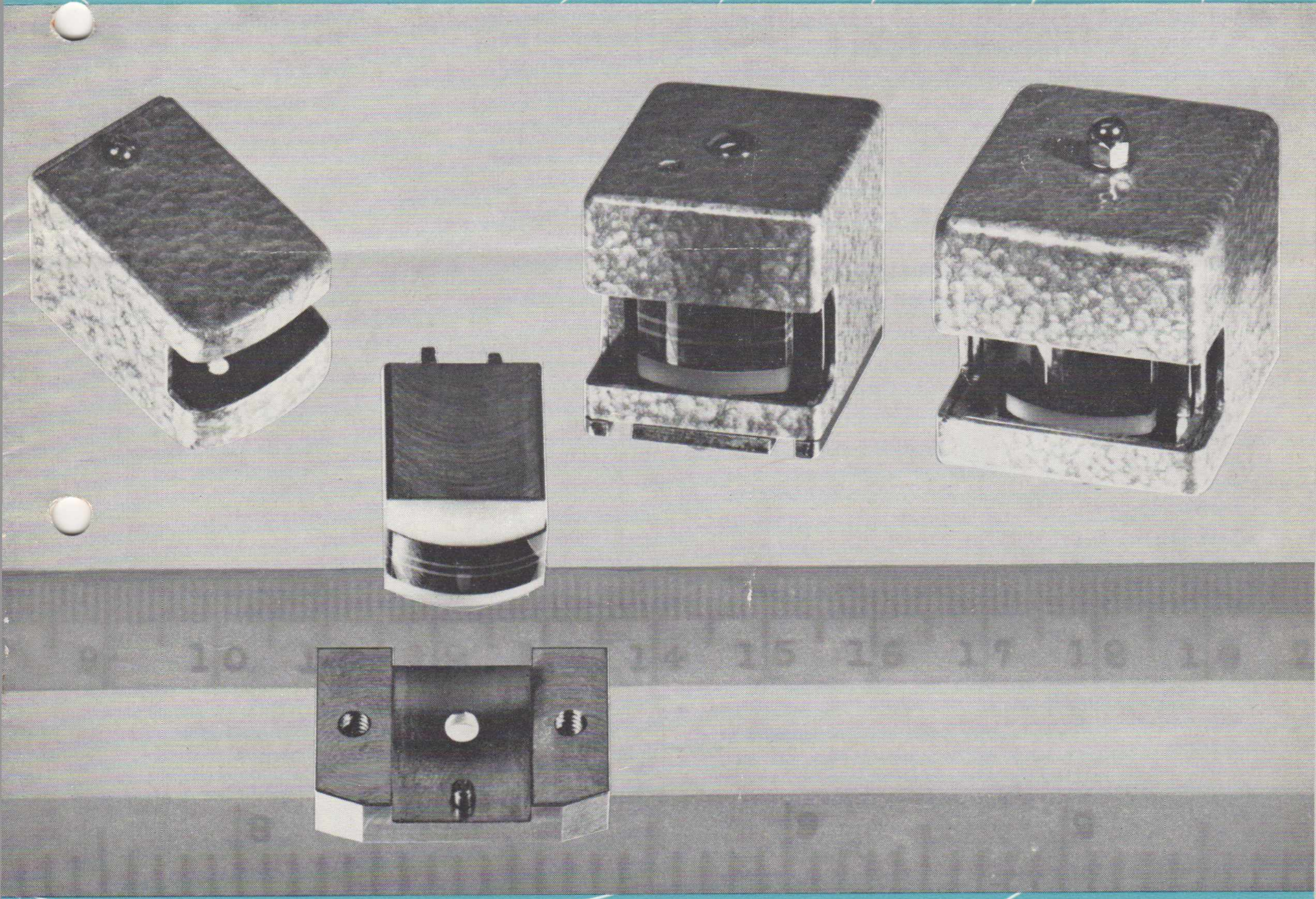
Mullard Outlook

AUSTRALIAN EDITION



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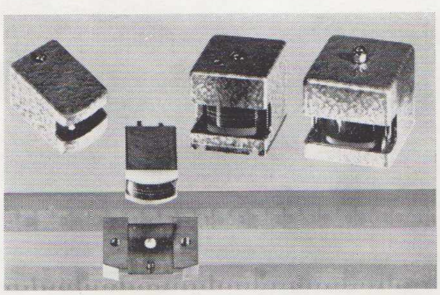

Examples from the new Mullard range of ferrite magnetic heads for audio recording equipment. These heads are believed to be the first of their kind offered as a standard range. Unlike laminated metal heads the electrical properties of the ferrite record and replay heads remain unchanged throughout their long working life. Thus, amplifier circuits associated with ferrite heads do not need the frequency compensatory adjustments which have to be made throughout the much shorter life of a metal head. Tests showed that after 300 hours running time at a tape speed of 7.5 in/s, the output of a ferrite head measured at 8kc/s was reduced by only 1.5dB and remained substantially constant after a further 5000 hours. More detailed information may be found on page 44 of this issue.

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A NEEDLE AND THREAD

Television receiver maintenance to some is a needle and thread approach and the heading on this page may well have been "Lurks and Banditry". Whether we like it or not, during these first ten years of television in Australia the man in the street has developed a certain scepticism regarding television service. The word "service" has been selected specifically to embrace all the lurk men who have contributed to destroying an image which never had a chance to develop—stunted by those who adversely influenced the merchandising pattern of this industry, the dishonest hire purchase encounters, the uneasiness of the thrifty should their receiver fail and just as vivid, perhaps, the peace of mind of those who rent TV.

In mending a pair of schoolboy's pants or grandfather's old coat, a patch is usually inevitable and acceptable—but visible and always a patch. Effective TV service demands a return to the original performanc—invisibly mended.

To suggest the tailor usually has the seat out of his pants is perhaps an overstatement or the black sheep serviceman neglecting his own TV receiver, being intent on belting the bonanza with charges to challenge the surgeon on his appendectomy sewing.

The constructive agenda for the Second National Television Service Convention sponsored by T.E.T.I.A. and T.E.S.A. to be held at the Chevron Hotel, Sydney, from 20th to 22nd October illustrates a mature awareness of what constitutes service in its true sense, a feeling for the customer and a fair deal by skilled operators that can only encourage a better understanding and develop its own public relations, for 3,500,000 service calls in Australia each year provide unlimited scope to create a more favourable image.

The real art is to keep the customer happy, have him pay with a smile and almost apologise for having you. Needless to say, all this is considerably enhanced and no patch job with Long Life Radiant Screen picture tubes, valves and components from the old firm.

See you at the Convention!

M.A.B.

VIEWPOINT WITH MULLARD

INDUSTRY TRENDS OVERSEAS

Our Chief Engineer, Mr. Harry Watson, returned home in July after a two months tour of the United States, Canada, Europe in addition to our parent company, Mullard Ltd., London. While in London he visited the I.E.A. Exhibition and was a delegate to the 3rd World Congress of the Industrial Federation of Automatic Control (IFAC). Mr. Watson here discusses several interesting trends.

As my tour was oriented towards specific tasks rather than a general perusal of the electronic industry, it is somewhat difficult to make general comment. However there are two areas worthy of discussion, namely the rapid growth in integrated circuits both in the United States and Europe and the apparent lack of interest in TV Hybridization together with some impressions of the radio and TV industry in America.

Integrated Circuits

Since the introduction of Photolithographic methods of etching and diffusion, tremendous progress has been made in monolithic circuits and it is now considered quite economic to solve circuit problems with large and complex arrays of diodes and transistors. This can be achieved on surprisingly small pieces of silicon at costs that are rapidly decreasing. For example, a small silicon chip of .050″ x .060″ can contain 16 transistors, 14 diodes and 21 resistors to form a so-called JK flip-flop. One slice of silicon of 1.3″ diameter contains approximately 500 circuits totalling 25 000 components!

Following my previous tour of 1963, I made mention of the very low yield and consequent high price of these complex circuits. With the improvement in yield, however, and increasing number of interested users, the intervening period has shown a dramatic price lowering and one can foresee the day when pounds will become shillings. The incentive to use integrated circuits, therefore, will in the future be price and not size or the so often claimed higher reliability.

Despite the rapid growth in monolithic circuits there are still many applications where a hybrid circuit would be more satisfactory or more economical depending on the number of passive elements required. Future hybrid circuit requirements are estimated to be approximately 15% of the total but will depend largely on the requirements of industrial electronics.

In spite of all the progress made in integrated circuits, a satisfactory envelope construction has not yet been established and remains the major problem for the immediate future. The original package has proved expensive in manufacture and expensive to mount in a circuit and current development is towards a dual in line plastic moulded envelope.

Integrated circuits can be roughly divided into two groups, digital circuits and linear circuits. Today the present digital circuits represent the major part of development and production, however linear circuits are gaining in importance, and Europe, where the linear application is of great interest, could well become the leader in this field whereas at the moment U.S.A. is the leader in the digital area. Linear circuits are already available in a large variety of types such as operational amplifiers, differential amplifiers, Class A and Class B amplifiers, IF and video amplifiers, hearing aids, etc. and it is anticipated that a reduction in production cost and an increased demand will open the door, in the not too distant future, to the use of these circuits in radio and television and possibly auto-electronics.

Radio and Television in America

Discussion with the major receiver manufacturers in Chicago left me with the impression that there is very little active interest in the application of transistors to television.

Apart from the fact that all development laboratories have their hands full with colour, the Industry feels that there is little to be gained and as current circuits are of acceptable price and performance to the consumer, there is little point in making radical design changes. There are, of course, all transistor and hybrid receivers produced by all major manufacturers but these are restricted to portables of 12″ and under and represent 5% of the total. Only one manufacturer has a partly transistorised colour receiver.

It is interesting to note that 70% of all monochrome receivers are 19″ or under; however, receivers less than 19″ total only 20% of this figure. Only two picture tubes are in general use for monochrome, 19″ and 23″, and in colour the sizes are limited to 19″ and 25″.

In discussion with the FCC and EIA I learnt that FM stereo broadcasting is growing rapidly despite the tremendous interest in colour television. Statistics are not readily available but it is believed that the annual production of stereo receivers will reach 5.6 million by 1970. At the present time some 600 of the 1 200 FM stations are broadcasting in stereo and in the Washington area alone some thirty programmes are available, at least half in stereo. ■

H. S. Watson.

MULLARD FILM FOR NATIONAL ARCHIVES

The Mullard film, "Thin-film Microcircuits", has been chosen by the National Film Archives for permanent preservation.

This is the sixth Mullard film to be so honoured. The others are "Ultrasonics", "Manufacture of Radio Valves", "Manufacture of Junction Transistors", "Conquest of the Atom" and "Mirror in the Sky".

"Thin-film Microcircuits" was first released in October 1964. It is a 14½-minute colour film which deals with the production of these devices from design stage to the finished product. Typical applications of thin-film microcircuits, including their use in rockets, miniature computers and industrial electronic equipment, are also described.

The film was awarded a silver medal (1st prize) in its category at the 10th International Festival of Scientific-Teaching Films organised by the University of Padua in connection with the 1965 Venice Film Festival.

The National Film Archives "preserve in the national interest films of historic and artistic value, carefully chosen and recommended by its selection committee". ■

SECOND NATIONAL TV SERVICE CONVENTION

Sponsored by the Television and Electronic Technicians' Institute of Australia (T.E.T.I.A.)

In Association with Television & Electronic Services Association (T.E.S.A.)

We are reminded that the Second National TV Service Convention is to be held at the Chevron Hotel, Sydney, from 20th-22nd October, 1966. The theme of the Convention will be the Tenth Anniversary of the inauguration of television broadcasting in Australia.

The Convention organisers have advised us that registration is not restricted to members of T.E.T.I.A. or T.E.S.A. but open to all connected with the industry and with the purpose of enabling technicians from all States to meet and discuss common problems.

The day-time activities are divided into business and technical sessions covering management, costing, credit control, contracts, newer developments in television, colour, the greater use of semiconductors and so on.

A comprehensive programme has been arranged for the ladies and the proceedings will be rounded off with a Gala Dinner Dance in the Chevron Ballroom on Saturday evening, 22nd October.

A feature of the Convention will be an Industry Exhibition.

Further information and details of the Programme, Registration and Accommodation are available in N.S.W. from Mrs. Thelma Mitchell, 88 Chalmers Street, Lakemba, 759 0612; in Victoria from Ken Black, 342 Flinders St., Melbourne, 61 2011.

DESIGNING A DUCTED-PORT BASS-REFLEX ENCLOSURE

Introduction

"Designing a Ducted Port Bass-Reflex Enclosure" is the third article in a series published in OUTLOOK over recent months. There is an optimum enclosure volume for best transient performance and maximum efficiency. In this article, a number of nomograms are set out to enable designers to calculate optimum enclosure volume for 8", 10" and 15" loudspeakers respectively. A further nomogram is included to determine proper enclosure dimensions, taking into account height, width and depth.*

The next part is devoted to the calculation of duct length in relation to the volume of the enclosure. These ducts are made from heavy cardboard tubes of the type used for mailing plans and maps. Suitable cardboard tubes are manufactured by: Australian Containers Pty. Ltd., Sydney, N.S.W., and may be obtained from major electronic parts distributors.

For further particulars the interested reader is referred to several articles published previously.

1. *OUTLOOK Vol. 9, No. 1, Page 4, "Low Cost High-Quality Solid State Audio Frequency Amplifiers".*
2. *OUTLOOK Vol. 9, No. 2, Page 16, "Mullard Mini Speaker Units".*
3. *OUTLOOK Vol. 9, No. 3, Page 28, "Mullard Mini Speaker Units".*
4. *Mullard "Circuits for Audio Amplifiers".*
5. *Mullard "Stereo Sound Systems".*

Mullard OUTLOOK (including relevant back copies) is available on a subscription basis from Mullard Head Office in Sydney.

Mullard "Circuits for Audio Amplifiers" and Mullard "Stereo Sound Systems" are available from Mullard Offices throughout the Commonwealth, priced at $1.25 (plus 13c postage) and $0.62 (plus 7c postage) respectively.

FURTHER READING

An excellent article, "Loudspeakers in Vented Boxes" by A. N. Thiele, deals with equivalent circuits of loudspeakers in vented boxes and shows that it is possible to make the low-frequency acoustic response equivalent to an ideal high-pass filter or as close an approximation as is desired. The simplifying assumptions appear justified in practice and the techniques involved are simple.

This article was published in "Proceedings of the Institution of Radio & Electronic Engineers Australia," (formerly Institution of Radio Engineers Australia), Volume 22, No. 8.

* This article by **James F. Novak** appears with the kind permission of the Editor of "Electronics World" and was first published in their January 1966 issue.

ONE of the most important yet often least understood, parts of a loudspeaker system is the loudspeaker enclosure. The enclosure — often called a baffle, cabinet, or just plain box—determines to a large extent the low-frequency performance of a loudspeaker system and, in many cases, governs it.

Enclosures may be divided into five main types: 1. flat baffle, 2. open-back cabinet, 3. completely enclosed cabinet, 4. horn-loaded, and 5. bass-reflex.

These five types can be further subdivided into as many as five additional variations on each type. The purpose of this article is to select one type of enclosure that will be simple to construct, require no mathematics to design, and yet give satisfactory performance with a large variety of loudspeakers. Nomograms are given which will enable the constructor to design a suitable enclosure for any given loudspeaker with a reasonable assurance of obtaining an optimum design.

Types of Enclosures

Obviously, no single type of enclosure will give utopian performance with all types of loudspeakers. When one considers all of the cost, complexity, and performance trade-off's, however, one type of enclosure does stand out above all others. This is the bass-reflex. It may be useful to discuss briefly the reasons for not choosing one of the others.

The main factor that determines the low-frequency cut-off of most loudspeaker systems is a resonance frequency of some kind, *i.e.*, either the resonance of the loudspeaker itself, its resonance in the enclosure, or a new resonance created by the presence of the enclosure.

The flat baffle and open-back cabinet are not very useful for high-fidelity applications. A loudspeaker radiates sound energy from both sides of the cone. These two sound fields are out of phase with each other, *i.e.*, when the front of the cone radiates a high-pressure wave, the back is radiating a low-pressure wave. These two waves tend to cancel each other when they are not isolated and this effect becomes more pronounced as the frequency becomes lower.

This problem can be minimized by making the baffle larger but this has its shortcomings. In order to obtain acceptable performance to say, 40 c/s, the length of one side must be at least a half wavelength long at that frequency or 14 feet. Of course, the flat baffle can be folded back on itself such as in the open-back cabinet, but the structure will still be quite ungainly. It is for this reason that baffles of this type are rarely found in present-day high-fidelity practice.

An obvious solution to this cancellation problem is to completely enclose the back of the loudspeaker so that the sound field from the back of the loudspeaker diaphragm cannot be radiated. One major difficulty with this type of enclosure is that the "air cushion" within the box stiffens the moving parts of the loudspeaker and increases the resonance. The low-frequency cut-off of simple baffles and enclosures is determined primarily by the resonance frequency of the speaker when in the baffle or enclosure. The resonance of a speaker in a closed box is determined by the volume of the box. Large cabinets will increase the resonance to a lesser degree than will small cabinets. Generally speaking, it will be necessary to use cabinet volumes of at least 3 cubic feet for 8-inch loudspeakers, 8 cubic feet for 12-inch loudspeakers, and 15 cubic feet for 15-inch loudspeakers. Small bookshelf-type enclosures require the use of rather specially designed loudspeakers having high mass and very low stiffness (high elasticity or compliance) in order to obtain fairly low resonance frequencies.

Horn-type loudspeakers are usually impractical to design readily because they require a complete knowledge of the mechanical constants of the speaker, such as mass, stiffness, flux density, etc. This type of data is seldom available outside of the speaker manufacturer's engineering department. Even if complete loudspeaker data is available, the design calculations are quite complicated and the cabinetry even more so.

From a constructional standpoint, the bass-reflex enclosure is hardly more complicated than the simple closed box. It is, in fact, exactly the same as a closed box except that there is an opening, usually on the front of the enclosure. This opening allows the sound from the rear of the loudspeaker to come around to the front. But, unlike the flat baffle or open-back cabinet, cancellation does not take place. Because the opening, called a port, has mass and the volume of the enclosure has compliance, a tuned circuit is created which shifts the phase of the sound waves so that they reinforce those from the front of the cone over a fairly wide frequency range. The enclosure/speaker combination now becomes a system of two tuned circuits. These two tuned circuits are closely coupled together. The result is that the original speaker resonance frequency disappears completely and is replaced by two other resonance frequencies, one above and one below the original speaker resonance.

The sound waves radiated from the port and speaker are opposite in phase at the lowest resonance frequency and, therefore, cause a significant cancellation in net output. At the original speaker free-air resonance, however, the sound waves from port and speaker are 90° out-of-phase. Because the cone amplitude and therefore

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radiation at this frequency is greatly reduced, the total amount of energy radiated is essentially a function of the acoustic properties of the port.

At the upper resonance, the port and cone radiation are in phase, resulting in an increase in total sound radiation.

Optimum Enclosure Size

A careful study of bass-reflex operation from a theoretical standpoint reveals a complexity far greater than the extremely simple construction would indicate. A number of generally unknown facts come to light concerning low-frequency extension and optimum transient response.

1. *A bass-reflex enclosure can be too large.* After a certain maximum volume is reached, further volume increases result in "boomy" bass rather than an appreciable extension of low-frequency response. This is particularly true when a speaker with a small magnet is used. It is best to use a completely closed cabinet in this case.

2. *A bass-reflex enclosure can also be too small.* A common assumption is that the enclosure can be made much smaller by using a duct behind the port. While the use of a duct allows one to tune the enclosure to very low frequencies when volumes are small, it is the ratio of enclosure air stiffness to speaker stiffness that determines the low-frequency cut-off. As the enclosure volume is made smaller, the enclosure stiffness increases and so does the cut-off frequency. This will remain true regardless of how the enclosure is tuned. A false "boomy" bass will generally result and the enclosure may as well be left closed. In some cases a better sounding bass will result if the back of the speaker enclosure is removed.

3. Only one condition of cabinet tuning and damping will result in optimum transient response, *i.e.*, freedom from hangover or boom. Because a speaker in a bass-reflex forms a closely coupled system of two tuned circuits, the system will tend to decay with two frequencies. The achievement of optimum transient response demands that the system decay with one frequency and with a specified time constant. In order to make the system decay in one frequency, the enclosure volume and port combination must be tuned to the free-air resonance of the speaker. A specified decay can be achieved by adding acoustic resistance, in the form of damping material, to the enclosure. The proper amount of damping material can be determined by means of a test method described later.

A nagging question in the design stage of any enclosure of this type is "How large shall it be?" It was pointed out earlier that the enclosure can be too large or too small for proper bass-reflex action. This implies that an *optimum volume* exists and indeed it does. This optimum volume does not depend upon the size of the speaker nor its resonant frequency *per se* but rather on the ratio of enclosure air stiffness to the speaker cone suspension stiffness. This optimum ratio is 1.44 or, looking at it another way, the speaker resonant frequency in the enclosure before porting should be 1.56 times the free-air resonance of the speaker. This size enclosure, when properly tuned, yields at the same time the most extended low-frequency response and a transient response with subjectively unnoticeable hangover, assuming sufficient damping exists. Compared to the entirely closed cabinet, the half-power point (3dB down) occurs at 0.7 times the closed cabinet speaker resonance for an extension of one-half octave.

Designing the Enclosure

In order to proceed with the actual design work, it is necessary to know the stiffness of the cone suspension. Since speaker manufacturers are notorious for not having this information readily available, it is necessary to derive this by measuring the speaker resonance in free air and in a "standard volume". A properly calibrated audio oscillator, a simple AC vacuum-tube voltmeter, and a 100- to 1000-ohm resistor are required. Although this value is not at all critical, the higher values will give more sharply defined readings. Use the largest value consistent with the oscillator output voltage and voltmeter sensitivity. Fig. 1A shows how these elements are connected.

The "standard volume" is nothing more than a small plywood box of known volume. Fig. 2 shows the constructional details of boxes for 8-inch, 10-inch and 12-inch, and 15-inch speakers. Although a single volume could have been used for all loudspeaker sizes, three separate volumes were chosen in the interest of economy.

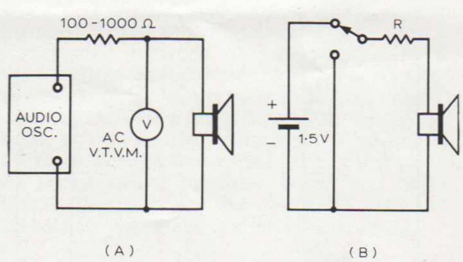


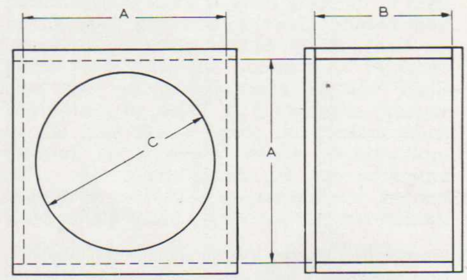
Fig. 1—Hookup for checking speaker resonance and damping

This box must be thoroughly sealed with caulking compound or putty to prevent leaks. Note: All measurements will be made with the speaker mounted on the *outside* of the box. All six sides should, therefore, be permanently assembled.

The first step after selecting a loudspeaker and constructing the appropriate "standard volume" is to measure resonant frequencies. Hook up the unbaffled speaker as shown in Fig. 1A. The speaker should be held in the air away from any large objects and the audio oscillator slowly swept through the low-frequency end of the audio range so that it passes through the speaker's resonant frequency. The voltmeter connected across the voice coil terminals will show a large rise in voltage at this frequency. The frequency corresponding to maximum voltmeter reading is the resonant frequency of the speaker.

After noting the free-air resonant frequency, place the speaker face down over the hole in the "standard box". A slight amount of hand pressure should be applied to the rear of the speaker to help get a good seal between speaker gasket and the box. The speaker resonant frequency is again determined as before. The resonant frequency determined this time will be higher than the free-air resonance. It is quite possible for this frequency to be two to four times the free-air resonance.

The proper nomograms of Figs. 3, 4, or 5 can now be used to determine the proper enclosure volume. The following example will clarify the technique.



SPEAKER SIZE (in.)	DIM. A (in.)	DIM. B (in.)	DIM. C (in.)	V (cu.ft.)
8	10	$8\frac{5}{8}$	$6\frac{3}{4}$	0·5
10	$14\frac{1}{4}$	$8\frac{1}{2}$	$8\frac{3}{4}$	1·0
12	$14\frac{1}{4}$	$8\frac{1}{2}$	$10\frac{1}{2}$	1·0
15	20	$8\frac{5}{8}$	$13\frac{1}{4}$	2·0

Fig. 2—Dimensions of "standard-volume" loudspeaker boxes

Assume an enclosure is to be built for a 12-inch loudspeaker with the following resonant frequencies: free-air resonant frequency, 62c/s resonant frequency in "standard box", 121c/s.

Using the nomogram of Fig. 4, draw a straight line between Point A, the speaker free-air resonance and Point B, the speaker resonance with the "standard box". From the intersection of this line and the reference line, Point C, draw another straight line through the construction point until it intersects with the optimum-volume line. The number read (3000 cubic inches) is the proper volume for this loudspeaker.

Unless the reader has reasons for making the enclosure conform to a special shape, the nomogram of Fig. 6 can be used for obtaining the proper dimensions for any desired volume. The resulting shape is based on industrial design philosophy that no rectangle will be interesting as an abstract shape until its width equals at least the diagonal of the square on which it is based. The width is, therefore, 1.414 times the height and the height is 1.414 times the depth. Note: The dimensions obtained from the nomogram are *inside* dimensions and must have the material thickness added to them.

The proper method of using this nomogram is to draw a straight line between the desired volume on the two outside volume scales and obtain the dimensions from the intersection of this line with the three inner scales. The dimensions obtained should be rounded off to convenient numbers such as

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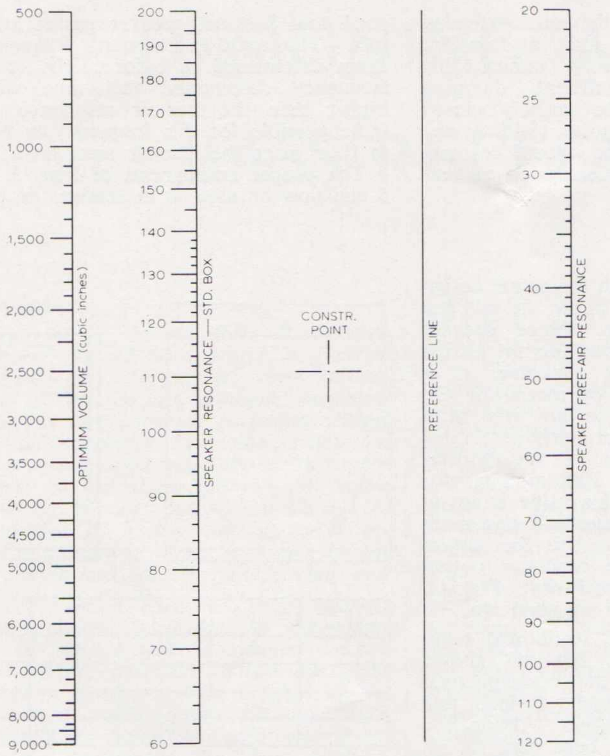

Fig. 3—Optimum-volume nomogram for use with 8-inch loudspeakers. Standard box in this particular case is 0.5 cubic ft.

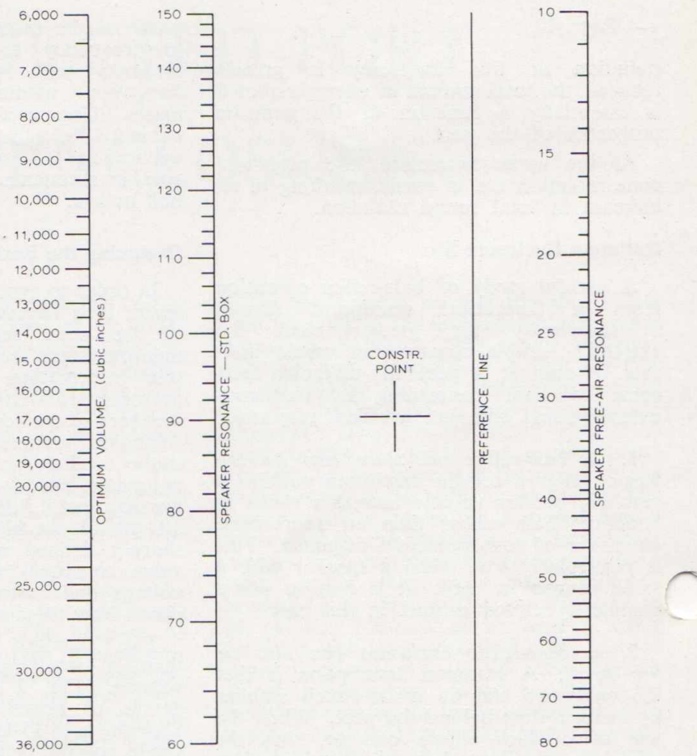

Fig. 5—Optimum-volume nomogram for use with 15-inch loudspeakers. Standard box size in this case is two cubic ft

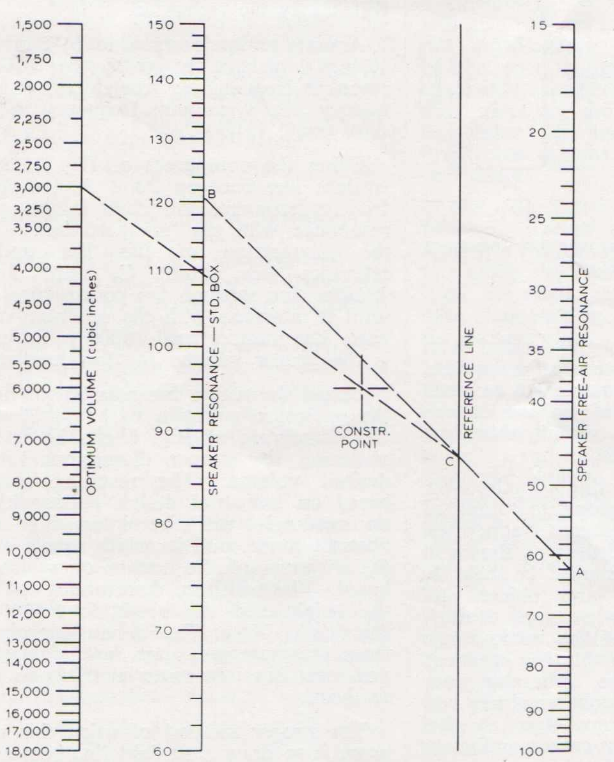

Fig. 4—Optimum-volume nomogram for use with 10-inch and 12-inch loudspeakers. Standard box here is one cubic ft

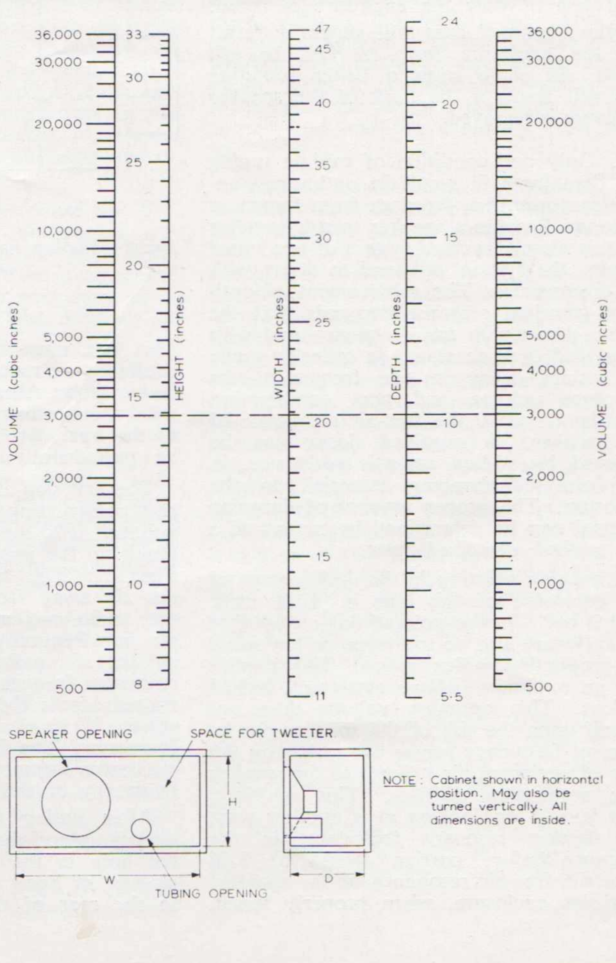

Fig. 6—Nomogram used to determine proper enclosure dimensions ➧

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height (H) = 14⅜″, width (W) = 20⅜″, and depth (D) = 10¼″, for the example cited. The resulting volume will be well within the limits of accuracy required.

The speaker cut-out should be placed towards one end of the enclosure. The table below lists proper size cut-outs for 8-, 10-, 12-, and 15-inch loudspeakers.

Speaker Size	Baffle Cut-Out
8-inch	6¾″ diameter
10-inch	8¾″ diameter
12-inch	10½″ diameter
15-inch	13¼″ diameter

Tuning and Damping

The enclosure must now be tuned to the free-air resonant frequency of the speaker. The charts of Figs. 7, 8, and 9 are used for this purpose. They are based on ducts made of heavy cardboard tubes. (*Heavy cardboard mailing tubes, or drawing or blueprint-carrying tubes, available in stationery or drafting stores, may be used. —Ed.*) The proper tube to use will be the largest diameter (inside) which gives a tube length of at least 1½ inches less than

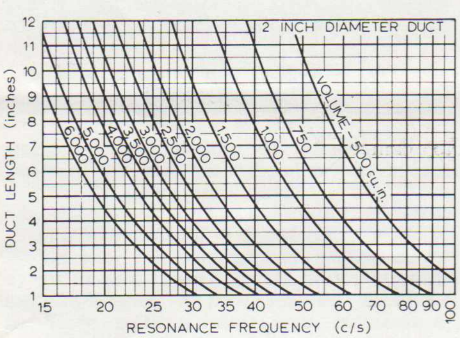


Fig. 7—Duct lengths for various free-air resonance frequencies using 2-in. tubing. Note: duct length measured from cabinet front

the inside depth of the enclosure. In the example chosen above, the duct is 4¾″ i.d. and has a length from the front panel of 3″.

The speaker and tube should now be installed in the enclosure with the tube being somewhere near the speaker. Although the enclosure volume and tuning are now correct, the system may not be free from hangover or boom. The usual method of determining if adequate damping exists by measuring the height of the impedance peaks with the circuit of Fig. 1A can often be misleading. A speaker system that appears underdamped with this measurement may be adequately damped when operated with a high-fidelity amplifier. The reason is that the circuit of Fig. 1A does not include damping contributed by the amplifier which can be appreciable. For example, an amplifier with a damping factor of 20 appears as a 0.4-ohm resistor in shunt across the voice-coil terminals of an 8-ohm speaker. Many of the transistor amplifiers have damping factors of 50 and greater. The shunt resistance will be less than 0.2 ohm in these cases.

Damping should be investigated with the circuit of Fig. 1B. The value of *R* can be determined if the amplifier damping factor and speaker impedance are known from: *R = speaker impedance/amplifier damping factor*.

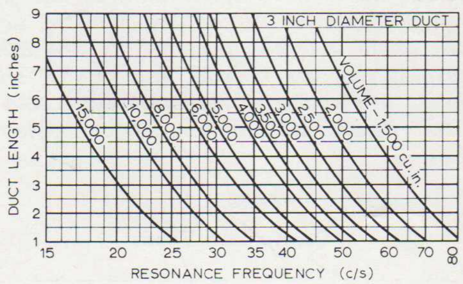


Fig. 8—Duct lengths for various free-air resonance frequencies using 3-in. tubing. Duct length is measured from cabinet front

If the amplifier damping factor is not known, a ½-ohm resistor may be used. The battery can be an ordinary flashlight type while the switch can be a push-button or toggle type.

The circuit of Fig. 1B is connected to the voice coil of the loudspeaker which is now installed in the tuned enclosure. The switch is operated between its two positions and the resulting sound produced by the speaker is observed. If the sound is a distinct "click" with no low-frequency boom or "bong" in both positions, the damping is adequate. Chances are, however, that the "click" will be accompanied by some boom and additional damping in the form of acoustic resistance will have to be added.

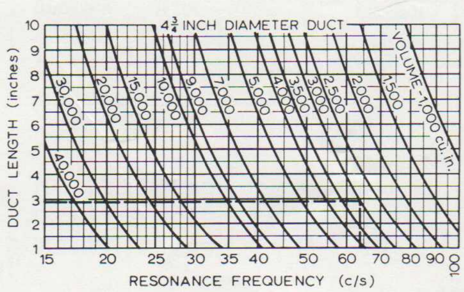


Fig. 9—Duct lengths for various free-air resonance frequencies using 4¾″ tubing. Duct length is measured from cabinet front

The author prefers not to place damping material in the port. Somewhat better overall results are usually obtained by placing it directly behind the speaker where it can then affect both "tuned circuits". Fig. 10 shows the method used. Generally a 1- to 2 inch thickness of lightweight fibreglass* stapled around the speaker so that the entire speaker is covered will produce a boom-free click.

Mechanics of Good Construction

The enclosure should transmit, not absorb energy. Walls that are allowed to vibrate will absorb energy that otherwise would be radiated as sound and the total system efficiency and smoothness of response will suffer.

The key to good construction is rigidity. The walls must be rigid so that they cannot be vibrated by the pressures developed inside of the enclosure. Wall vibration can be minimized by using a good grade of at least ¾-inch thick plywood or ¾-inch composition board. The walls should be fastened together with adequate amounts of furniture glue and good-sized wood screws. Nails should not be used. It is common practice to use glue blocks inside the cabinet when exposed screw heads would be objectionable. All joints inside of the enclosure should be caulked after assembly to prevent leaks which could cause troublesome buzzes.

Sometimes, large heavy panels will vibrate in spite of good construction techniques and additional means of stiffening must be used. A 1″ x 3″ cross brace applied "on-edge" diagonally across the panel will usually suffice. In stubborn cases, a sturdy cross-strut reaching across from the center of one panel to the opposite one will be required.

A piece of grille cloth can be stretched over and stapled to the front panel prior to assembly. The assembled enclosure may be finished on four sides.

A final word of caution concerning the removable back is needed. This panel is

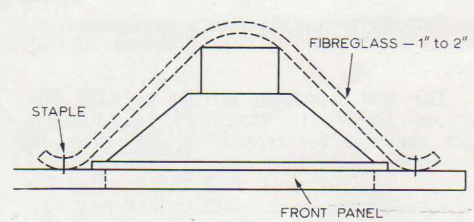


Fig. 10—Method of installing fibreglass for damping purposes*

very often improperly made because it is usually hidden from view. It is important that the construction be as good as that of the exposed panels, although this panel need not be finished. The speaker system connection terminals are located on the back and the terminal board used must not permit air leaks. The back must be made of the same material thickness, must fit properly, and must be fastened to the main structure by at least five good sized wood screws along each edge. In addition, felt stripping should be applied between the mating surface of the back and enclosure so that a proper seal is obtained and panel buzzes are prevented.

A number of loudspeaker enclosures have been constructed employing the design principles that have been described in this article. These enclosures have performed well and in accordance with expectations. ■

* In Australia this material is available as "Innerbond" (16 oz./sq. yd. 1″ thick) from Wonder Wool Pty. Ltd., 87b James St., Leichhardt, N.S.W.

MAGNETIC HEADS FOR PROF

Standard Range of Ferrite Transducer Assemblies

Ferrite recording and replay heads of the Mullard standard range are characterised by an electrical performance that is virtually constant with time. The recurrence and cost of servicing audio equipment which until the advent of these ferrite heads were determined by the poor wear performance of metal heads—are thus reduced to a minimum by the use of the Mullard heads. • Good overall frequency performance, low distortion and small inherent core losses are other important properties of the ferrite heads. The small bias currents that are needed thus enable significant economies to be made in the design of the head amplifiers. • Twenty-two different track and gap configurations are available in the Mullard range of magnetic heads, sixteen for ¼-inch systems and six for ½-inch systems.

Properties of Ferrite Core Material

The low resistivity of metals results in high power losses in magnetic heads, even when laminated cores are used. Because of the laminations, these losses increase with increasing frequency of operation. Furthermore, in laminated core sections, an uneven distribution of flux is obtained which reduces the effective permeability progressively as the frequency increases. The very much higher resistivity of ferrites and their comparatively low dielectric constant mean that eddy currents even at megacycle frequencies are low. Therefore solid ferrite cores can be employed so preserving the uniformity of the flux distribution in the cores and giving a uniform field. This is significant in terms of performance and efficiency of the head, particularly during recording. The low losses imply a low value of intrinsic head noise, which is extremely important if a good signal-to-noise ratio is to be obtained during reproduction.

The low losses in ferrites at high frequencies also mean that lower bias currents are required for recording. For example, at 100kc/s, the bias current required for a ferrite head is about half that needed for a metal head having laminations only 0.2 mm thick. At even higher frequencies, the current required by ferrite heads is a smaller fraction of that required by metal heads.

The initial permeability of ferrites is much lower than that of metals. However, in actual heads, the difference in effective permeabilities is much less. The permeability of metals diminishes considerably during assembly because of unrelieved stressing of the crystal structure of the materials, a non-magnetic skin being formed when the pole faces and contact area are polished. This deterioration continues during subsequent operation as the heads are worn by continual lapping on abrasive magnetic tapes. This skin limits the resolving power and performance that can be achieved, since very small electrical gap lengths are then extremely difficult to obtain. Ferrite materials are stress-free, and the magnetic properties exist through the material up to the mechanical boundaries. Consequently the electrical gaps obtained approximate much more closely to the actual mechanical gaps. Since mechanical gaps as small as 1.5μm can be obtained, the resolving power of a ferrite head can be much greater than that of a metal head. The precision of gap geometry of the Mullard audio heads is illustrated in Fig. 1.

The consistency in electrical performance during their operational life is an important advance achieved with the ferrite-cored heads when compared with metal-cored heads. Because of this, adjustments to the associated head circuitry in audio systems to compensate for the changing performance of the head with wear are unnecessary, and servicing time, with its related costs, is minimised. This feature of the Mullard audio heads is illustrated in Fig. 2, which shows the variation in head output with operating time. The curves relate to heads in contact with a general-purpose professional tape running at a speed of 7.5in/s at a head-to-tape pressure of 70g/cm². They show that after 300 hours, the output measured at 8kc/s is reduced by only 1.5dB and that after a further 5000 hours of operation, the output has remained substantially unaltered.

TABLE 1

Quarter-inch Heads

Head Description	*Gap Length (μm)*	*Type Number*	
		Fixed Head	*Adjustable Head*
Half Track			
Record	7	ER7500	ER7516
Record	12	ER7501	ER7517
Replay	3	ER7511	ER7527
Full Track			
Record	7	ER7502	ER7518
Record	12	ER7503	ER7519
Record	25	ER7504	ER7520
Replay	3	ER7512	ER7528
2-2 Track			
Record	7	ER7505	ER7521
Record	12	ER7506	ER7522
Replay	3	ER7513	ER7529
2-4 Track			
Tracks 1 and 3			
Record	7	ER7507	ER7523
Record	12	ER7509	ER7525
Replay	3	ER7514	ER7530
Tracks 2 and 4			
Record	7	ER7508	ER7524
Record	12	ER7510	ER7526
Replay	3	ER7515	ER7531

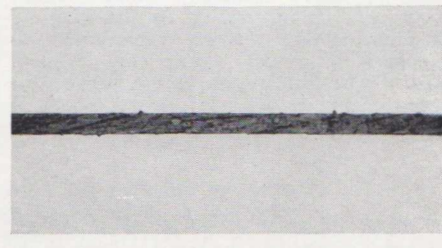


Fig. 1—Typical gap in audio head (3μm gap×1000)

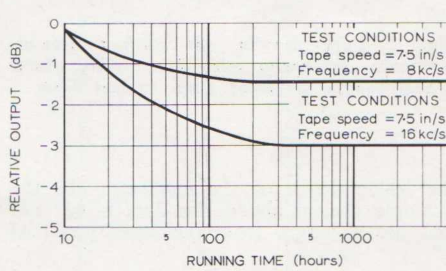


Fig. 2—Variation in head output with time
Tape speed: 7·5in/s
Head-to-tape pressure: 70g/cm²

Mullard Range of Audio Magnetic Heads

The Mullard range of audio record and replay heads includes a series of fixed heads for systems in which the normal adjustments are built onto the equipment and a series of adjustable heads in which the height and tilt controls are preset and the azimuth

ESSIONAL AUDIO RECORDING

Mechanical Details of Quarter-inch and Half-inch Heads

control is adjustable to meet final requirements. Heads are available for ¼-inch and ½-inch tape systems.

There are five basic track configurations for ¼-inch record and replay heads: half, full, stereo/twin, quarter-track twin with tracks 1 and 3, and quarter-track twin with tracks 2 and 4. Mechanical details of the five track configurations are given in Fig. 3 and of the fixed and adjustable heads in Figs. 5 and 6 respectively.

For ½-inch record and replay systems, two track configurations are available. These are 3-track and 4-track heads. Mechanical details of the two track configurations are given in Fig. 4 and of the fixed and adjustable heads in Figs. 5 and 6 respectively.

Replay heads have a gap length of 3μm. Record heads have gap lengths of 7, 12 or (for full-track heads) 25μm. The full range, with type numbers, track configurations and gap lengths is listed in Table 1 (¼-inch heads) and Table 2 (½-inch heads). ■

NOTE: Outlines and dimensions of Mounting Accessories appear on page 46 and a tabulation of Properties of Quarter-inch Heads on page 47.

TABLE 2
Half-inch Heads

Head Description	Gap Length (μm)	Type Number: Fixed Head	Type Number: Adjustable Head
3-Track			
Record	7	ER7532	ER7538
Record	12	ER7533	ER7539
Replay	3	ER7536	ER7542
4-Track			
Record	7	ER7534	ER7540
Record	12	ER7535	ER7541
Replay	3	ER7537	ER7543

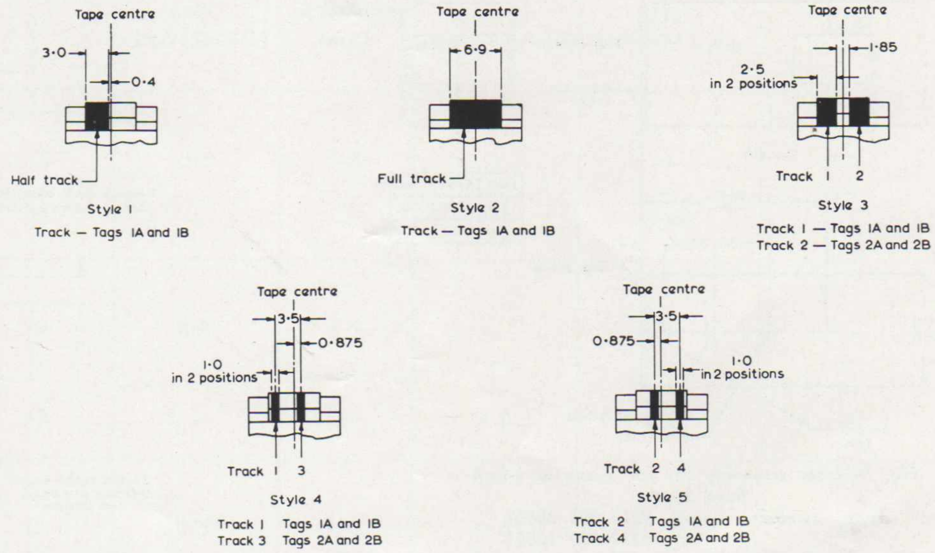


Fig. 3—¼-inch track configurations

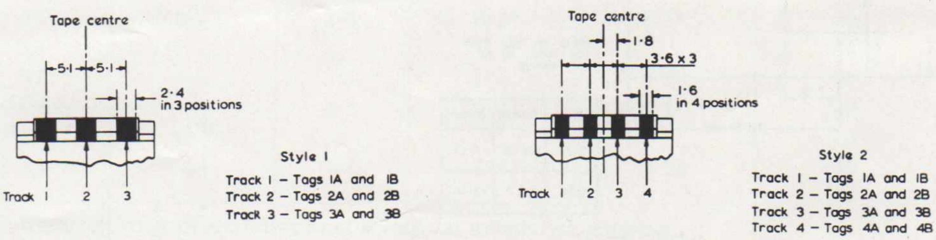


Fig. 4—½-inch track configurations

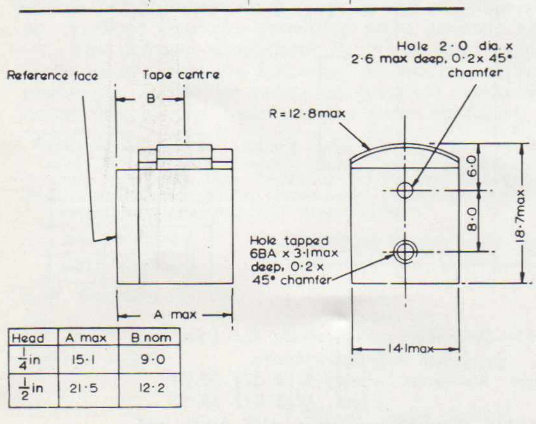


Fig. 5—Outline drawings for fixed heads

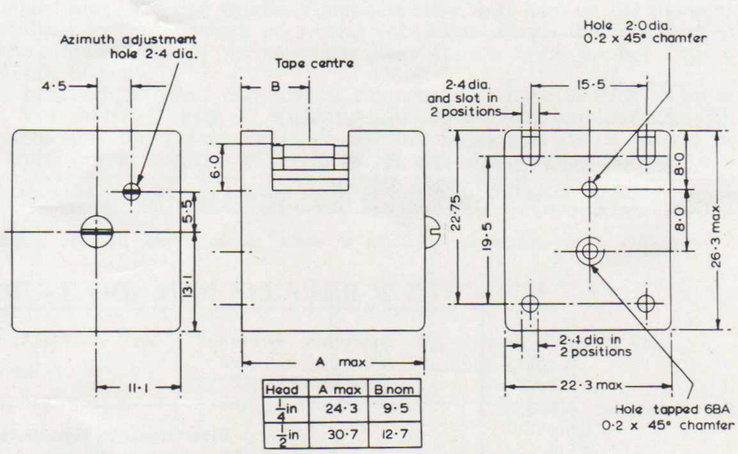
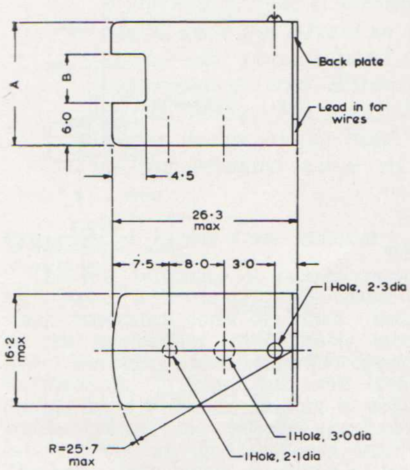


Fig. 6—Outline drawings for adjustable heads

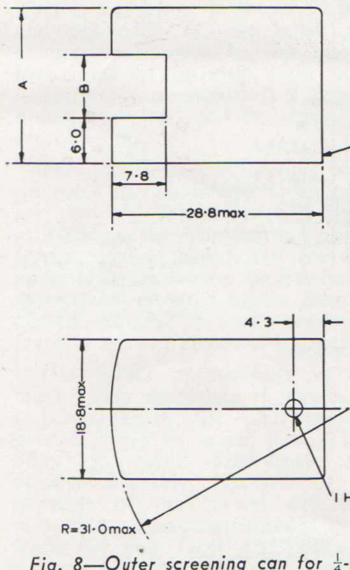
Mounting Accessories for Quarter-inch and Half-inch Heads

Five accessories are available for use with both $\frac{1}{4}$-inch and $\frac{1}{2}$-inch heads. For the series of fixed heads, these are inner and outer screening cans, a mounting shim to raise the track height by 0.5mm and a mounting adaptor which enables the Mullard heads to be used as replacements in various tape mechanisms; for the adjustable heads, a screen assembly is available. Mechanical details of these accessories are given in Figs. 7 to 11.



Head	A max	B nom
$\frac{1}{4}$ in	17·2	7·0
$\frac{1}{2}$ in	23·7	13·4

Fig. 7—Inner screening can for $\frac{1}{4}$-inch or $\frac{1}{2}$-inch fixed heads
Type numbers: $\frac{1}{4}$-inch, 4313 022 30001
$\frac{1}{2}$-inch, 4313 022 30051
(Cans supplied complete with bolts and washers)



Head	A max	B nom
$\frac{1}{4}$ in	19·5	7·0
$\frac{1}{2}$ in	25·7	13·4

Fig. 8—Outer screening can for $\frac{1}{4}$-inch or $\frac{1}{2}$-inch fixed heads
Type Numbers: $\frac{1}{4}$-inch, 4313 022 30101
$\frac{1}{2}$-inch, 4313 022 30151
(Cans supplied complete with bolts and washers)

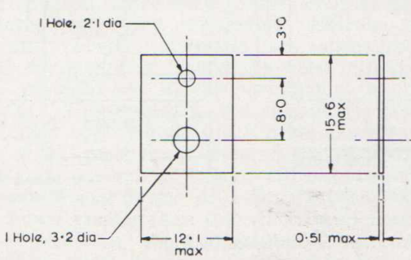


Fig. 9—Shim. Type number: 4313 021 20101

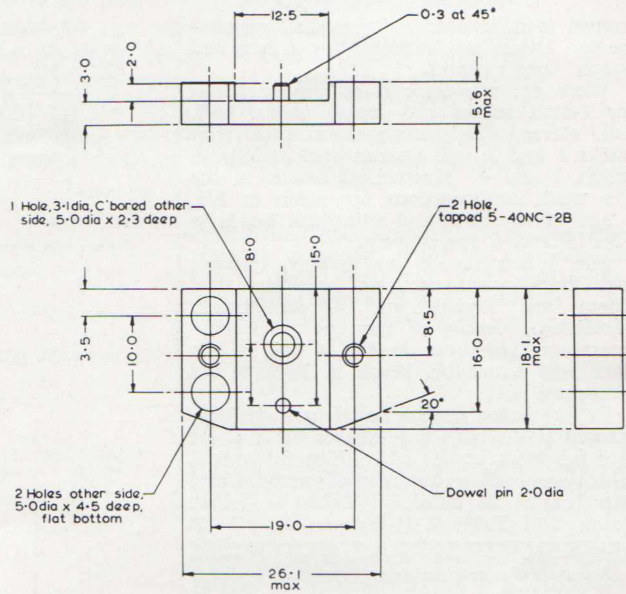
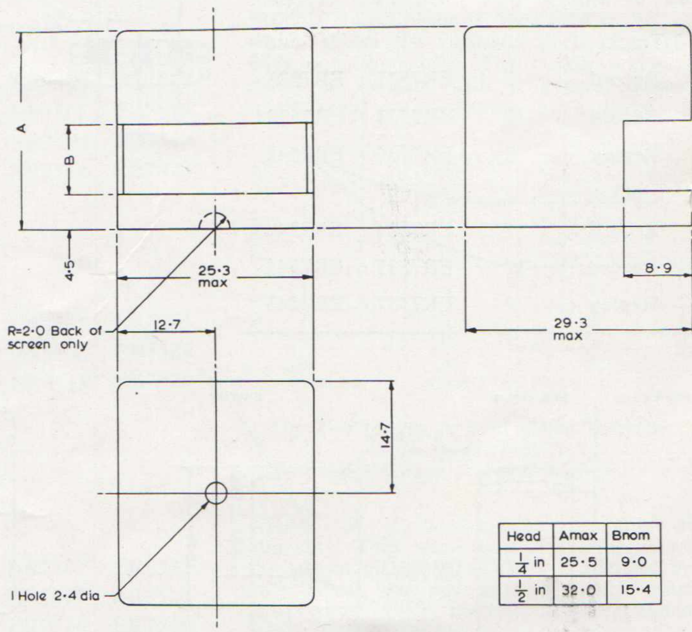


Fig. 10—Adaptor. Type number: 4313 021 20151

Dimensions in Figs. 3 to 11 are in mm



Head	A max	B nom
$\frac{1}{4}$ in	25·5	9·0
$\frac{1}{2}$ in	32·0	15·4

Fig. 11—Screening can assembly for $\frac{1}{4}$-inch or $\frac{1}{2}$-inch adjustable heads.
Type Numbers: $\frac{1}{4}$-inch, 4313 022 30201
$\frac{1}{2}$-inch, 4313 022 30251
(Assembly supplied complete with bolts and washers)
Typical Mullard fixed and adjustable $\frac{1}{4}$-inch ferrite recording heads

Properties of Quarter-inch Heads

TABLE 3

Type Numbers	*Inductance at 1kc/s (mH)*	*D.C. Resistance (Ω)*	*7·5in/s Record Current (mA) (DIN45513/3)*	*H.F. Bias Current at 100kc/s (mA)*	*Output (mV)*		*Crosstalk (Transformer) (dB)*
					1kc/s at 32mMx/mm	*333c/s at 25mMx/mm*	
Half-Track Heads							
ER7500/ER7516	7	6	0·6	3·5	—	—	—
ER7501/ER7517	7	6			—	—	—
ER7511/ER7527	80	25	—	—	2·5	0·65	—
Full-Track Heads							
ER7502/ER7518	7	4	0·8	4·5	—	—	—
ER7503/ER7519	7	4			—	—	—
ER7504/ER7520	7	4			—	—	—
ER7512/ER7528	80	13	–	—	4·0	1·1	—
2-2 Track Heads							
ER7505/ER7521	7	12	0·5	3·0	0·6*	0·15*	37
ER7506/ER7522	7	12					37
ER7513/ER7529	80	33	—	—	1·8	0·5	40
2-4 Track Heads							
ER7507/ER7523	7	16	0·4	2·3	0·4*	0·1*	40
ER7509/ER7525	7	16					40
ER7514/ER7530	80	47	—	—	1·1	0·28	40
ER7508/ER7524	7	16		2·3	0·4*	0·1*	40
ER7510/ER7526	7	16	0·4				40
ER7515/ER7531	80	47	—	—	1·1	0·28	40

*Output characteristic when one track of recording head is used for monitoring purposes.

MULLARD MINI SPEAKER UNITS

After the type of amplifier has been selected from the Mullard range of High Quality Amplifiers,* the next item on the shopping list should be the loudspeaker enclosure. In many cases it is difficult to decide which of several enclosures sounds the best, and of course other factors, such as price and physical size of the enclosure must influence the selection. The Mullard Mini Speaker Unit is an excellent example, providing good acoustic efficiency and smooth response.

The demand throughout Australia (and even New Zealand) has been so great that several cabinetmakers have decided to make available an enclosure following the outlines given in OUTLOOK Vol. 9, No. 2, page 17.** Messrs. Magnavox have requested that all prototypes should be submitted for their evaluation. Approved enclosures are obtainable from distributors shown, and it should be noted that as this issue goes to press additional Mini Speaker Units are in progress of being tested and approved by Magnavox.

* Information on the Mullard range of High Quality Amplifiers may be found in the following Mullard publications: Circuits for Audio Amplifiers, priced at $1.25 (plus $0.13 postage) Stereo Sound Systems, priced at $0.62 (plus 7c postage) OUTLOOK, obtainable on subscription basis, priced at $1.80 (6 copies per year) from Mullard-Australia Pty. Ltd., 35-43 Clarence St., Sydney, N.S.W.

** A comprehensive leaflet summarising articles published in OUTLOOK on the Mullard Mini Speaker Units is available on receipt of a self-addressed stamped envelope endorsed "Mini Speakers".

SUPPLIERS OF APPROVED MULLARD MINI SPEAKER UNITS

E. W. Goulding Pty. Ltd.
433 Liverpool Rd.,
Ashfield, N.S.W.

Built and polished cabinet only. (For Loudspeaker see Magnavox)

T.O.S.C.A.
180 Lyons Rd.,
Drummoyne, N.S.W.
Completely assembled and tested Units.

Classic Radio Service,
245 Parramatta Rd.,
Haberfield, N.S.W.
Completely assembled and tested Units.

Magnavox (Aust.) Pty. Ltd.,
6-8 O'Riordan St.,
Alexandria, N.S.W.
(or their distributors)

6WR and 3TC Mark II Loudspeakers

Broadway Electronics Pty. Ltd.,
32 Glebe Point Rd.,
Sydney, N.S.W.

Completely assembled and tested Units.
Complete kit of parts (cabinet built and polished, or pre-cut)

Regal Cabinets Co.,
6 Duffy St.,
Burwood, Vic.
Completely assembled and tested Units.

Tedco Pty. Ltd.,
579 Murray St.,
Perth, W.A.
Completely assembled and tested Units.

NEW SILICON PLANAR TRANSISTORS BF167 AND BF173

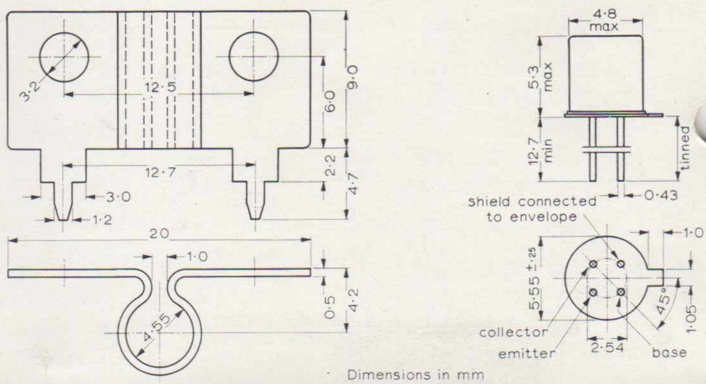
The BF167 and BF173 Silicon Planar Transistors have been designed for use as a controlled IF transistor and a large-signal IF output transistor respectively in television receivers. Gain control is a prime requirement of the first IF stage in order that maximum signal-to-noise ratio can be achieved for all signal levels. For this reason, the BF167 has been provided with a large control range which ensures that receiver noise can be made less than transmitted noise before control of the tuner begins. The IF gain-control characteristic of the device is held within narrow limits in order to maintain consistency in the transfer of a.g.c. from the IF amplifier to the tuner. • The problem of distortion of the response curve during the application of gain-control has received attention in the design of the BF167, and very satisfactory performance can be achieved over the desired control range, typically 60dB. The feedback capacitance of the BF167 is so small that no neutralisation is necessary, while permitting a high gain to be achieved. • The BF173 is a large-signal device which has a low bottoming voltage at high frequencies and maintains its gain at high current levels, such as commonly encountered in the output stage of television video IF amplifiers.

RATINGS

Limiting values of operation according to the absolute maximum system.

Electrical	BF167	BF173	
V_{CBO} max. ($I_E = 0$)	40	40	V
V_{CEO} max. ($I_B = 0$)	30	25	V
V_{EBO} max. ($I_C = 0$)	4·0	4·0	V
I_C max.	25	25	mA
I_{CM} max.	25	25	mA
P_{tot} max. ($T_{amb} \leq 45°C$)	130	200	mW
P_{tot} max. transient ($T_{amb} = 25°C$, $t \leq 20s$)	—	400	mW
Thermal			
T_{stg} min.	–65	–55	°C
T_{stg} max.	175	175	°C
T_j max.	175	175	°C
$\theta_{j\text{-}amb}$ (in free air)	1·0	0·65	°C/mW
$\theta_{j\text{-}amb}$ (with cooling clip 56263)	—	0·50	°C/mW

OUTLINE, DIMENSIONS AND COOLING CLIP



COOLING CLIP 56263 (for BF173)

Dimensions in mm Scale 2:1

SILICON PLANAR TRANSISTOR BF167

ELECTRICAL CHARACTERISTICS
($T_{amb} = 25°C$ unless otherwise stated)

I_B	Base current $I_C = 4·0mA$, $V_{CE} = 10V$	70	μA
	$I_C = 10mA$, $V_{CE} = 2·0V$ (max.)	1·1	mA
$*V_{EB}$	Emitter-base voltage $I_C = 4·0mA$, $V_{CE} = 10V$	–700	mV
c_{re}	Reverse transfer capacitance $I_C = 1·0mA$, $V_{CE} = 10V$, $f = 10·7Mc/s$	–150	mpF
f_T	Transition frequency $I_C = 4·0mA$, $V_{CE} = 10V$	350	Mc/s
NF	Noise figure $I_C = 4·0mA$, $V_{CE} = 10V$, $G_s = 10mmho$, $f = 35Mc/s$	3·0	dB

Small signal y-parameters

Measured at $I_C = 4·0mA$, $V_{CE} = 10V$, $f = 35Mc/s$

g_{ie}	Input conductance	4·8	mmho
c_{ie}	Input capacitance	45	pF
$\lvert y_{re}\rvert$	Reverse transfer admittance	37	μmho
ϕ_{re}	Phase angle of reverse transfer admittance	268	deg
$\lvert y_{fe}\rvert$	Forward transfer admittance	95	mmho
ϕ_{fe}	Phase angle of forward transfer admittance	337	deg
g_{oe}	Output conductance	30	μmho
c_{oe}	Output capacitance	1·2	pF
$\frac{\lvert y_{fe}\rvert^2}{4g_{ie} \cdot g_{oe}}$	Maximum unilateralised gain $I_C = 4·0mA$, $V_{CE} = 10V$, $f = 35Mc/s$	42	dB

$*V_{EB}$ decreases by about 1·7mV/°C with increasing temperature.

SILICON PLANAR TRANSISTOR BF173

ELECTRICAL CHARACTERISTICS
($T_{amb} = 25°C$ unless otherwise stated)

I_B	Base current $I_C = 7·0mA$, $V_{CE} = 10V$	80	μA
	$I_C = 20mA$, $V_{CE} = 2·0V$ (max.)	1·3	mA
$*V_{EB}$	Emitter base voltage $I_C = 7·0mA$, $V_{CE} = 10V$	–740	mV
c_{re}	Reverse transfer capacitance $I_C = 1·0mA$, $V_{CE} = 10V$, $f = 10·7Mc/s$	–230	mpF
f_T	Transition frequency $I_C = 5·0mA$, $V_{CE} = 10V$	550	Mc/s

Small signal y-parameters

Measured at $I_C = 7·0mA$, $V_{CE} = 10V$, $f = 35Mc/s$

g_{ie}	Input conductance	4·5	mmho
c_{ie}	Input capacitance	45	pF
$\lvert y_{re}\rvert$	Reverse transfer admittance	55	μmho
ϕ_{re}	Phase angle of reverse transfer admittance	266	deg
$\lvert y_{fe}\rvert$	Forward transfer admittance	145	mmho
ϕ_{fe}	Phase angle of forward transfer admittance	338	deg
g_{oe}	Output conductance	65	μmho
c_{oe}	Output capacitance	2·1	pF
$\frac{\lvert y_{fe}\rvert^2}{4g_{ie} \cdot g_{oe}}$	Maximum unilateralised gain $I_C = 7·0mA$, $V_{CE} = 10V$, $f = 35Mc/s$	42	dB

$*V_{EB}$ decreases by about 1·7mV/°C with increasing temperature.

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