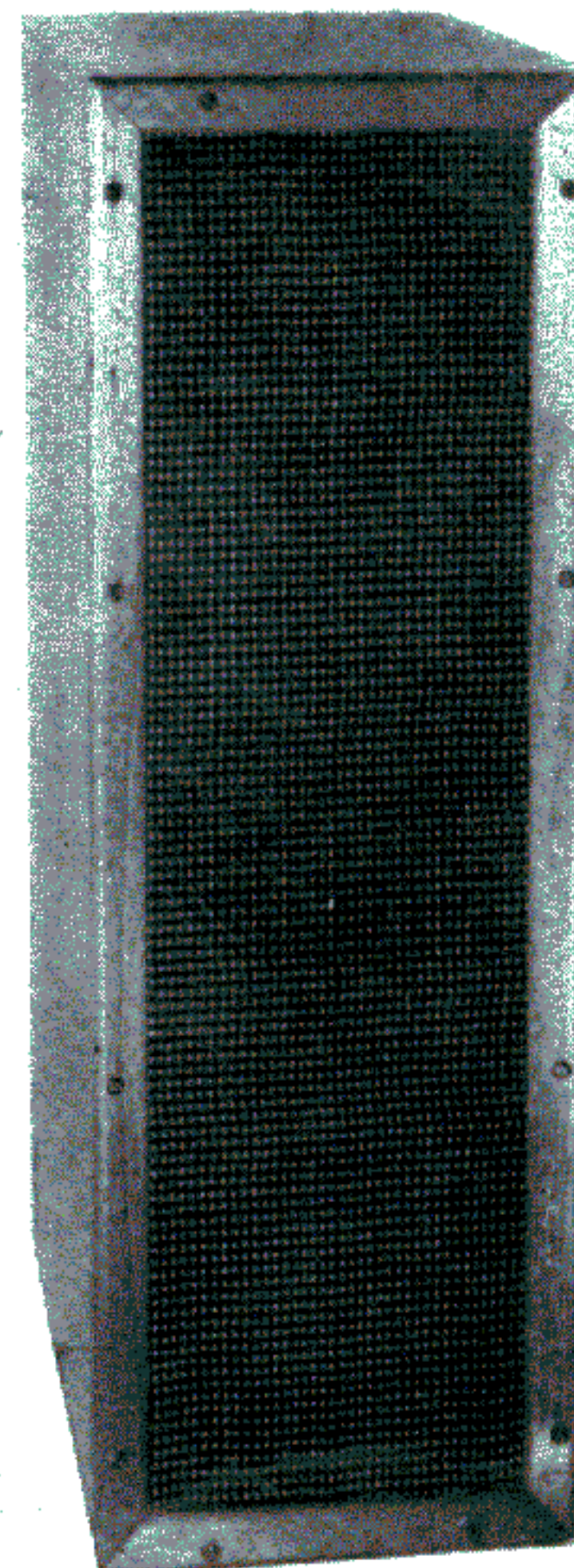
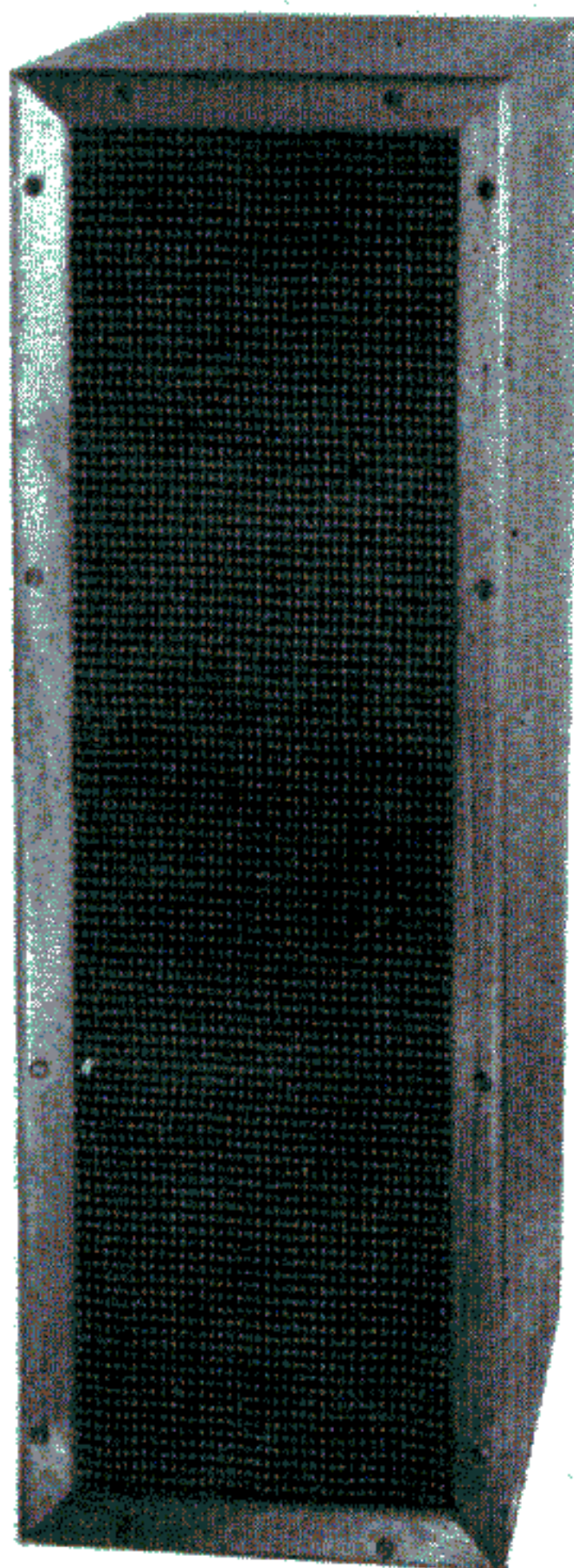
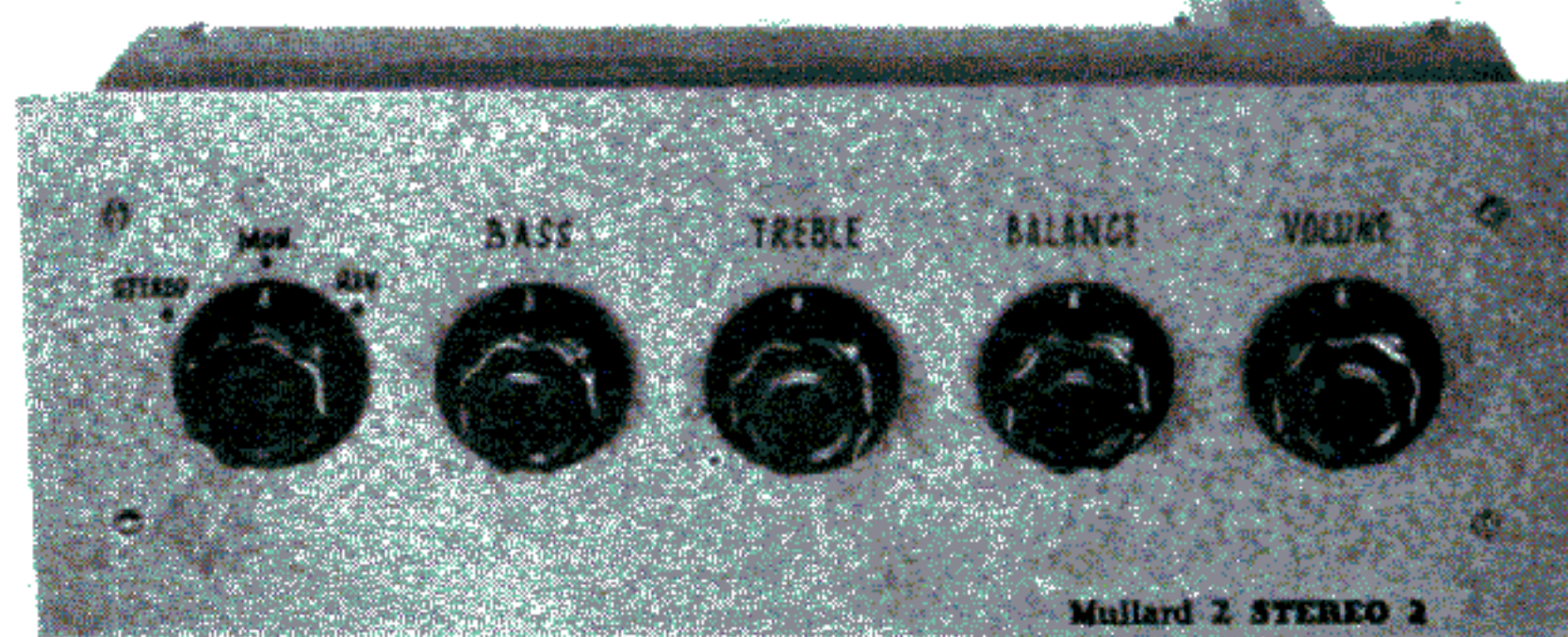
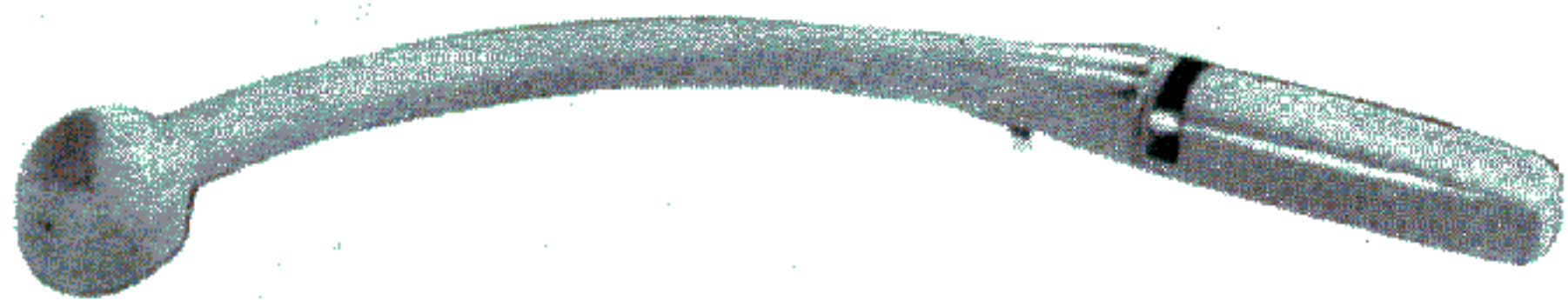


Mullard 2 STEREO 2

A QUALITY STEREOPHONIC AMPLIFIER
FOR THE HOME CONSTRUCTOR



THIRD REPRINT
MAY, 1959

INTRODUCTION

In recent years remarkable improvements have been made in the field of sound reproduction, in that progress in the design of pickups, amplifiers and loud speakers, together with the introduction of high quality disc and tape recordings and VHF sound broadcasting has set new standards for the discriminating listener. However, all too frequently insufficient attention is paid to the acoustic side of sound reproduction as a means of furthering the illusion of three-dimensional sound.

The results of engineers' endeavours to recreate sound contours so that the sound source is apparently defined in space rather than the listener experiencing a fixed point source of sound is the achievement of binaural and stereophonic recording and reproducing techniques. True binaural reproduction requires the listener to wear head-phones

and this method of "captivating" an audience is likely to find favour with few music lovers. On the other hand, stereophonic reproduction requires two speaker systems spaced some six to ten feet apart — the preferred listening area being centred on the apex of an equilateral triangle of which the loud speaker systems define the base line. Whilst stereophonically recorded programme material is currently available both on tape and disc the simpler handling of the gramophone record has in this field again brought it to the fore as domestic entertainment.

It is as well at this stage to be aware that the equipment necessary for stereophonic reproduction comprises two entirely separate channels and although these can be obtained in the one power amplifier by hybrid connections at both input and output, the more obvious approach which places

no additional limitations on quality is to provide two separate power amplifiers. Since with the hybrid technique it is difficult to obtain a wide frequency response and low levels of distortion, the two-amplifier approach is recommended for the home constructor and discriminating listener.

A number of possibilities are immediately apparent and in order of decreasing power these are:—

- (a) Two 5-20 Amplifiers
- (b) Two 5-10 Amplifiers
- (c) Two 3-3 Amplifiers

A suitable pre-amplifier to cope with stereo magnetic cartridges, tape input, etc., will be detailed in the near future. At the moment, however, stereo crystal cartridges appear to be more readily available than their magnetic counterparts and for this reason a design based on two 3-3's for a stereo crystal pick-up input has been investi-

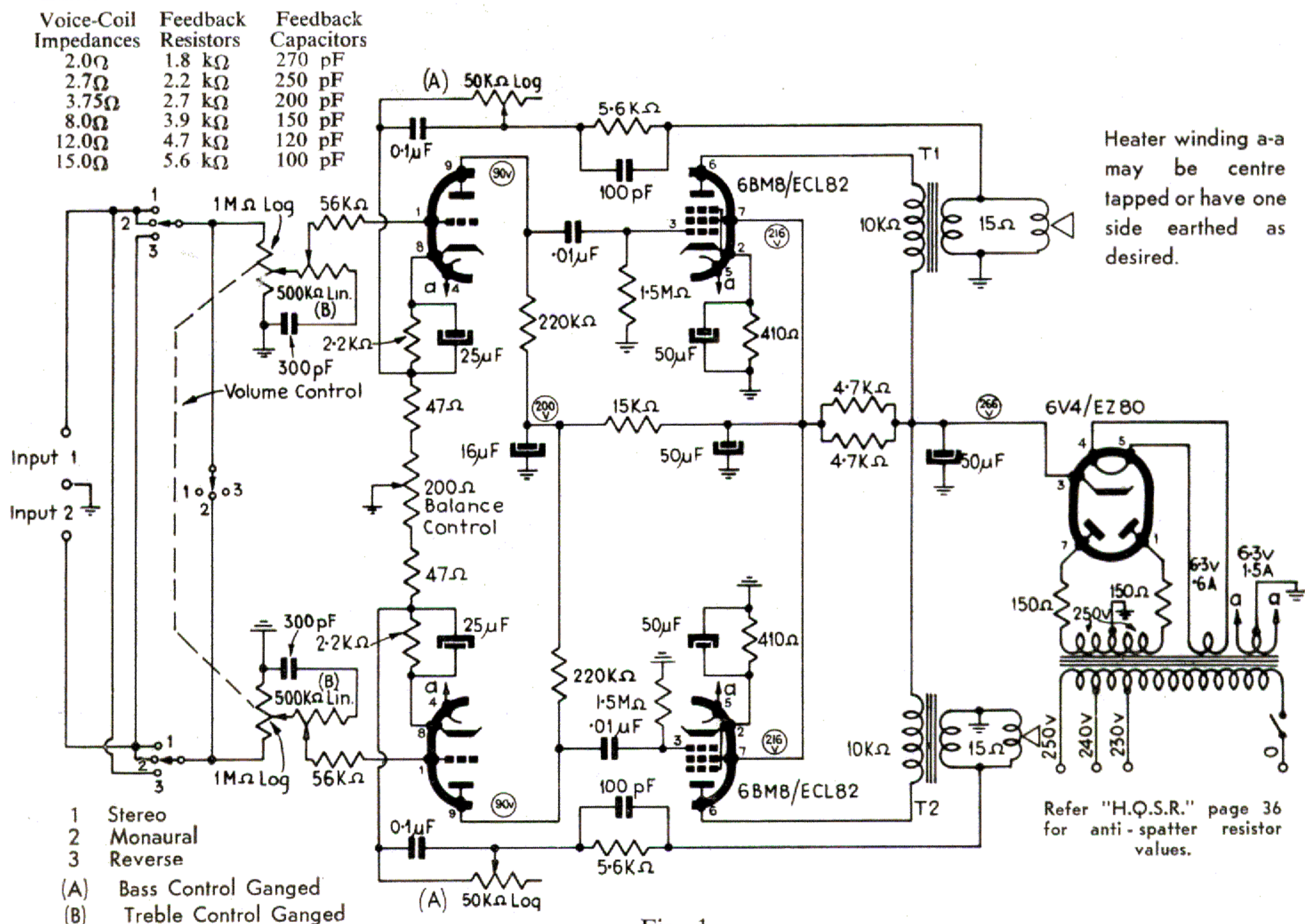
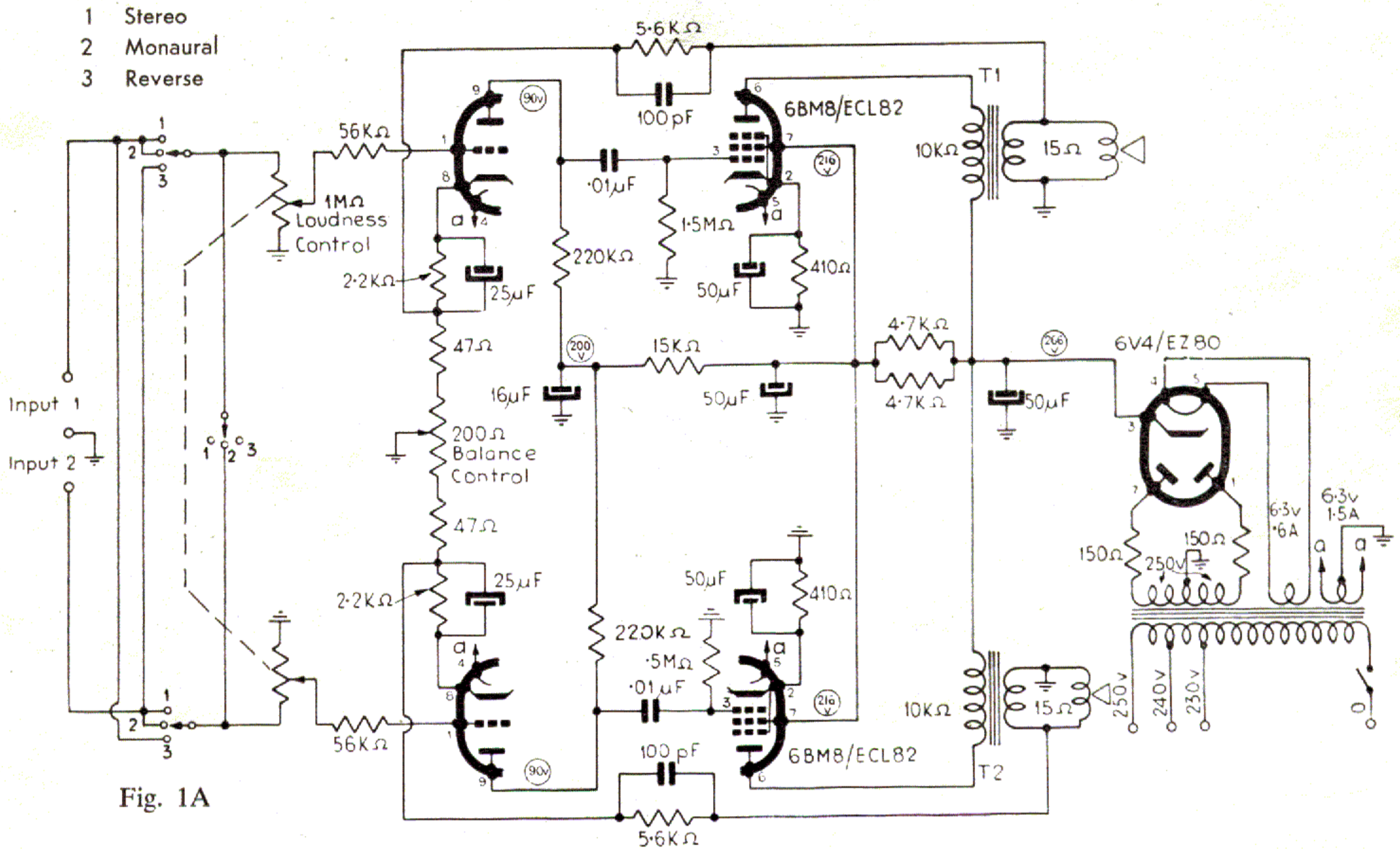


Fig. 1



gated. Detailed examination shows, however, that a more compact and efficient amplifier is obtained with a design featuring two 6BM8/ECL82 valves.

THE 2 STEREO 2 AMPLIFIER

This design is presented in two forms — (a) with volume control and separate bass boost and treble cut controls, and (b) with loudness control. The circuit has been designed by Mullard engineers for those constructors who wish to assemble a low cost quality stereo amplifier. It is suited to most types of stereo crystal pickups and has a rated output of 2W per channel at less than 2% total harmonic distortion.

CIRCUIT DESCRIPTION

The amplifier, which is operated from the A.C. mains, uses three Mullard valves, a 6BM8/ECL82 as triode voltage amplifier and pentode output stage in each channel and a 6V4/EZ80 as the rectifier. Figures 1 and 1A show the schematic with alternative control arrangements whilst the comparatively high sensitivity of 200mV for 2W output in each channel coupled with an input impedance of

1 megohm accommodates most stereo crystal pickups and allows if required input equalising networks.

In this design the triode section of the 6BM8/ECL82 is used as a voltage amplifier to feed the output pentode section. As the overall gain of this configuration is such that the amount of negative feedback which can be employed is limited to about 9dB if an input sensitivity of 200mV is to be maintained, careful selection of the operating conditions of the pentode

section is necessary to ensure low distortion. Additional to this is the problem of ensuring a low hum and noise level without bulky and costly filtering components in the high tension supply and these two requirements are met by the adoption of a set of operating conditions for the pentode section of the 6BM8/ECL82 where the screen grid voltage is lower than the anode voltage. With 9.5dB of feedback a nominal amplifier delivers 2W to the loud speaker at

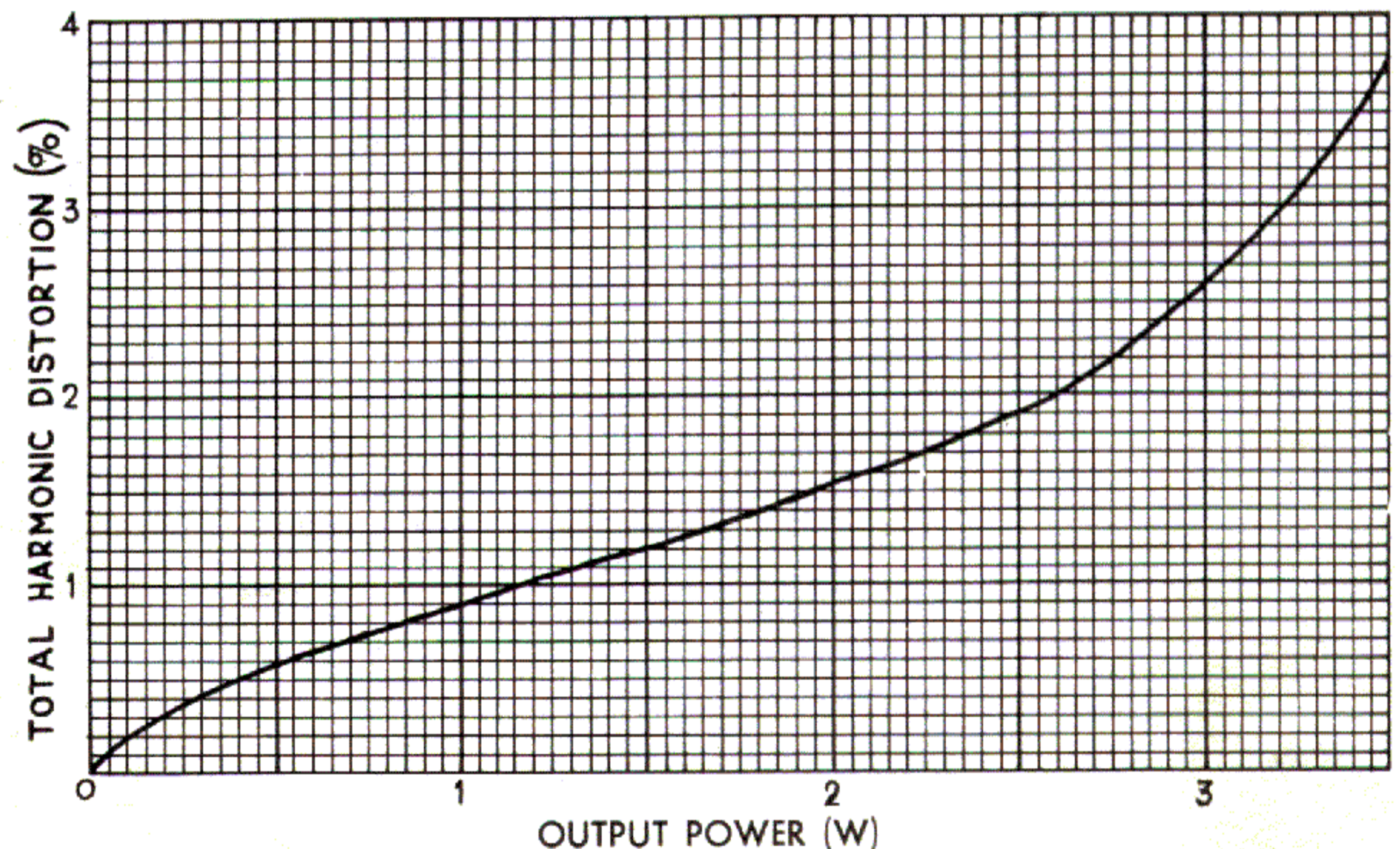


Fig. 2

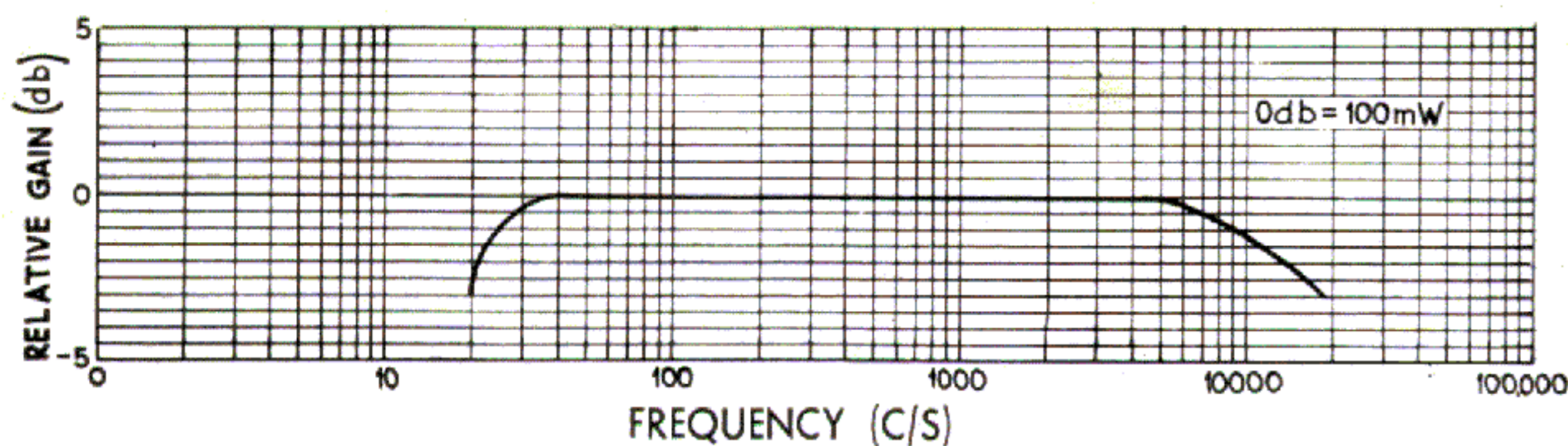


Fig. 3

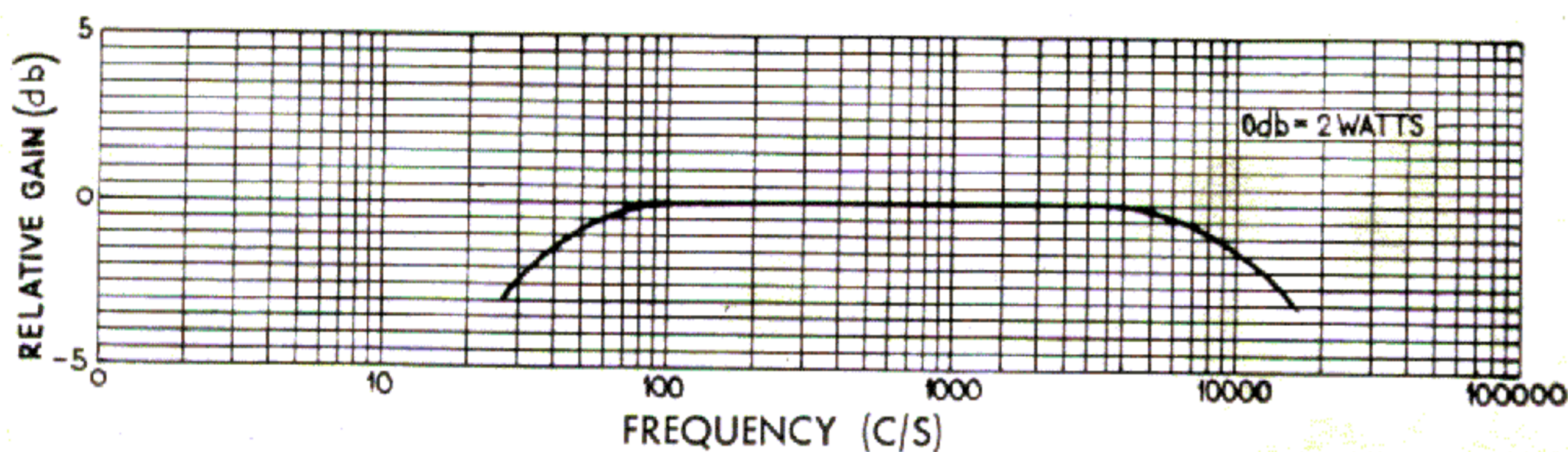


Fig. 3A

1.5% total harmonic distortion and 3.2W before the onset of clipping as shown in figure 2. Figures 3 and 3A illustrate the frequency response of each channel at the 100mW and 2W output levels respectively. The range of the tone controls is illustrated in figure 4.

There may be some home constructors who feel that 2 watts per channel at one and one half per cent. distortion is inadequate for realistic reproduction but with a high efficiency speaker system such as the one described over leaf the 2 stereo 2 has been used in rooms of 1200 cu. ft. to reproduce the dynamic range of an orchestra and effects such as trains, aircraft flying

overhead, motor racing, etc., without the need being felt for a more powerful amplifier. In larger rooms and halls more power will be required and discriminating enthusiasts will demand lower distortion but for a serious introduction to stereo the low cost 2 stereo 2 amplifier represents a forthright approach.

ACOUSTICS

Although it is generally conceded by most authorities that listeners are unable to appreciate the direction of sound waves below 300 c/s and therefore this band of frequencies cannot

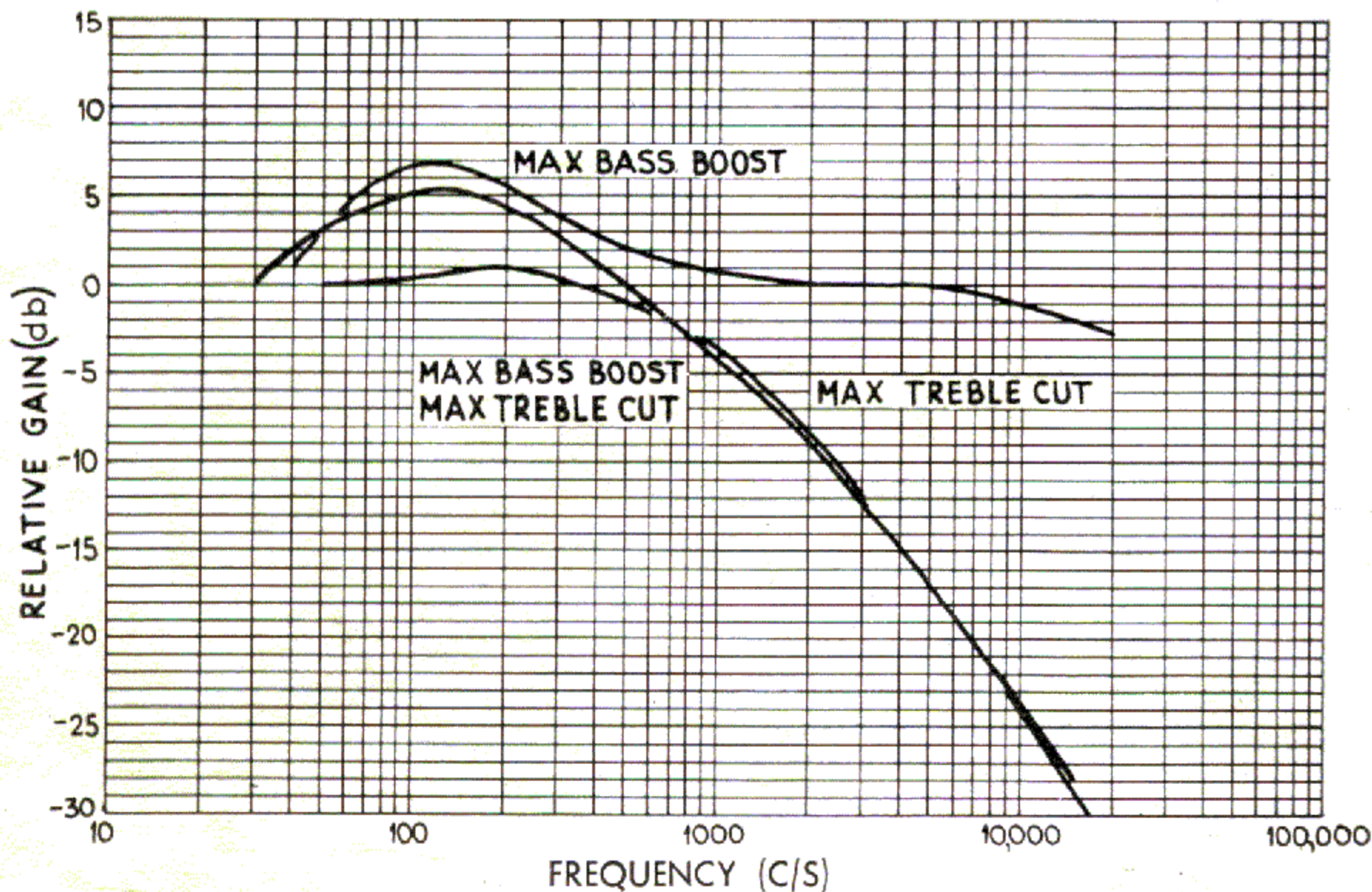


Fig. 4

assist the stereo effect, it has been noted by other acoustic researchers that double bass and drum passages can be defined in space when reproduced stereophonically. The view that frequencies below 300 c/s do not contribute to the illusion has led to the technique that the bass of both channels is fed to a common "woofer" or low frequency speaker system with separate mid and high frequency speakers for each channel located for optimum stereo effect. Indeed, as a result of this premise we find some manufacturers suggesting a separate amplifier and speaker unit covering the audible range above 300 c/s as an "add on unit for stereo."

The performance of these two arrangements seldom approaches that of two identical loud speaker units and this latter approach is recommended for the home constructor and professional alike.

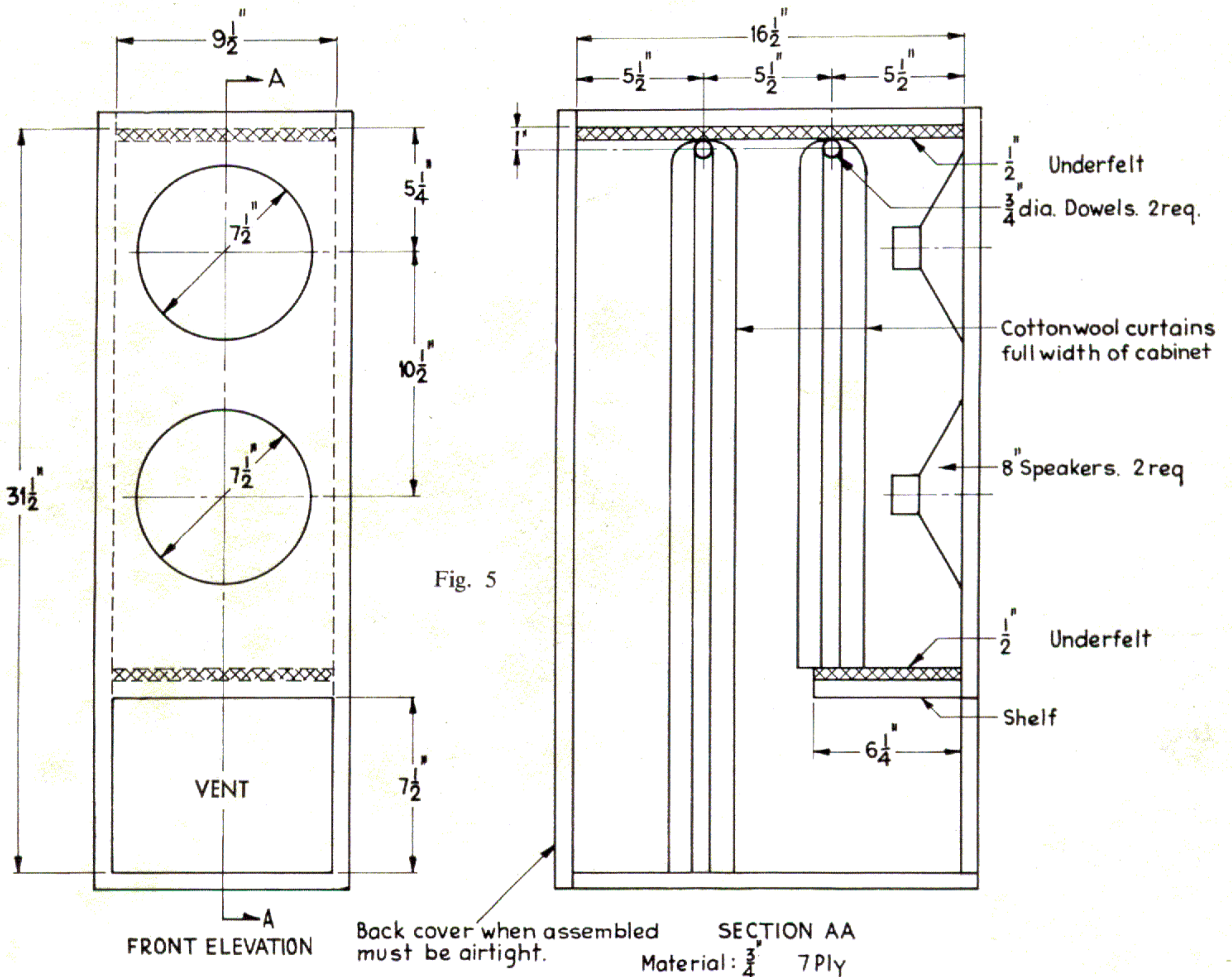
ENCLOSURES

The duplication of any suitable loud speaker enclosure will be satisfactory for a stereo reproducing system, but two normal sized enclosures may tend to crowd the smaller living room and lead to protests from the distaff side. For this reason constructional details are included of a small vented enclosure housing two 8" speakers capable of providing full well-damped bass to 35 c/s. As two of these enclosures (one for each stereo channel) occupies less space than many conventional monaural enclosures and the double 8" speaker vented enclosure can be readily adapted for side mounting by ensuring that the cotton wool curtains hang in the vertical plane.

Small Swedish style legs enable the unit to be used as a contemporary coffee table, thus simplifying the problem of introducing stereo to the home.

ENCLOSURE CONSTRUCTION

Figure 5 details the front and sectional elevation of the enclosure. It will be noted that to ensure rigidity and freedom from panel resonances $\frac{3}{4}$ " 7-ply has been specified for the construction. Carpet underfelt $\frac{1}{2}$ " thick is affixed to the upper side of the shelf forming the tunnel and the interior of the top panel and together with the two double thickness cotton wool curtains results in a close approximation to critical damping with quality 8" loud speakers. Suggested units for this enclosure are the Philips 9710M, the Magnavox 8WR and the Rola 8MX although any wide range 8" speaker with a free air cone resonance of approximately 45 c/s should be suitable. Slight modification to the thickness of



LIST OF MATERIALS

(For two enclosures)

- 1 only sheet 6' x 3' 7 ply
- 1 only sheet 7' x 3' 7 ply
- 2 only 12" wide 16 oz. rolls cotton wool
- 4' of $\frac{3}{4}$ " dowel stick
- 5' under carpet felt $\frac{1}{2}$ " thick, 12" wide
- Beading for front of enclosure
- 2' of speaker silk 36" wide.

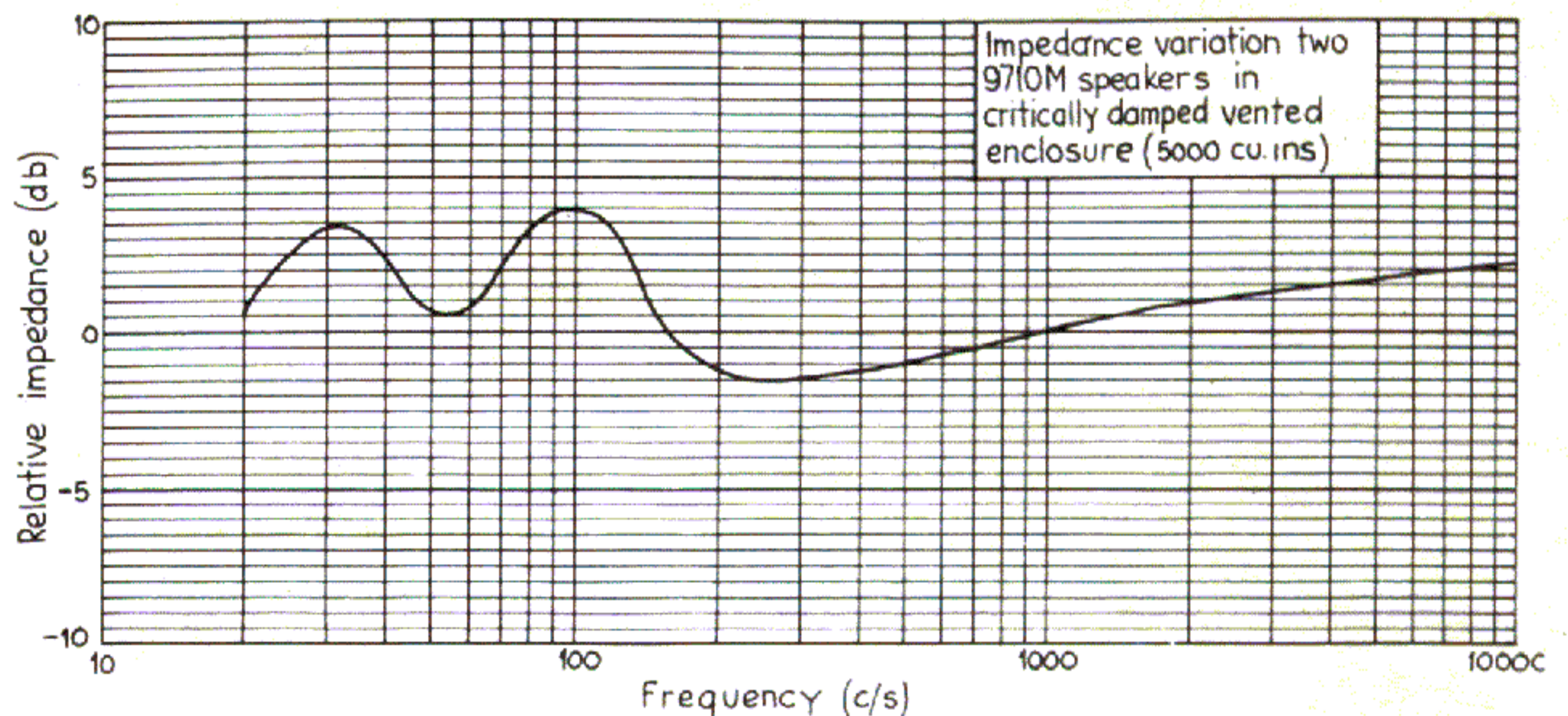


Fig. 6

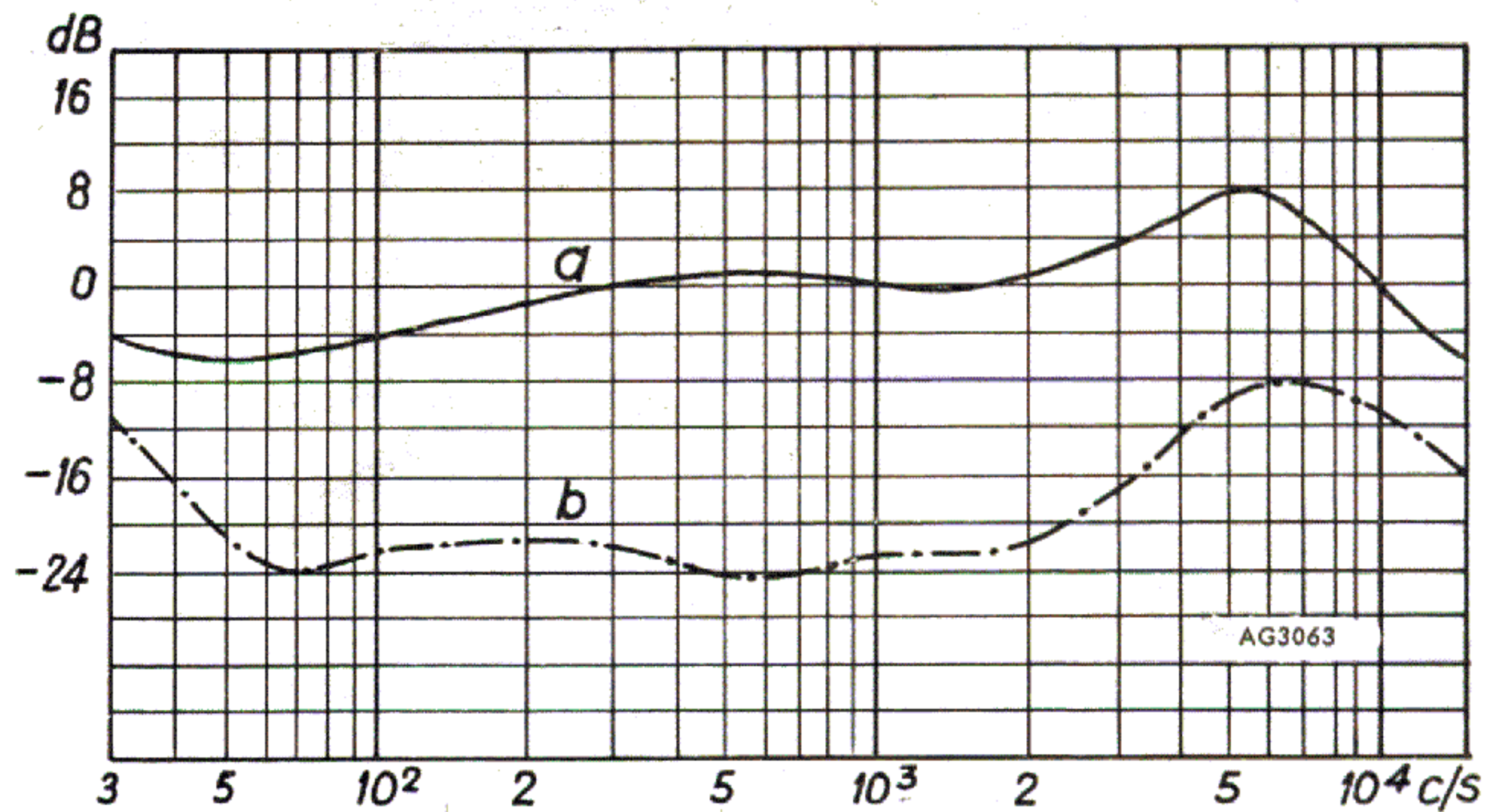
the cotton wool curtains may be necessary to critically damp the enclosure and figure 6 illustrates the impedance curve of two 9710M speaker units in this critically damped enclosure. Whilst exterior treatment is usually determined by existing furnishings a simple functional treatment which is unobtrusive in most surroundings is that illustrated on the cover. Here the cabinet is polished to match other furnishings and a suitable open weave non-fluffy material or expanded aluminium attached to the front with a suitable trim. If expanded metal is used, care must be taken in the mounting to ensure that rattles do not develop. It is likewise important in the construction of the enclosure to ensure that the removable back provides an air tight seal when finally assembled.

FACTORY CONSTRUCTED ENCLOSURE

For those who prefer to purchase a factory constructed enclosure, samples have been submitted for our approval by Albert Wright of 793-795 New Canterbury Road, Hurlstone Park, N.S.W. The enclosure is also available in kit set form from Cabinet Kits, 160 High Street, St. Kilda, Vic.

PICKUPS

No matter how excellent the amplifier the final quality of any music system can never be better than the quality of the programme source. Recently crystal pickups have become



a. Frequency response (velocity loaded 100K)
b. Cartridge crosstalk

available which permit excellent reproduction from stereo records. The Acos GP71-3, Philips AG3063 and the Ronette BF40 have been used successfully with this amplifier without the need for equalisation. A constructional view and performance curves of a typical stereo cartridge are shown on this page.

Consistent with the high quality moderate cost theme, the performance of the AG2002 record player, and AG1014 (AG1003T) changer-player, fitted with the AG3063 stereo head, is comparable with much more expensive units.

TECHNICAL SERVICE

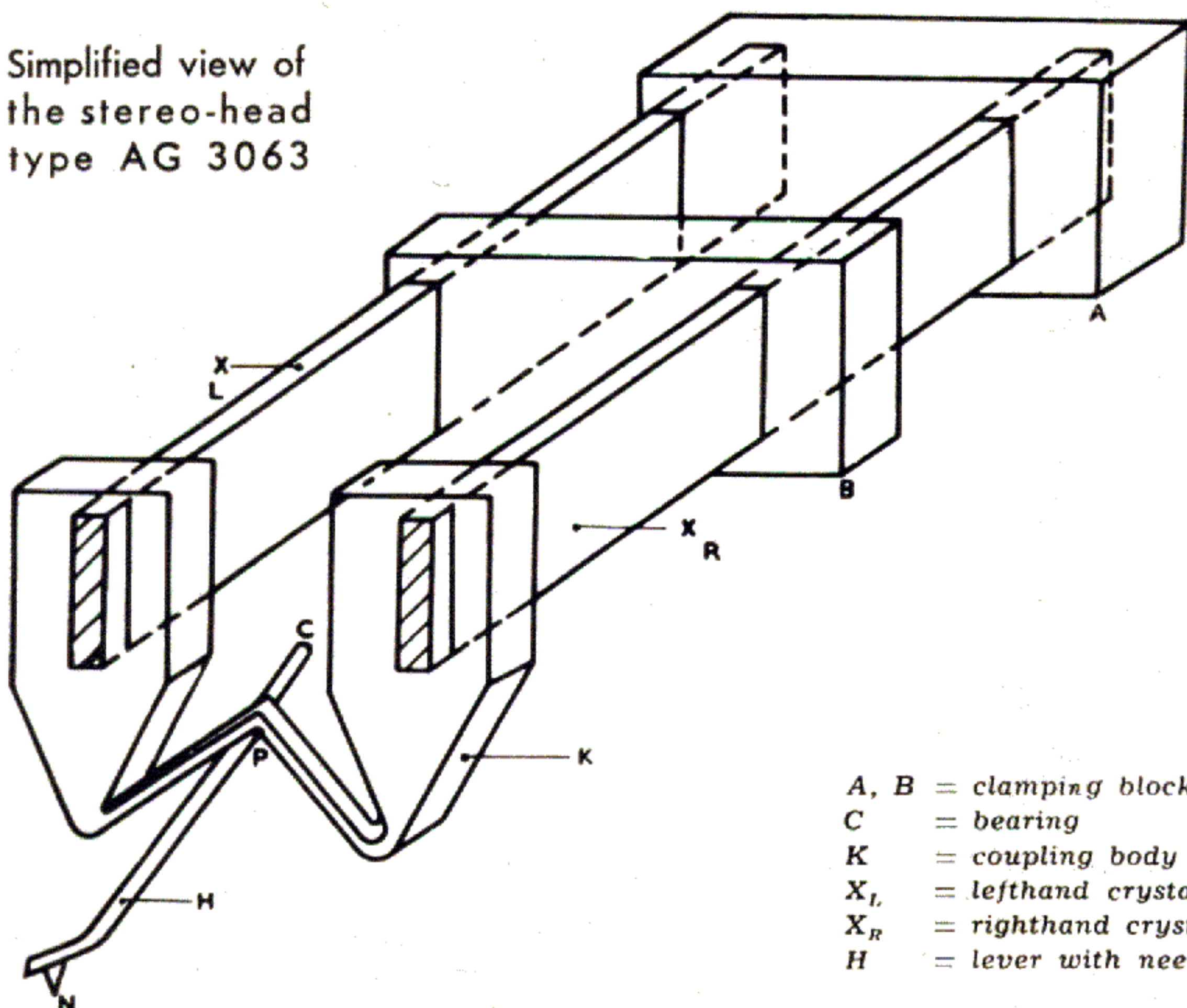
Because of the engineering effort in the design of this amplifier no trouble should be experienced by the home constructor music lover if approved output transformers are used and construction details followed. Should, however, the performance not be to your expectations do not hesitate to contact the Mullard Technical Service Department, 35-43 Clarence Street, Sydney; or 592 Bourke Street, Melbourne.

TECHNICAL DATA

AG 3063

Output voltage per system	120mV/cm perpendicular to groove wall at 400 c/s
Load resistance	≥ 0.5 MΩ
Load resistance (velocity loading)	= 100 kΩ
Channel separation	-20 dB at 1000 c/s
Compliance	lateral 3×10^{-6} cm/dyne vertical 2×10^{-6} cm/dyne
Capacity	1500 pF
Recommended vertical needle force	4 - 6 grams
Needle tip radius	AG 3060 diamond tip 18 μ AG 3063 sapphire tip 18 μ

Simplified view of the stereo-head type AG 3063



- A, B = clamping blocks
- C = bearing
- K = coupling body
- X_L = lefthand crystal element
- X_R = righthand crystal element
- H = lever with needle tip N.

LIST OF COMPONENTS

HARDWARE		RESISTORS	
2	Audio Input Sockets	2	220 kΩ
5	Knobs	2	56 kΩ
1	Mains Switch 230V, 2A	1	15 kΩ
1	Miniature Speaker Socket	2	1.5 MΩ
1	3 pole, 3 position Switch	2	5.6 kΩ
3	Valve Holders B9A	2	4.7 kΩ
		2	2.2 kΩ
		4	820 Ω
		2	47 Ω
		2	150Ω 3W
		1	200Ω W/W Pot.

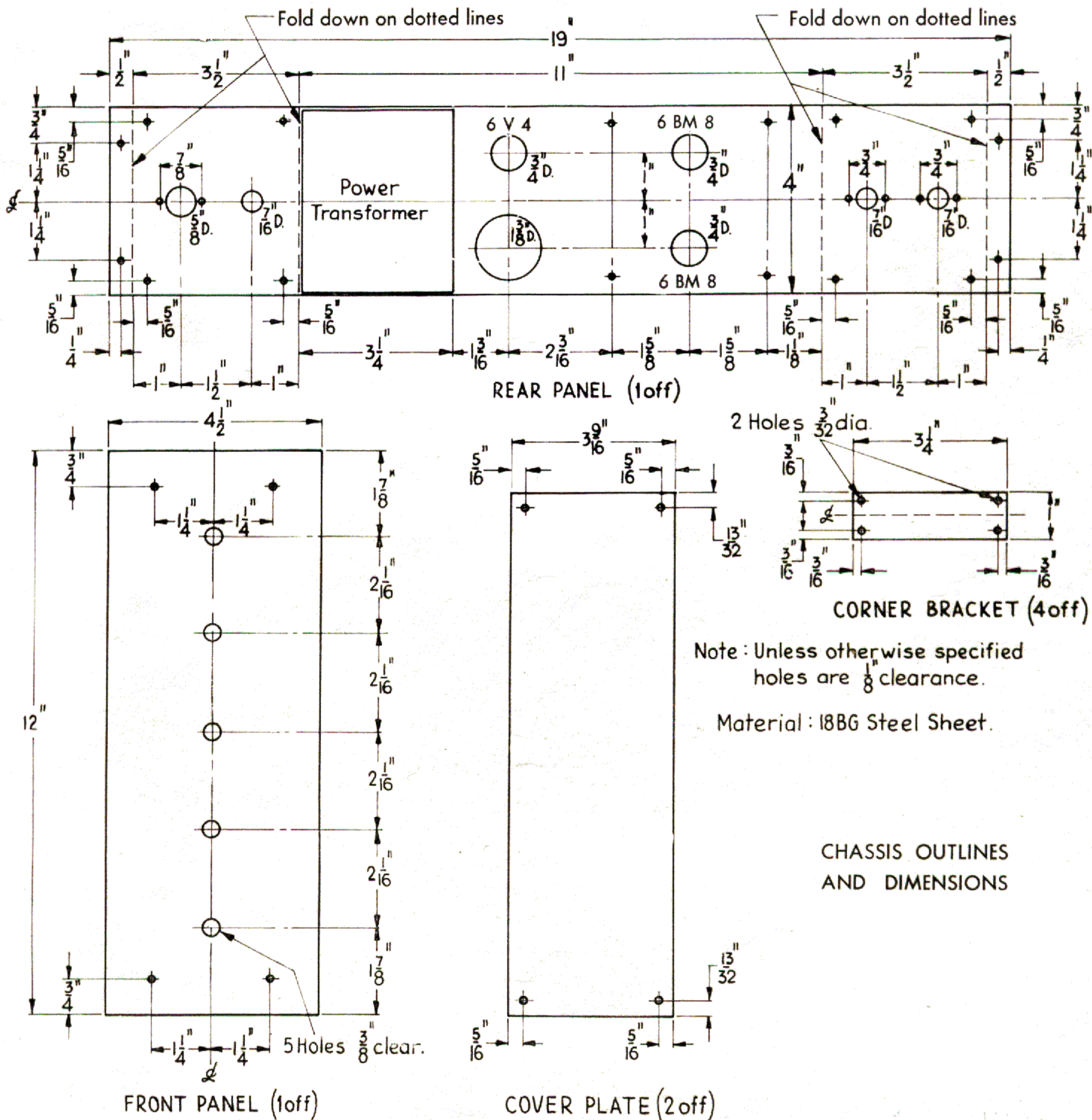
- TRANSFORMERS**
- Mains—Transformer
Sec: 250-0-250 V, 80 mA,
6.3 V, 1.5 A and 6.3 V, 0.6 A
 - Output—Transformers
Prim. 10,000Ω, Sec: as required.

*1 1MΩ/1MΩ Log, Ganged Potentiometer
 *1 ½MΩ/½MΩ Lin, Ganged Potentiometer
 *1 50kΩ/50kΩ Log, Ganged Potentiometer
 All resistors ½ watt 10% unless otherwise specified.

CONDENSERS

*2	300 pF	Mica or Ceramic	10%	
2	100 pF	Mica or Ceramic	10%	
*2	.1 μF	Paper	350	VW
2	.01 μF	Paper	600	VW
2	25 μF	Electrolytics	12.5	VW
2	50 μF	Electrolytics	25	VW
1	50 μF/50 μF	Dual Electrolytic	300	VW
1	16 μF	Electrolytic	300	VW

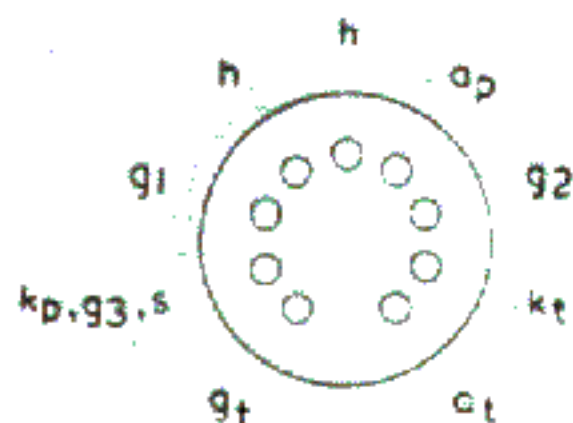
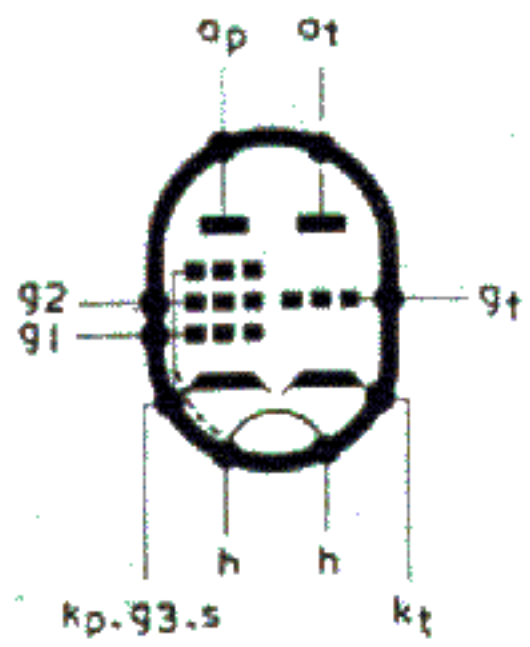
*Deleted if loudness control is used.



6BM8/ECL82

TRIODE PENTODE

Combined triode and output pentode with separate cathodes.



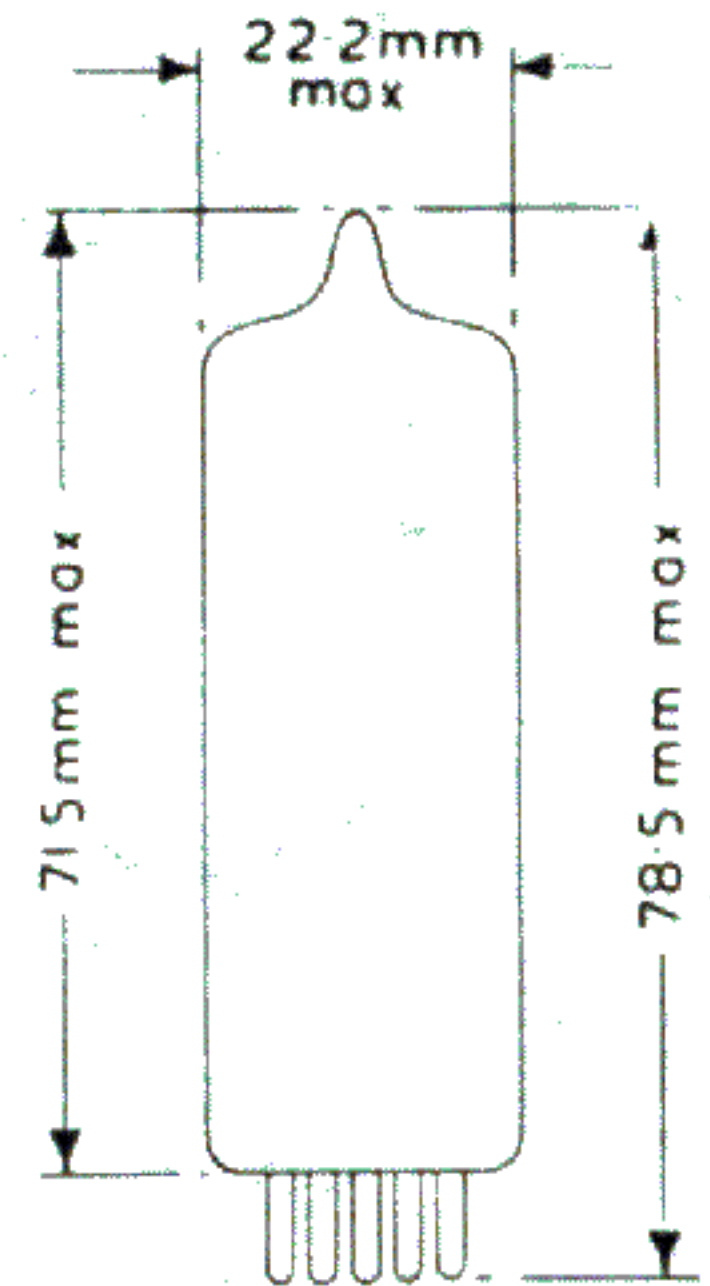
B9A Base

HEATER

V_h	6.3 V
I_h	780 mA

MOUNTING POSITION

Any



CHARACTERISTICS

Pentode Section

V_a	170	200	250	V
V_{g2}	170	200	250	V
I_a	41	35	28	mA
I_{g2}	8.0	7.0	5.7	mA
V_{g1}	-11.5	-16	-22.5	V
g_m	7.5	6.4	5.0	mA/V
r_a	16	20	25	k Ω
μ_{g1-g2}	9.5	9.5	9.5	

Triode Section

V_a	100	V
I_a	3.5	mA
V_g	0	V
g_m	2.5	mA/V
r_n	28	k Ω
μ	70	

6V4/EZ80

FULL-WAVE RECTIFIER

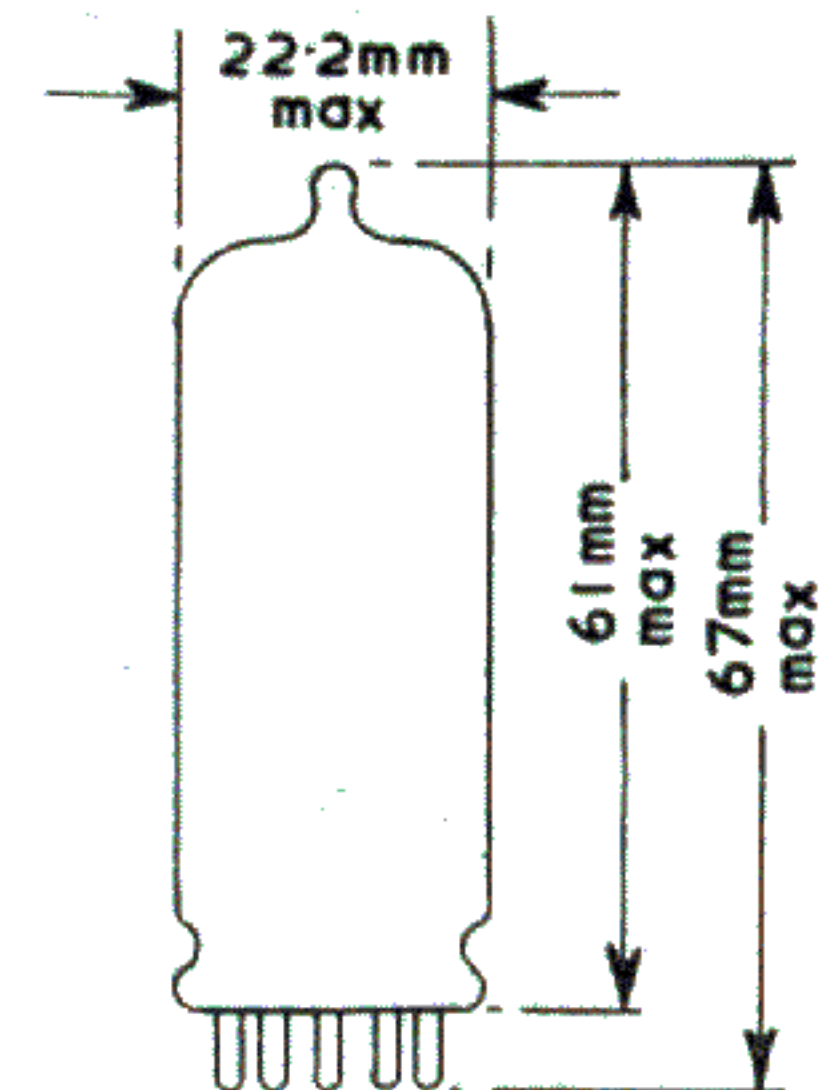
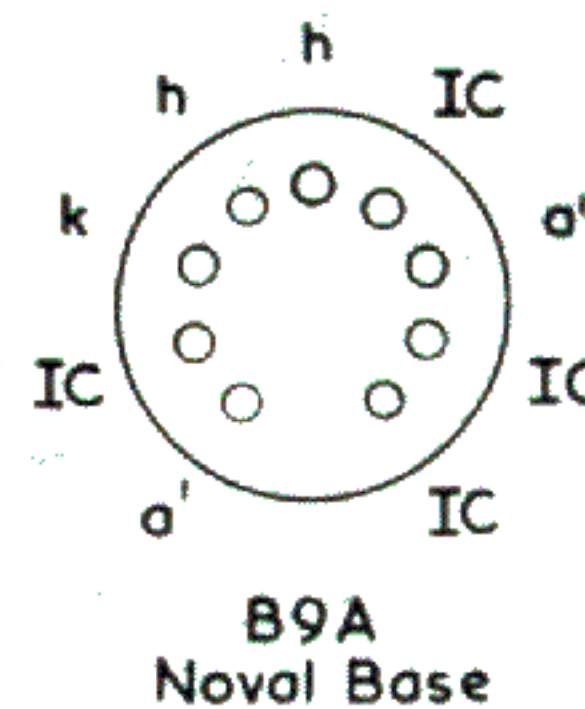
Indirectly heated full-wave rectifier, primarily intended for use in A.C. mains-operated equipment.

HEATER

V_h	6.3 V
I_h	0.6 A

OPERATING CONDITIONS

$V_{a(rms)}$	2x250	2x275	2x300	2x350	V
C_{filter}	50	50	50	50	μF
R_{lim} min. (per anode)	125	175	215	300	Ω
I_{out}	90	90	90	90	mA
V_{out}	265	285	310	360	V



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