RADIOTRONICS

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THE TR24

A 24-watt Transistorized High Fidelity Amplifier

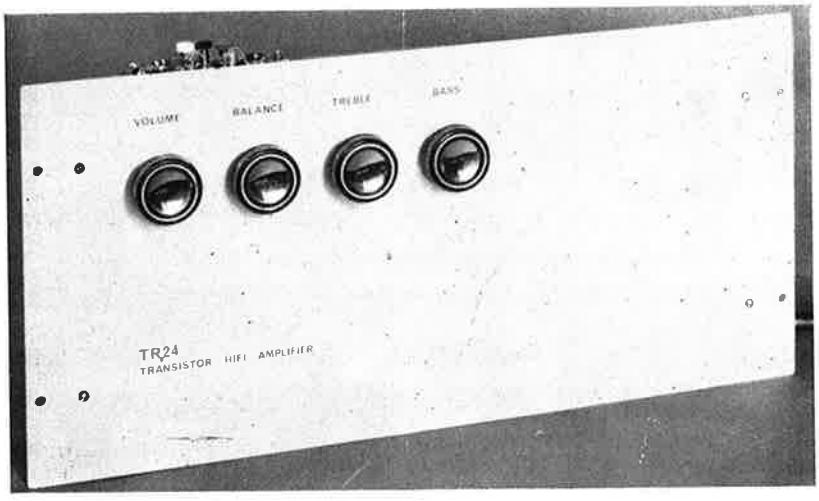
Part 2—The Preamplifier

Last month we featured a stereo high fidelity amplifier using the new drift transistors now being made in Australia. The main amplifier, which was described last month, requires an input of the order of 750 millivolts to drive it fully, so that some further amplification is needed between the unit and the pickup. In addition, it is of course desirable to include some form of tone control.

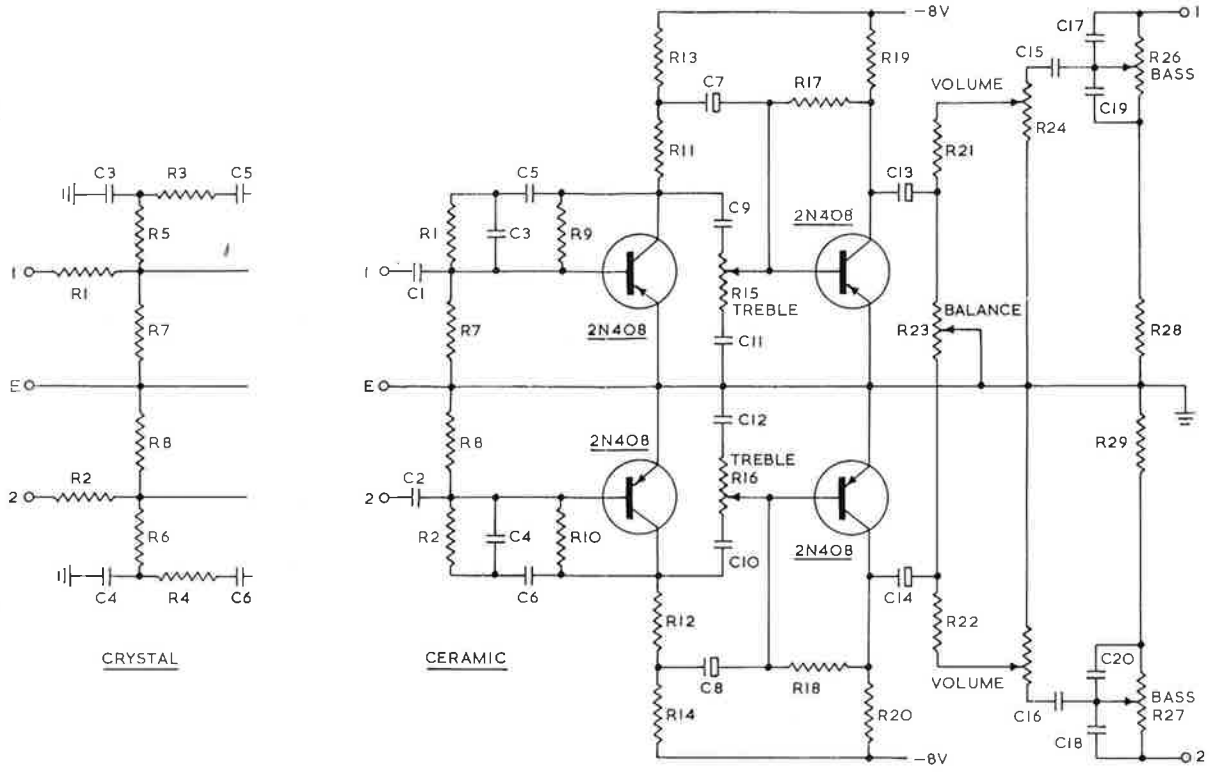
The illustrations of the main amplifier section which were shown last month indicated provision for a preamplifier. As a matter of convenience during development, the main amplifier and the preamplifier in the model stage were built on to two separate panels. In the construction of further units, however, it would be more convenient to build them on to the same panel. In that case they could not be separated, as we did, for the purposes of photography.

It was mentioned in relation to the main amplifier that the layout was not critical. The lower impedances involved in most transistor circuits allow much more latitude in this regard than is customary in the case of valve units. With slight reservation and usual precautions, the same remarks would apply to the preamplifier unit.

Because of the large number of crystal pickups in use, and the growing popularity of some of the high-grade ceramic units which are just beginning to offer such competition to magnetics, it was decided that the first model preamplifier would be suitable for these types of pickup. A word of warning must be used here. The unit described here has two alternative input circuits, one for a representative type of ceramic pickup, and one for a crystal pickup. In the case of the crystal pickup, a flat response has been provided



View of the complete TR24 unit. The main amplifier section was described last month.



Circuit diagram of the stereo preamplifier. The alternative inputs for ceramic and crystal cartridges are shown, see text.

PARTS LIST

Semiconductors

4 AWV 2N408 transistors.

Capacitors

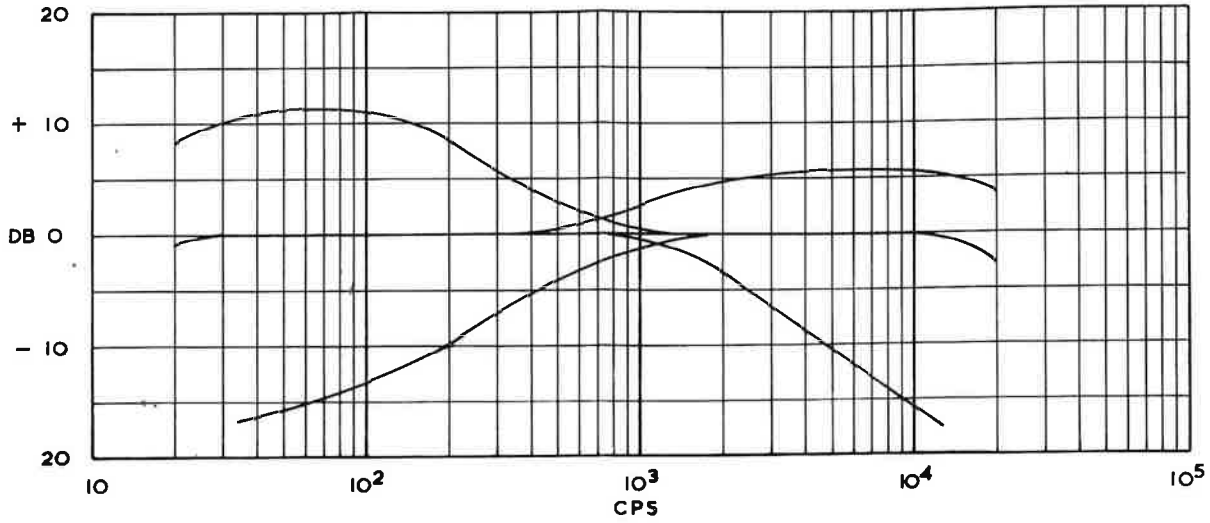
C1, C2 Version A. Not used.
Version B. 0.01 μf, 25 vw, ceramic.
C3, C4 Version A. 1800 pf, ceramic.
Version B. 0.015 μf, ceramic.
C5, C6 0.047 μf, 25 vw, ceramic.
C7, C8 5 μf, 12 vw, electrolytic.
C9, C10 0.1 μf, 25 vw, ceramic.
C11, C12 0.47 μf, 25 vw, ceramic.
C13, C14 5 μf, 12 vw, electrolytic.
C15, C16 2 μf, 3 vw, electrolytic.
C17, C18 0.1 μf, 25 vw, ceramic.
C19, C20 0.47 μf, 25 vw, ceramic.

Resistors

All resistors are ½ watt, 10% except where stated.
R1, R2 Version A. 100 K ohms.
Version B. 3.9 K ohms.
R3, R4 Version A. 33 K ohms.
Version B. Not used.
R5, R6 Version A. 33 K ohms.
Version B. Not used.
R7, R8 10 K ohms.
R9, R10 220 K ohms.
R11, R12 1.2 K ohms.
R13, R14 27 K ohms.
R15, R16 Dual ganged potentiometer, 10 K ohms, log.
R17, R18 39 K ohms.
R19, R20 1 K ohm.
R21, R22 270 ohms.
R23 Potentiometer, 10 K ohms, linear.
R24, R25 Dual ganged potentiometer, 5 K ohms, log.
R26, R27 Dual ganged potentiometer, 10 K ohms, linear.
R28, R29 270 ohms.

Miscellaneous

Aluminium panel, matrix board and pins, hardware.



Performance curves of the complete TR24 unit, showing the operation of the tone controls.

for use with cartridges such as the Ronette, the characteristics of which do not require further equalization of response in the amplifier. In the case of the ceramic pickup, RIAA equalization has been provided in the normal way. As the degree of equalization required with different makes of ceramic pickup may vary, some adjustment may be required, and the maker's recommendations should be followed.

This unit is not suitable for use with low level inputs such as that obtained from a tape head or magnetic cartridge. It is hoped at a future date to present a further preamplifier suitable for these applications.

It will be seen that the circuit of this preamplifier as presented here uses only four controls, all ganged to adjust both channels simultaneously. Readers can make their own additions in the way of input selector switches, mono/stereo switches, and the like.

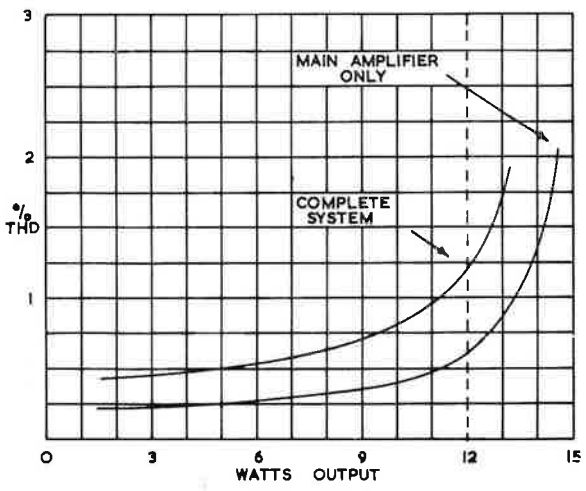
Circuit Description

The circuit of the preamplifier is very simple, and requires little comment. Two AWV 2N408 transistors are used in each channel, and the nominal 8-volt collector supply is tapped off from the 8-volt supply in the main amplifier, also used to power the predriver stage.

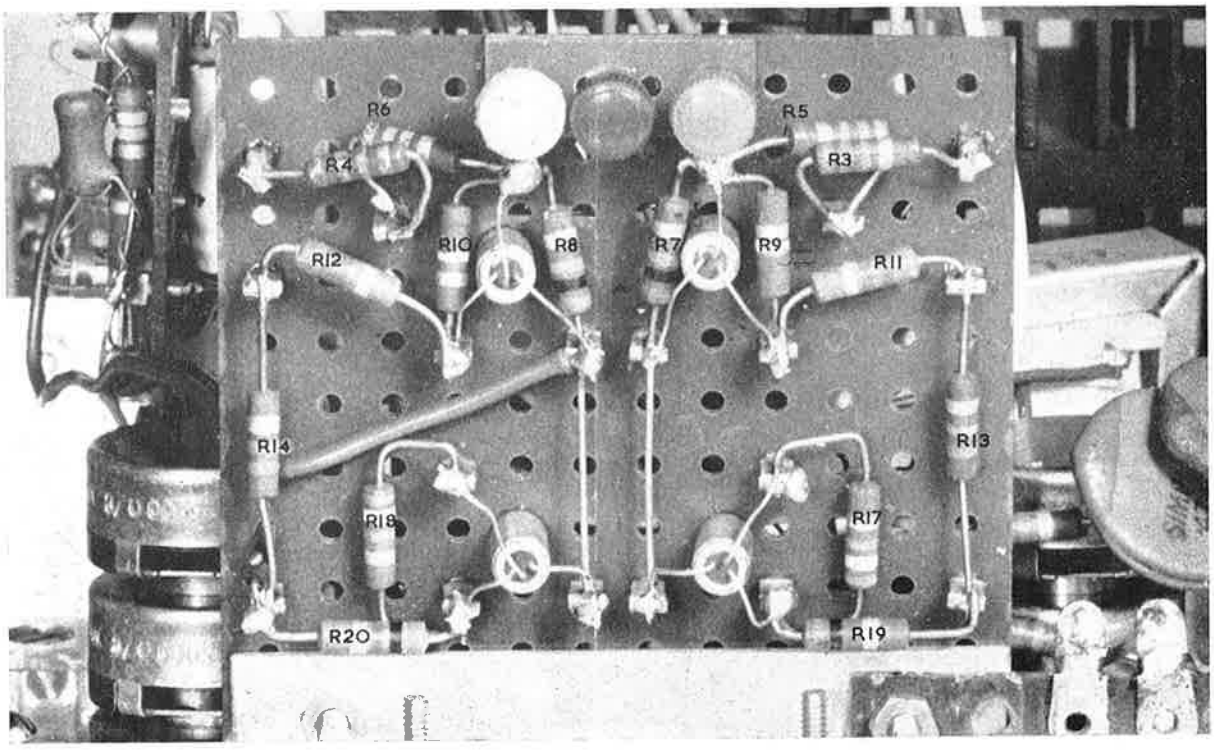
The tone controls used in this circuit are the familiar lossy type. Perhaps a little less usual is the arrangement and order of appearance of the controls in the circuit. This is done to preserve the correct loading conditions through the preamplifier. Those readers already very familiar with transistor circuitry will not find this unit too unusual.

The input circuit for the ceramic pickup version of this unit has a resistance-capacitance feedback network between the collector and base of the input transistor. This network provides the required RIAA equalization. The alternative input circuit for crystal pickup has been modified to provide a flat response, and at the same time the input impedance has been "built out" by the series input resistor. This has been done to avoid loss of bass response from the otherwise rather low input impedance of the circuit.

The series resistor is a very cheap and simple way of overcoming the problem of holding up the bass response of the pickup. It can only be used



Output versus distortion characteristic of the complete TR24 unit.



View of the preamplifier from above, showing matrix board and the four 2N408 transistors.

where the resultant loss of gain can be tolerated. It will be seen that the series resistor and the input impedance of the first stage form a potentiometer which considerably reduces the effective input signal voltage. In this case there is gain to spare, which avoided the use of more complicated and expensive measures.

Construction

The accompanying photographs show how the preamplifier was put together, and it will be obvious that the actual construction is a very simple exercise. The four controls are mounted into the front sub-panel, whilst the four 2N408 transistors and some of the smaller components are mounted on a small section of matrix board. This board is fixed to the front sub-panel by means of a small length of $\frac{1}{2}''$ aluminium angle.

When making the complete amplifier on one front sub-panel, in the manner already mentioned, it would be a good idea to complete the construction of the main section of the amplifier before adding the preamplifier. There are only four interconnections between the main amplifier and the preamplifier. They are ground, -8 volt supply, and the two signal inputs to the main amplifier.

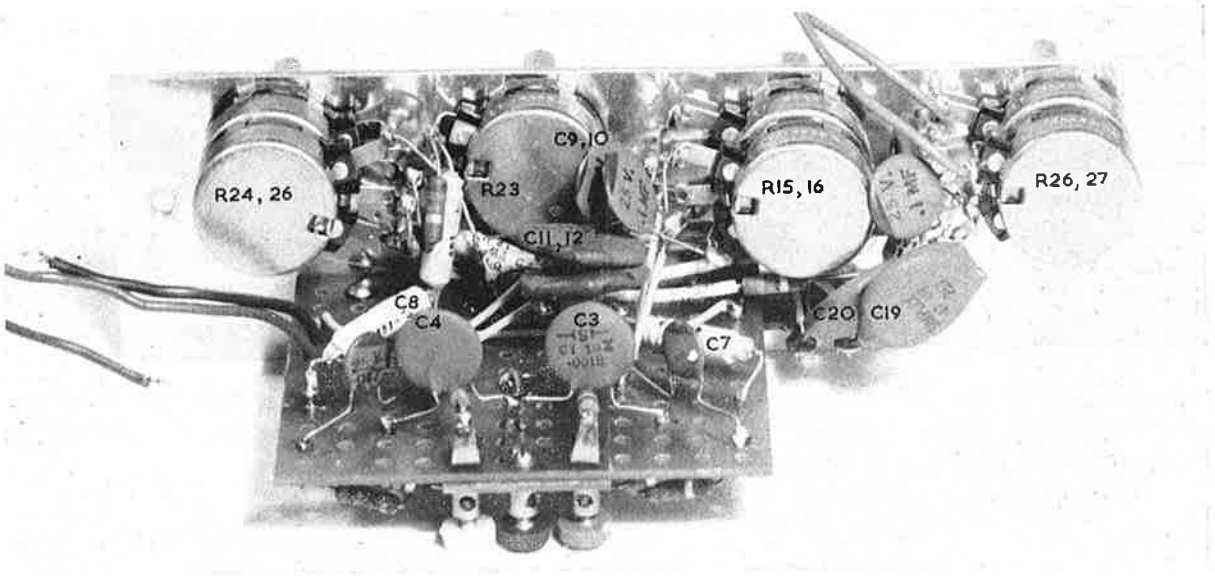
As in the case of the main amplifier, the matrix board assembly is best completed before mounting the board on to the preamplifier. A much neater and quicker job can be done this way, and it is certainly a lot easier. For those not familiar with this type of construction, the board comes in fixed sizes which can be cut as required. The small tags, or pins, as they are called, come loose, and are pushed into the holes in the board as required. Once this has been done, the various components are placed with their leads passing through the slots in the pins, and the soldering operation carried out.

With this type of construction, and in fact with all units using transistors, a small soldering iron of the "Oryx" or similar type should be used to avoid damage. These small irons are a pleasure to use; they are very light in weight, and they do not overheat the way larger irons do when left switched on. Further, because they are usually fed from a transformer which provides the 12 volts or so required to run the iron, the chance of leakage damaging transistors and diodes is removed.

Performance

The response curves of the preamplifier were measured in conjunction with the main amplifier section. The curves presented here, therefore, relate to the complete unit; they show the overall response with the tone controls set to the neutral positions, and also the operation of the tone controls.

The bass tone control provides a variation of $+12$ db -16 db at 50 cps. The treble tone



Underside view of the preamplifier, showing further assembly details.

control provides a variation of +6 −16 db at 10 Kc. The treble boost is restricted, as this is the area where least control of the frequency response is usually required.

Distortion has been measured both on the main amplifier section alone, and on the complete amplifier comprising the main amplifier with the preamplifier, i.e., an overall system measurement. The accompanying curves show the results of these tests at various output power levels, the curve for the main amplifier alone being shown and that for the complete system. The noise performance of the complete amplifier system is 60 db below 12 watts output.

The signal input level required to load the amplifier to full output depends, of course, on the type of input circuit selected. The crystal cartridge input circuit requires an input of the order of 100 millivolts, whilst the input circuit for the ceramic type of cartridge requires an input of about half that value.

Summary

The TR24 unit consists of a main amplifier section with a performance comparable with that of some of the best valve circuits. The performance is obtained at moderate cost by the use of a new type of transistor recently introduced to Australia and now in local production. The preamplifier provides basic facilities for crystal or ceramic cartridge, which can be added to by the individual builder as required. Further development work is proceeding on other designs using the 2N2147 and 2N2148 transistors, and will be published in these pages as it becomes available.

RANDOM REFLECTIONS

An occasional article in which an effort is made to answer queries on subjects of general interest.

Radiotronics Designs

By the time this gets into print, readers will already be seeing the results of some months of work directed towards the reintroduction into these pages of practical circuits for experimenters and home constructors. A large part of this effort has been directed initially towards audio amplifiers, as this is a field in which the largest single block of interest lies.

As time goes on, however, it is hoped to extend the field to other things. But these things, like Rome, are not built in a day. These units which we feature in these pages are in general specially produced for these pages, and they must meet a number of requirements of rather a special kind.

It goes without saying that, firstly, every effort is made to ensure that the designs are as sound as they can, with human foresight, be made. Secondly, they are put together using only the simplest of tools and equipment, such as any home constructor may be expected to have. An example of this will be seen in the stereo control preamplifier unit originally designed for use with the "Music Lover 12" system. This preamplifier uses a specially designed chassis in order to obtain good layout and low noise. But this chassis is very simple to make. All that is needed is some 14-gauge aluminium sheet, ½" aluminium angle, a hacksaw and a ⅛" clearance drill, and the necessary nuts and bolts to hold the whole thing together.

Readers' opinions are always welcomed, even though it may take months to bring adopted suggestions into effect. One of the things we are giving a lot of thought to at the moment is the amount of assistance needed by the average constructor in the way of component layout diagrams, more photographs, or similar measures. We have been taking the view that, except in the simplest of equipment suitable for the younger readers and beginners in the art, where extensive layouts may be useful, the provision of clearly read circuits and good photographs is sufficient for the average constructor.

We have to remember that most people who undertake, for example, to build a high-grade amplifier set-up already have had some experience in construction. On this basis it would be wasteful and possibly annoying to them if we presented copious diagrams telling them where to put each small resistor and capacitor. There is a further point, too, in that probably very few readers will construct a unit in exactly the way we would. The individual reader may want a unit of different mechanical size, or he may want to add or delete some features.

If you have an opinion on this subject, please let us know so that we can gauge the requirement. In the meantime, however, we will go on as we have been doing, giving good photographs of the units to convey the general scheme of things, and allowing individual readers to manage the minor details for themselves.

Pickups Again

If you are just in the throes of getting started in high fidelity, or are in the stage where you are considering replacement of your existing pickup or cartridge, take a close look at ceramic cartridges today. This type of unit has been with us some time and, in the minds of many, appears to be just another type of crystal cartridge which is more resistant to climatic conditions.

This is not quite true. It never has been, but the difference between them is becoming greater all the time. This is evidenced by developments in the field of ceramic pickups just now coming out of Britain and the U.S.A. Some of these new units are very good indeed, and it is already being suggested in some quarters that these new ceramic units will displace the magnetic cartridge as the first choice of the audiophile.

Generalisations, of course, have to be treated as such. It is a fact, however, that the performance claimed for some of these new units is very high from a purely technical standpoint; it is even more impressive when viewed in the light of their cost as compared with magnetic units. It must not be forgotten that the ceramic unit does not need the high-gain preamplifier, with all its attendant troubles, thus showing a further possible saving.

Power Output Again

It is amazing how the same subject will keep cropping up.

We had a few words to say recently on this subject and on the methods of measuring the power output of an audio amplifier. The most obvious and simple way to measure power output is to connect a load to the amplifier, drive the amplifier, and measure the power developed in the load by measuring either the current through it or the voltage developed across it. Because the power output of an amplifier means nothing unless related to the distortion figures, power output and distortion measurements will usually be made at the same time, in order to decide either the output of the unit at the rated distortion figure, or vice versa.

Because the characteristics of the loudspeaker as a load vary from type to type, a resistive load is generally employed for this type of measurement. The tests are carried out with sine wave inputs. This type of test, whilst easy to carry out and quite reproducible from one unit to another, is widely regarded as telling an incomplete story.

Two factors enter into this. One is the fact that in the reproduction of music, a complex waveform rather than a pure wave is being amplified. The second is that a sustained tone of an amplitude sufficient to hold the amplifier at full output is virtually never encountered. Music is more transient in nature.

Because of the transient nature of music, it is argued that a measurement of the output under transient conditions will present a truer picture of the amplifier's capability. Incidentally, this will also rate the amplifier at a much higher output, and so make it sound a better amplifier on paper. Why should this be?

Any amplifier has less than perfect regulation in the power supply, any output transformer must have some dc resistance in its windings, and so on. Under these conditions, the application of a steady tone to load the amplifier fully will result in a fall of voltage, be it however small, on the B+ line and increased IR losses throughout the circuit. This will not happen under transient conditions, where voltages will hold their no-signal values for a short time after the application of the transient, dependent on the time constants present.

In order to overcome the problem of more realistic power output ratings and in an attempt to get some standardisation, the Electronic Industries Association (U.S.A.) adopted a standard RS234 entitled, "Power Output Ratings of Packaged Audio Equipment for Home Use." This standard defines the method to be used in determining the power output of an amplifier, and defines the terms to be used. It must be pointed out, however, that this specification will not necessarily have a universal acceptance, particularly in countries other than the U.S.A.

The standard in question defines a term "Music Power Output," which means the power output obtained with a single frequency input at 5% total harmonic distortion, or less if specified, the power output measurement to be taken immediately after the application of the input signal and before the supply voltages within the amplifier have had time to change from their no-signal values.

There is an obvious practical difficulty in applying this test, and in fact there is only one reasonably simple way to do it. For the purpose of the test, the amplifier must be used with an external regulated power supply, which will maintain the supply voltages at the no-signal values after the signal is applied. The measurements can then be made.

A further term introduced in the standard under discussion must be drawn to attention, as there is a great danger of confusion. The second term is "Maximum Music Power Output," and this is defined as the maximum power output, taken as described above, without regard to distortion. In high fidelity language, therefore, this rating is almost meaningless, but because of the similarity in the names of the two ratings, care should be exercised that there is no confusion in terms. The "Maximum Power Output" rating is the important one, which is taken for a maximum total harmonic distortion of 5%, or for such lower value of distortion products as may be specified. Note particularly that where no distortion figure is quoted in conjunction with the music power output, then it must be assumed that distortion is 5% total at the output quoted.

Differences of ratings measured on the same amplifier with the two different systems can be astonishing. Because power developed increases as the square of the applied voltage, the comparatively small change of supply voltage involved in the tests can have a large effect on the power developed. Cases where the music power output measures at 40% above the output measured with the simpler test described are common.

There is another point not quite so obvious. The simple test takes into account the regulation of the power supply and treats the amplifier and power supply as one unit, which effectively they are. In the measurement of music power output the load characteristic of the power supply does not appear, and therefore it is possible that the same amplifier could show better results when provided with an inferior power supply. With reputable manufacturers there is no danger that the conditions of test may be used to fit a poor power supply, but to be realistic we have to remember that the situation is there.

Why Change?

The question may be asked whether RADIOTRONICS will adopt the EIA standard in view of its acceptance overseas in the U.S.A. This partly brings us back to the point we were making earlier on, that we wish our designs to be completely reproducible, and this also goes for the test results that we claim. Most home constructors would not have the necessary facilities for tests of this kind, although the figures would be interesting to them.

Possibly the best compromise at this stage is to quote both sets of figures. If then a reader can get the power output quoted for the amplifier with its own power supply, it is reasonable to assume that the music power output rating would also be achieved were that test also to be carried out.

It will be readily seen that the largest difference between the two types of rating will occur where the power supply current variation between no-signal and full load is largest; that is, in Class B circuits, to quote a very severe case. To quote a specific example of the difference between the two ratings, we made further tests on the TR24 main amplifier (recently mentioned in these pages). This amplifier has been rated by us at 24 watts, that is, 12 watts per channel, at better than 1% total harmonic distortion.

We set this unit up and checked the no-signal collector supply voltage. Then the amplifier was driven to 12.2 watts, the distortion measured, and the new value of collector supply voltage checked. Arrangements were then made to hold up the collector supply voltage whilst a further load test was applied. The second test resulted in a music power output of 15.5 watts at the same distortion figure, a difference of 3.3 watts. The music power output is therefore 27% up on the simpler test. Incidentally, the fall in collector supply voltage during the first test was 2.5 volts.

Tools and Techniques

One of the more or less standard types of query we receive from time to time concerns the enquirer's would-be entry into the field of electronic construction. Some are worried by the feeling that a large expenditure in tools and facilities is required, whilst others are over-worried about the fact that they have no previous experience in making up apparatus.

We plan to meet this requirement in two ways. Under preparation for new entries to the field is a list of tools we feel would be useful and adequate, without spending too much money; we hope to publish this list in the near future. Also under preparation is a collection of workshop hints and tips which can make the work much easier.

B.J.S.

THE MUSIC-LOVER 12

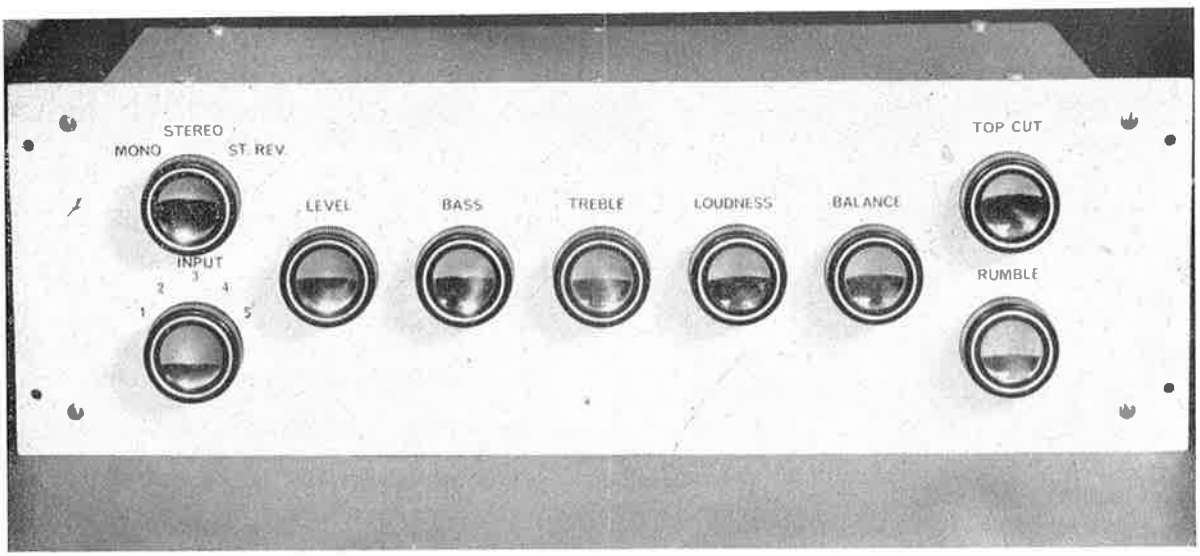
By B. J. SIMPSON

PART 2—A STEREO CONTROL PREAMPLIFIER

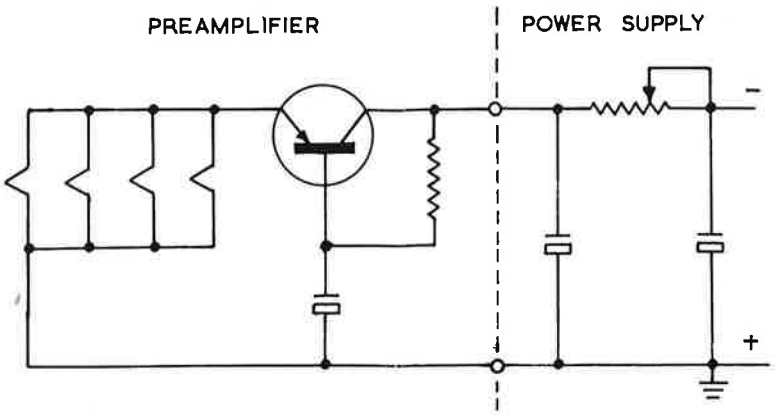
We recently published in these pages details of a good quality audio amplifier suitable for home construction, together with a power supply unit. This month we are presenting data on another unit in the system, the stereo control preamplifier.

Before going on, however, to describe this unit, there are a few details to clean up with regard to the main amplifier and power unit. The first point relates to the performance of the main amplifier unit. We are now able to claim somewhat better performance figures than those originally quoted for the first model, as a result of further measurements taken on a "clean" unit; that is, one that had not been pulled about during development. These figures should have been presented with the previous article but, due to pressure of time, were held over for analysis later.

The response of the main amplifier is still substantially the same as that originally quoted. The distortion figures, however, show an improvement. Further careful measurements of distortion have been made, and are shown in the accompanying curve of distortion versus power output. This curve relates to the preamplifier alone, as shown by the solid line, and to the complete



View of the completed stereo control preamplifier unit. This unit is intended to be mounted by the front panel, either through a cut-out in existing cabinet work, or in a separate cabinet made for the unit.



Complete circuit of the dc heater supply for the preamplifier, showing components in the power supply unit and at preamplifier itself.

system comprising main amplifier and stereo control preamplifier, as shown by the dotted line.

At a late stage in the development of the stereo control preamplifier, it was decided to incorporate an electronic filter for the dc heater supply. This was considered well worth while in view of the importance of low noise in the preamplifier. Further, it makes the unit more suitable for home construction where, in some cases at least, the care taken in construction and layout may be a little less than the optimum.

A 2N301 power transistor was chosen for the filter. Because this is a p-n-p type, the best and easiest operation of the unit as a filter is obtained when it is placed in the negative lead of the supply. The circuit diagram of the power supply shows the dc heater supply with the negative side grounded and the positive side active. This was therefore changed around, and readers who have already built the unit should modify it accordingly. No extra parts are required in the power supply, only a rearrangement.

To make sure that there is no mistake about this point, the correct arrangement is shown in a supplementary diagram herewith. When the circuit is modified, the preset resistor in the dc heater circuit is adjusted as originally instructed for 6 volts across the heaters in the preamplifier. Incidentally, because the heaters take a few seconds to attain full operating temperature, the voltage across the heaters will measure at a low value on first switching on, and will then come up to full value after about 15 seconds. This is because the cold resistance of the heaters is low, causing a higher drop across the series resistance in the circuit. It would be advisable to make a recheck of the heater voltage after about 10 minutes' operation to be on the safe side.

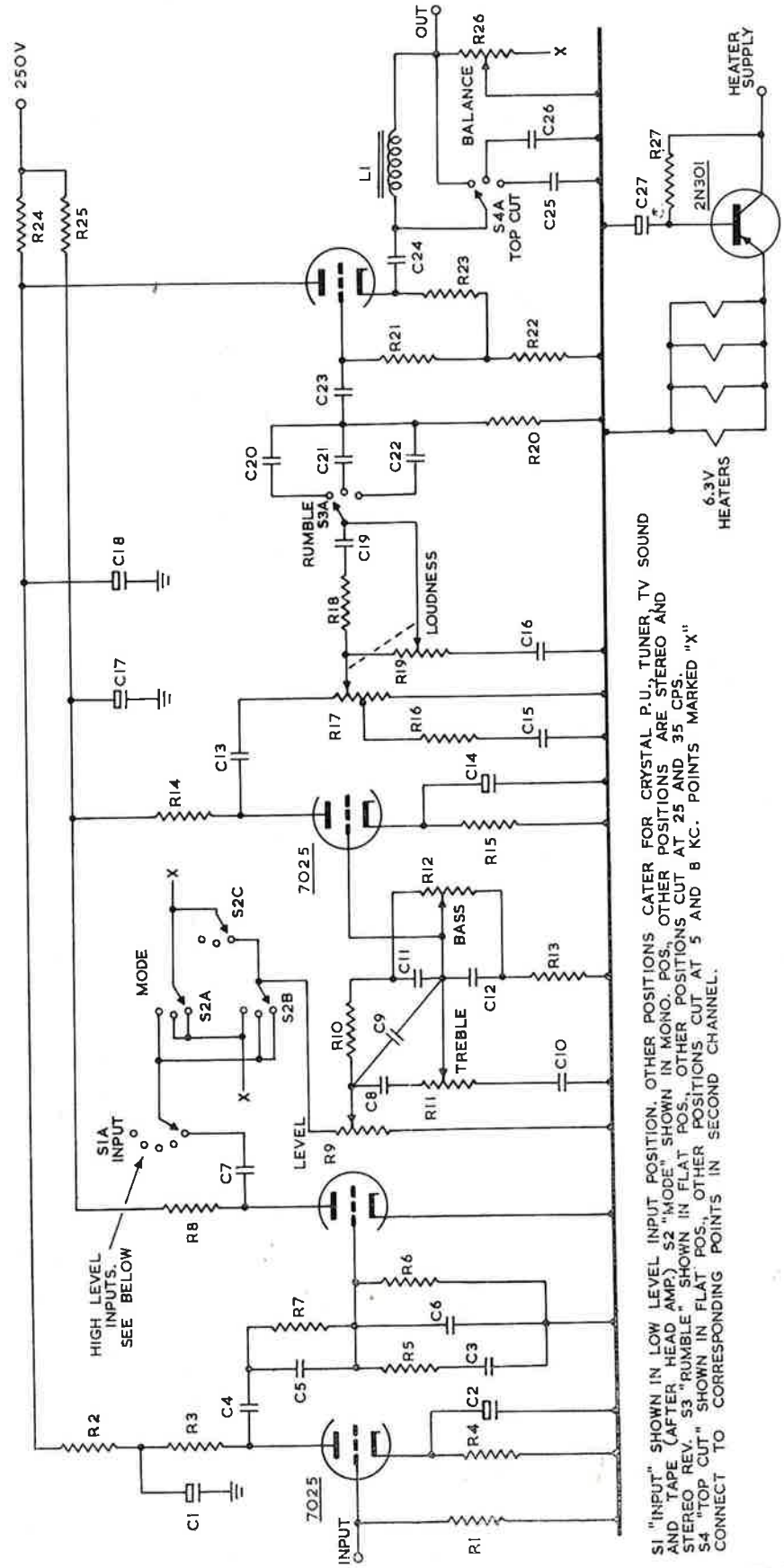
Circuit Description

Having cleared up these preliminary points, we can now go ahead with details of the stereo control preamplifier itself. The circuit diagram presented here shows one channel only, together with the common heater supply. The complete unit, of course, consists of two complete channels. Common units between the two channels are the INPUT and MODE switches, the RUMBLE and TOP CUT switches, and the BALANCE control. The LEVEL, TREBLE, BASS and LOUDNESS controls are dual ganged units which control both channels simultaneously.

Each channel of the preamplifier uses two twin triodes. I used 7025's because they are specially tested for low hum and microphony, and are especially suitable, therefore, for this type of unit. These valves are electrically identical with the 12AX7, so that 12AX7's can be used if you choose to take the risk of getting higher noise levels. No circuit changes would be required for the use of 12AX7's instead of the 7025's.

It will be seen from the circuit diagram that adequate decoupling of the B+ supply is provided, an essential in this type of unit. Each channel, of course, has its own decoupling arrangements. Because this unit was intended to be of universal application, all the features considered necessary were included. The constructor can use his own discretion whether he includes them all or not.

The first stage of the preamplifier handles low level inputs from a magnetic cartridge or tape head. Three millivolts is more than enough to load the system up to full output. As shown in the circuit diagram, the network between V1A and V1B provides RIAA equalization for record



Circuit diagram of the stereo control preamplifier. One channel only is shown here, together with the common heater supply circuit and filter.

PARTS LIST

Note that two identical channels go to make up the complete stereo preamplifier unit, so that, with the exception of the components in the heater supply filter, or as otherwise stated in this list, two sets of components will be required.

Valves and Semiconductors

The total requirement for the unit is:

4	Super Radiotron 7025 or 12AX7. (See text.)
1	AWV 2N301, with mica washer.

Capacitors

C1	50 μf, 300 vw, electrolytic.
C2	100 μf, 6 vw, electrolytic.
C3	2500 pf, ceramic.
C4	0.05 μf, paper.
C5	5 pf, ceramic.
C6	750 pf, ceramic.
C7	0.1 μf, paper.
C8	75 pf, ceramic.
C9	22 pf, ceramic.
C10	620 pf, ceramic.
C11	250 pf, ceramic.
C12	2500 pf, ceramic.
C13	0.1 μf, paper.
C14	100 μf, 6 vw, electrolytic.
C15	5000 pf, ceramic.
C16	3000 pf, ceramic.
C17	25 μf, 300 vw, electrolytic.
C18	25 μf, 300 vw, electrolytic.
C19	25 pf, ceramic.
C20	0.02 μf, paper.
C21	6800 pf, ceramic.
C22	5000 pf, ceramic.
C23	5600 pf, ceramic.
C24	0.1 μf, paper.
C25	0.018 μf, paper.
C26	0.0125 μf, paper.
C27	1000 μf, 25 vw, electrolytic.

Resistors

All resistors ½ watt, 10% except where stated.

R1	47 K ohms, or to suit pickup.
R2	100 K ohms, 1 watt.
R3	270 K ohms, 1 watt, high stability.
R4	3.3 K ohms.
R5	120 K ohms.
R6	10 M ohms.
R7	1 M ohm.
R8	270 K ohms, 1 watt, high stability.
R9	See below.
R10	1 M ohm.
R11	See below.
R12	See below.
R13	120 K ohms.
R14	270 K ohms, 1 watt, high stability.
R15	3.3 K ohms.
R16	100 K ohms.
R17	See below.
R18	820 K ohms.
R19	See below.
R20	1 M ohm.
R21	100 K ohms.
R22	150 K ohms.
R23	2.7 K ohms.
R24	56 K ohms, 1 watt.
R25	56 K ohms, 1 watt.
R26	See below.
R27	220 ohms, 1 watt.

Potentiometers

The total requirement for the unit is:

R9	1 M ohm, dual ganged unit, logarithmic. (Includes R9 for second channel.)
R11	2.5 M ohms, dual ganged unit, logarithmic. (Includes R11 for second channel.)
R12	2.5 M ohms, dual ganged unit, logarithmic. (Includes R12 for second channel.)
R17, 19	Four gang unit. Two 1 M ohm tracks, linear, matched, with centre tap (R17) plus two 1 M ohm tracks, logarithmic, matched, (R19). (Includes R17 and R19 for second channel.)
R26	2 M ohms, linear. (Common to both channels.)

Inductor

L1	800 mh at 1 Kc. (See text.)

Switches

The total requirement for the unit is:

S1	4-pole, 5-way, M.S.P. type AK19225. (See text.)
S2	3-pole, 3-way, M.S.P. type AK19213.
S3	3-pole, 3-way, M.S.P. type AK19213.
S4	3-pole, 3-way, M.S.P. type AK19213.

Miscellaneous

5	5-pin socket, M.S.P. Part No. 9637531.
5	3-pin plug, M.S.P. Part No. 9100369.

14-gauge aluminium plate and ½" angle, matrix board and pins, valve sockets and screens, grommets, knobs, miscellaneous hardware.

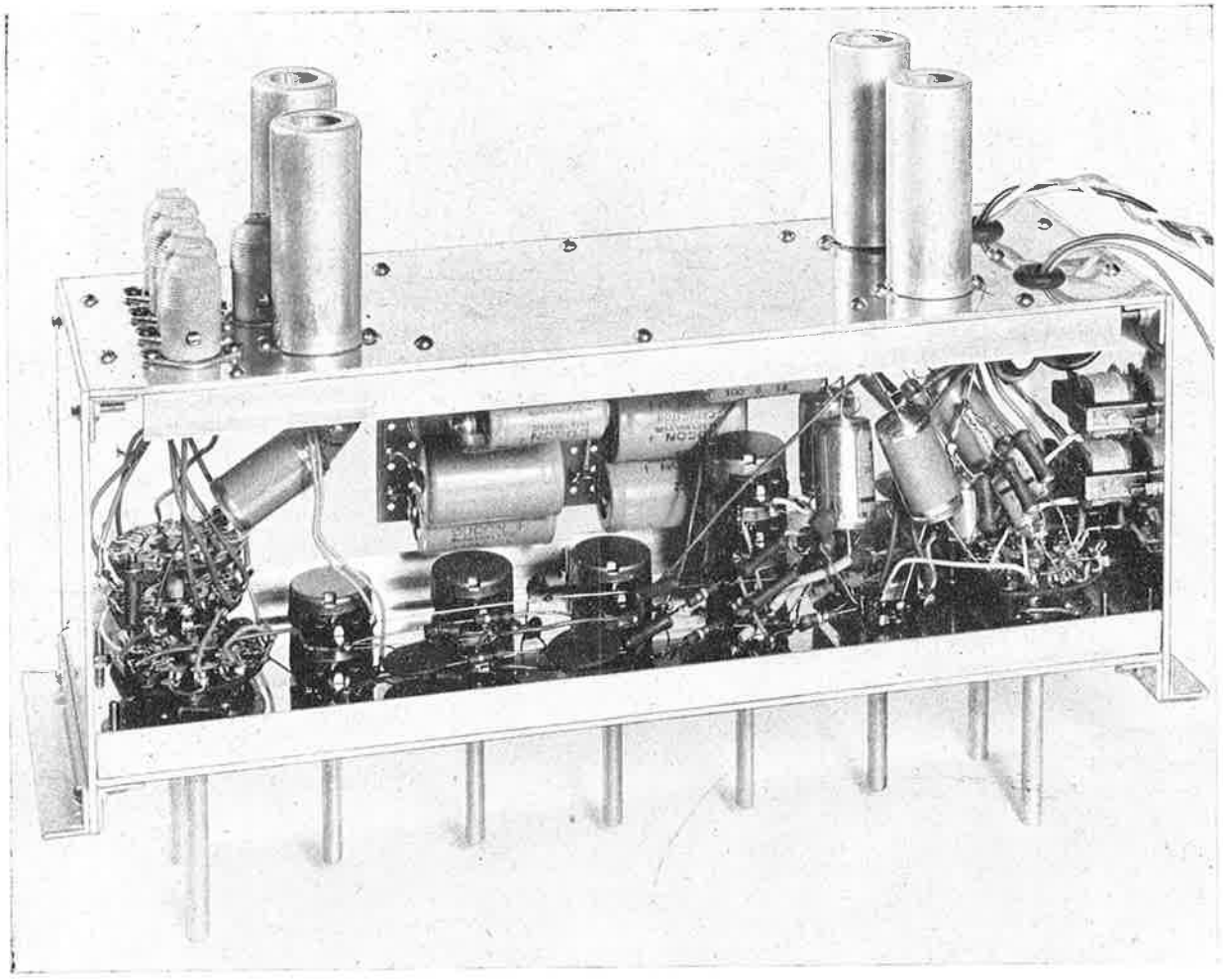
reproduction. The RIAA curve has now been standardised, and there seemed little point in complicating the unit with various choices of equalization. If a tape input is required, then NARTB equalization will be required.

It may be asked why the two equalization circuits were not both put in and a switch provided. This could be done if required, but I did not adopt this idea because I prefer a separate tape head amplifier placed close to the tape deck. This amplifier then feeds the signal at a level of about 100 millivolts to one of the high level inputs of the control unit. This is the system envisaged with this design and explains the high level tape input socket.

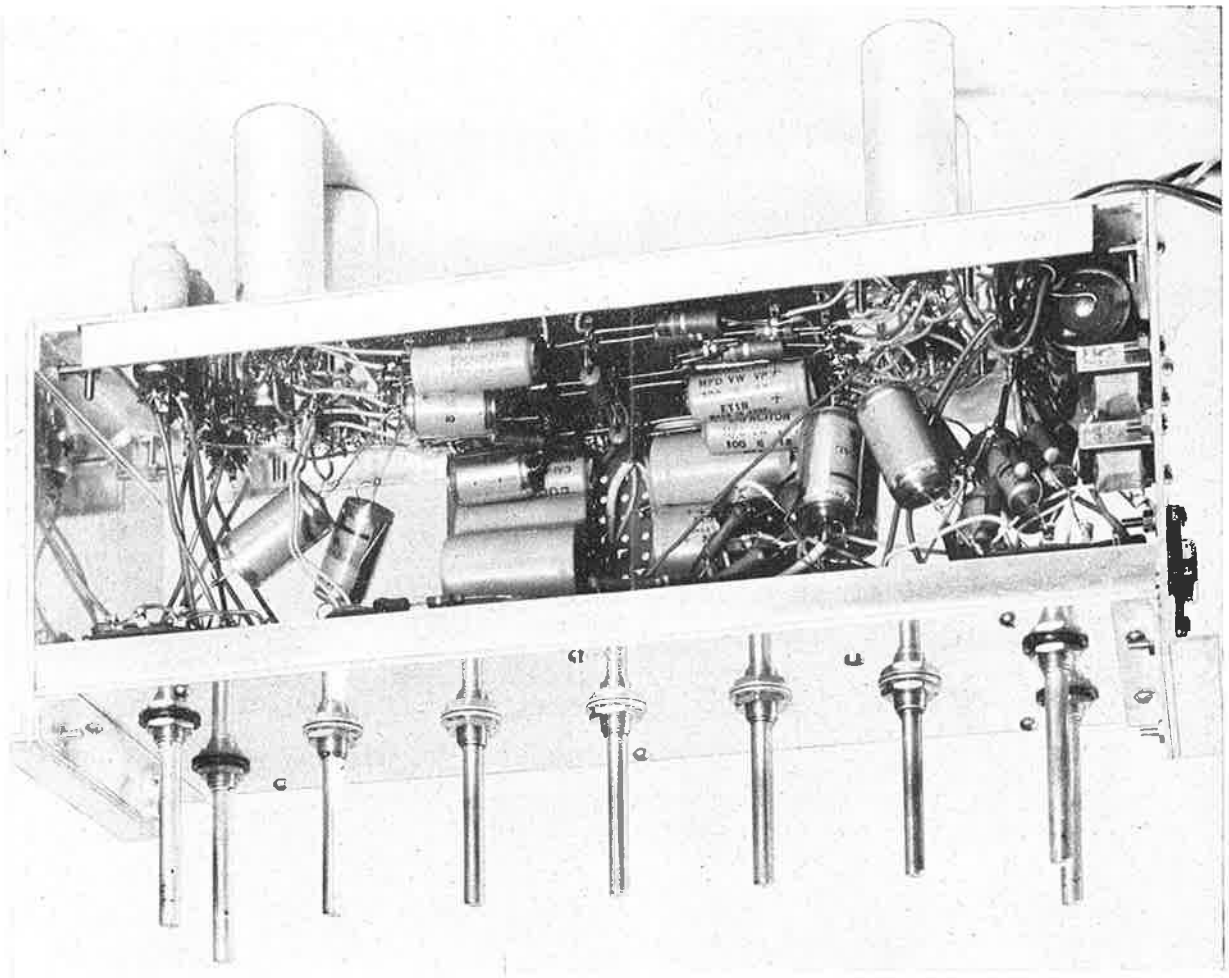
So much for the first two stages, which are followed by the MODE and INPUT switches. The first of these switches will place the unit in one of three conditions, namely, MONO, where a signal on either side is applied to both channels simultaneously, STEREO and STEREO REVERSED, which are self-explanatory. It is possible to combine the functions of these two switches into one switch, but unless a large number of positions is provided in the switch, the flexibility of the system is reduced.

After these two switches comes the LEVEL control. This is a very useful control in a complex unit of this kind. It allows the user to vary the level at the input to the subsequent stages, particularly if the pickup or other device connected to one of the high level inputs produces an output in excess of that needed to load the preamplifier, i.e., approximately 150 millivolts. Several crystal cartridges, for example, have outputs greater than this level.

The perfectionist may like to provide separate level controls preset for each input. The tab-



View of the preamplifier with the front panel and top and bottom screens removed to show the interior. This illustration and the accompanying one also show the construction of the special chassis for the unit.



A further view of the preamplifier taken from the underside. This view shows the matrix boards which carry plate and cathode resistors, and decoupling components.

mounting type of control could be used here, and in this case would be inserted between the appropriate input and the selector switch.

The tone controls following the LEVEL control are conventional in arrangement and require no comment. The performance of the tone controls is shown in the response curves of the pre-amplifier. The loss in the tone control network is made up in the next stage, V2A, which feeds the LOUDNESS control.

Most readers will be familiar with the loudness control, several forms of which are possible. It will be seen that each control consists of a 1 megohm linear potentiometer with a centre-tap ganged with a 1 megohm logarithmic unit, together with associated resistors and capacitors. The purpose of this control is not only to vary the volume in the usual way, but to raise progressively the level of the bass register with respect to the middle and treble register, as the control is used to reduce the volume.

This counteracts the well-known effect which is noticed with standard volume controls, in that when the overall level is reduced, the ear appears to detect a greater reduction in the level of the bass register than elsewhere. This is due to the characteristics of the ear, and is illustrated in the Fletcher-Munson curves of audibility available in any good book on high fidelity. The LOUDNESS control is designed to correct this situation, and is a very desirable feature of any high fidelity unit.

The final stage of the preamplifier, V2B, is arranged as a cathode follower. No gain, therefore, is obtained in this stage, but it does allow a lot of latitude in the length and characteristics of the connecting leads between the preamplifier and the main amplifier unit. The BALANCE control allows the user to vary the

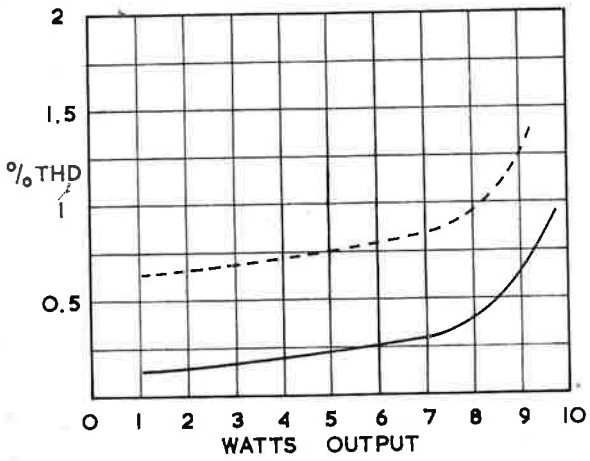
level of one channel with respect to the other. The arrangement shown is the simplest available, consisting of a simple linear potentiometer with the slider connected to ground. Each half of the potentiometer is effectively in parallel with one of the 1 megohm input resistors of the main amplifier when the units are connected up.

If a better but slightly more expensive BALANCE control is desired, then a ganged unit consisting of one logarithmic track and one antilog. track can be used. In this case both the units should be 1 megohm.

Because the preamplifier may be used in a set-up in which the turntable is less than perfect, provision has been made for rumble filtering. The switch has three positions, corresponding to "flat," 25 cps cut-off, and 35 cps cut-off. The effect of the rumble filter is shown in the response curves. This is a simple but very effective form of filter.

The last control to be mentioned is the TOP CUT filter. This has been included expressly for playing old records. Most of us have a few old records which we cherish in spite of the horribly high surface noise, and this will allow us to play them without too much distress. This switch also has three positions, corresponding to "flat," and cuts at 5 Kc and 8 Kc. The performance of the filter is shown in the response curves.

A lot of discussion can arise out of just where rumble and top cut filters should operate; that is, what cut-off frequencies should be provided for these functions. As far as I know, no one has ever achieved unanimity on the subject, so that the matter is open for debate. If you want to change the cut-off points in this design, it is only a matter of varying the associated capacitors. I would suggest, however, that if you seem to need a higher cut-off frequency than 35 cps for the rumble filter then you take a very critical look at your turntable equipment. The best units should be satisfactory with the control in the "flat" position, which gives a 3 db cut-off point at a little below 20 cps.



Output versus distortion curves for the complete system (main amplifier and preamplifier), shown dotted, and for the preamplifier alone, shown in solid line. The distortion measurements on the preamplifier were taken at the output level required to drive fully the main amplifier to the output levels shown.

As far as the high register is concerned, the curves show that the response of the preamplifier is only 1 db down at 50 Kc. It must be remembered, however, that the high frequency response of the main amplifier is not and should not be flat out to this frequency, and the overall response of the system will be modified accordingly. An approximation of the overall response would result from a combination of the two response curves.

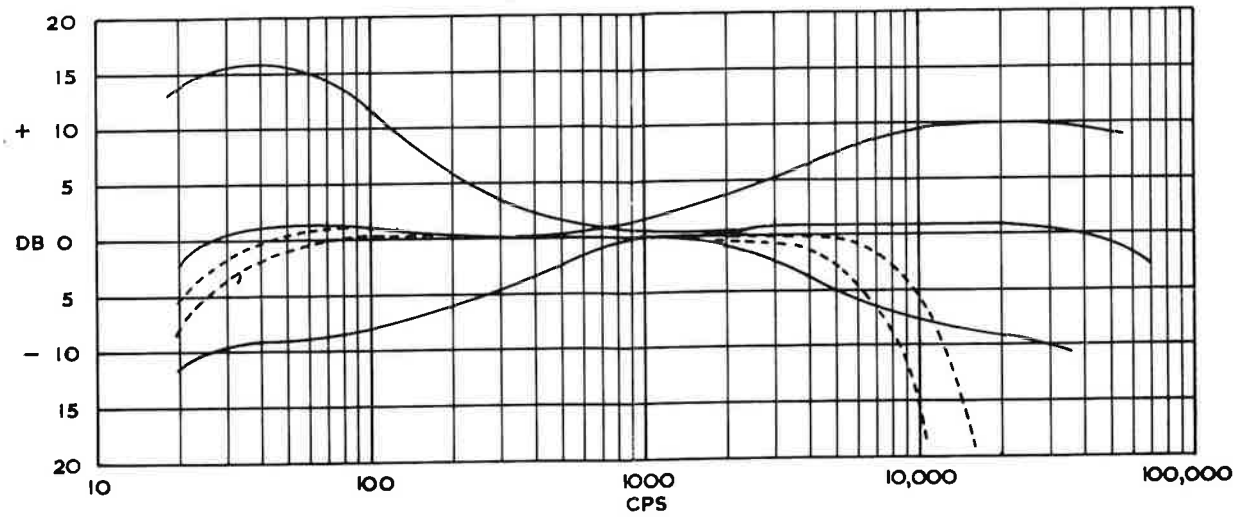
Performance

The distortion of the preamplifier has been measured in conjunction with the main amplifier, so that an overall system distortion figure was obtained, related to power output. This is shown in one of the accompanying curves. The overall system noise is 58 db relative to 6 watts output. As previously mentioned, the low level input for 6 watts output is less than 3 millivolts, whilst the high level input for the same output is 150 millivolts.

It will be seen from the response curves of the preamplifier reproduced here that the response with the tone controls in the neutral or "flat" position extends from 25 cps to 50 Kc $\pm$ 1 db, and goes 18 cps to 70 Kc at + 1 — 3 db. Cross-talk between channels is better than 35 db down when one channel is operating at the maximum level required to drive the main amplifier unit to 6 watts.

Bass boost available at 40 cps is 14.5 db, whilst the available bass cut at the same frequency is 10.5 db. Treble boost and cut available is 8.5 db at 10 Kc. It will usually be found that figures of this order provide all the tone control that can be used whilst still preserving realism. My own feeling in the matter is that if material is so poor or degraded that more control is required, then it is not likely to be worth listening to in any case. The region where control is most usually required to the largest degree is in bass boosting, and here the amount of control is higher at 14.5 db available boost.

To repeat the operating characteristics of the filter controls for the sake of completeness here,



Response curves of the stereo control preamplifier, showing in solid lines the "flat" response of the unit, and the operation of the tone controls. Dotted lines show the operation of the rumble and top cut filters.

the rumble filter provides two degrees of cut-off, at 25 cps and 35 cps, the response being 3 db down at those points. In a similar way, the low-pass filter providing the top cut applies cut-offs at 5 Kc and 8 Kc, response at these points being 3 db below that at 1 Kc.

Construction

In a unit of this kind, which is very susceptible to hum and noise, great care must be taken in the layout and construction of the unit to ensure satisfactory performance. As it is, one usually has to make a number of compromises, one of them being necessary to obtain handy and pleasing arrangement of the controls. These remarks apply particularly to the low level section of the preamplifier.

The arrangement of the preamplifier shown in the illustrations is a good one for this type of unit. It ensures good screening of the active portions of the unit, it requires a minimum amount of panel space, and ensures short lead lengths in the internal wiring of the amplifier. The arrangement does, however, make the unit slightly more difficult of access. This can largely be overcome by following a predetermined plan and sequence in the construction of the unit.

The chassis of the unit is formed by using four aluminium plates bolted together with short lengths of aluminium angle to form a box without top or bottom. One of the long sides of this box then carries the controls, whilst the other long side carries the valve and input sockets, output and power cable entries, and minor items.

The internal arrangement of the unit is such that, with a few exceptions, the circuitry can be assembled and connected on one or other of the two long sides of the box before they are finally brought together to make up the complete unit. At that stage there are left only a few connections to make across the inside of the box. Finally, two further plates are fixed to the top and bottom to enclose the box completely. The accompanying photographs illustrate the construction and arrangement of the unit.

The wiring behind the control panel is carried out, with a small exception, by mounting and wiring the various small components on to the potentiometers and switches. In the case of the back panel of the unit, the plate and decoupling resistors, cathode circuit components and a few other items are mounted on a section of matrix board fixed to the panel. The decoupling electrolytics are mounted on a further section of matrix board held at right angles to the former piece by fixing it to one of the stiffening flanges of the box.

The two low-pass filter inductors and the 2N301 transistor for the heater supply filter are mounted on one of the side panels of the preamplifier. Incidentally, the two inductors are not, so far as is known, available commercially. They were made up on the spot by winding 1,000 turns of No. 40 swg (0.0048″) single silk and enamelled covered wire on to a quarter-inch stack of 1″ x ¾″ grain-oriented silicon steel laminations 0.015″ thick. The measured inductance at 1 Kc is 800 millihenries, and it is considered that almost any small inductor of that value would suit.

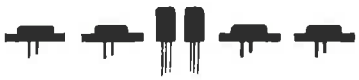
In the model of this unit, the five inputs were brought in through small 5-way sockets used with 3-way plugs. Alternatively, 3-way sockets are available, but there was a reason for the arrangement described. The same reason also involved the provision of two additional poles on the 5-way input selector switch. The reason was that it was felt that, at some future date, the additional poles on the switch and connections in the sockets may be useful. This has already borne fruit, because frequently the application of TV sound to a high fidelity unit requires the disconnection of the internal speaker in the TV set.

In this case, and in similar cases, the additional pole(s) on the switch and connections in the sockets can be used to switch on a relay in the TV set which disconnects the speaker and substitutes a dummy load. Other similar examples will readily come to mind. Where such an application is required, 5-way plugs can be used from the outset, or at a later stage the existing 3-way plugs can be changed for 5-way units without requiring any modification to the preamplifier unit itself.

Summary

This stereo control preamplifier unit is a high-grade unit of universal application. It can therefore be used with any suitable equipment as well as with the 12-watt stereo unit with which it is grouped here. The individual builder will in general make such changes to the facilities provided as may suit his particular requirements. For example, he may not be interested in making provision for five inputs, or his turntable equipment may be so good that a rumble filter is not required.

It will also be seen that where a reader wishes to add this unit to an existing system, where provision for the dc heater supply is not in existence, it is a simple matter to convert the preamplifier to a self-powered unit. All that would be needed would be a mains transformer and rectifier to provide 250 volts B+ supply, with two 6.3 volt 2 amp. windings. The two heater windings would then be used in place of those on the PF162 transformer. Refer to the previous article on this system, which dealt with the power supply, and to the circuit diagram of the power supply.



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