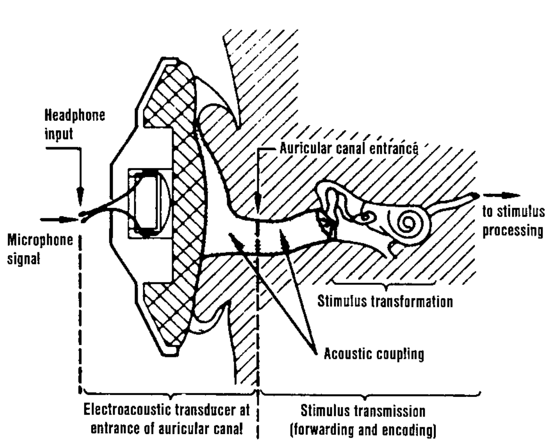


Fig. 7b: The ear with headphone reproduction

First let us clarify a few terms with the aid of the drawings in Fig. 7. If the ear is within the field of sound (Fig. 7a), the external ear (trunk, head and pinna) functions as an acoustic antenna. On reception, the signal achieves transmission by stimulus via the auricular canal entrance, which has the effect of a coupler. This constellation is not altered if, in place of the acoustic antenna, the headphone acts on the auricular canal entrance by way of an acoustic coupling.
The transmission function *K* of the headphone is defined by the signal relationship between auricular canal input and headphone input.

Formally, the linear distortions caused by the headphone are therefore also defined; these are present when $K \neq 1$. Linear distortions in headphone reproduction can thus be theoretically measured in the same way as distortions occurring in an amplifier wired in front of the headphone.

However, practical difficulties arise here for two reasons:

a) The auricular canal entrance is not anatomically definable with any accuracy.
b) The measuring probe cannot be placed at the auricular canal entrance without any reactive effect.

It is possible to avoid these difficulties (cp Figs 8a, 8b).

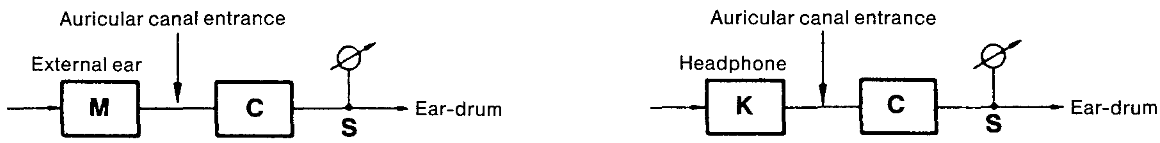
The auricular canal entrance is defined physically and not anatomically (Fig. 8a). For every sound incidence direction Ω, the transmission function is measured in the auricular canal up to the measuring point *S*. It is composed of the direction-specific component $M(\Omega)$ and the constant component *C*.
In the case of an infinit number of sound incidence directions (in the diffuse field), the direction-specific component $M(\Omega)$ shifts toward 1.

In the case of sound received by headphone (Fig. 8b), *C* is just as large as in the sound field (Fig. 8a) when measurements are made at the same point *S* of the auricular canal. Therefore $K = M$ when the measured transmission functions $M \cdot C$ and $K \cdot C$ coincide.

If $M \cdot C$ and $K \cdot C$ coincide in the diffuse field, $K \to 1$ because $M \to 1$. This means: if the headphone transmission function, measured at any point of the auricular canal, is the same as the diffuse-field trans-

Fig. 8a

Fig. 8b



M = M (Ω) : Transmission function of external ear

C = const : Transmission function of auricular canal entrance - measuring point S

K = const : Transmission function of headphone

C = const : Transmission function of auricular canal entrance - measuring point S

Fig. 8: Equivalent circuit diagram for the measurement of trasmission functions

mission function of the ear, measured at the same point in the auricular canal, the headphone sensitivity is frequency-dependent.

Thus, linear distortions in headphone reproduction are physically defined as a deviation of the headphone sensitivity from the external ear sensitivity in the diffuse sound field. Linear distortions in headphone reproduction are therefore physically measurable, for instance: according to the IRT submission DIN 45 619, Part 3 (Special Measurements) [8]. Detailed substantiation is presented in [3] and [9] why volume comparison measurements are unsuitable.

Practical Significance of Diffuse-field Equalization

Various quality assessment tests have confirmed that a flat diffuse-field sensitivity curve of a headphone is a guarantee of optimum sound neutrality.

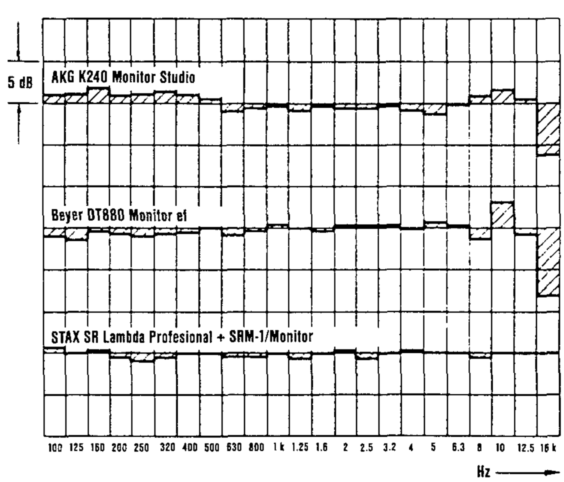


Fig. 9: Diffuse-field sensitivities of three headphones with IRT equalization

Headphones with exact IRT equalization are now being manufactured by various companies.

Fig. 6 shows three examples of these new headphones. Deviations are of similar magnitude to the diffuse-field sensitivity of studio microphones (cp also Fig. 5).

Studio microphones (including the KU 81) and studio headphones form a virtually distortion-free transmission path. Thus the necessary conditions have been created to make headphone reproduction uniform and neutral in timbre, both in the sound studio and in the ears of the listener. This applies equally to the reproduction of conventional (space-related) recordings and to dummy head recordings.

For the sound engineer, headphone reproduction is not only significant for dummy head productions, but also for the listener who makes use either of headphones for critical listening to obtain extra-high fidelity of reproduction at effordable cost. He can easily assess the quality of sound recordings with a very high standard of accuracy.

It has been revealed that various shortcomings in the quality of recordings can be more clearly detected with headphone reproduction than with loudspeaker reproduction. For example, a listening test showed that the s/n ratio necessary for "noiselessness" was 10 dB greater with headphone reproduction than with loudspeaker at "equivalent" volume.

Similar observations have been made with respect to quality impairment by extraneous studio noises, tape splices and nonlinear distortion. The same is true for clicks (caused by bit errors or overmodulation in digital recordings), quantizising errors (audible in cases of undermodulation) and so on. With the headphone, the listener has at his disposal a monitoring device which, concerning important quality parameters, can be more sensitive than the control loudspeaker.

For the judgement of specific quality parameters (timbre, dynamics, extraneous noises, etc.), headphones are in principle more suitable in the sound studio than loudspeakers. The IRT has therefore caused an appropriate amendment of the CCIR Recommendation 562. This was desirable, as it now makes a suitable form of standardization for studio headphones possible.

Especially for the assessment of timbre, the standardization of headphones appears to have value. Since the properties of the control room play no part, standardization can be achieved at little cost and great precision by maintenance of a flat diffuse-field response. Linear distortion is then eliminated.

4. Summary

Intimately associated with the advanced development of head-related stereophony, theoretical ideas on the function of the ear regarding spatial hearing began to be expanded some three years ago.

With the aid of a simple model, the optimum equalization of the interface between the recording and the reproduction side was made subject to a general definition: When head-related signals via loudspeaker or space-related signals via headphones are listened to, the integral of all external ear transmission functions must be adopted as the basis, to avoid timbre errors (coloration). Therefore, a form of equalization between the recording and reproduction side was proposed as a "universal interface", with reference as a matter of principal to the diffuse field.

This so-called diffuse-field equalization has been the standard equalization for studio microphones for a long time. It is also applied with an adequate degree of accuracy to the studio dummy head KU 81, so that its tonal results are comparable with those achieved with standard studio microphones.

A further advantage for headphone reproduction is the fact that linear distortions (independently of the recording method) are physically definable and measurable. Divers practical quality assessment tests have confirmed that headphones cause no linear distortions only when they exhibit a flat diffuse-field response, measured according to the IRT Submission DIN 45 619, Part 3 (Feb. 83).

Meanwhile, headphones with precise IRT diffuse-field equalization have been offered by various manufacturers. As a result, headphone reproduction can occur in standardized form and without linear distortion, both in the sound studio and in the listener's home. This applies equally to the reproduction of normal stereo recordings and the reproduction of dummy head recordings.

As opposed to the present norms, IRT diffuse-field equalization is a guarantee of perfect tonal neutrality, and thus enables exacting tolerances to be applied. It is recommended for the standardization of studio headphones.

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Comparison between two Dummy Head Systems with Due Regard to Different Fields of Application

by G. Theile and G. Spikofski, IRT Munich

1. Two New Dummy Head Systems

Some three years ago, two new dummy head systems were introduced:

- The KU 81 (Neumann), developed for dummy head stereophony in radio broadcasting at the Institut für Rundfunktechnik (Institute for Radio Technology (IRT)) in Munich in collaboration with the Institut für Allgemeine Elektrotechnik und Akustik (Institute for General Electrical Engineering and Acoustics) of the Ruhruniversität Bochum [1], [2], [3], [4].

- The IENT Dummy Head developed for acoustical experiments at the Institut für Elektrische Nachrichtentechnik (Institute for Electrical Communications Engineering (IENT)) of the TH in Aachen [5], [6].

Both heads use a precise duplication of the outer geometry of the external ear. This was accomplished in both cases by measurements of the directional part of the transmission functions of the external ear or pinna on test persons. The "typical" test person was ascertained by special structure averaging methods.

Both heads made use of the fact that the influence of eardrum impedance on the directional characteristic is negligible [7]. Therefore, the coupling of the external ear to the microphone can be optimized with regard to equalization and signal-to-noise ratio [3], [5].

The two dummy heads differ in two respects:

1. In contrast to the IENT head, the KU 81 does not include a replica of the chest and shoulders. This results in disparate directional characteristics, especially in the frequency range below 2.5 kHz.

2. The KU 81 has diffuse-field equalization. Appropriate one-third octave measurements reveal a flat diffuse-field response within ± 2.5 dB. The IENT has free-field equalization. One-third octave measurements show a flat free-field response within ± 2 dB (at 8 kHz: – 4 dB).

2. Comparison of Image Definition

A comparison of image definition is interesting not only for scientific reasons, but also with regard to the wide range of practical possibilities of use of dummy head systems.
A number of different listening comparisons were conducted:

- The dummy heads were placed side-by-side during the test recordings (spaced at 0.7 m).

- An analog recording was made with the telcom c4 Compander.

- The monitoring headphones were the "STAX SR Lambda professional", the equalization of which was switched to suit the dummy head. Specific details of the diffuse-field and free-field equalization realized will be found in [8].

- The listening level was identical for both systems.

- Each listening test was performed symmetrically, i.e. system-related errors arising from the head positioning, sequence of signal presentation, etc. have the same effect on both dummy heads.

- At least 26 persons participated in each listening test.

2.1 Listening Test One (Localization)

Execution:

A speaker addresses the dummy head from various directions. Direction change is stochastic in steps of 30°. The test person assigns to each direction distinguished a "time" on an imaginary clock dial round the dummy head, counting only "full hours". Previously, the speaker had announced the 12 various directions by defining the corresponding "time".
Assessments are made for two recordings - one in the open at a distance of seven meters between dummy heads and speaker.

Results:

The relative frequency of correct assessments is shown in Fig. 1. The average is exactly 45% for both heads.

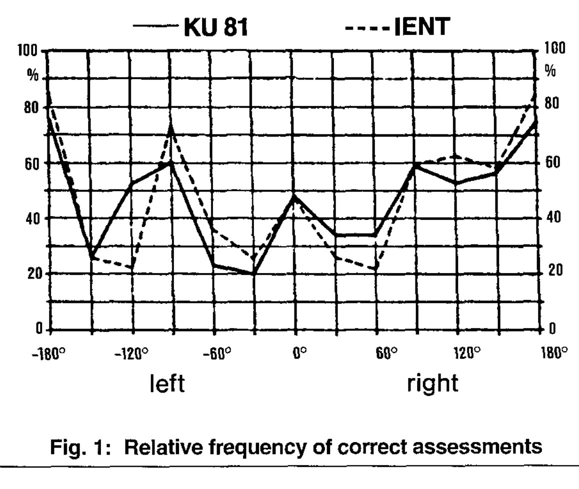

Fig. 1: Relative frequency of correct assessments

There are some slight differences in the relative frequency of distance inversions (i.e. front-to-back reversals), Fig. 2.

The average is 16% for the IENT and 20% for the KU 81.

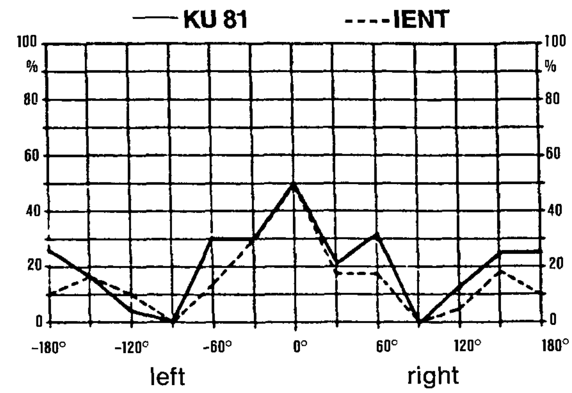

Fig. 2: Relative frequency of direction inversions

Front sound location is equally difficult with both heads, but rear sound location is less of a problem with the IENT system.
On the other hand, it can be concluded from the comparison of data in Figs. 1 and 2 that other image-forming errors occur less with the KU 81 than with the IENT head (35% against 39%).

Fig. 3 shows the directional relationship between sound event and hearing event. The curves are plotted without incorporating the assessments with direction inversion. Standard deviations are also

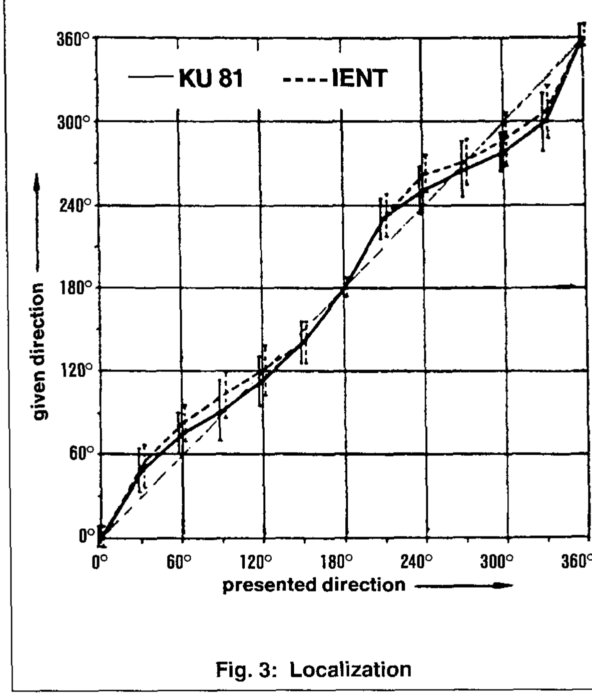

Fig. 3: Localization

shown. Both systems tend to displace the direction of the hearing event toward the frontal plane (axis 90° - 270°), both for the front and rear direction of the sound event.
The curves however show that both dummy head systems have good properties concerning the image formation.

2.2 Listening Test Two (Spatial Image Formation)

Execution:

Comparative assessments of spatial image formation are submitted in seven different recording instances.
Each example contains the test signal sequence A-B-A-B; the signals A and B are assigned variously to the two dummy head systems.

Fig. 4 shows the assessment aspects; they have been previously explained in detail. All examples are speech recordings in the open and in various rooms, and are specially selected for the assessment of individual aspects.

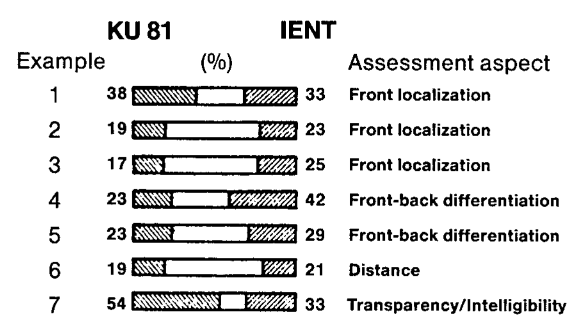

Fig. 4: Assessment aspect: "Localization"

Results:

Fig. 4 illustrates the relative frequency of preferences. The length of the central portion of the bar reflects the frequency of the replies "no difference". For the assessment aspect "front localization", the result is virtual parity (KU 81: 25%, IENT: 27%).
As expected and shown in Fig. 2, the front-to-back differentiation results in advantages for the IENT system (KU 81: 23%, IENT: 35%). As opposed to this, a babble of speech was received with obviously better transparency with the KU 81 recording, as illustrated in Fig. 7.

2.3 Listening Test Three (Timbre)

Execution:

In 8 different recording examples, comparative quality grades are awarded concerning naturalness of timbre.
Points are given on a scale between – 3 (A clearly more natural than B) and +3 (B clearly more natural than A).

During each example, switching between A and B was performed in a fixed 5-second cycle.

The assignment of the dummy heads to the test signals A and B was changed stochastically between examples. Examples 1 to 4 were speech and noise recordings, examples 5 to 8 were of music recorded in Frankfurt's Alte Oper (position of dummy heads: 4th row of stalls, middle, height three meters).

Results:

The results are shown in Fig. 5. The timbre is clearly more natural when the KU 81 is in use.

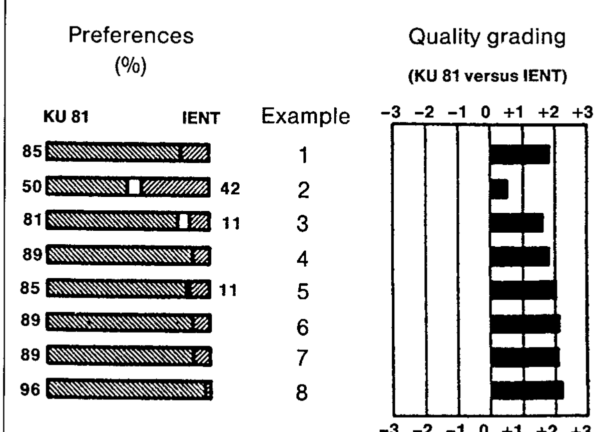

Fig. 5: Assessment aspect: "Naturalness of timbre"

Except for Example 2 ("key chain"), preference for the KU 81 lies at over 80%, and for the music recordings it averages 90%.

In the quality scale, the KU 81 rates at + 2.1 over the IENT head for music recordings.

If only the findings of the 10 experts are evaluated (sound engineers, hi-fi specialists), the results are even more conclusive.

3. Conclusions

The spatial image-forming properties of both dummy head systems are comparable. The reproduction of timbre, on the other hand, contains errors with the IENT dummy head.
The cause of discoloration is assumed to be linear distortion occuring in the transmission path from dummy head to headphone. The measured free-field response of the IENT dummy head proves that the dummy head system was correctly equalized (cp Part 1). Very probably the free-field equalization of the headphone has been erroneously determined.

An additional listening test shows conclusively that the headphone equalized according to [5], [6] is not compatible with the free-field equalized dummy head: If the test person is asked to choose the optimum headphone equalization (choice of diffuse-field, free-field and STAX original equalization, cp [8]), free-field equalization is rejected for the IENT head (10 test persons, recording examples 5 to 8 in Part 2.3): only 6% of evaluations were in favor of "free-field" (as opposed to 92% of preferences in favor of "diffuse-field" with KU 81 recordings).
This gives rise to questions which cannot be answered without knowledge of the headphone measuring technique used to determine the free-field equalization of the STAX SR Lambda. No precise information is available on this subject yet.

A discussion of system properties does not therefore seem meaningful at this point. First, the reason for the discoloration caused by the IENT dummy head system must be analyzed.

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The Dummy Head during recording natural sounds

Investigations into Optimum Headphone Equalization (Extract)

by G. Theile, IRT Munich

4. Quality Assessment of Headphones

4.1 Determination of Sensitivity

DIN 45 619, Page 1 [6] prescribes that the free-field sensitivity of headphones is to be determined "by volume comparison, with a progressive sound wave".

This method was introduced under the assumption that "a similar sound impression" [1] to that of loudspeaker reproduction would be achieved.

This method does not consider the design of the headphone and assumes that the headphone generates the same loudness for each one-third octave [14]. This assumption appears plausible. It is, however, called into question by the following:

1. If a headphone actually duplicated the transmission function from loudspeaker to auricular canal, the sound impression would be just as bad as if the loudspeaker were in an anechoic chamber. This applies also when based on the reference "loudspeakers in stereo arrangement" (LSE method [15]).
   The reference "loudspeakers in living room" would be far more favorable for determining the transmission function.

   The transmission function contains many parameters that are very difficult to define, but the intention "loudspeaker-simulating sound image" would be far better realized.
   However, it would only be logical if the measurement and duplication of the extremely complex transmission function loudspeaker/room/auricular canal could be done so precisely that outside-the-head localization would occur.
   Otherwise the reference "loudspeakers in the living room" would lead to particularly unfavorable results.

   Understandably neither the probe measurements on headphones (in free field), so often referred to in literature, nor the exact duplication of the special transmission functions have been taken up by headphone manufacturers to improve headphones.

2. It is undesirable to equalize the headphone with the aid of probe measurements when the sound field to which reference is made in the equalization process enables the listener to localize the sound source(s).

   If it is done, the headphone equalized in this way must provide the same localization to function without coloration of the timbre.

   Localization is practically eliminated in the diffuse sound field, so that probe measurements may be taken as reference here.

3. If loudness measurements are taken as reference according to DIN 45 619, different measurements

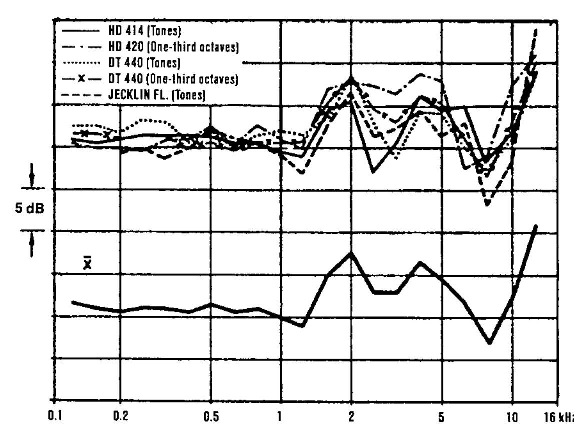

Fig. 3: Differences von headphones free-field responses (loudness versus probe measurements)

are obtained compared to corresponding probe measurements. Fig. 3 shows several differences in the free-field sensitivity of various headphones (loudness minus probe measurements, from literature figures and own results), and below them the average difference. Especially in the middle frequency range, either the loudness measurement delivers figures that are too high or the probe measurement figures are too low.

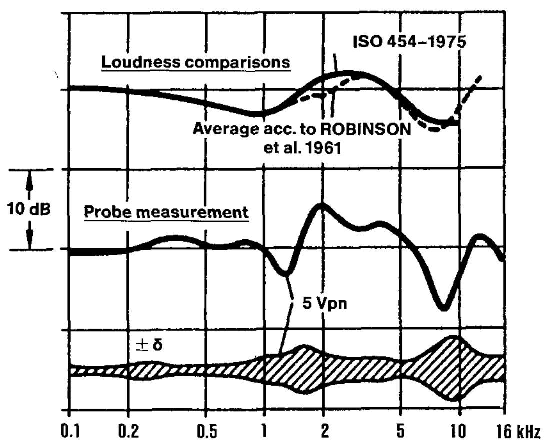

Fig. 4: Directivity index of external ear (loudness and probe measurement)

4. If the diffuse field is taken as reference for the free field (frontal sound incidence), the result is a specific difference in the response.

   Fig. 4 shows the "directivity index" of the external ear, i.e. the difference 0°-free-field minus diffuse-field response ("diffuse-field-related free-field sensitivity" [15], front DFF).

   The front DFF was measured on five test persons with the probe. For comparison, the average curve from loudness measurements [16] plus the figures in the ISD 454 [17] were used.

   In principle the front DFF is suitable for converting the free-field matching of a headphone to the diffuse-field matching and vice versa.

5. Fig. 4 presents a similar curve outline to that in Fig. 3. The free-field response of a headphone determined according to DIN 45 619, Page 1, displays a relatively slight difference from the diffuse-field response as measured with the probe. This circumstance coincides with the experience gained during this investigation.

Net result: The diffuse field is the optimum reference for headphone equalization when probe measurements are taken as reference. If the free field is taken as reference, the result with probe measurements is a headphone which causes linear distortion corresponding to the inverse front DFF curve (Fig. 4). It is true, however, that this fault is smaller when a loudness measurement is the reference. The reason for this has not been more closely examined.

4.2 Measurements on Headphones

The free-field and diffuse-field response was measured on seven headphones of various design. This was performed with the aid of a typical test person [15]. The results are summarized in Fig. 5. Analogously to dummy head equalization [3], one-third octaves were used because a narrower-band measurement is likely to bring forth disadvantages and one-third octave frequency responses are quite adequate for the assessment of linear distortion [3].

The results are summarized in Fig. 5. They show first - as expected - that all headphones are better diffuse-field matched than free-field matched. Also the headphones display a quite widely differing degree of equalization. A recognized high quality head- phone, the STAX SR-Lambda, is already particularly well diffuse-field matched.

4.3 Listening Test

To test whether diffuse-field equalization provides optimum timbre neutrality with headphones as it does with dummy heads, all seven headphones were both free-field- and diffuse-field-matched. This was accomplished via suitable filters according to the measured data in Fig. 5.

In the listening test, the test persons could choose between headphones with free-field, diffuse-field and no equalization at all. In any one session, only one of the headphones was used.

The test material was carefully selected in preliminary tests; it consisted of the categories "Orchestra", "Jazz" 1 and 2, "Pop" and "Speech". For the category "Orchestra", five examples were presented, these being the same extracts from five different recordings of an orchestral piece.

The recordings were made by various sound engineers during the past 20 years. Thus, there was no

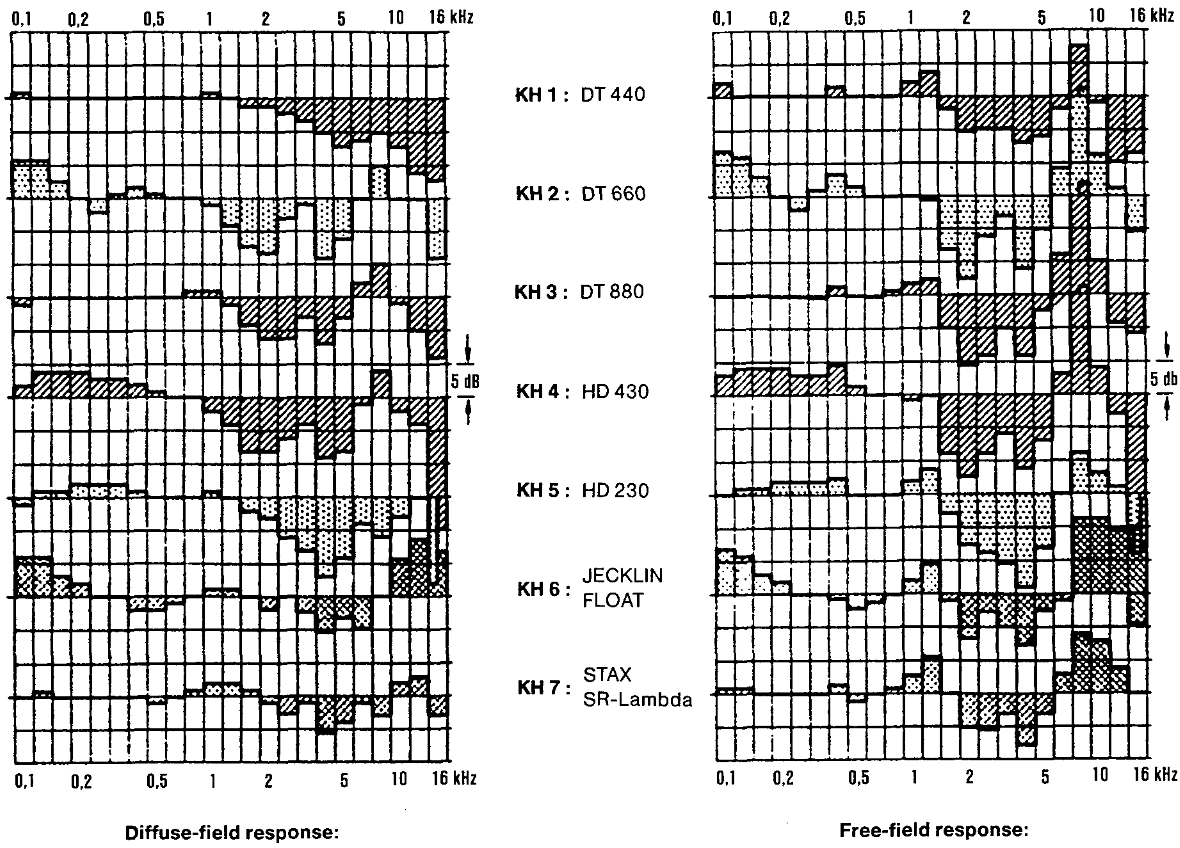

Fig. 5: Frequency responses of headphones (probe measurements on typical ear)

chance that any special sound image preferred by any particular sound engineer could have any effect on the result. Twenty-four persons participated in the listening test, mostly broadcast technicians (including four sound engineers) and test persons practiced in the assessment of transmission quality.

For each headphone and for each test example it was noted which of the three sound images (one out of three possible equalizations) was preferred concerning the assessment criteria "natural" and "pleasant". These assessment aspects have proven to be especially significant in various quality tests of loudspeakers and headphones.

The results are shown in Fig. 6, in which the average values and confidence intervals of the nine programme examples regarding preferences for more "natural" and/or "pleasant" are entered.

It can be seen that diffuse-field matching was significantly preferred in the case of all headphones. Only in the assessment aspect "pleasant" was the significance for the headphones 2, 7 and 3 of a lower order. Frequencies vary, depending on the original response of the various headphones. Particularly slight is the spacing of the assessment between headphone 7 (STAX SR-Lambda) without correction and that with diffuse-field matching.

This conforms with the good coincidence of the original response and the optimum diffuse-field response (cp Fig. 5).

The diffuse-field responses were preferred significantly over the free-field responses, but only slightly more than the corresponding original responses. Particularly in the case of headphones 4 (HD 430) and 1 (DT 440).

In summary, the diffuse-field matching is a guarantee of particularly natural reproduction. However, this does not imply pleasing sound image results via the headphones 2, 7 and 3; obviously the manufacturer here has succeeded in realizing a sound which is well suited to the taste of listeners and to a certain

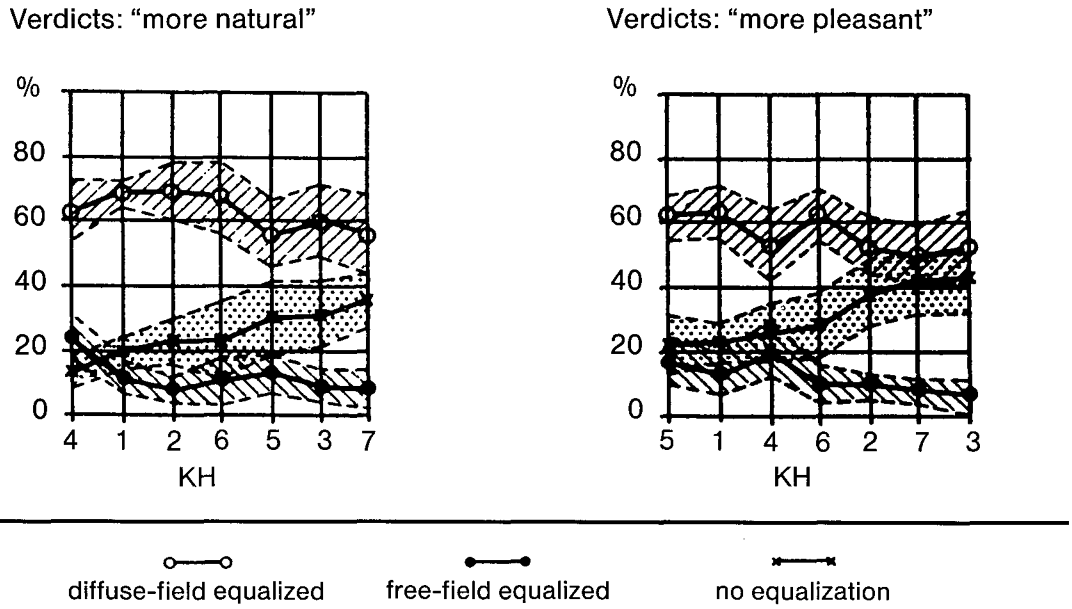

Fig. 6: Headphone assessment, overall results, see text

kind of programme material. A deeper analysis shows that this applies predominantly to the programme examples "Jazz" and "Pop".

In conclusion, the sounds of the various uniformly diffuse-field-equalized headphones differ only very slightly. The tolerance field of a standardization prescribes probe measurements on the external ear and a diffuse-field equalization. It can be considerably narrower than in the case of the present-day standard DIN 45 500 [11].

It is not necessary to measure the diffuse-field response in a reverberation chamber - the free-field response can continue to be determined in the usual way, although only with probe measurements. This can easily be converted to the diffuse-field response with the aid of the front DFF introduced in the foregoing .

Special thanks are due to Herr Dipl.-Ing. Spikofski for many useful suggestions and for undertaking the measurements and listening tests.

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Head-related Stereophony

New Knowledge Gained in Productions and Reception

by Hans W. Steickart, Audio Electronic, Düsseldorf

Recording Aesthetics

1. Space-related Stereophony

Space-related stereophony is intended to provide the listener with the best possible hearing experience [1] in his living room by means of electroacoustic transmission. To accomplish this in practice is difficult. On the one hand, microphones were placed close to the sound source; on the other hand many individual microphones were used to obtain a "transparent" and "direct" representation of the musical score [2].
The original room is to a large extent eliminated, since the listener, when listening via loudspeakers in his living room also hears the spatial elements of the room in which reproduction takes place. An increase in contrast - made apparently necessary by the absence of visual clues - was created. The loudspeaker is the representative of the sound source [3].

The resulting shortcomings are as follows:

a. Dynamic restriction.
   With loudspeaker reproduction in normal living rooms, the restriction of dynamics might appear to be even desirable, because

b. reproduction at the original loudness level is not possible, and the "otophysiological" volume level adjustment results in further disadvantages [3].

c. The directional characteristics of sound sources are lost.

d. There is a superimposition of the original room on the reproduction room, whereby in "normal" stereophony the original room remains restricted to the front part of the reproduction room.

e. A different sound is heard in different rooms, even if the same loudspeakers are used. This makes any qualitative comparability and the international exchange of programs difficult.

2. Head-related Stereophony

For the true-to-life reproduction of a real sound event occurring in a real room, it appears obvious that the audio signals must be simulated with two microphones.
And, after transmission, they must be reproduced at the ears of the listener [4].
This is done with the aid of a dummy head, a stylized replica of a human head. It is made of soft plastic material with fully-formed external ears and the recording microphone in the auricular canal.

The Neumann model KU 80 acc. to Kürer/Plenge/Wilkens was originally developed for research purposes, and was publicly introduced for the first time at the 1973 Radio Exhibition in Berlin.

With reproduction via headphones the result is virtually a concert hall experience, as the direction and distance of the body of sound are clearly recognizable, together with the specific sound of the original room.

Radio dramas too are a great success, exploiting the properties of the dummy head with stunning effects.

Reasons for the Failure of the First Generation of Dummy Heads

The first flush of enthusiasm was quickly sobered. Various problems began to arise, and demands for compatibility were not met [1/5/6].

a. The in-the-head localization. The front localization was unsatisfactory in many cases; when hearing events in the median plane, the sound source was perceived as being near the head.

b. An inversion of direction occurred especially in sound sources positioned ±15 degrees in front of the dummy head; these were located behind the head.

c. Elevation, i.e. an apparent elevation of the sound, especially with front sound sources, was a subject of complaint. A possible explanation might be that many people, when they listen attentively, e.g. in the concert hall, unconsciously allow the head to sink. In addition, many recordings are made with the dummy head tilted.

d. The dummy head generated a great deal of inherent noise, together with shortcomings in the high frequency reproduction and distortion at high sound pressure levels.

e. Coloration was audible with loudspeaker reproduction. Since the dummy head is in greater demand by broadcasting authorities than by record companies, loudspeaker compatibility is held to be absolutely necessary.

   There is a basic contradiction in this method. With loudspeaker reproduction, each loudspeaker signal arrives at both ears, whereas with headphone reproduction, the appropriate dummy head signal reaches the corresponding ear without any acoustic interference [1].

   It should be added that it transpired later, in the light of today's knowledge, that wrong equalization was the main source of inadequate loudspeaker compatibility [4/5].

At the time, it was mainly the dummy head recording microphone that was examined. Errors occurred also in the transmission path (noise on broadcasts, clicks and sizzling noises on records), and these assume greater importance in dummy head reproduction, as the listening level is higher with headphones [8].

The salient advantage of dummy head reproduction is also this real perception of the original volume and dynamic range, and thus the correct judgment of distance and magnitude.

Finally, the quality of dynamic headphones at the time (Sennheiser HD 414 and Beyer DT 440) was accepted without any intensive experiments regarding frequency and phase coincidence of the recording and reproducing gear.

New Headphone Generation with Diffuse-field and Free-field Equalization

1. The Aachen Dummy Head

Klaus Genuit presented for the first time at the Sound Engineers' Convention 1981 the IENT dummy head [7/10]. It was based on preliminary studies by the Institute for Electrical Communications of the Technische Hochschule Aachen. These in turn can be traced back to reports on Sound Engineers' Conventions going back as far as 1972 [11/12].

The dummy head was conceived in the first place for noise research and for this reason, among others, it is free-field equalized, to deliver results compatible with calibrated microphones.
In contrast to the Neumann stylized dummy head, it has a precisely calculated typical head form, complete with "hair styling", shoulders and upper body [34/55].

Further possibilities inherent in the system include that of audiometry. In addition, the technical journal AUDIO is using it for several years in conjunction with a correspondingly equalized electrostatic headphone STAX-SR-Lambda Professional as a measuring instrument for headphone tests [19/20].

The current version is being presented during this Sound Engineers' Convention as part of a new products forum.

2. Neumann KU 81 i

The shortcomings of the Neumann KU 80 described above spurred the scientists to create an improved model.
At the same time, easy conversion from the old model to the new was kept in mind [5/9].

Work has been going on since 1979 at the Institute for Broadcasting Technology. They collaborated with the Institute for General Electrical Engineering and Acoustics at the Ruhr-Universität, Bochum to improve transmission properties.

This aim was to be achieved not only in respect of headphone reproduction, but also for loudspeaker reproduction, with regard to a standard of compatibility adequate for radio broadcasting [4/5/21].

An important prerequisite was the recognition that the terminal impedance of the auricular canal is unimportant. At a distance of a few millimeters from the entrance of the auricular canal, no acoustic measure for the correct orientation of the dummy head can do any harm [21]. Therefore, instead of the subjective measurements which had been usual until now, tests could go ahead with probe microphones placed 4 mm inside the auricular canal [22/28/48].

Free-field equalization can only apply to one direction of sound incidence, although it does affect sensitivity for all directions and falsifies them for the dummy head signal [5/9]. Dummy head recordings are made as a rule at some distance from the sound source, in order to be compatible with other microphones for loudspeaker reproduction. Therefore, no preference was given to any specific direction of sound incidence; a diffuse-field equalization integrated in the dummy head was developed.

Theile's association model provided an important theoretical basis [22/27/54]. Simultaneously, the maximum modulation was increased by some 10 dB, and eyelets were fitted to the top side of the head, in order to provide better means of suspension.

3. Comparison of Dummy Heads

Parallel to the development and improvement of the new dummy head generation, there have been many scientific investigations and tests concerning optimum reproduction.

In headphone reproduction, the best results were obtained with electrostatic models with correct equalization, presumably because, apart from a flat frequency response, a corresponding phase relationship is important [23/24/25/30].

The Aachen dummy head is supplied in combination with the electrostatic headphone STAX SR-Lambda Professional and a suitable free-field equalized amplifier [26/43/55/62].

The IRT examined the "Standardization of a Studio Headphone" [27] and recommended diffuse-field equalization for best reproduction of recordings [1/24]. The reference headphone was the electrostatic STAX SR-Lambda Professional used with the diffuse-field equalized professional headphone amplifier STAX SRM-Monitor [27/28]. This combination is also the most suitable for the reproduction of dummy head recordings with the Neumann KU 81 i [30].

The complete system is used by the test laboratory of the technical journals Stereo, Fono Forum and Hi-Fi-exklusiv for headphone measurements [31].

These dummy heads were compared in various tests [32/55]. Lately, the same electrostatic headphone was employed for the listening test, together with a prototype of the headphone amplifier for research purposes, which featured both types of equalization [33].

The results, which were indeed excellent in comparison with the first generation, can easily be attributed to the improvements that distinguished the system in all respects:

a) an improved dummy head

b) digital memory

c) electrostatic headphone with the same equalization as the dummy head.

In this way, what Steinke described as the superiority of head-related stereophony [1] has now become audible.

Success has been obtained in

- representing the original room convincingly, especially concerning spatial impression and reverberation;
- distributing the entire sound sources, i.e. vocalists, speakers, musicians and eventually their movements over the entire audible perspective up to the direct vicinity of the ear. At the same time forming the sound images with true distance and directional fidelity;
- conveying high transparence by means of exact localization;
- conveying the timbre and tone correctly, thus aiding differentiation between voices, instruments and so on.

The enrichment of the listening experience by the transmission of the spatial atmosphere outside the head enables the imagination of actually being in the original room and a part of the sound scene. This, despite the absence of the optical clues.

Front Localization and Loudspeaker Compatibility

There are two questions which need to be discussed in connection with all improvements of the dummy head system: Front localization and loudspeaker compatibility.

a. Front Localization

Some listeners, although clearly less than formerly, still have problems in localizing a signal from the front which has been recorded frontally by the dummy head. This psychoacoustic phenomenon occurs even when a correct signal arrives at the ear.

One attempt at an explanation says that this is a relic from the distant past, when man was exposed to many natural dangers. His sense of sight warned him from perils approaching from the front, while his sense of hearing was responsible for alarm signals from the rear.
The brain was then able to inform him from which quarter the danger was approaching. When now an ear signal reaches the brain with the directional information "front", the brain relegates the hearing event to the back.
This, although the (dominating) organ of sight does not deliver an adequate front signal.

It is possible to learn front localization. This takes effect most easily with moving sound sources and when the subject is able to listen in a room with his eyes closed, alone and undisturbed. At the same time he should be given information about the recording in the form of photos, drawings, etc. Sometimes front localization suddenly materializes in the same way as a picture puzzle which can be interpreted in several different ways.

The knowledge that front localization was not possible with former dummy head recordings can be a hindrance in this learning procedure.
Consequently, most of the young listeners or non-technical participants in demonstrations at exhibitions hear correctly. It is noticeable in this respect that in almost all cases front localization is possible when the listener has been present during the recording and he does his listening subsequently at the same spot where the dummy head was placed [34].

b. Loudspeaker Compatibility

One of the most important requirements imposed on dummy head recordings was that they should be audible via loudspeakers without any loss of quality. Here mention must be made again of the contradiction between dummy head recordings which take in the recording room and "normal" recordings with microphones close to the sound source. But even with loudspeaker reproduction, the trend toward reducing the influence of the listening room is recognizable [35].

The compatibility of dummy head recordings increases in proportion to the closeness of the dummy head to the sound source during the recording process. Moreover, in proportion to the diminishing complexity of the sound source and the listener's closeness to the loudspeaker on reproduction, i.e., the lessening of the influence of the listening room. Many recordings with the new dummy head systems have met with good to very good assessments by the critics concerning loudspeaker reproduction [36/37/38/39].
A further improvement will be described during this Sound Engineers' Convention by D. Griesinger [41].

Rooms and Sounds that are especially Suitable for Head-related Stereophony

As far back as 1975, Schlemm [13] established that head-related stereophony, when it comes to directional location, is a method which has no equal for authenticity. Therefore, a type of music is specially favored in which the room plays a significant part; there is an inexhaustible repertoire of 16th - 18th century music, to say nothing of the avant-garde genre.
The works of the classical and romantic composers were not only "made-to-measure" for the singers of the day, but also written for special occasions and rooms. Why should their music not be given due recognition?

In many cases, the composers were also music masters. They had to plan exactly the disposition of the players and the kind of rooms in which they would sound best.

It would certainly be very interesting to make dummy head recordings in the rooms in which such works were first performed, or to duplicate them acoustically. In live recordings, the dummy head is placed in or above the public. Then there is the danger that audience noises (coughing, etc.) are picked up with unwanted clarity and become a nuisance.

Experience has shown that expansive bodies of sound in churches with soloists, choir, organ and orchestra can be recorded without difficulty: The dummy head must be placed relatively high and tilted toward the body of sound. In such cases, reproduction via headphones results not only in an improvement of the extreme spatial depth by reducing the distance to the various sound sources. It results also in a grading of height levels which, in practice, comes over acoustically as an arrangement of the choir in tiers.
With some recordings, the listener and record critic is required to make comparisons not with the conventional kind of recorded matter, but with the reality of the concert hall. This is especially the case with a symphony orchestra, where the secondary instruments are not given undue prominence, but sound as they would in the recording room. The latter is subject to stringent requirements, as it becomes part of the recording. It must be ensured, in the interest of good location of the instruments, that this room has a volume commensurate with the size of the orchestra. Then, reflections do not become a disturbing factor.
Thus, the Glenn Miller CD was, at our request, not recorded in Studio 2 of Radio DDR, where the Big Band normally plays, but in the main broadcasting studio. This is actually the domain of the Symphony Orchestra.
A concert grand piano also sounds different to what one is accustomed from records when a recording with stereo effect is heard which has been made with the aid of several microphones. It is therefore worthy of note that famous pianists, such as Alfred Brendel [55] and Jörg Demus are enthusiastic about the realistic effect of dummy head recordings.
It happens repeatedly that artistes acclaim the method when listening to the very first trial recording. The apparent simplicity of the method should not give the technical sound engineer any reason to fear he might loose his job. Quite a large amount of experience and meticulous attention to detail is necessary to achieve optimum results.
In the production of a CD with the Aulos Wind Quintet a few months ago, it took more than one and a half hour and several trial recordings after the dummy head had been set up. Then the sound engineer, the music director, the producer and the artists were in agreement about the balance between the direct sound of the instruments, the harmony of the ensemble, the spatial component and the permissible contribution of valve noises. (All this apparently is very important for some hi-fi fans). The position of the dummy head was altered yet only by about 30 cm from its original place for the first tryout.

Experience with Cutting and Multitrack

There are no problems associated with cutting dummy head recordings. We can draw on experience with 38 cm/s tape and Telcom C4, Sony F1, recorded on PCM 1630 and, recently, on DAT. In order not to impair the spatial effect (it was the Aulos Quintet recording referred to in the foregoing), the pauses between movements were included.

Two LP's with Multitrack are available; one features the African group Kalifi, first in the open air on drums. In the second recording, the group continues to play, while the first recording is blended in via headphones. In order to retain the spatial effect, it is important not to change the position of the dummy head.

The papers read by M. Wöhr and H. J. Goeres [40] at this Convention report on results obtained with secondary microphones on binaural recordings. The frontiers of this method are arrived at when an authentic live event is recorded. This could be the performance of a rock-jazz group with their PA system in the middle of rapturously enthusiastic public.

Prospects

If high-quality equipment is used for recording, transmission and reproduction, dummy head stereophony offers, on only two channels, a fascinating spatial effect and a real sense of "being there". The enthusiasm of listeners and critics [39/50/56/57/58/60/61] should give the spur to further productions. An unmistakable trend in the direction of high-quality headphones is discernible, while in addition, new dummy head recordings are loudspeaker-compatible.

It is worth while to forget prejudices arising from previous disappointments, and have another good look at dummy head stereophony.

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