WHAT MAKES ATC DIFFERENT?

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INTRODUCTION

Started in 1974, ATC has built a reputation for the design and manufacture of loudspeaker drive units of the finest quality and highest performance. Every ATC drive unit is painstakingly assembled by hand and checked at every stage of assembly to ensure its ultimate quality and reliability. In fact it is true to say that as a consequence of our comprehensive design and development, methods of manufacture and very tough quality control ATC drive units have set new standards of performance, reliability and manufacturing consistency.

ATC DRIVE UNITS - IN PARTS

1. THE MAGNET ASSEMBLY

All ATC drive units use ceramic magnets. The magnet assembly is made up of a magnet, a front plate, a back plate and a pole. All parts are fully machined to ensure fine tolerance assembly and to maximize magnetic performance. (SEE FIG 1).

The back plate and pole of ATC drive units are forged from magnetic steel in a single piece and then machined on all critical faces. The pole is undercut to improve the linearity, strength and symmetry of the magnetic field and a hole is drilled through the back plate-pole to improve air circulation and therefore heat dissipation due to convection from the voice coil.

ATC front plates are either forged or fine blanked from magnetic steel and then machined on all critical surfaces. The back plate-pole and front plate are zinc plated black to maximize radiant heat dissipation from the voice coil and provide a corrosion protective coating.

When assembled all parts are bolted and glued to prevent the magnet assembly ever going off-centre and a gauge disc is fitted over the hole in the pole, under the label, to prevent dust and grit reaching the magnet gap.

2. THE VOICE COIL ASSEMBLY

All ATC voice coils are of edgewise wound copper ribbon wire, wet wound on our own purpose designed machines to ensure excellent adhesion, a precise winding length, number of turns and D.C. resistance. This technique of winding gives the advantages of 30% more copper in a given coil cross section over round wire coils, a much lower coil hot spot temperature due to the single layer winding, smaller magnet gap tolerances and improved heat distribution in the coil as well as high motor efficiency. (SEE FIG 2).

ATC voice coil formers are either aluminium for bass drivers or KAPTON for bass-mid or midrange drive units. Both materials have excellent thermal characteristics and the voice coil assembly is then made mechanically robust and dimensionally stable by the lamination of 3 layers of kraft paper to the outside of the former above the voice coil winding. A fillet of epoxy resin is laid-in below the voice coil winding to the former to hold the coil firmly in place.

The voice coil assembly is then baked in an oven for $3^1/_2$ hours to cure the winding adhesives and ensure its high temperature performance in use.

3. MAGNET GAP-VOICE COIL GEOMETRY

Voice coil-magnet gap geometry is a principal source of non-linear distortion in loudspeaker drive units. All ATC high fidelity drive units, including the midrange dome, have a short coil in a long magnet gap. This geometry has the following advantages:

a) Improved heat dissipation from the voice coil and therefore a reduced operating temperature.

b) Low harmonic distortion because the voice coil during normal operation will never leave the linear magnetic field in the long magnet gap.

c) Minimization of the change is inductive reactance of the voice coil in relation to its instantaneous position in the magnet gap. (SEE FIG 3A).

All ATC public address drive units and almost all other high fidelity drive units have a long coil in a short magnet gap. This geometry has the following limitations:

a) Higher gap flux density and therefore drive unit efficiency but at the cost of higher non-linear distortion.

b) Reduced magnet assembly cost. (SEE FIG 3B).

4. THE DIAPHRAGM VOICE COIL AND SUSPENSION ASSEMBLY

All ATC drive unit diaphragm assemblies have a geometry designed to provide minimum distortion and maximum structural integrity, from the domed diaphragm of the SM75-150S soft dome midrange drive unit to the curvilinear cone diaphragm of the SB75-314 studio bass drive unit. Curvilinear diaphragm geometry reduces the generation of bell modes (sub-harmonics) in the diaphragm structure. The tones associated with bell modes are usually impure due to the sub-tones being enharmonic and the presence of higher intermodulation frequencies which cause harshness. (SEE FIG 4).

Equally important to diaphragm geometry is the choice of diaphragm material. All ATC high performance diaphragms are manufactured from soft fibrous materials with high internal damping characteristics coated with a viscous damping medium to ensure that the structure is better than critically damped at all frequencies over its operating band. This means that any structure bourne resonances will be suppressed and will therefore not be intrusive in any reproduced signal.

SUSPENSIONS

The suspension system is another major source of non-linear distortion in dynamic loudspeaker drive units. This is principally due to the spider which is required to perform simultaneously the function of large axial excursions whilst maintaining precise centering for the voice coil in close tolerance magnet gaps. This function is achieved in ATC drive units by a fabric suspension formed with triangular corrugations.

The front rubber roll surround provides very little centering force to a diaphragm assembly yet must properly terminate the edge of the cone and be able to perform large axial excursions without stress or non-linearity. The major problem of rubber roll surrounds occurs when it decouples from the diaphragm assembly at between 400 - 1000Hz causing a change in level in the magnitude response of the drive unit and producing audible distortion. This is a common characteristic of small two-way loudspeakers. (SEE FIGS. 5A,B & C).

ATC resolves this problem in the SCM10 and SCM20 by the use of a decoupling joint between the diaphragm and rubber surround.

DIAPHRAGMS

The viscous damped fabric roll surround of the SM75-150S is designed to provide both linear axial excursions of the dome and precise centering of the voice coil in the magnet gap. Because of its low mass, high damping and small area it does not cause any significant interference to the magnitude response when it decouples from the diaphragm assembly.

Both the SM75-150S and the SB75-150 have a former stiffening ring fitted to the inside of the voice coil former. This minimizes voice deformation due to diaphragm breakup and therefore dramatically increases the power handling capability. The SB75-150 also has holes pierced through the voice coil former to equalize pressure differentials which occur between the inside cavity of the voice coil former, the volume under the dustcap and outside the former, and therefore reduces air flow noise around the voice coil-magnet gap.

5. THE CHASSIS

The chassis of ATC drive units are all of diecast aluminium with strongly ribbed and filleted sections to ensure structural rigidity and dimensional stability. Each chassis is epoxy coated all over, sealing it to the atmosphere to prevent oxidation of the surface of the chassis and crystallization of the aluminium due to exposure. All chassis are bolted to a magnet assembly with up to 12 bolts to guarantee that the chassis is mounted absolutely rigidly and square to the voice coil magnet gap.

6. DRIVE UNIT ASSEMBLY

Finally the diaphragm is mounted and glued into the chassis magnet assembly using centralized shims between the voice coil former and magnet pole to guarantee their concentricity. When the adhesives are fully cured the shims are removed and the drive unit is tested. The dustcap is then fitted and the drive unit tested again to ensure that it meets ATC's high standards of performance.

ATC LOUDSPEAKER SYSTEMS - DESIGN CRITERIA

The performance of high quality loudspeaker systems can be defined under the following headings.

1. Magnitude Response
2. Phase Response
3. Time Domain Anomalies
4. Directivity
5. Harmonic Distortion
6. Amplitude Intermodulation Distortion
7. Hysteresis Distortion
8. Dynamic Range

1. MAGNITUDE RESPONSE

By definition a "Linear Magnitude" refers to a magnitude response that has a constant level with frequency. This is practically not achievable as the impulse response of a loudspeaker is largely dominated by the low and high frequency roll-off characteristics and by any resonant peaks in the amplitude response.

It is possible however, to produce loudspeaker systems that maintain a variation in magnitude response within +/- 1.5dB consistently between 100 Hz and 10 kHz and that have an excellent overall balance between bands. At ATC we believe that the balance between drive unit frequency bands is critical, particularly between bass and midrange in three way systems, and should always be better than 1dB. All ATC systems meet this design criteria. (SEE FIG 9 and 10).

2. PHASE RESPONSE

A system will be defined as being "Linear Phase" if the phase response is a straight line, when plotted against a linear frequency scale and passing through the origin. The effect is then of a true time delay and will therefore not cause any linear distortion.

In practical loudspeaker systems however, the aim is to design for a minimum phase response free from any abrupt changes that are usually indicative of high Q resonances. It is also relevant to mention that the delay between drive units due to acoustic centre misalignment is not audible, we believe, for delays below 2 ms. Therefore, providing the overall delay is within 2 ms and there are no sharp phase response irregularities, then the system should be free from any subjective phase effects. ATC has incorporated analogue excess phase correction, operating through the crossover regions, in its active loudspeakers since 1982. The result of such active filtering is to give much better control over the filter shapes with greater phase coherence and therefore a more uniform group delay characteristic. The subjective result, when compared with the same loudspeaker system but with a passive crossover, is of a broader and more stable stereo image with much more coherent drive unit integration and improved openness and timbre of reproduced sounds.

3. TIME DOMAIN ANOMALIES

A high performance loudspeaker should have no high Q or delayed resonances and must also minimize multiple arrivals of the same signal caused by reflections and diffraction effects as these add a hard and claustrophobic coloration to the sound, masking ambient detail and confusing the stereo image. Time domain anomalies are without doubt the most intrusive and tiring to the listener of all distortions. Careful drive unit and crossover design can ensure a flat and even magnitude response free from any low Q broad band resonances or response irregularities. (SEE FIG 11). High Q and delayed resonances are common in hard (metal, ceramic etc) undamped diaphragms and poorly designed crossover filters, unlike ATC's heavily damped flexible diaphragm structures which have high internal resistance and great structural integrity.

ATC drive units use quite steep curvilinear and domed diaphragms formed from fabric which is then impregnated with viscous damping mediums to control resonant break-up modes which occur at high frequencies.

It is also equally important for the fundamental system resonance to be well damped, that is have a Q between 0.3 and 0.6.

Loudspeakers with an underdamped system resonance produce ill defined bass which sounds uncontrolled and excessive and masks midrange detail.

In fact in a high performance loudspeaker all resonant systems should be at least critically damped whether they are due to diaphragm break-up or the fundamental system resonance.

4. DISPERSION AND DIRECTIVITY

The relationship between direct and reverberant sound is very important in high performance loudspeakers. It is clear that not only must the on-axis magnitude response be accurate and linear but also that the behaviour off-axis must be both broad and even with frequency exhibiting no abrupt dips in level.

All ATC SCM SERIES loudspeakers meet this criteria and it can be seen in figure 12 that the SCM20 has an exceptional power response.

The way we perceive magnitude band balance and the full energy of percussive or impulsive sounds, is dependent upon the power response of the loudspeaker or how evenly it excites the reverberant field with frequency.

A dramatic effect of poor midrange dispersion, common in many two way loudspeaker systems, is demonstrated by recording engineers making incorrect magnitude band judgments and applying equalization, usually to the upper midrange, in an attempt to compensate for the apparent lack of energy in that region. Many examples of pop recordings are available which demonstrate this characteristic. That is, a hard strident upper midrange which masks high frequencies, and makes vocals sound recessed while accentuating the bass.

5. HARMONIC DISTORTION

There are three principal sources of non-linear distortion in loudspeakers and they are all related to the drive system.

The first relates to the voice coil and magnet gap geometry and the non-uniformity of the distribution of magnetic lines along the length of the magnet gap. A short coil in a long gap renders the best solution regarding geometry, although not the most commonly used, and the distribution of magnetic lines will be improved by the use of an undercut centre pole.

The second principal source of non-linear distortion is generated in the suspension system of the diaphragm assembly and is mainly contributed to by the spider.

The third source of distortion is due to the variation of the permanent magnetic field caused by the alternating field created by the voice coil. This mechanism can be minimized by the use of a shorting ring on the pole of the magnet which will also benefit the high frequency response due to the consequent reduction in voice coil inductance.

In practice it will be careful drive unit magnet system and suspension design that will most effectively minimize harmonic distortion.

Having said all of that, since the main use of loudspeakers is to listen to music and speech, both of which have complex structures dominated by harmonically related tones, the presence of low order harmonic distortion is generally considered to be less audible and more tolerable than other forms of distortion.

6. AMPLITUDE INTERMODULATION DISTORTION

Amplitude intermodulation distortion, however, is much more intrusive than harmonic distortion due to the products not being harmonically related to the original sound.

A recent review of active and passive loudspeakers at A.T.C. confirmed that active loudspeakers, due to each drive unit amplifier operating only over a restricted frequency band, will have much lower amplifier borne amplitude intermodulation distortion than the same loudspeaker operated passively driven over the full audio frequency range. Figures 13 and 14 show a full 20dB difference in amplitude intermodulation distortion in favour of the active system.

7. HYSTERESIS DISTORTION

Hysteresis distortion, as much as it exists in loudspeaker suspension systems and heavily damped soft diaphragm assemblies, does not manifest itself as an intrusive distortion. In fact, if care is taken over the choice of both diaphragm and suspension materials then they will largely have the characteristics of a simple damped spring and exhibit negligible hysteresis.

8. DYNAMIC RANGE

The issue of dynamic range is a complex one and although it is primarily controlled by voice coil operating temperature and magnet total flux, it must be considered along with the mechanical integrity and freedom from break-up of the diaphragm and suspension structure. There can be no doubt that system dynamic range significantly effects the clarity of reproduced sound. Even quite simple combinations of instruments, for example a string quartet, will produce a maximum SPL well in excess of 100dB at 2m when starting from just audible pianissimo passages.

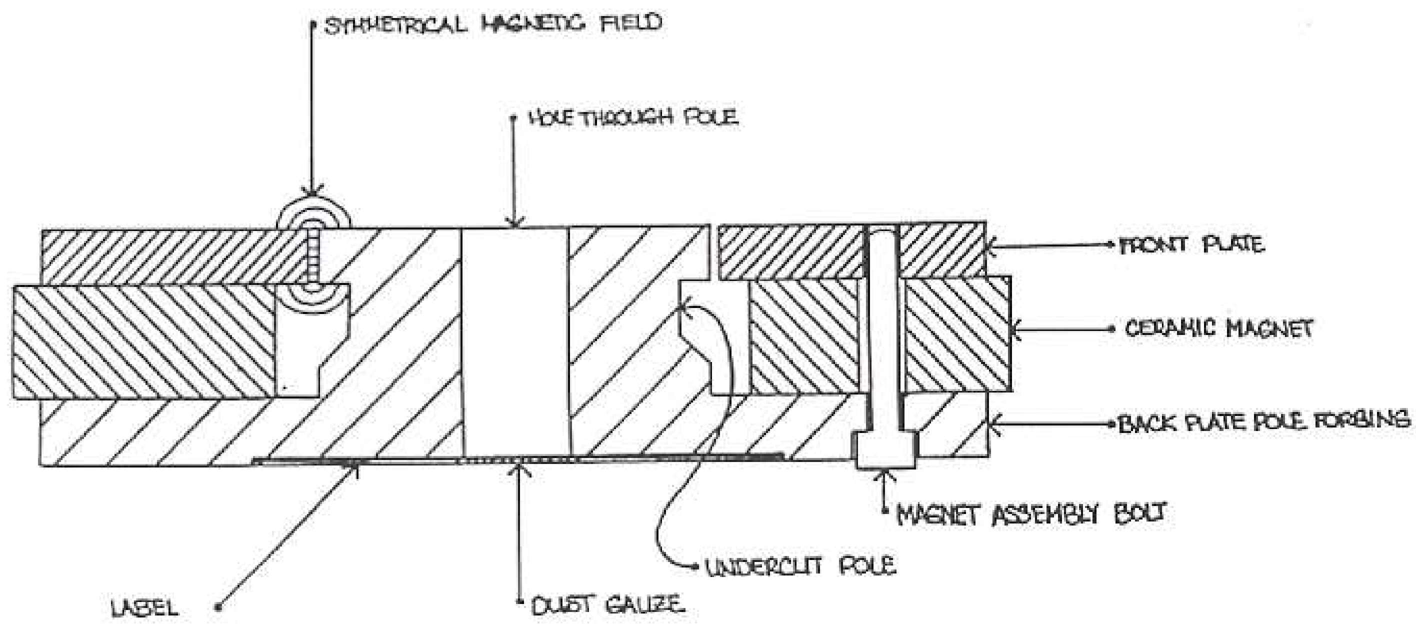
A passive loudspeaker that has significant power compression will tend to sound dull and boomy and the high voice coil temperature and consequent resistance rise will effect the loading of the passive crossover and therefore also modify the frequency response of the system.

The dynamic range of direct radiating loudspeakers is in fact almost entirely determined by cost. Designers do strive to produce more sensitive small systems through the use of very light diaphragm structures but the scope for manoeuvre is limited if a correct balance between bass and midrange magnitude response is to be achieved for a given diameter of drive unit. Furthermore, light diaphragm structures almost always have low internal damping and therefore a tendency to exhibit high Q resonances.

To qualify in all respects as a high performance loudspeaker the requirements of dynamic range will for most designs be the largest compromise. A choice which is made much more difficult as a consequence of the rapid developments in digital electronics during the past decade. Digital recording mediums offer a huge dynamic range with a peak to average signal ratio of typically 12-16dB which means that even the most modest loudspeaker wearing the tag "high performance" must be capable of continuous output of at least 94dB at 1m while being driven from an amplifier of 100 watts or more.

The fact is that the majority of Loudspeaker manufactures use what are basically relatively inexpensive volume produced commercial drive units. It is not unusual to see high end Hi Fi speakers costing many thousands of pounds using the same drive units that appear in systems produced by larger companies at a fraction of the price. This policy is often defended by claims regarding cabinet design or drive unit "modification". Only ATC has committed itself totally to the manufacture of Loudspeakers that perform to the limits set by present day technology. Our investment is huge, we cannot use standard chassis or readily available parts and the pay-off is small, the rewards are the satisfaction we derive from technical and sonic excellence and the delight it brings many happy users around the World.

FIG 1 ATC MAGNET ASSEMBLY CROSS-SECTIONAL VIEW SHOWING BOLTED CONSTRUCTION AND SYMMETRICAL MAGNETIC FIELD



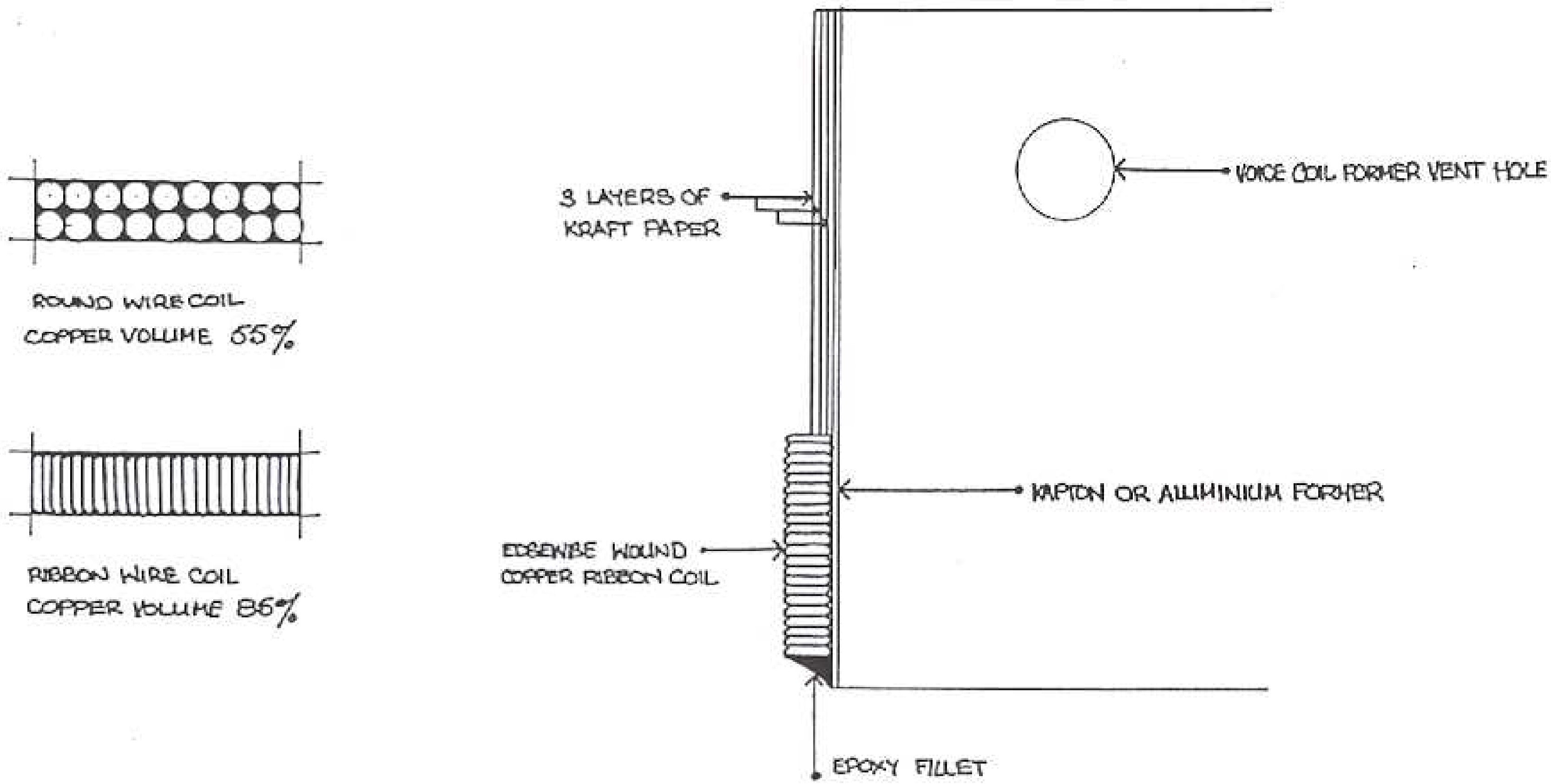
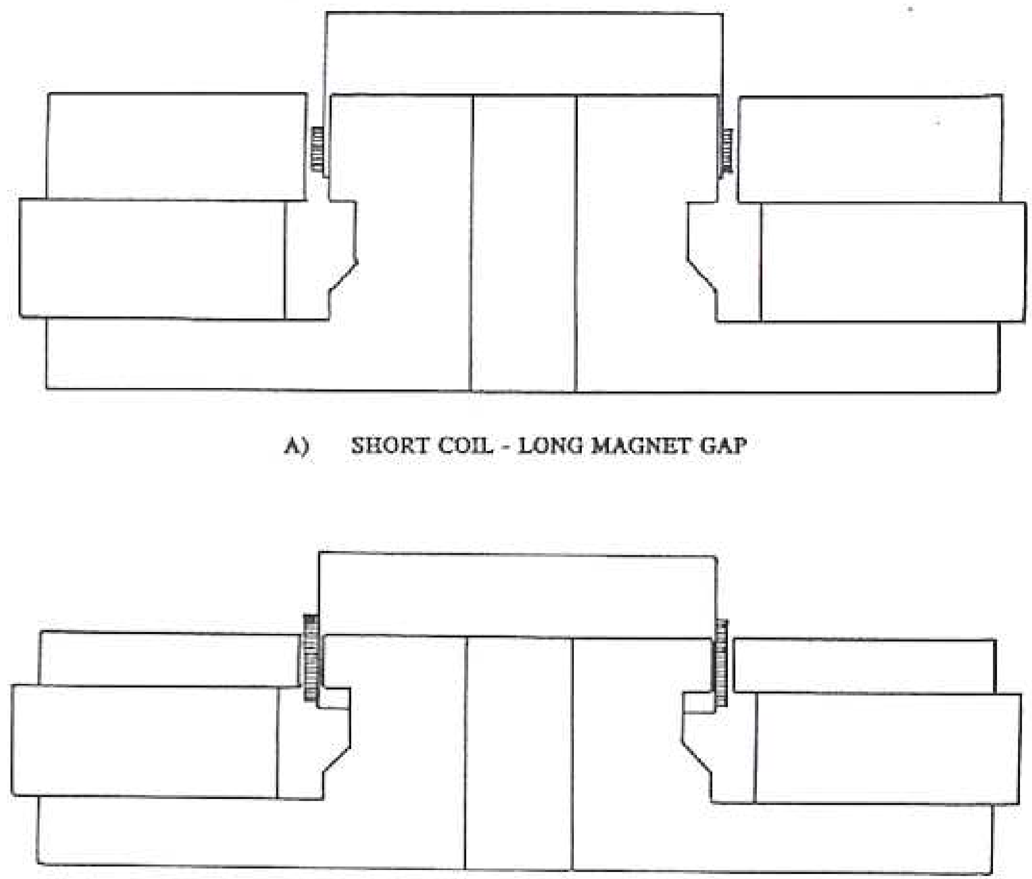


FIG 2 ATC VOICE COIL CROSS-SECTIONAL VIEW SHOWING EDGEWISE WOUND COPPER RIBBON WIRE WINDING AND FORMER CONSTRUCTION



A) SHORT COIL - LONG MAGNET GAP

B) LONG COIL - SHORT MAGNET GAP

FIG 3 ATC VOICE COIL - MAGNET GEOMETRY

A) SM75-150S SOFT DOME MIDRANGE

B) SB75-150 BASS-MIDRANGE FOR SCM20 AND SCM20T

C) SB75-314 BASS FOR SCM100 AND SCM200

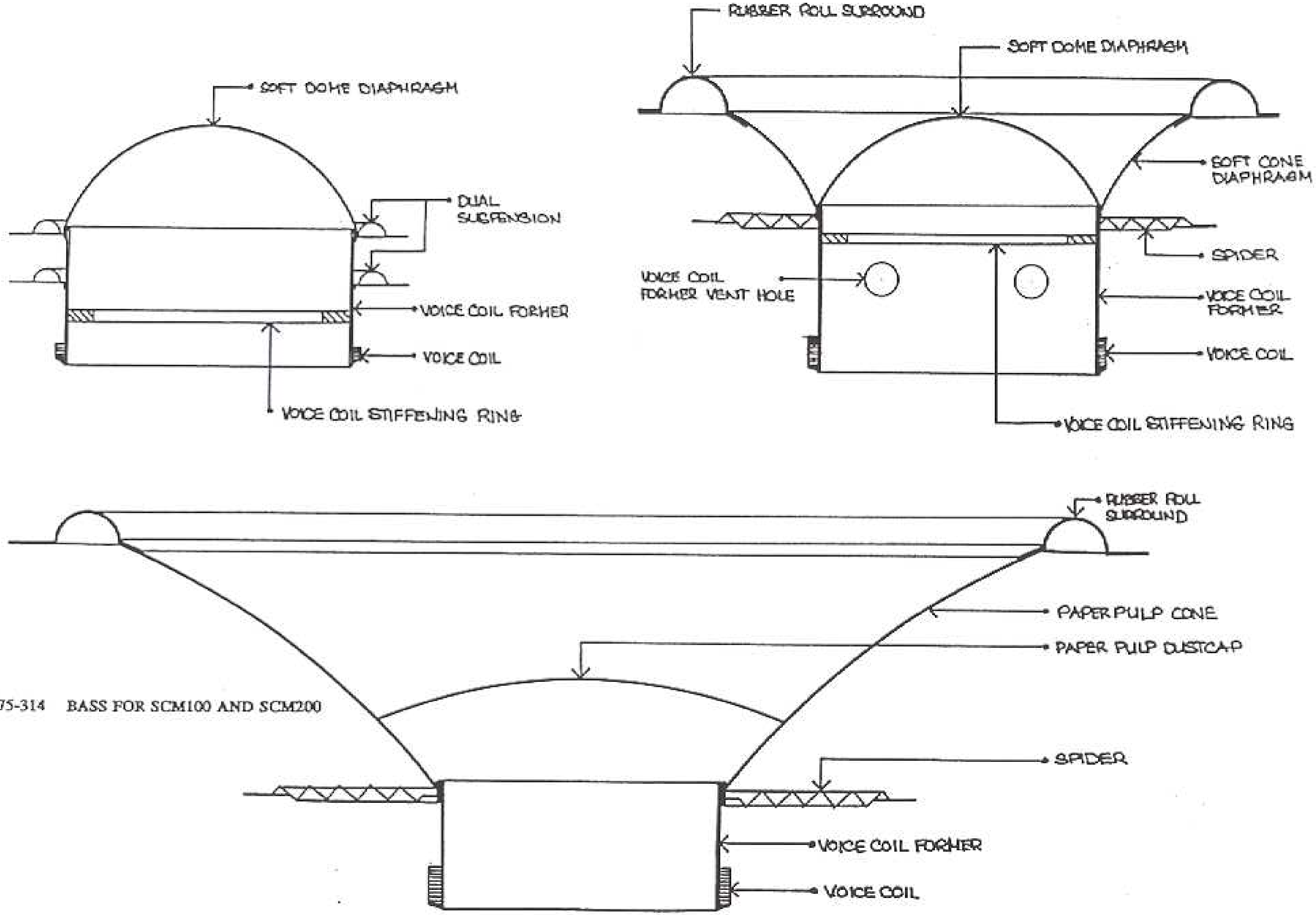


FIG 4 ATC HIGH PERFORMANCE DIAPHRAGM-COIL ASSEMBLIES

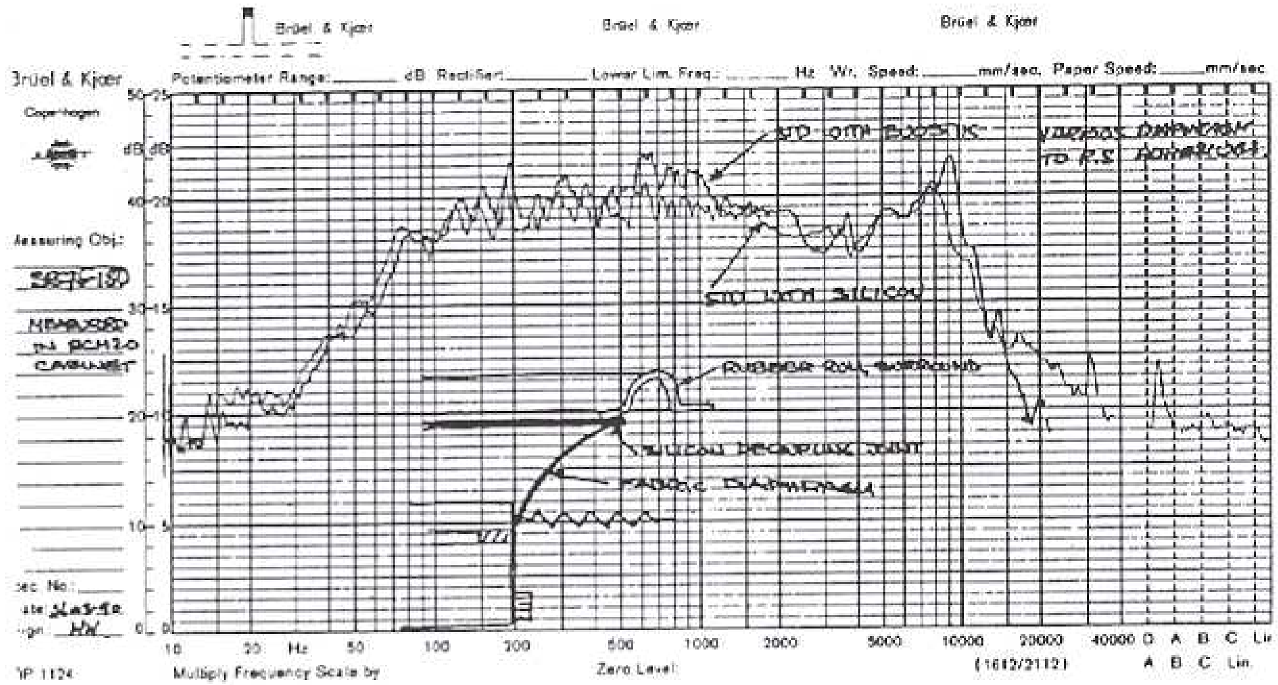


FIG 5 RUBBER ROLL SURROUND DECOUPLING CURVE

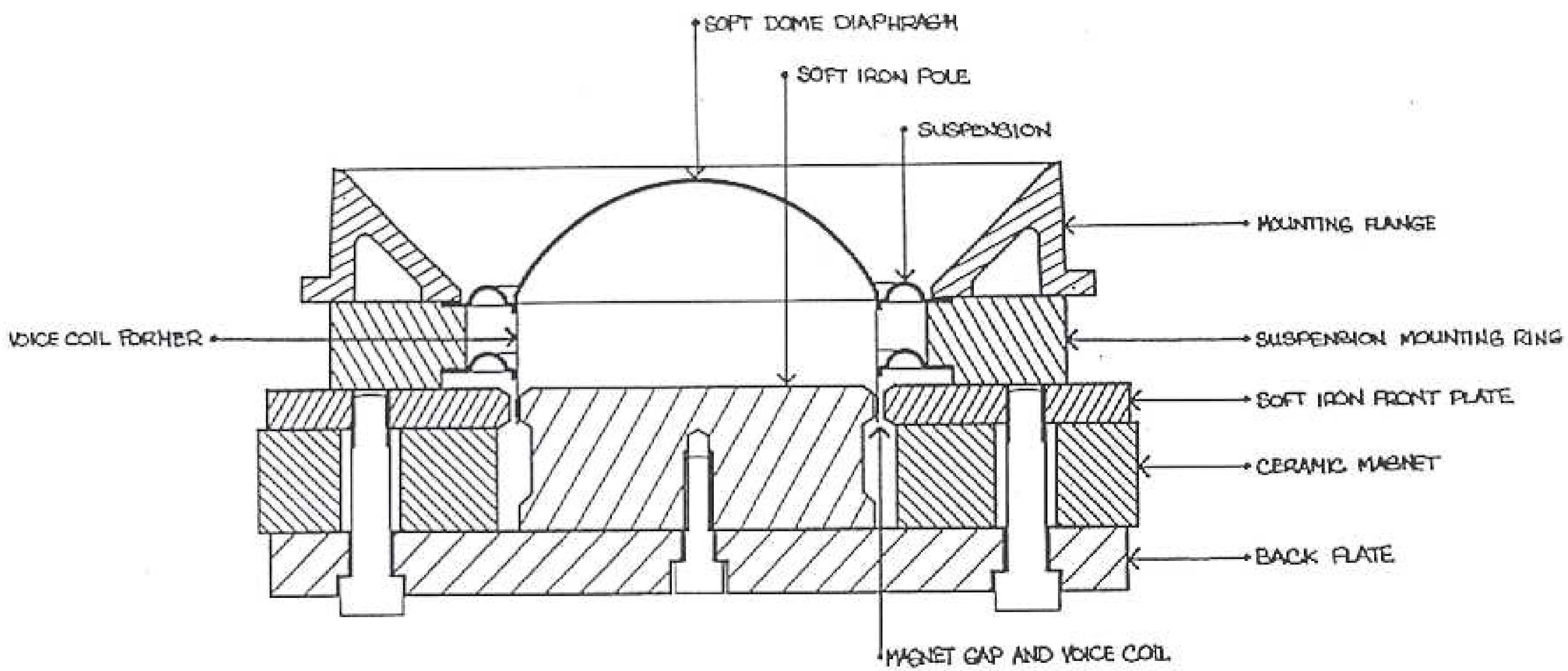


FIG 6 ATC SOFT DOME MIDRANGE SM75-150S
CROSS SECTIONAL VIEW

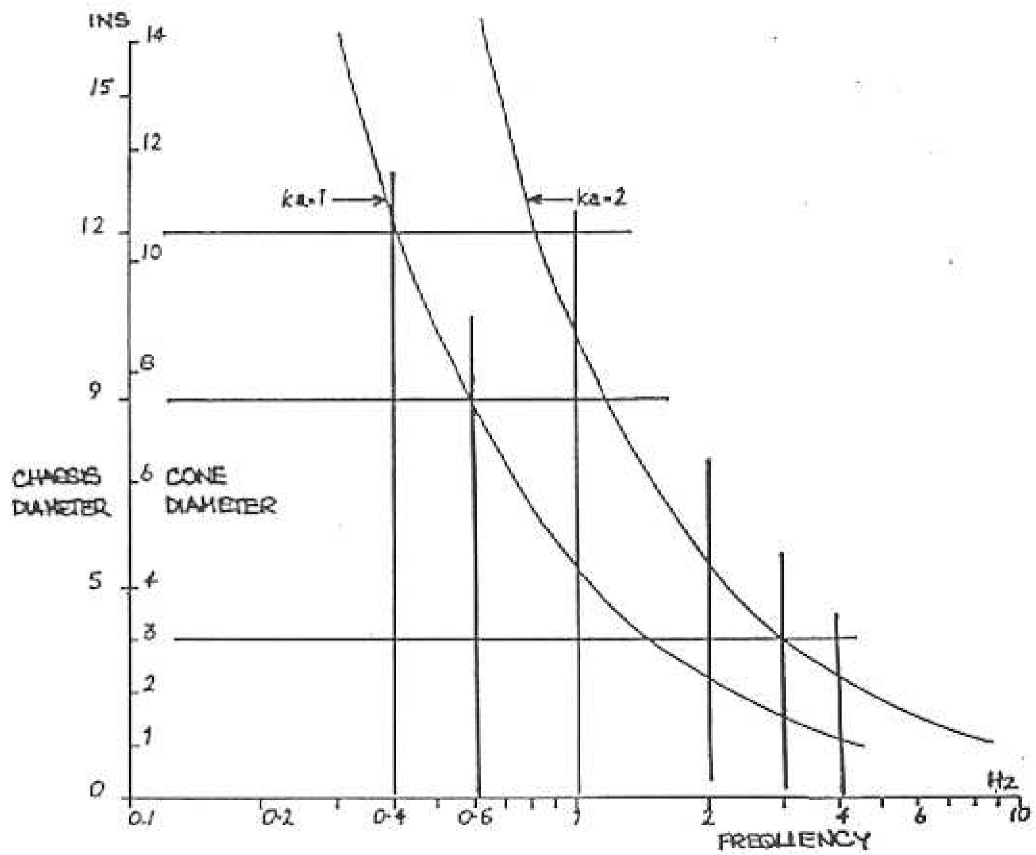


FIG 7 CURVES OF DRIVE UNIT DIAMETER vs FREQUENCY

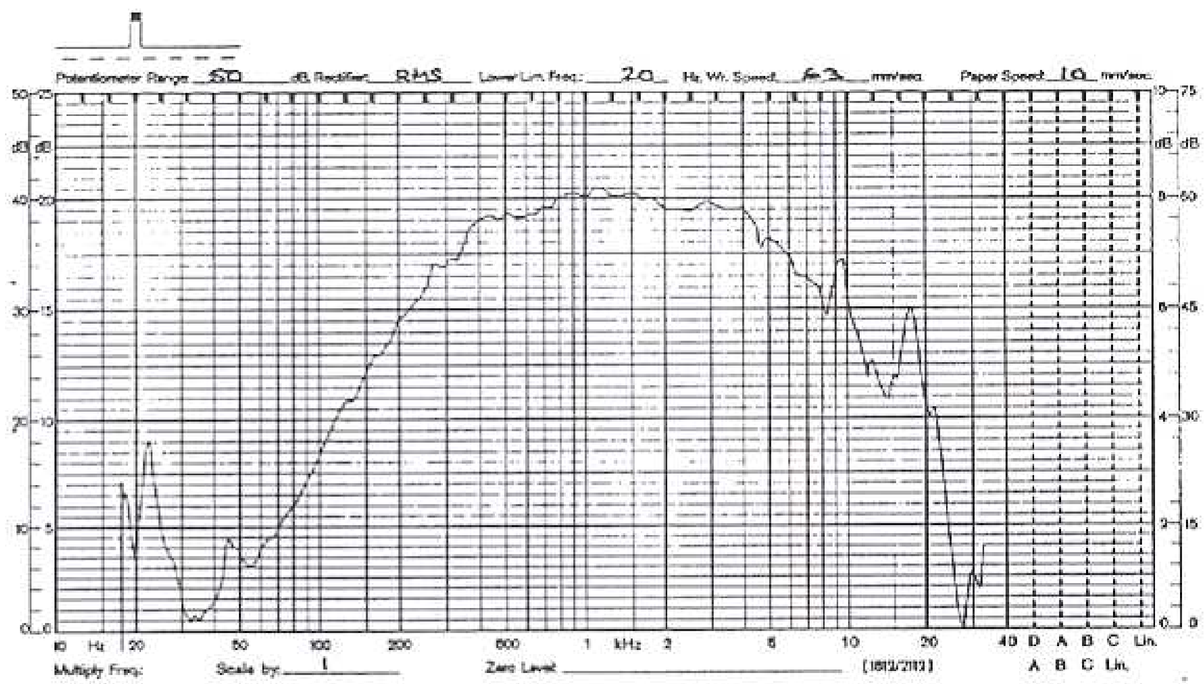


FIG 8 ATC SOFT DOME MIDRANGE SM75-150S
MAGNITUDE RESPONSE CURVE

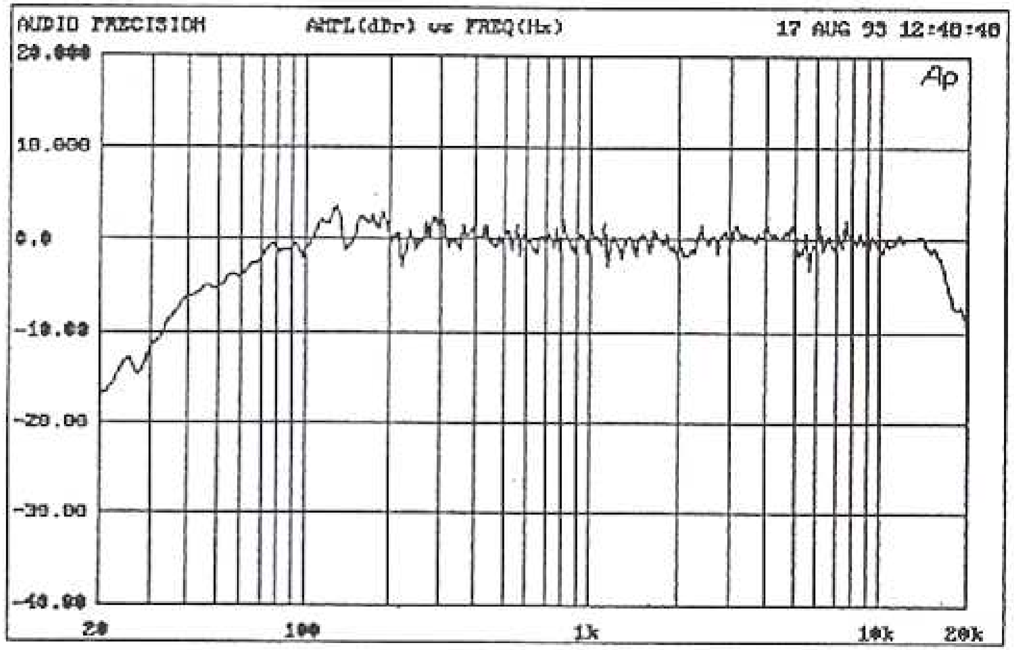


FIG 9 ATC MODEL SCM100A MAGNITUDE RESPONSE CURVE

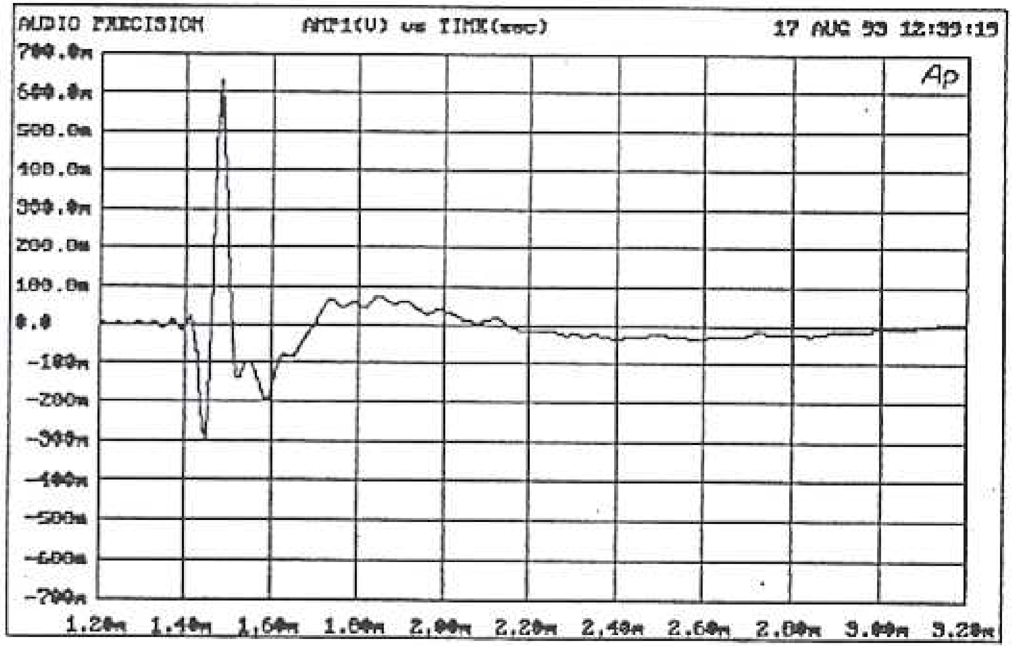


FIG 10 ATC MODEL SCM100A IMPULSE RESPONSE

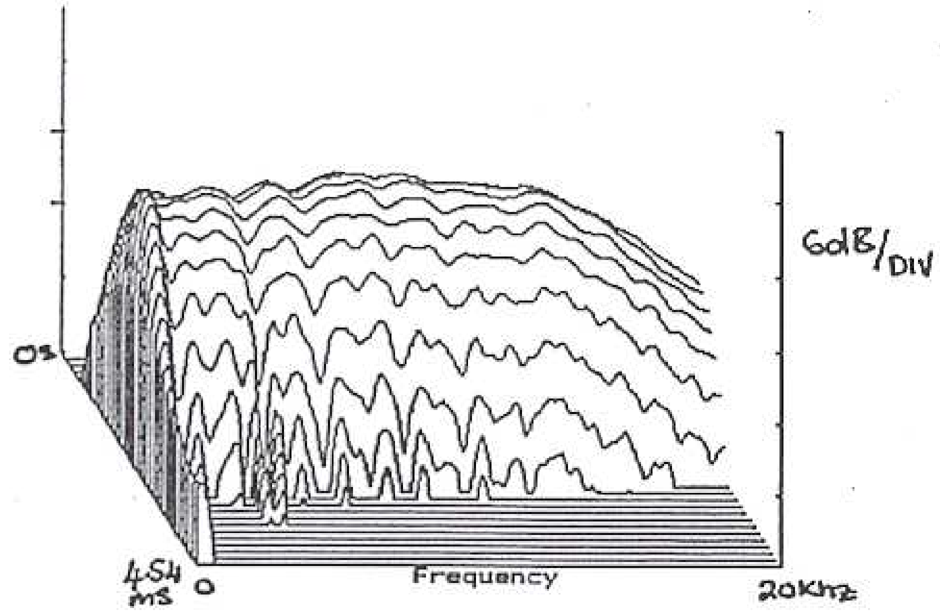


FIG 11 ATC MODEL SCM100A TIME-FREQUENCY DISTRIBUTION CURVES

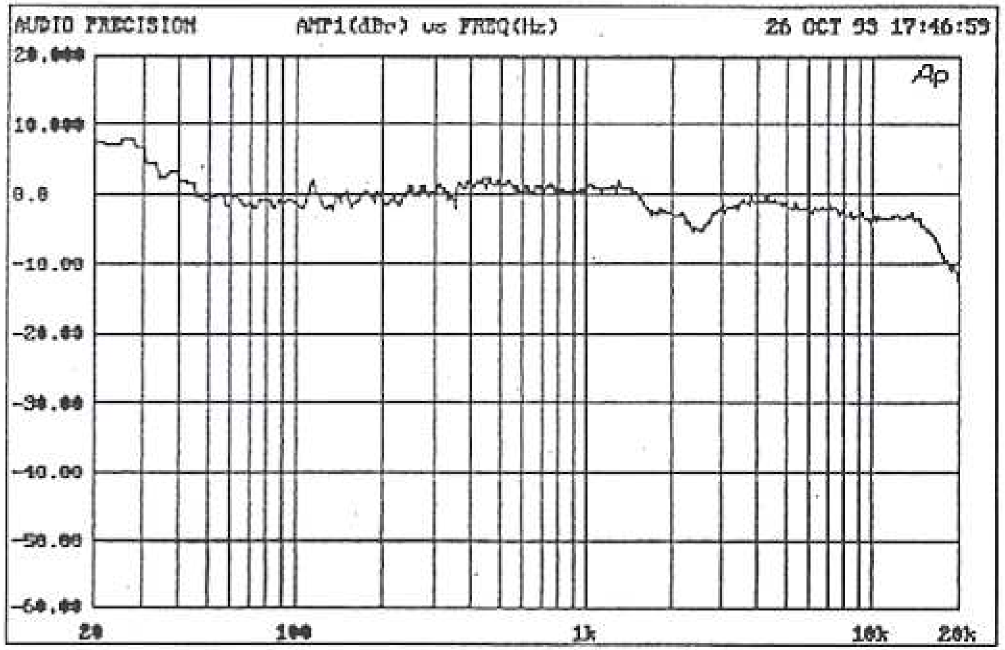


FIG 12 ATC MODEL SCM20 ROOM AVERAGED RESPONSE DEMONSTRATING POWER RADIATED IN A TYPICAL LISTENING ROOM

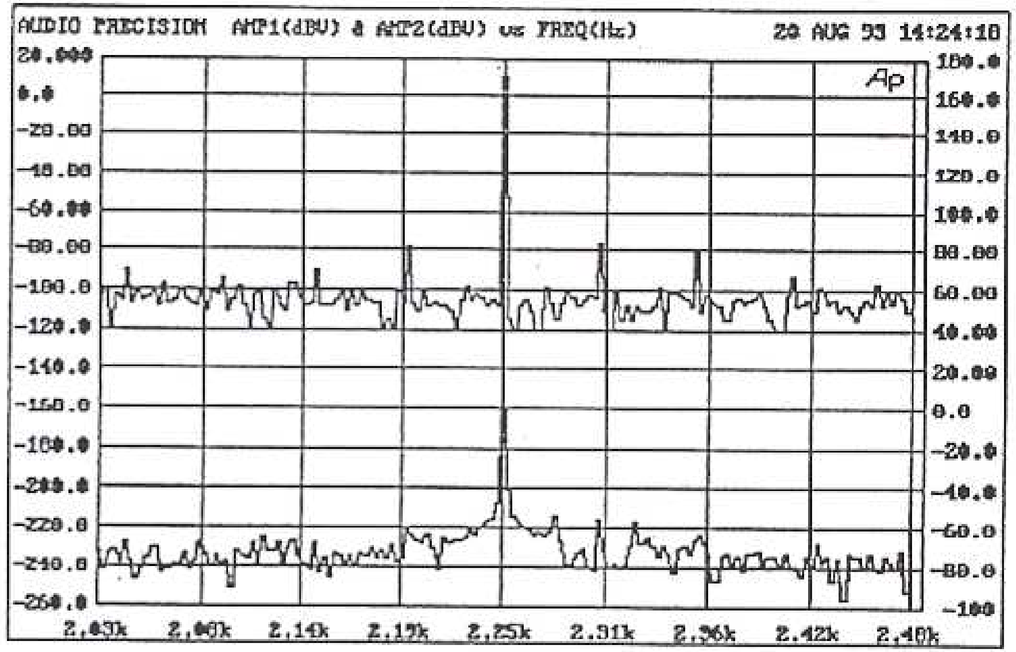


FIG 13 INTERMODULATION FROM 2.25kHz AND 50Hz TONES WITH AN SCM100P (PASSIVE) LOUDSPEAKER. (THE UPPER TRACE AND LEFT HAND SCALE SHOW THE AMPLIFIER VOTAGE OUTPUT. THE LOWER TRACE AND RIGHT HAND SCALE SHOW THE MEASURED SOUND PRESSURE AT 0.5m REF 92dB SPL).

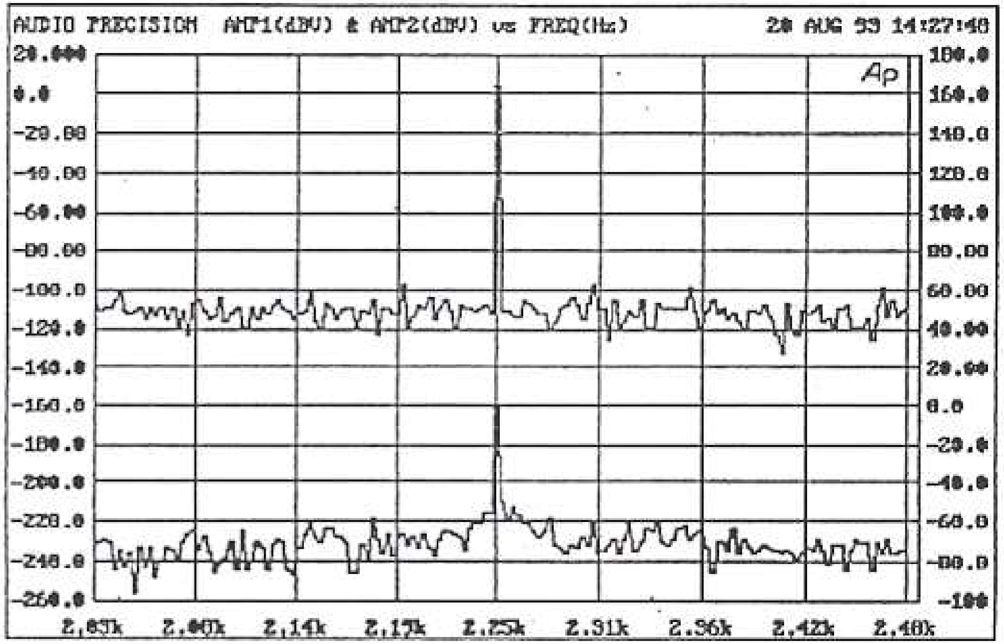


FIG 14 INTERMODULATION FROM 2.25kHz AND 50Hz TONES WITH AN SCM100A (ACTIVE) LOUDSPEAKER. (THE UPPER TRACE AND LEFT-HAND SCALE SHOW THE MID FREQUENCY AMPLIFIER VOLTAGE OUTPUT. THE LOWER TRACE AND RIGHT HAND SCALE SHOW THE MEASURED SOUND PRESSURE AT 0.5m REF 92dB SPL).