KEF REFERENCE SERIES MODEL 105.4

PRODUCT DESIGN STORY

KEF ELECTRONICS LIMITED

MODEL 105.4 - DESIGN STORY

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Introduction

The unveiling of the prototype Model 105 at the Summer Consumer Electronics Show in Chicago 1976 marked the beginning of a double revolution. The Model 105 certainly raised the performance of multi-way, dynamic speakers to a much higher level than had previously been achieved, for not only was the tonal balance and absence of colouration significantly improved over every dynamic loudspeaker then on the market, but the sharpness and stability of the stereo images produced with appropriate source material was immediately obvious to all listeners. This latter quality, which is probably the Model 105's finest achievement, was so marked that it became possible to hear previously undetected detail in very old stereo recordings going back to the very beginning of the commercial stereophonic era.*

The second revolution occurred in the production arrangements at Tovil which were reconstructed and dedicated to the production of Reference Series speakers. Here for the first time entirely new methods of assembly were introduced in 1978. Instead of the conventional procedure of assembling loudspeaker systems from randomly selected drive units and dividing networks followed by an adjustment on final test to bring the frequency response within tolerance, the frequency response of each individual drive unit is measured using digital computer techniques. The digitally stored data is then used to grade the drive units in terms of sensitivity and frequency response shape culminating in a complicated matching routine which results in sets of closely matched drive units and other vital components grouped ready for installation in a pair of systems.**

These new manufacturing methods made it possible to produce in large quantity a very high quality loudspeaker system to a standard of matching and consistency exceeding that which was achieved only a few years ago for small production batches of professional studio monitoring loudspeakers.

These developments further enhanced the prestige of KEF Electronics in world markets and altered the general direction in which future loudspeaker development is likely to progress.

3858)

* Mozart : Song Recital, Schwarzkopf (recorded 1955 EMI ASD)
Prokofiev : Classical Symphony (recorded 1955 EMI SXLP 30437)
Rimsky-Korsakov : Scheherazade (recorded 1957 EMI SXLP 30253)

** KEFTOPICS Volume 3 No. 3.

The general success of the Model 105 design, both Series I and Series II is unquestionable. But it does suffer a few disadvantages nonetheless. Despite the employment of a special form of bass loading to reduce the size of the LF enclosure, the overall appearance of the loudspeaker is often judged to be bulky in small rooms. Moreover, its rather science fiction appearance does not blend well with classical or conventional decor and its price is rather high for general purpose use. In these circumstances therefore, it is not surprising that a demand arose for a less bulky and less costly loudspeaker having similar performance features to those of the 105.

Son of the 105

The design brief for the Model 105.4 called for a reduction in both bulk and cost of manufacture compared with the Model 105.2 whilst retaining as many as possible of its significant performance characteristics. At the same time the efficiency of the system was to be made as high as possible consistent with a reasonably low cut-off frequency.

It was felt that a worthwhile reduction in size and cost could be achieved employing the same head assembly in conjunction with a newly designed LF section. In the event it was found possible to reduce the cost of the head assembly to some extent by omitting some of the intermediate values of peak level indication thus saving the cost of the elaborate switching and associated circuitry. The final design uses a three-position rotary switch with simplified circuitry. Further cost reduction was achieved by substituting the T33 for the very much more expensive T52 HF unit, with a worthwhile increase in overall sensitivity.

The design of the LF section finally settled on a pair of 8" drive units. During an earlier stage of the design a single 10" unit was considered as an even cheaper alternative but this was later abandoned on the grounds that new chassis and diaphragm forming tools would be required and these would have delayed the start of production.

General Description

Model 105.4 is a three-way loudspeaker system employing twin eight inch diameter bass drivers. The mid-range and high frequency radiators are housed in a separate head assembly appropriately shaped to minimise the adverse effects of diffraction on the direct sound field.

The three radiating systems are combined through dividing networks with crossover points at 400 HZ and 3,000 Hz. The acoustic rate of attenuation, taking account of drive unit characteristics, the effect of housings and filter network sections, is nominally 24 dB per octave either side of each crossover point.

The three radiating systems are arranged geometrically to produce zero inter-unit time delay along the preferred listening axis (or design axis). Provision is made for tilting and swivelling the head assembly so that its design axis may be aligned with the listening area by the aid of a simple optical arrangement located within the head assembly itself.

The entire loudspeaker system is electronically protected against spurious overload signals by means of a multi-channel sensing circuit operating in conjunction with a relay operated switch and voltage dropping resistor.

LF Enclosure

Energy within the low frequency pass band of 55 - 400 Hz is radiated by a pair of identical 200 mm diameter bass units type SP1076. The general specification of these drive units is given in the appendix. The two units are mounted in vertical array on the sloping front face of the 40 litre enclosure constructed from 18 mm particle board.

The drive units are constructed on the now familiar trochoidal-shaped chassis with its three-point, stress-free mounting and both are isolated from the enclosure front panel by means of compliant rubber mountings. In the early production these will consist of moulded rubber grommets and metal spacers, but these will be replaced eventually with specially fabricated one-piece components. Because the compliant mounting is so effective in reducing cabinet excitation it has been possible to omit expensive panel damping without audible colouration. KEF engineers have made good use of modal analysis in evaluating and optimising the drive unit mounting and internal bracing of the enclosure.

The Bextrene cone drive units which are identical are each nominally of 4 ohms impedance and are driven in series presenting a combined impedance of approximately 8 ohms. Each unit has an effective piston area of 232 cm^2 and the two operating together gain a little extra effect due to mutual radiation resistance.

The twin drive units are fed via a series 480 microfarad capacitor to improve the transfer of energy from amplifiers having low internal resistance. The complete circuit diagram of the dividing network is shown in Fig. 1.

Acoustical absorbent material is installed within the LF enclosure to maintain the required value of Q. This is provided in the form of blocks of expended polyurethane foam.

The overall frequency response of the LF section extends smoothly downwards from the crossover point to 60 Hz where it is -3 dB. In this respect, it is half an octave short of the equivalent cut-off frequency of Model 105.2 but the difference is scarcely audible on most musical programme.

Non-linear distortion products are commendably low due mainly to sharing of the input power between two drive motors.

The LF enclosure houses all the filter networks, the protection relay and attenuation resistor on a single printed circuit board located on the rear panel. Input connections are made using large jaw clamps as fitted to the Model 105.2

MF and HF Head Assembly

The radiation of energy in the frequency range above 400 Hz is provided by two drive units housed in a specially shaped plastics moulding.

Mid-range frequencies from 400 - 3,000 Hz are handled by a 110 mm diameter Bextrene cone driver SP 1057 fitted with PVC roll surround and 25 mm diameter voice coil. A full specification will be found in the appendix. This driver is mounted in a sealed enclosure having a volume of 8.5 litres and suitably damped with foam plastics absorbent material. Excitation of the enclosure is reduced by compliantly mounting the mid-range unit on rubber grommets.

The size of the front face of the head assembly and the shape of its edges have been chosen to ensure adequate baffling of the mid-range unit at the lower end of its pass band and to avoid serious discontinuities in the path of developing wavefronts.

The B110 is driven via an auto-transformer to raise the overall sensitivity in the mid-range pass band.

High frequencies from 3,000 Hz upwards are handled by a T33 type SP1074. This was chosen for its high sensitivity to accord with the requirement of the design brief to raise efficiency as much as possible. The use of an HF unit with voice coil smaller than T52 and hence lower thermal capacity was made possible due to the protection from accidental overloading by the newly developed S-STOP circuit.

The frequency response of the head assembly extends smoothly to 20 kHz. Within the listening window of $\pm$ 20° horizontally and $\pm$ 5° vertically response is maintained within 1 dB of the reference axis response up to 10 kHz.

Electronic Overload Protection

The S-STOP self-powered, automatic electronic overload protection system which has proved so successful with Model 101 and Model 105.2 has been incorporated in the Model 105.4. However some modifications have been adopted in the latest version, partly as economy measures and partly as a result of experience with earlier products.

The S-STOP sensor module effectively monitors the temperatures of all four drive units and is set to activate the protection relay should any voice coil exceed its safe operating temperature. The input voltage is also monitored and the S-STOP will trip if the peak input voltage exceeds 70V anywhere within the frequency range DC - 50 kHz.

It has been found unnecessary to apply excursion limiting to the LF drive units since on test they were found to operate safely and without bottoming at peak voltages of up to 100V. In these circumstances, it was considered desirable to omit the excursion limiting feature as this is sometimes a nuisance in that it may trip the S-STOP circuit when there is no permanent danger to any part of the system.

The LED, which primarily serves to align the listening window, also doubles as a peak level indicator and test facility. By turning the three position rotary switch to TEST, the S-STOP circuit can be actuated at a level far below normal operating conditions making it possible to check the operation of the relay using amplifiers of small to medium power output.

Peak Level Indicator

Warning of excessive peak voltage is only provided at the full rated power of the system - namely 200 Watts. This has been done to economise on the ten-way rotary switch and associated components as fitted in the Model 105.2. In the case of the Model 105.4 a three position switch is fitted to the rear of the head assembly. As there is no OFF position, the other two being LISTENING WINDOW and S-STOP TEST, the peak level indicator switch should be turned to 200 W PLI in normal use. In this condition the LED will be illuminated momentarily to give warning when overload conditions are being approached, for normal musical programme. If the LED continues to flash then the S-STOP relay will eventually operate to protect the system.

Listening Window

The listening window angles are precisely the same as those prescribed for Model 105.2 e.g. horizontally $\pm$ 20° and vertically $\pm$ 5°. The head assembly may be swivelled through $\pm$ 30° horizontally and tilted vertically $\pm$ 7° about its mean position. Alignment of head assembly and listeners is facilitated by switching the three-position control to LISTENING WINDOW. A low level of programme will then be sufficient to fully illuminate the LED and the attitude of the head assembly should then be adjusted until the listeners can see both left and right hand LEDs in the central target area. Although there is little danger of generating non-linear distortion with the latest circuit in the event of the loudspeaker being operated with the switch in the LISTENING WINDOW position, it is recommended that the control be switched to 200 W for normal use.

Head Cover

As in the case of Model 105.2, the new model is supplied in standard form with the head assembly exposed. A head cover will be available at extra cost for use with the standard LF enclosure grille. There will be no redundant parts.

Optional Finishes

Model 105.4 will be available in a choice of walnut, teak or rosewood veneers as well as in black ash, with black grille fabric.

Performance

During blind listening tests carried out at Tovil, the Model 105.4 revealed very little difference in comparison with the 105.2. This result was hardly surprising in view of the many similarities between the two models. It is expected that people will hear differences on organ music and other programme material in which extreme low frequencies predominate, but for general symphonic music and pop the extra half octave should rarely be missed.

The chief benefit of restricted bandwidth is in higher efficiency resulting in an increase of 2 dB in sensitivity over the Model 105.2. It will be interesting to note in due course if this improvement proves to be of greater commercial significance than the slight restriction in the bass.

The overall frequency response of Model 105.4 is shown in Fig. 2, taken at 2m on the design axis.

The impedance is nominally 8 ohms and does not fall below 6 ohms at any frequency within the operating range.

Quality Assurance.

All loudspeaker manufacturers promise quality control but few do little more than make a cursory examination of random samples. Model 105.4, like other systems in the KEF Reference Series, is produced by a unique process which incorporates quality assurance at every stage of assembly.* All components are inspected individually. Each drive unit is measured using high speed precision impulse methods pioneered by KEF. Digitally recorded data is then used to computer match sets of drive units which are complemented with paired dividing networks. These novel and precise production methods guarantee the frequency response of Model 105.4 within fine limits and result in stereo reproduction of outstanding perspective and sharpness.

* KEFTOPICS Volume 3 No. 3.

Specification

Frequency Range	60Hz - 22kHz ±3dB at 2m on design axis (-10dB at 35Hz and 30kHz)
Directional Characteristics	Within 1dB of response on design axis up to 20,000 Hz for ± 5° vertically up to 10,000 Hz for ± 20° horizontally
Characteristic Sensitivity Level	86dB spl at 1m on design axis for pink noise input of 1W (anechoic conditions)
Maximum Output	108dB spl on programme peaks under typical listening conditions
Distortion	Second Harmonic: less than 1% from 50 - 20,000Hz Third Harmonic: less than 1% from 30 - 20,000Hz Measured at 1m on design axis at mean spl of 90dB.
Enclosures	Low frequency enclosure: 40 litres Mid and high frequency enclosure: 8.5 litres

Power Handling Capacity*:

Programme Rating	200 W
Maximum Continuous Sinusoidal Input	20V rms, 20-50Hz rising to 28V rms from 100-500Hz falling to 20V rms from 1,000-2,500Hz falling to 7V rms from 4,000-20,000Hz

* Electronic Protection (S-STOP)
The system is protected against any continuous or intermittent fault conditions which produce input signals not greater than 70V peak from DC to 50kHz.

Nominal Impedance	8 ohms
Peak Level Indicator	LED flashes to indicate input power level of 200 W
Listening Window Indicator	LED glows continuously to indicate orientation of head assembly and facilitate alignment of listening window
Dimensions	936 x 350 x 360 mm
Weight	22kg (Including Head)

B200 Specification Number SP 1076

Low/mid range unit with visco-elastic damped Bextrene diaphragm, Neoprene roll surround and high temperature coil assembly, suitable for use where low distortion and high power handling are required.

Net weight: 1.47 kg

Nominal impedance: 4 ohms

Nominal frequency range: 25 - 3,500 Hz

Power handling: 100W programme

Magnet: Flux density 1.1T (11,000 gauss)
Total flux 7.15×10^{-4} Wb (58,000 Maxwells)

Voice coil: Diameter 32.6 mm (1 1/4 inches)
Max. continuous service temperature (30 min.) 250°C
Max. intermittent temperature (5 sec.) 340°C
Nominal DC Resistance, R_{DC} 3.9 ohms (tolerance ±5%)

Diaphragm: Effective area, S_D 232 cm² (36 sq. in.)
Max. linear excursion, X_D 6 mm peak-peak (0.25 in)
Max. damage limited excursion 20 mm peak-peak (0.8in.)

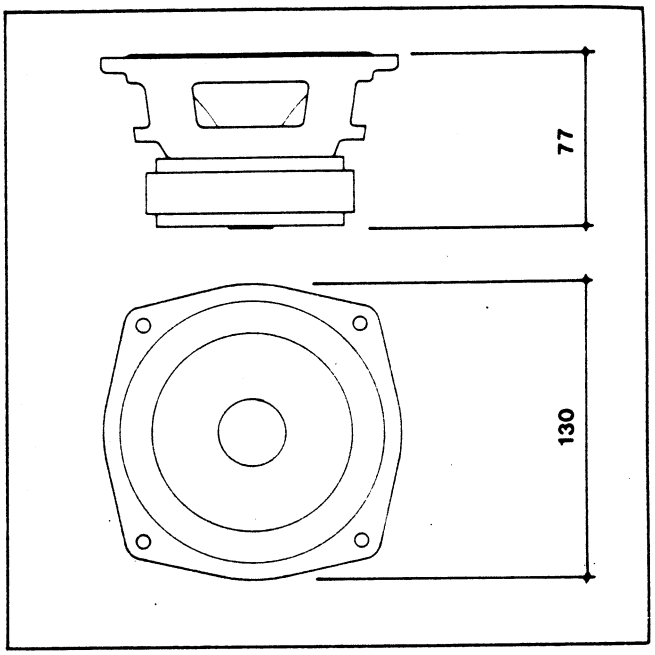
Free air resonance frequency, f_s:
Nominal 25 Hz (tolerance ±5 Hz)
Typical production spread 24±2.2 Hz. *

* "Typical production spread" is derived from statistical analysis of a large number of units, and is calculated to include 95% of all units.

KEF DATA SHEET

ISSUE 0677

Model B110
Specification Number SP1057



Compact, long throw bass/mid range unit, suitable for use in either a compact full range system, or as a specialised mid range unit in a multi-way system.

Net weight: 1.13 kg (2.5 lb)

Nominal impedance: 8Ω

Nominal frequency range: 55-3,500 Hz

Typical enclosure volumes:
Totally enclosed box 5-10 litres (0.2-0.4 cu ft)
MF enclosure 4 litres (0.15 cu ft)

Power handling:
Continuous sine wave 28 V RMS (see note 1)
Programme full range 50 W (see note 2)
Programme mid range only 150 W (see note 2)

Magnet:
Flux density 1.0 T (11,000 gauss)
Total flux 5.8 x 10^{-4} Wb (58,000 Maxwells)

Sensitivity: Pink noise input for 96 dB SPL at 1 metre on axis 11.2 V RMS

Voice coil:
Diameter 26 mm (1 in)
Inductance 0.45 mH
Max continuous service temperature (30 min) 250°C
Max intermittent temperature (5 sec) 340°C
Thermal time constant 11 seconds
Thermal resistivity (temp rise per applied Watt) 6.2°C/W
Nominal DC Resistance, R_{DC} 7.1Ω (tolerance ±10%)
Typical production spread 6.7±0.2Ω (see note 3)
Minimum impedance (in nominal frequency range) 7.8Ω at 280 Hz

Diaphragm:
Effective area, S_D 92 cm^2 (14 sq in)
Effective moving mass, M_D 9.8 gm
Max linear excursion, X_D 6 mm peak-peak (¼ in)
Max damage limited excursion 12 mm peak-peak (½ in)

Free air resonance frequency, f_s:
Nominal 37 Hz (tolerance ±5 Hz)
Typical production spread 38.0±2.0 Hz (see note 3)

Total mechanical resistance of suspension, R_{MS}: 1.0 mech Ω

Suspension compliance, C_{MS}: 1.8 x 10^{-3} m/N (1.8 x 10^{-6} cm/dyne)

Equivalent volume of compliance, V_{AS}: 23.6 litres (1,440 cu in)

Force factor, Bl: 7.1 N/A

Damping:
Mechanical Q_M 2.44
Electrical Q_E 0.38
Total Q_T 0.33 (see note 4)

Notes

1 Continuous Power Rating (Pc).

$$Pc = \frac{V^2}{R}$$

V is the RMS voltage which can be applied to the unit continuously without thermal overload of the voice coil. At low frequencies the continuous power rating of the speaker may be reduced because of limitations imposed on diaphragm excursion by the acoustic loading.

2 The programme rating of a unit is equal to the maximum programme rating of any system with which the unit may be safely used in conjunction with the recommended dividing network and enclosure.
The programme rating of any system is the undistorted power output of an amplifier with which the system may be satisfactorily operated on normal programme over an extended period of time.

3 "Typical production spread" is derived from statistical analysis of a large number of units, and is calculated to include 95% of all units.

4 $$Q_M = \frac{2\pi f_S M_D}{R_{MS}} \qquad Q_E = \frac{2\pi f_S M_D}{(Bl)^2/R_{DC}} \qquad \frac{1}{Q_T} = \frac{1}{Q_M} + \frac{1}{Q_E}$$

KEF Electronics Limited Tovil Maidstone ME15 6QP England ☎ 0622 672261

T33 Specification Number SP 1074

Net weight: 0.55 kg

Nominal impedance: 8 ohms

Nominal frequency range: 3,000 - 20,000Hz

Power handling: 100 W programme
continuous sine wave 9V rms (see note)

Magnet: Flux density 1.2T
Total flux 2.9×10^{-4}Wb

Voice coil: Diameter 25.4mm
Max. continuous service temperature (30 min) 120°C
Max. intermittent temperature (5 sec) 200°C
Nominal DC resistance, R_{DC} (tolerance 5.6 - 6.4ohms)

Diaphragm: Effective area, S_D 6.29 cm^2
Effective moving mass, M_D 0.36g

Free air resonance frequency, f_s:
Nominal 950 Hz $\pm$ 200 Hz

Total mechanical resistance of suspension, R_{MS}: 0.5 mech ohms

Suspension compliance, C_{MS}: 7.8×10^{-5} mN^{-1}

Force factor, Bl: 3.5 NA^{-1}

Damping: Mechanical Q_M 4.39
Electrical Q_E 1.04
Total Q_T 0.84

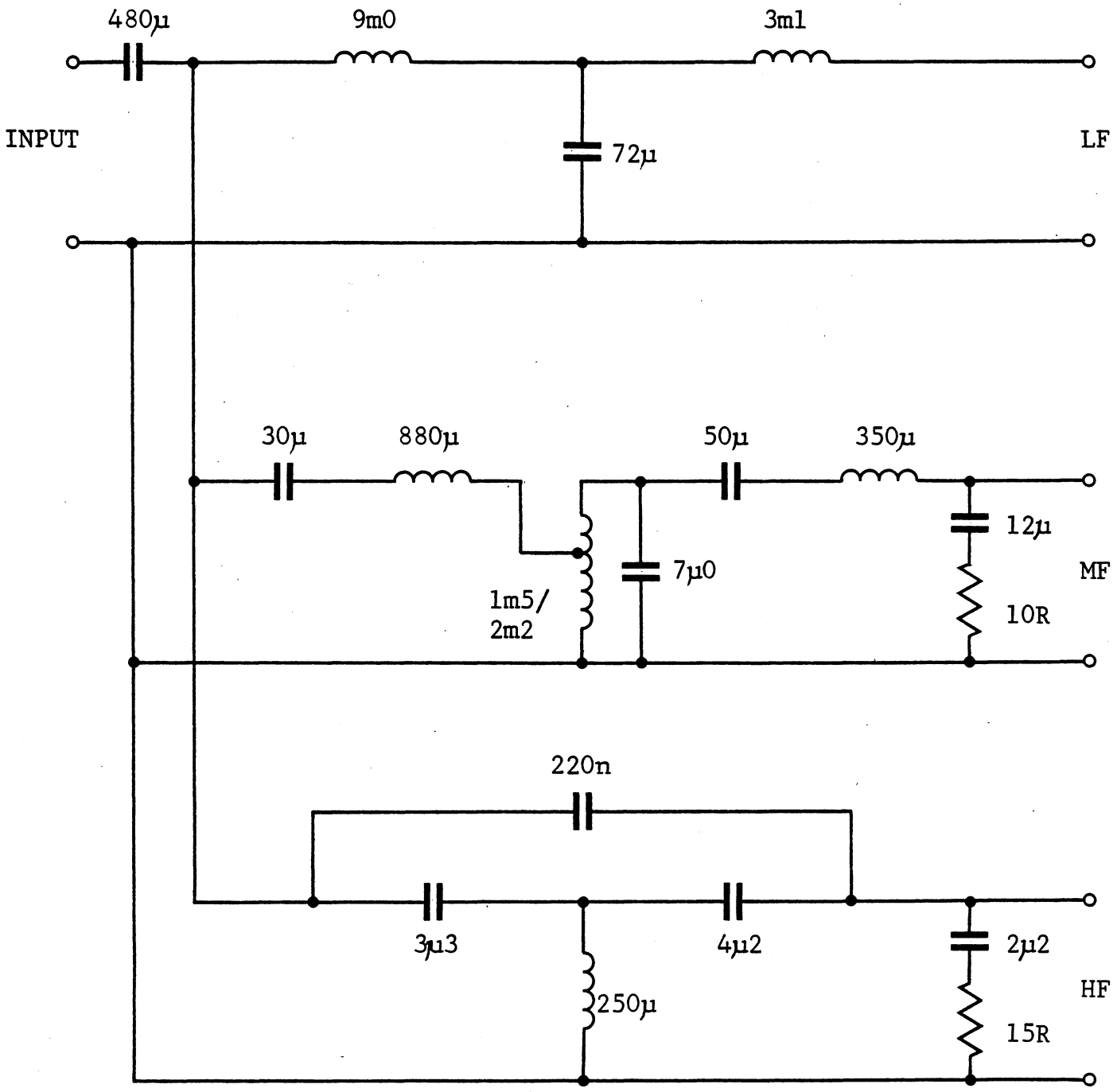
Note

1 Continuous power rating (Pc) $Pc = \frac{V^2}{R}$

V is the rms voltage which can be applied to the unit continuously without thermal overload. At low frequencies the continuous power rating of the speaker may be reduced because of limitations imposed on diaphragm excursion.

Fig.1

MODEL 105.4 DIVIDING NETWORK



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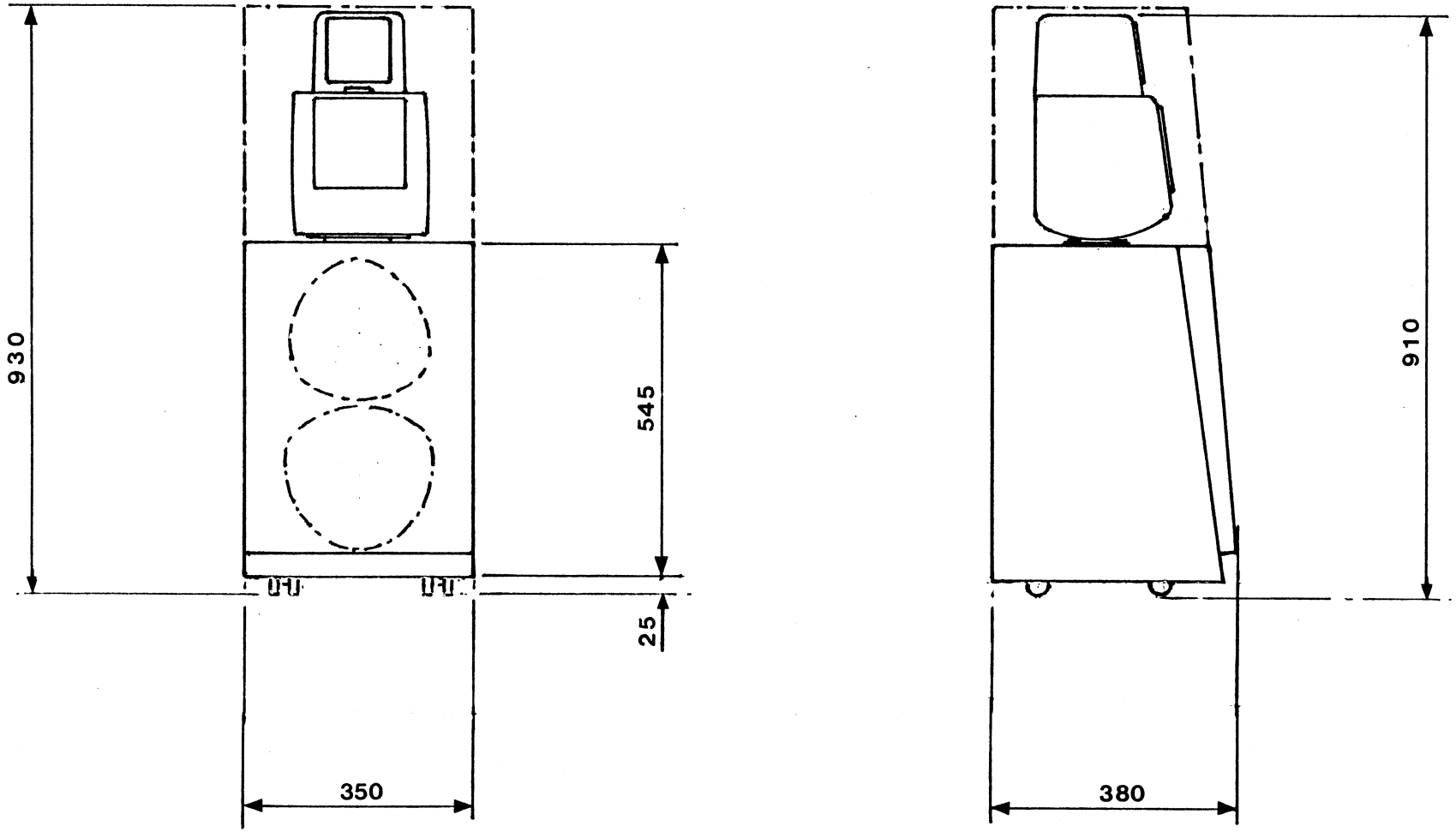


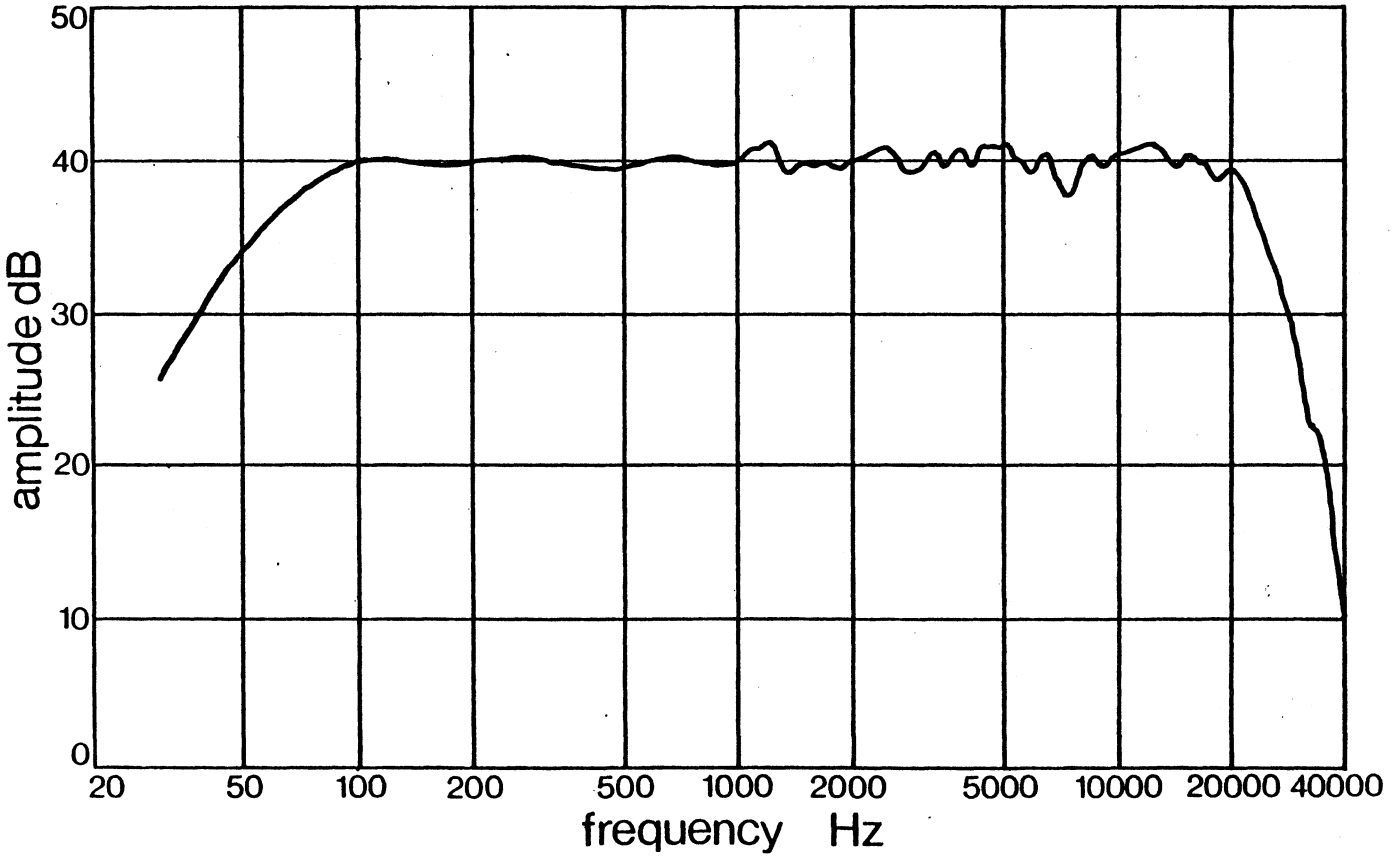
MODEL 105.4 OUTLINE DRAWING

Published by KEF Electronics Limited

Part No. SL243EN01

Fig. 2

MODEL 105.4 AMPLITUDE RESPONSE



KEF products are manufactured in England and distributed in the United Kingdom by:
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Telephone: 0622 672261
Telex: 96140

Distribution in the USA by:
Intratec
PO Box 17414
Dulles International Airport
Washington, DC 20041 USA
Telephone: 703-435 9100

Printed in England