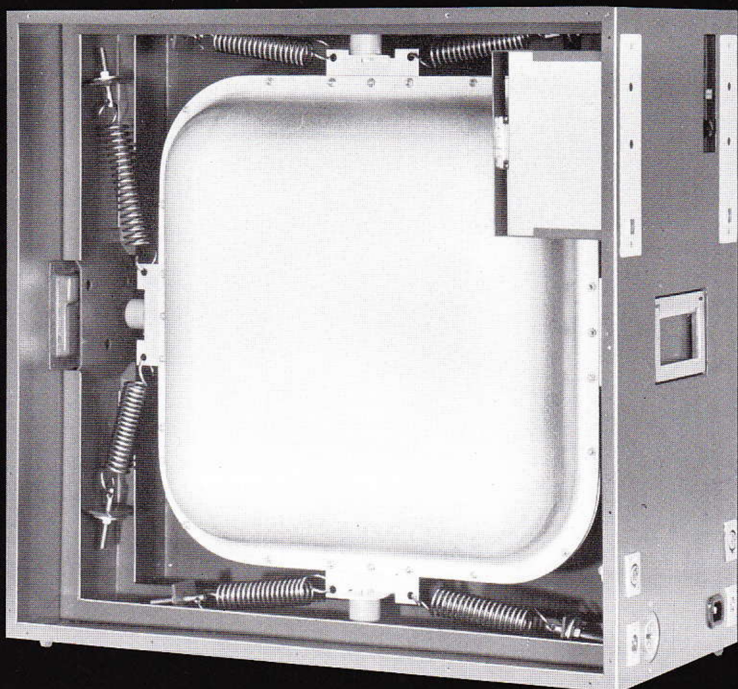
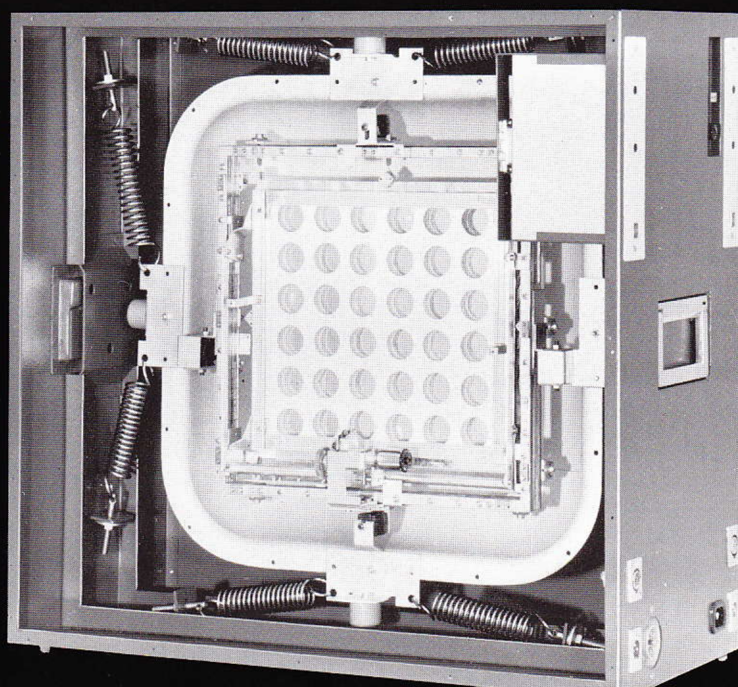
REVERB FOIL
EMT 240
the transportable golden sound

The new EMT 240 is a major break through: realistic reverberation without coloration smaller and lighter — therefore mobile and more economical.



The inside housing

The inside housing is of stiff construction and relatively great mass and is elastically suspended within the unit. This assures sound isolation to the lowest frequencies.



Damping plate and gold foil

After removal of the inside cover, the gold foil becomes accessible. The damping plate has various size perforations which serve to influence the damping response. The use of this damping principle assures that no reverb time peaks will appear at any point in the frequency response of the damping characteristic.

REVERB FOIL
EMT 240

Flat plates under tension have been in use for the past 15 years for the production of reverberation in studio technology.

A proven principle

has now been developed even further: An electrolytically produced foil of special gold 12 inches square replaces the steel plate used until now. As a result the advantages of this principle are maintained:

- a constant resonant density over the audible range
- no flutter echo repeats
- minimum dispersion
- constant reverb decay according to an exponential function.

In significant miniaturization

The new unit has only 1/5th the volume of the previous EMT 140 unit!

With improved characteristics

- double the resonant density, therefore no perceptible coloration.
- three times the delay of the first reflection.
- greatly improved isolation against shock, vibration and ambient noise.

Easily transportable

Operation near speakers in control rooms and O.B.-vans is possible.
Simply secured for transport. No retensioning or recalibration required after transport.

With continuously variable reverb time

Change in reverb time is produced by a damping plate which approaches the reverb foil more or less. This produces proportional damping of all frequencies and avoids formation of decay peaks.

Universally applicable

For both stereo and mono channels. Remote controllability of the decay time.
Equally applicable for stationary and mobile use.

PE-111-4-U

Technical data EMT 240

Reverberation time at 500 Hz	1 . . . 4 seconds
Variation of reverb time is effected by a damping plate which is varied in its distance from the reverb foil.	
Density of resonances	> 3/Hz
Maximum ambient noise level:	≦ 80 phon
Max. dimensions:	63 x 67 x 30 cm 24.8" x 26.4" x 11.8"
Max. weight:	60 kg (132 lbs.)

AMPLIFIER:

Frequency response from 40 Hz . . . 15 kHz relative to standard curve:	± 2 dB
Total harmonic distortion at 1 kHz and max. output:	≦ 0.5 %
Signal to noise ratio (unweighted):	≧ 60 dB
Input:	
balanced and floating; impedance:	≧ 5 kohm
max. input signal:	+ 21 dB
Output:	
balanced and floating; impedance:	≦ 30 ohm
max. output signal:	+ 21 dB

Specifications subject to change without notice!

The reverberation plate EMT 140 was developed by the INSTITUT FÜR RUNDFUNKTECHNIK and the inventor Dr. Walter Kuhl. The unit is manufactured by EMT since 1956 and covered by world-wide patents. This co-operation was followed-up in connection with the development of the small reverb foil EMT 240 for which new patents in Germany and abroad are applied for.

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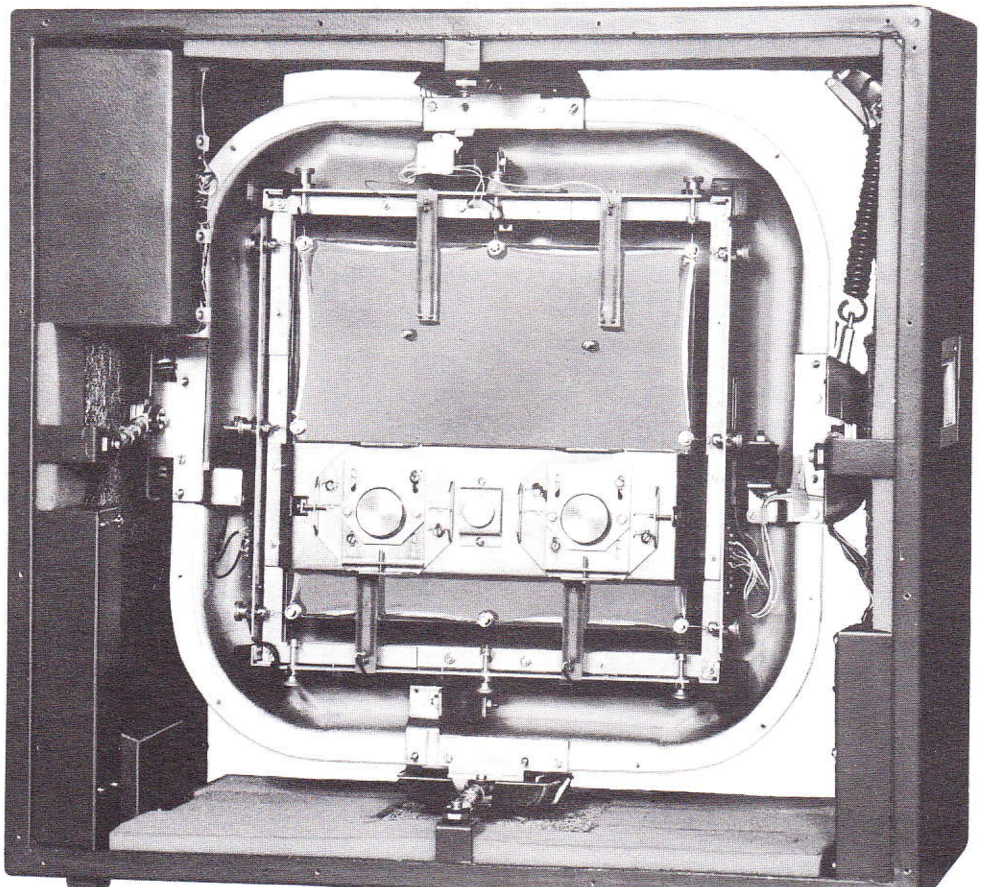
AUDIO / SIGNAL PROCCESSING

EMT 240

Reverb Foil



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BASIC CONSIDERATIONS

For many years the reverberation plate EMT 140 has been used for producing artificial reverberation (1).

Although it has proven excellent in use, it is too large for many applications. Consequently, for some time there has been a demand for a smaller unit. This should, however, have the same or better electro-acoustical properties.

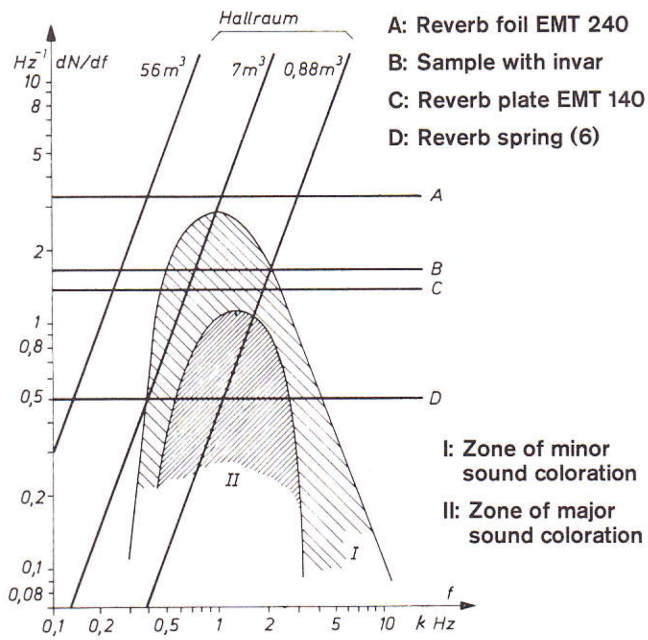
The INSTITUT FÜR RUNDFUNKTECHNIK in Hamburg and Messrs. EMT have been working in collaboration for several years on a solution of this problem. The primary objective was the development of a suitable material for the reverberation plate itself. The most important properties were the necessary damping characteristics for the reduced plate dimensions and particularly the achievement of a high density of resonances frequencies (Eigenfrequencies). As KUHL showed in 1968 (2), reverberation which is to be free of subjectively noticeable resonances should have a density of resonance frequencies of more than three per Hertz in the midfrequency range. None of the existing reverberation units was satisfactory in this respect and it was by using a special gold alloy that it was possible to achieve a resonance frequency density of 3 to 4 resonances per Hz (1) with the proposed dimensions of the plate. The exact dimensions of the plate are 270 mm by 290 mm with a thickness of 18 microns.

When the suitability of the material had been established considerable work was involved in the development of the necessary technology for the production of the plates. Both components of the alloy are simultaneously deposited electrolytically through suitable choice of the current densities upon an electrode. The material of the electrode in conjunction with a suitable electrolytic pretreatment enables the plate to be separated from the electrode afterwards. The process enables the thickness of the plate to be maintained $\pm 10\,\%$ over its entire surface. After the electrolytic deposition a diffusion process permits the precise control of the inter-crystalline thermal conductivity damping which is decisive for the reverberation time achievable at high frequencies (3).

The most important property of a reverberation unit is the amount of reverberation which can be obtained and this can be represented by way of the reverberation-time against frequency-response. Figure 2 shows the measured values obtained from tests on a number of plates. The new reverberation unit also uses the variable proximity of a porous absorbant for controlling the reverberation time. It should be emphasized that the new unit has a very even reverberation-time against frequency-response compared with other reverberation units, due to the high density of resonance frequencies well into the low frequency range together with very high resolution.

After solving the technological problems of manufacturing the plates, the second major problem was the development of the necessary transducers. If the unit is to be used in mobile recording units the associated mechanical vibrations present considerable additional problems. The reduction in the size of the plate has reduced the transverse wave input impedance (4).

If the transducer principles are to be the same and if the required equalizations are to be maintained for both units, the permissible mass for the driver system will be 23 mg and for the pickup system only 7.2 mg. Furthermore, the point-excitation and pickup on the plate which has been used hitherto would require a contact area of approximately .3 mm diameter — due to the wave length reduction compared with the large plate to about 1/10.

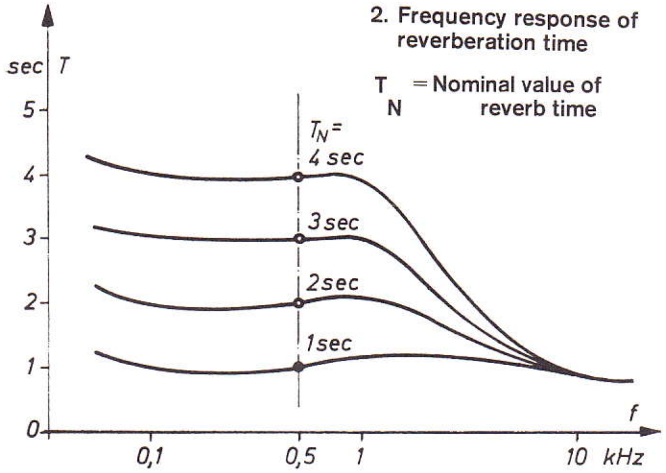


1. Zones of sound coloration

In view of the requirements for mobile application of the unit it is therefore not possible to realize a permanent mechanical contact between the moving part of the transducer and the plate.

With a moving-coil driver transducer a further difficulty arises: the moving coil which is fixed to the plate has to move in a magnetic gap which is only about 1 mm wide. A larger air gap would reduce the efficiency of the transducer to such an extent that the electrical energy dissipated in the coil would cause overheating and possibly damage. This small air gap brings, however, the danger of the moving coil being displaced or even broken away from the plate during transport. Therefore a different type of driver transducer had to be used. The solution was found in a piezo electric transducer.

The pickup transducer presents a much more serious problem than the driver transducer. The most important



2. Frequency response of reverberation time

T_N = Nominal value of reverb time

considerations in the development are the very small loading of the plate with only20mg and the achievement of the necessary sensitivity. The piezo electrical principle which is used with the large reverberation plate cannot be used because of the impedances involved. A variety of magnetic and dynamic transducers were therefore investigated. At the starting point of all these considerations was the very small available amplitude from the plate. The maximum amplitude in the low frequency range is about .1 micron for a permissible distortion (5), which corresponds to a peak velocity of approximately 6.3×10^{-3} cm/s. The maximum available mechanical input power to the transducer is therefore approx. .01 microwatt.

After extensive research a dynamic transducer was found to be the most suitable.

In conclusion, mention should be made of the measures taken for reducing noise due to air coupling and direct vibration. Particular attention was apaid to the requirements in mobile use. Regarding the insulation against direct air sounds, provisions are made for the plate to be used in control rooms or control booths of outside broadcast trucks where the reverberated program is to be monitored on loudspeakers.

The necessary attenuation of 30 dB was achieved by means of a two-shell arrangement. The reverberation plate is stretched in a frame which is enclosed in a thick-walled housing consisting of two metal half-shells. This inner housing is mounted sound-insulated in a further steel housing which determines the outside dimensions of the unit. The size is approx. .65 m x .65 m x .30 m and its volume is therefore one-tenth of the existing unit EMT 140.

The insulation against vibration consists of three stages; it must essentially meet the requirements of mobile operation.

TRANSDUCERS

An important step in the work on the reverberation plate EMT 240 was the development of special electro-mechanical transducers. Because the impedance of the transducer appears in parallel with the mechanical transverse-wave impedance of the thin foil, the mass of the transducers had to be kept very small. On the other hand the pick-up transducer must possess a high sensitivity because the transverse waves in the foil have amplitudes of less than one micron. As the transverse wave input impedance is independent of frequency, the mass impedances determine the basic frequency response of the entire reverberation system.

Driver Transducer

While the large reverberation plate EMT 140 uses a dynamic transducer a piezo electric (ceramic) driver transducer is used in the EMT 240 (Figure 1). The active element of the transducer consists of a thin disk of lead zirconate-titanate which is glued directly on to the foil. A mass of 5 g. is glued to the other side of the disk. Above the turnover frequency, which is made to lie below the frequency response of the system, the inertia impedance becomes much larger than the transverse wave input impedance of the foil so that at higher frequencies the countermass can be dynamically considered as stationary. The electrical connections to the piezo-oxide disk are made through the foil on the one side and through the counterweight on the other. In order that lead wire should have a negligible effect on the system it must be extremely thin (.02 mm). As the total mass of the transducer is small the resulting bending moment produced on the foil by the transducer is correspondingly small, and no additional mechanical fixing is therefore necessary. This does away with considerable problems of the dynamic system such as the adjustment of the coil in the magnet gap and securing during transit.

When the system is driven with a constant AC voltage transverse waves of constant amplitude over the entire frequency range, which lies above the turnover frequency, are produced.

Pick-up Transducer

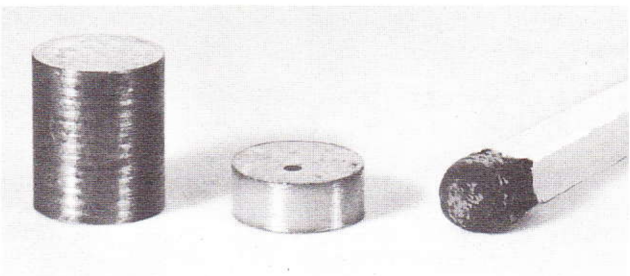
The pick-up transducer uses a moving coil system, similar to the type used in dynamic microphones, but with a much smaller coil diameter (Figure 2). The air gap is made very large in order to facilitate the alignment of the coil.

The magnetic induction in the air gap necessary to achieve the high sensitivity of the transducer necessitates the use of a magnetic material with high energy density and a core material with a very high saturation induction (Figure 3).

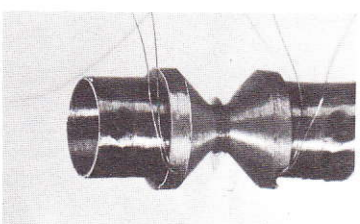
The moving coil has a mass of 12 mg and is stuck onto a former made of electron with a mass of 5 mg. This coil former is cone-shaped, with the thin end attached to the foil, in order to avoid a treble loss due to integration over

SOUND INSULATION

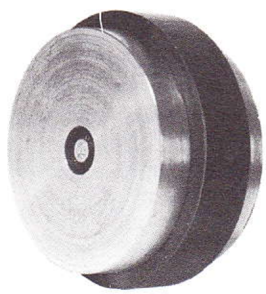
a wavelength. The mass of the moving system in conjunction with the transverse wave input impedance of the coil determines the turnover frequency of the pick-up transducer of 100 Hz. For a constant amplitude in the foil this produces therefore an output voltage which rises by 6 dB/Oct. below the turnover frequency and is constant above the turnover frequency.



1. Driver transducer
left: seismic mass, Middle: piezo driver
right: match for comparison



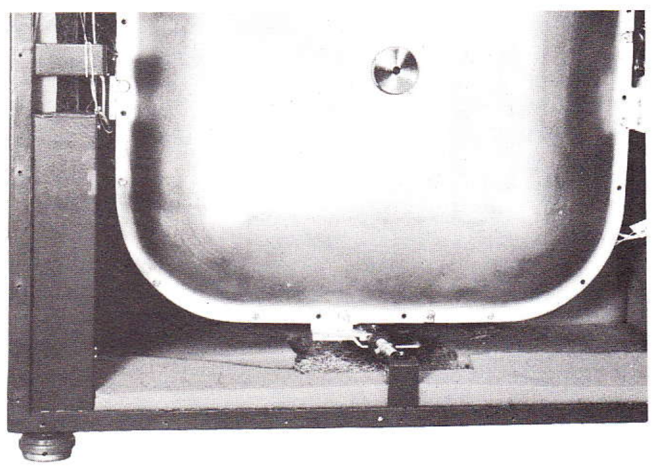
2. Pick-up system on the foil



3. Magnet for pick-up system

4. Damping plate

In the design of a transportable reverberation system such as the reverb foil EMT 240 the problems of insulating mechanical and air vibration are particularly critical. A transportable unit of this type will be used in recording trucks with considerable ambient noise and vibration. People getting in and out of the truck and even worse the opening and slamming of truck doors during a recording will cause considerable mechanical vibration. Furthermore, there is the sound of the program itself (monitor loudspeaker) as well as extraneous noises (conversation of the recording engineers during the recording) to be considered.



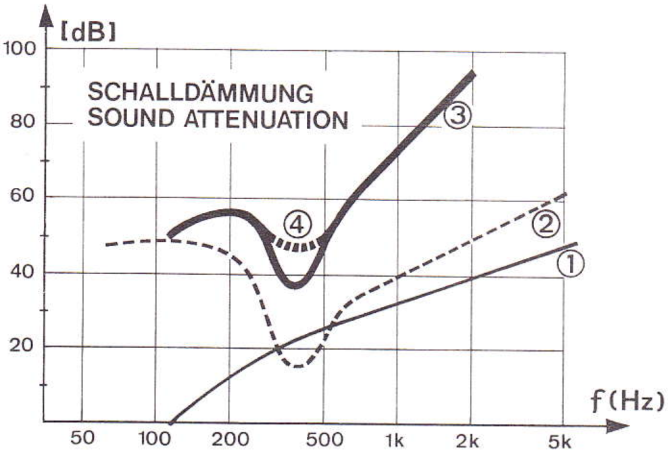
1. Inner housing

Insulation of Airborne sounds

The necessary protection against airborne sounds is achieved by means of a two shell system. In the illustration the outer cover plate is removed and the inner shell can be seen in the shape of a lens shaped housing. Due to its great rigidity this shell has a relative good and constant attentuation at low frequencies (curve 2 in the following illustration). At frequencies above 1 kHz the attenuation from this shell increases with frequency due to the mass of the shell. Between these two frequency ranges however there is a distinct minimum at about 400 Hz which is due to the basic resonance of the lens shaped shell.

The outer housing which consists of a flat sheet of steel which is heavily damped by sound absorbing coating and is screwed virtually airtight onto the housing gives a further damping curve in accordance with curve 1.

These two curves act together giving curve 3 the overall attenuation of the system.



2. Sound attenuation as function of frequency

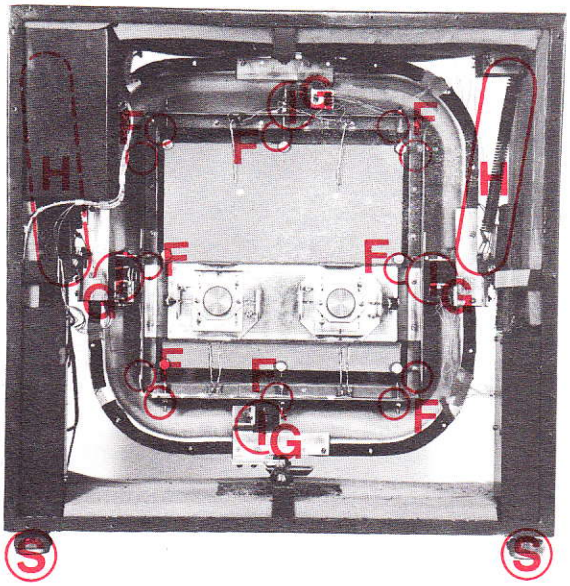
Curve 3 still shows a pronounced minimum at 400 cycles. This is eliminated by an additional arrangement consisting of a damped spring and auxiliary mass which is made to resonate at the frequency of the mimimum (the auxiliary mass can be seen in the center of Figure 1). Curve 4 shows the improvement which can be achieved through an arrangement of this type. The attenuation is well over 50 dB in parts of the relevant range.

In connection with the transducer properties of the foil an external sound field of 74 dB will generate a signal in the reverb foil output which is still less than the noise level of the unit.

Insulation of Physical Vibration

When dealing with rumble vibration two different methods of attenuation have to be considered:

- Low frequencies are reduced by suitably dimensioned mass-spring system.
- High frequencies travel on springs in the form of longitudinal vibrations which must be suitably attenuated.



3. Unit with inner housing opened

As reported previously the insulation against low frequency rumble vibration is basically effected in 3 stages. The first oscillating system consists of the mass of the lens shaped housing (together with the mass of the inner frame) in conjunction with the long main springs (H). It is desirable to make the fundamental resonance of this first stage as low as possible. This was achieved through the large mass of the lens shaped housing together with a long and soft spring: the resonance frequency of the first stage is about 2 Hz.

The use of long soft springs brings with it the danger of the suspended mass moving out of position when the position of the unit is changed. For this reason the system employs additional stabilizing springs. The positioning of the unit is thereby made uncritical.

The second isolating stage consists of the spring suspension (I) of the inner frame within the lens shaped housing. The resonance frequency of this second isolation stage is substantially higher in order to prevent a disturbance at the resonance frequency of the first stage from being passed on.

The third stage finally consists of the spring mounting (F) of the gold foil itself.

An additional fourth damping stage (S) is produced by spring mounting the entire unit instead of standing it on ordinary feet. This enables the overall mass of the unit to be used once more for damping.

In order to avoid sharp resonances and to attenuate higher noise frequencies from travelling as longitudinal vibrations all the springs are heavily damped. In suitable places such as the suspension of the tensioning frame rubber moldings (G) are used to further attenuate high frequency disturbances.

Reverberation Time - Frequency Response

The reverberation time of a room or of a reverberation unit is usually given for 500 Hz. At other frequencies the reverberation time is not necessarily the same. This relationship is known as the frequency response of the reverberation time.

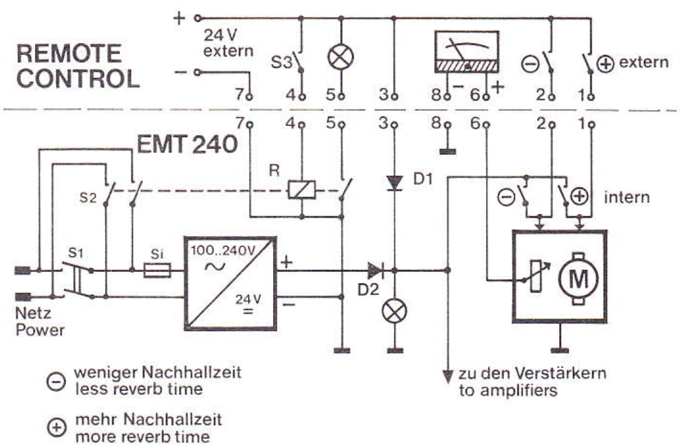
If the reverberation is to sound pleasant and natural it is particularly important that the frequency response of this reverberation time should be free of pronounced peaks and discontinuities. Otherwise if the system is rung with a mixture of frequencies the peak frequency would prevail at the end, thus producing coloration of the decaying sound.

Such resonances occur particularly at low frequencies. This makes the reverberated sound dull, there will be an overall lack of presence and similar troubles are experienced as with badly constructed bass-reflex cabinets.

The reverberation time is varied at low and mid frequencies by altering the distance of a damping plate. The reverberation frequency response of the reverb foil EMT 240 is equalized by incorporating suitably frequency dependent acoustic resistances in this damping plate.

REMOTE CONTROL

The remote control elements for the reverb foil EMT 240 are the same as those used for the reverberation plate EMT 140. In fact even the connecting plug is the same. It is therefore possible to use existing remote control stations for the reverberation plate EMT 140 and the associated cables for the reverb foil EMT 240.



6. Power supply and remote control connection

The AC mains section on the left in the illustration is suitable for all standard AC mains voltages. The output of the section provides about 25 V DC which is used for the remote control motor as well as for the individual channel amplifiers.

This makes the operation very flexible and the following variations are of particular interest:

- Unit operated from AC mains but remote control system on 24 V DC ring. This corresponds exactly to the existing operation of the reverberation plate EMT 140. The unit may also be remote switched on or off by means of the relay R and the switch S. Pin 3 of the plug is not used in this mode of operation.
- Operation of the entire unit from the DC ring or from a 24 V car battery. The unit can also be remote switched on if point 4 of the remote control system is connected with point 3 of the reverberation unit. The diodes D1 and D2 enable the reverb foil EMT 240 to be safely connected to a 24 V DC ring and AC mains simultaneously. Normally most of the current is provided by the AC mains section with its slightly higher output voltage thereby saving a battery in circuit. In the event of the failure of one of the supply sources the other source takes over automatically providing a very high reliability factor.
- If no 24 V DC ring or external 24 V battery is available and the unit is run on AC mains the remote control can derive its supply from the unit itself. For this purpose the diode D1 should be bridged. Remote switch-on however is not available in this mode of operation.

TECHNICAL DATA

EMT 240 with Amplifier EMT 262	
Reverberation time referred to 500 Hz	0.7 . . . 5 s
Noise level at $T_r = 2$ s	
Unweighted Signal-to-Noise ratio, rms	≧ 65 dB
Weighted Signal-to-Noise ratio, peak	≧ 60 dB
Minimum input signal for full drive	
Peak measured	0.775 V rms (0 dB)
vu measured	approx. 0.4 V rms (−5 dB)
Input impedance	≧ 5 kΩ, balanced and floating
Maximum output level at 1 kHz and $T_r = 2$ s	+21 dBm for 1% THD
Usual reverberation return level	−6 . . . −10 dB, relative to direct channel
Output source impedance	≦40 Ω, balanced and floating
Minimum load resistance	200 Ω
Remote control	Silicone damped linear motor with control electronics and position indicator.
Power requirement	24 VDC/0.25 A
Power supply	
a) AC supply	switchable 200 . . . 250 V or 100 . . . 130 V, 50/60 Hz
b) DC supply	24 VDC/0.8 A
Weight	67 kg (148 lbs.)
Dimensions	640 x 300 x 625 mm (25½" x 12" x 25") (w x d x h)

Subject to change.

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