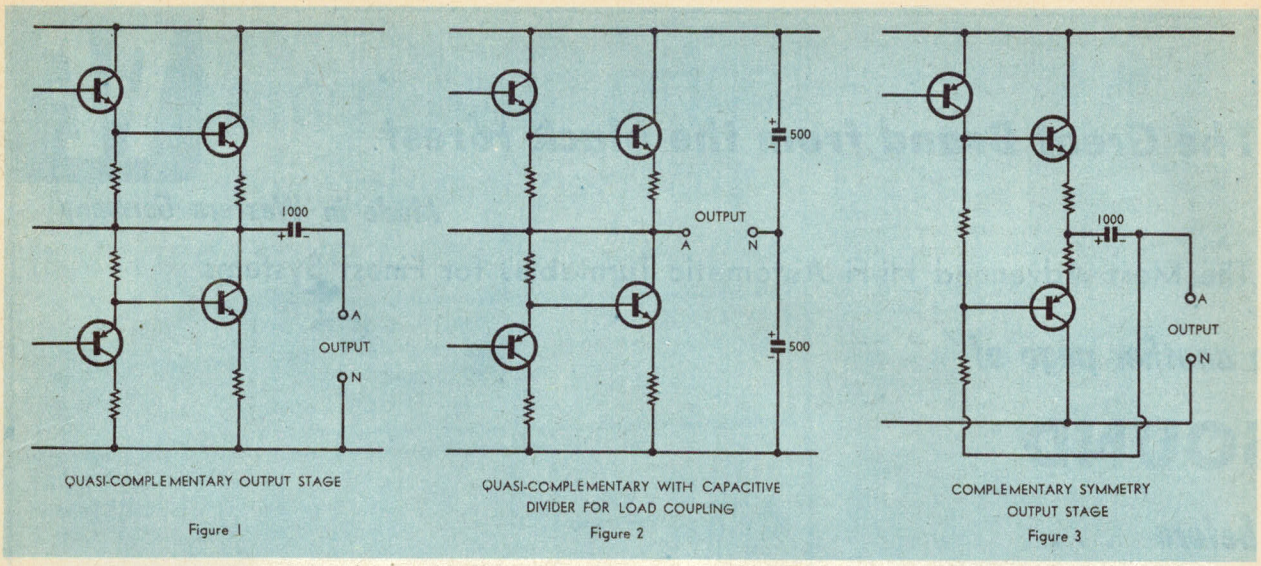


QUASI-COMPLEMENTARY OUTPUT STAGE
Figure 1

QUASI-COMPLEMENTARY WITH CAPACITIVE DIVIDER FOR LOAD COUPLING
Figure 2

COMPLEMENTARY SYMMETRY OUTPUT STAGE
Figure 3

Typical output stage configurations for transistor power amplifiers. A headphone adaptor would need a blocking capacitor in the case of figure 2. None would be necessary for figures 1 and 3, or for valve type amplifiers, which almost invariably use an output transformer.

A STEREO HEADPHONE ADAPTOR

In answer to the requests of many readers, this article discusses a universal headphone adaptor which is suitable for all types of amplifier, valve or transistor and all types of stereo headphones, regardless of impedance. Two pairs of headphones can be connected and a switch is provided to silence the loudspeakers.

By LEO SIMPSON

The only experience that many people have had of headphones is with a pair of "cans" bought from a disposals store and connected to a short-wave radio or a crystal set. Because the frequency response of such phones is usually peaked in the middle of the range, the sound may sound "clear" enough but it lacks the balance that is essential to high fidelity reproduction. The distortion content is also rather high, as a rule.

In addition, the sound lacks any sense of dimension. In fact, if the individual phones are balanced and connected so that the diaphragms move inwards together and outwards together, the sound appears to originate from a point source right in the middle of the listener's head. It is, in fact, a most peculiar place to have a full orchestra, or a grand organ!

Modern, high fidelity headphones exhibit lower distortion and a response that is much wider and smoother than any of the older, general purpose types. Reproduction, overall, compares very favourably with that from high fidelity loudspeakers.

Furthermore, by feeding the phones separately from the respective channels of a stereo system, the apparent signal source no longer remains captive inside the listener's head.

On fully dispersed stereo program material, the listener has the sensation of sitting right in the middle of the orchestra, with instruments dispersed on either side, and his head, maybe, inside the lid of the grand piano!

With the more gimmicky "two-channel" type of stereo recording, the listener has the impression of sitting between two distinct groups of musicians. With a "three-channel" type of recording, there is an additional group inside his head!

These impressions are not present when listening to a normal stereo loudspeaker set-up. The sound sources are usually in front of the listener, not adjacent to his ears. Each ear hears each sound source, both by direct and reflection paths, and the listening situation more closely approaches that which it would obtain if the performers were actually located at the far end of the listening room.

Because of the rather unnatural—though startling — illusions created, it is possible to argue that headphones are not a legitimate method of listening to ordinary stereo program material. Be that as it may, however, the reproduction can be very satisfying and an alternative, far to be preferred to no listening at all.

Headphones do not suffer from apparent attenuation of the high frequencies due to "beaming" effects as do loudspeakers, since the headphone aims right into the ear, as it were. At low frequencies, provided the phones are adequately sealed to the head by flexible surrounds, headphones can produce plenty of undistorted bass; they do not have to set up a large wavefront in a room and cannot excite boomy room resonances. Finally, because the diaphragms need to make only small excursions to move a limited amount of air, they may well contribute less distortion than loudspeakers.

However, the real reason for the continuing popularity of headphones is, as we intimated, that they enable one to listen to music as loud as desired without disturbing the neighbours, babies or parents-in-law.

As far as the listener is concerned, headphones cushioned to the ears are far more sensitive than any kind of loudspeakers standing several feet away. This leads to certain immediate and serious complications.

The first arises from the fact that all practical amplifiers have some inherent noise and hum output, even with the volume control turned right down. Through a loudspeaker system this is normally not troublesome but, heard through earphones, it is generally quite objectionable and sufficient to compromise or ruin enjoyment of the program.

Another aspect is that since so little audio power is necessary to produce adequate output from the headphones, the volume control may have to be set at a critical position, not far advanced from fully off. If, by chance, it hap-

pens to be turned up too far, the headphones could easily be damaged.

A possible secondary effect is that, at such low volume control settings, the balance in the two sections may be anything but good, requiring manipulation of the balance control to equalise the two channels.

What is clearly required is some kind of an attenuation circuit, such that only portion of the voltage at the output of the amplifier ever reaches the headphones. It will reduce the hum and noise fed to the phones and allow the amplifier to be operated with the volume control somewhere near the setting normally employed for loudspeaker listening.

Many commercial amplifiers have jack sockets for one or two sets of headphones and these are fed from amplifier outputs via resistors which may have a value from 150 to 500 ohms. While these resistors may give a suitable order of attenuation for low impedance headphones, e.g., 8 ohms, they will be less effective for the many headphones on the market which have impedances ranging up to 600 ohms, and as high at 10K in one particular case.

What is needed is a voltage divider network which can provide a suitable order of attenuation regardless of the type of headphone used. To this end, we have used a pair of 100-ohm slider resistors fed by 47-ohm resistors for each set of headphones. (See circuit diagram.) By adjusting the moving contact on the slider resistor, the amount of attenuation can be varied over a wide range.

The above network provides only light loading of the amplifier output circuits. While most transistor amplifiers are tolerant of light loading, a few valve types are prone to damage if they are inadvertently overdriven without a load; others may tend to instability. Complementary-symmetry amplifiers (see figure 3) will not operate unless they are loaded, as the load forms part of the bias network for the output transistors.

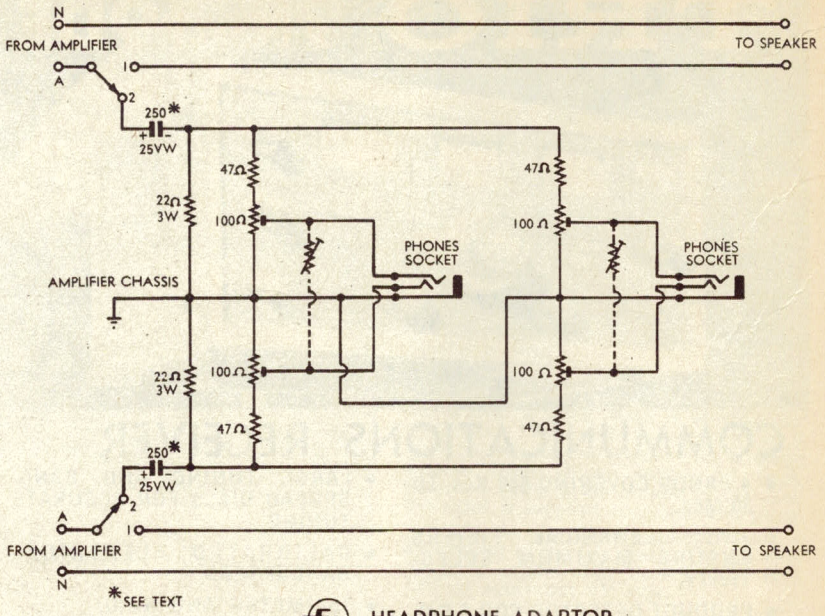
For the above reasons we have specified a 22-ohm, 5-watt resistor as the dummy load for each channel. This value is low enough to ensure correct operation of all amplifiers likely to be encountered and is high enough for the 5-watt rating to be quite adequate for likely levels of operation.

In normal stereo systems, the loudspeakers are independent units, each fed by an entirely separate twin lead. The output circuits of the two amplifiers can be entirely independent of each other in respect to both the active and neutral wiring. It is wise to preserve this isolation, at least in respect to the loudspeakers, to minimise any risk of introducing unforeseen complications.

However, isolation cannot be preserved with many types of headphones because they use a common return (or neutral) lead. For this reason we have suggested a 5-wire circuit between the amplifier and headphone adaptor. Four wires provide the separate active and neutral leads for loudspeaker operation; the fifth wire allows the headphones to be connected from the respective activities to chassis.

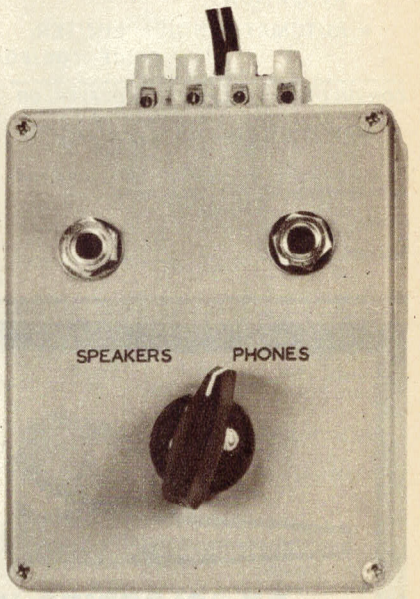
The use of a common earth return circuit with headphones will cause a complication with those amplifiers which operate with the loudspeaker above chassis potential, i.e., neither side of the loudspeaker is connected to earth, via the chassis.

A case in point is the Playmaster 115 Stereo amplifier published in the April, 1967, issue of "Electronics Australia." This uses the familiar quasi-complementary output stage but, instead of using the normal large electrolytic capacitor for loudspeaker coupling, it uses a capacitive voltage divider across the positive and negative supply rails to eliminate the charging pulse delivered to the speakers at the point of switch-on. This places the load at about 25 volts D.C. above chassis potential, which means that the common earth return system used in the adaptor cannot be used without the addition of D.C. blocking capacitors. For this reason, we have incorporated the 250uF/25VW electrolytic capacitors in the circuit so that one side of load can be connected to the amplifier chassis (common earth).



EA HEADPHONE ADAPTOR

The circuit of the headphone adaptor and, at right, the unit itself. Note that the plugs and sockets for the phones must be of the "stereo" type.



PARTS LIST

- *1 Eddystone utility box, 4-5/8 x 3-5/8 x 2-1/8 inches.*
- *1 two-pole, two-position switch.*
- *2 Stereo jack sockets.*
- *2 13-lug tagstrips.*
- *1 4-way insulated terminal block.*
- *2 250uF/25VW electrolytic capacitors (see text).*
- *2 22-ohm, 5-watt resistors.*
- *4 47-ohm, ½-watt resistors.*
- *4 100-ohm slider resistors.*
- *1 knob, 4-conductor cable with shield, cord clamp, solder lug, hook-up wire, screws, nuts, etc.*

With amplifiers other than those just mentioned the capacitor may be omitted. With complementary-symmetry amplifiers the capacitor must be omitted, since the load forms part of the D.C. bias network for the output transistors, as mentioned earlier.

If there is any doubt as to whether the amplifier on hand should be used with the blocking capacitors, this can be determined without reference to a circuit diagram by measuring the D.C. potential of the loudspeaker voice-coil circuit with respect to the amplifier chassis with no signal applied. If it is zero, then no capacitor is necessary.

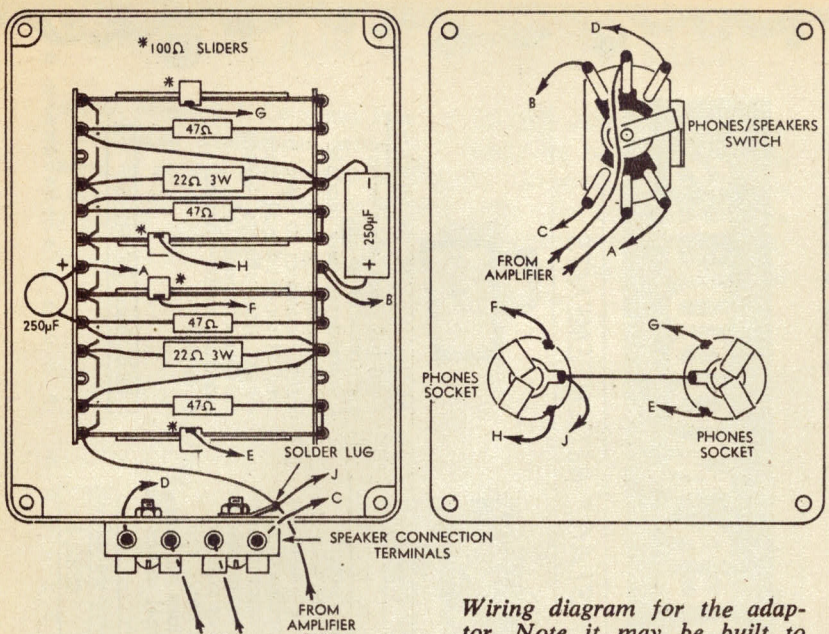
Note that if the D.C. potential of the voice coil proves to be negative with respect to the chassis, as was the case with one or two circuits we have seen in overseas magazines, the polarity of the electrolytic capacitors in the adaptor unit would have to be reversed to that shown in the circuit and wiring diagrams.

Problems to do with the internal circuitry of amplifiers are mainly con-

fined to transistor types. Valve type amplifiers almost invariably used output tranformers with no D.C. potentials associated with the secondary winding; in most cases, one side of the secondary winding was earthed to chassis. No blocking capacitor is necessary in a headphone adaptor but, by the same token, the presence of a blocking capacitor would not adversely affect its operation.

The prototype headphone adaptor was constructed in an Eddystone die-cast metal box, which is available from most electronic part suppliers. All the components are installed between two 13-lug tagstrips. The switch to select loudspeakers or phones is a two-pole, two-position type. The wiring layout is not critical but should be neat and tidy and follow good wiring practice.

The cable to the earphone adaptor needs five effective conductors and could logically be five insulated leads inside an outer covering. Because it was most readily available, we used a cable with four insulated conductors, two of which have a common outer braided shield; this was used as the fifth conductor and logically as the earth lead from the amplifier chassis.



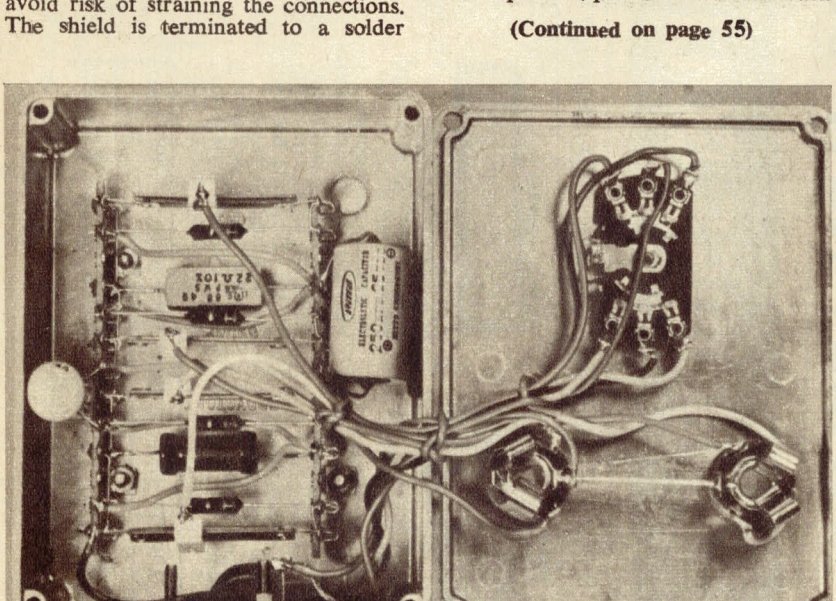
Wiring diagram for the adaptor. Note it may be built to suit only one set of headphones.

The four insulated leads are used for the active and neutral loudspeaker leads; the neutral lead is that lead which is at zero A.C. potential with respect to the amplifier chassis, i.e., the earthy side. On these amplifiers with screw terminals for the loudspeaker connections, the active side may be coloured red or coded with a "plus" sign. If this is not the case, the active side of the speaker output may be determined by trial and error when the adaptor is completed; if the headphones are effectively connected between neutral side of the amplifier output and the amplifier chassis, no sound will be heard.

The cable enters the case through a grommetted hole and is clamped to avoid risk of straining the connections. The shield is terminated to a solder lug which is secured by the same screw which secures the cord clamp. The neutral lead from the amplifier are then brought out through the grommetted hole and terminated on the four-way insulated terminal block. The two leads from the "speakers" lugs on the the speakers/phones switch (terminal 1) are also brought out through the grommetted hole and terminated on the four-way terminal block. The four leads from the loudspeakers can then be taken from the other side of the terminal block.

Alternatively, the terminal block may be dispensed with and the four insulated leads in the cable used to take the active leads from the amplifier to the speakers/phones switch and back

(Continued on page 55)



A view inside the utility box showing disposition of components. We used electrolytic capacitors which were on hand, hence the different (but typical) mounting arrangements for the two.

to a terminal block on the rear panel of the amplifier.

Once the adaptor has been completed the slider resistors should be set to the position which would give minimum volume in the headphones. After having connected the various leads to the amplifier and connected the loudspeakers to the appropriate points in the adaptor circuit, program material should be played through the loudspeakers with volume, balance and tone controls at their normal settings. Leaving these set, switch to the headphones and adjust the appropriate slider resistors for a suitable level in each channel. With the levels set in this way, switching from speakers to headphones can be done without the need for resetting the volume control. The effective signal/noise ratio should be about the same.

The diagrams provide for operating two pairs of headphones but, if provision has to be made for only one pair, one of the sockets may be omitted, along with the associated 47-ohm and 100-ohm slider resistors.

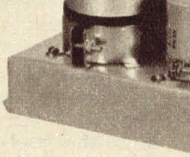
Readers may care to experiment with the idea of cross-coupling the two headphone circuits to diminish deliberately the isolation between the two channels.

This has been the subject of a fair amount of discussion in overseas audio journals. The circuits usually involve various configurations of L, C and R, intended to make the cross-coupling frequency and phase conscious, in an effort to simulate the conditions which obtain in ordinary loudspeaker listening.

Before being qualified to offer an opinion about the various circuits which have been suggested, it would be necessary to conduct quite lengthy listening tests with a variety of stereo program material and this we have just not had time to do. It is obvious, however, that provision of even the simpler kind of network would add materially to the cost, bulk and complexity of a headphone adaptor.

For those who wish to experiment on a simpler basis, however, low value resistors or a potentiometer may be tried in the position shown dotted on the circuit diagram.

Go out and purchase yourselves a pair of headphones then, build this adaptor unit and you can listen to stereo any time you like. You may even listen to bagpipes at 3 a.m. on Sunday morning — as long as it's on headphones! ■



Noise silencer on Lamb principle. Product detector and ceramic high-stability BFO.

We also plan to feature next month a high power basic stereo amplifier delivering up to 60 watts per channel and catering for load impedances between 16 and 4 ohms, with distortion figures from 0.05 per cent. The amplifier is intended to complement the Playmaster 127 control unit described in the November issue, and, with it, will constitute a high-performance, state-of-the-art Playmaster system.

Watch out, too, for a balanced-bridge metal locator!