SPECIAL HI-FI CIRCUIT ISSUE

RADIOTRONICS

VOL. 25, No. 8.

AUGUST, 1960

PRICE ONE SHILLING

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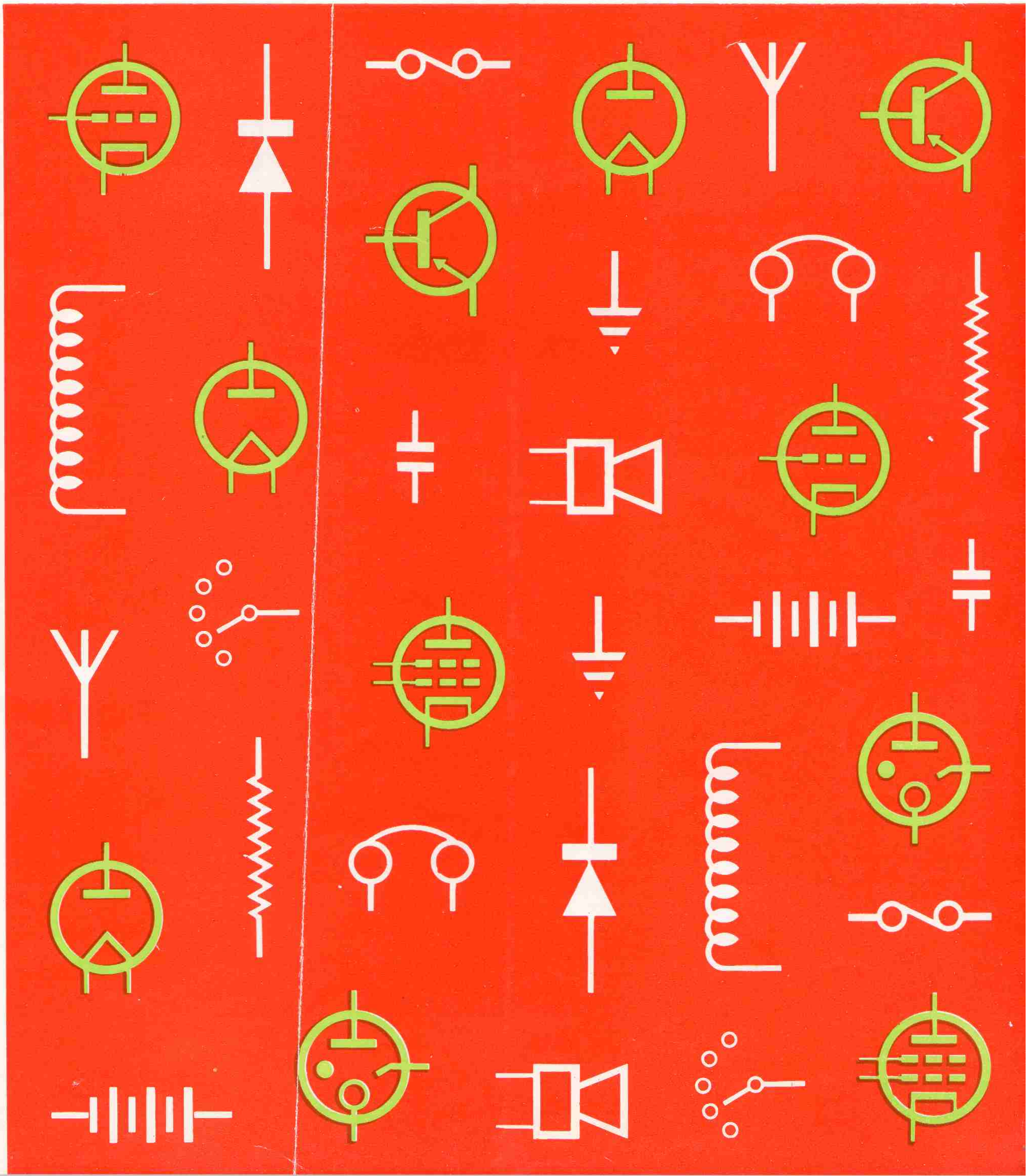

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RADIOTRONICS

Vol. 25, No. 8, 1960

Editor, Bernard J. Simpson

IN THIS ISSUE

Radiotronics is published twelve times a year by the Wireless Press for Amalgamated Wireless Valve Company Pty. Ltd. The annual subscription rate in Australasia is 10/-, in U.S.A. and other dollar countries $1.50, and in all other countries 12/6.

Subscribers should promptly notify Radiotronics, Box 2516, G.P.O., Sydney, and also the local Post Office of any change of address, allowing one month for the change to become effective.

CHOOSING A PICKUP OR CARTRIDGE

B. J. Simpson

Whether we are buying a replacement pickup cartridge, perhaps converting to stereo, or buying a complete pickup with integral cartridge, performance and price are the factors we find it most important to consider. The price is a personal matter, but performance we can freely discuss.

Let us say at the outset that any pickup or cartridge will "colour" sound to some extent, and therefore the buyer and the buyer only should decide which component is the most suitable for his own use. Furthermore, the colouration of sound also extends to the buyer's amplifiers and loudspeakers, so that to be really worthwhile, his listening tests should be carried out using a music system as close as possible to his own. The ideal thing would be to take a selection of components home and try them there. This is not usually possible however, and we must compromise. Always carry out listening tests on recordings with which you are familiar.

The relative merits of replaceable and interchangeable cartridges used with a "universal" type of tone arm, and an integrated design of complete pickup, largely depend on the facilities required and the money available. For those with limited funds available, the choice of an integrated design possibly offers the best solution. This includes those units where the cartridge is detachable but is not intended to be interchangeable with other makes of cartridge. On the other hand, those who like to try out new things that come along would be more likely to choose a good quality arm and then shop around for cartridges.

Most integrated designs show a better compliance (discussed later) than arm and cartridge combinations, although the integrated designs used with autochangers often have low compliance to give the stiffness necessary to track well and trip the change mechanism. This is one of the factors which make many enthusiasts dislike autochangers. By the way, if you are converting to stereo, don't be surprised if your turntable equipment suddenly proves inadequate, because the stereo pickup is required to have both lateral and vertical compliance.

When looking for a pickup or cartridge we find ourselves immersed in a jumble of figures which purport to show how good the various components are. How are we to judge and compare these figures? Just what do they mean? Like many figures used in specifications, they must be used carefully. They will be taken under certain conditions or at certain frequencies. Other conditions or frequencies may (and probably would) produce different results. The properties specified may have inherent limitations which must be borne in mind. The best-sounding figures may not necessarily produce the best results for YOU.

Don't misunderstand this. The figures quoted by reputable manufacturers are honest and capable of substantiation. The maker however must obviously have certain standard conditions under which he makes his test. He cannot cater individually for all the thousands of different music systems in use. For the purchaser and user, it is a matter of intelligent evaluation and application of the maker's data. As a step in this direction, let's consider the more important properties of cartridges and pickups which we will find specified.

Frequency Response

The frequency response of a cartridge is expressed in terms of the variation of output (or sound intensity) over a specified frequency range. A typical specification would indicate a flat frequency response $\pm$ 2 db over the frequency range 20 to 20,000 cps. This means of course that the total variation over this range could be 4 db, which is a voltage ratio of about 1.6:1. Different makers make varying claims for the frequency response of their cartridges, and of course no reputable manufacturer will make claims which cannot be substantiated.

It is a fact however that relative frequency response figures are not necessarily very significant, whilst varying methods of measuring the frequency response make direct comparison very difficult. The final analysis as far as frequency response is concerned must depend on the characteristics of the amplifier and loudspeaker used with the cartridge to form a complete system.

Stereo Channel Separation

Channel separation is always worth a long argument among hifi enthusiasts, generally centred around how much separation is desirable. Separation is quoted in terms of db at a specified frequency or frequencies. Whilst an ideal cartridge would provide the same channel separation over its entire frequency range, this is not so in practice, so that the frequency of measurement becomes significant.

The measurement is usually made at 1,000 cps, and figures of 20 to 30 db are customarily quoted. A cartridge will generally show the widest separation at 1,000 cps, so that this figure does not indicate just how the cartridge will perform over the entire audio spectrum. For this reason some makers supplement the figure taken at 1,000 cps with a further figure indicating the minimum separation over a specified frequency range, or a separation figure taken at a higher frequency.

A cartridge with 25 db separation at 1,000 cps may exhibit only 8 db separation (say) at 10,000 cps. This figure is far more significant than the one taken at 1,000 cps, and for practical purposes could be regarded as the operative figure. Most enthusiasts argue for a minimum separation of 12 db, although a figure of 6 db minimum has some supporters. Like frequency response the final judgment of effect depends to some extent on other factors in the complete system.

Output

The cartridge output should be expressed as a voltage measured at a specified recorded velocity, measured in centimetres per second. Without the qualification of recorded velocity, an output voltage figure is meaningless. It is like saying a generator has an output of 1,000 volts without saying how much energy is required to turn it and how fast it should be turned.

Recorded velocity is expressed in centimetres per second. The velocity referred to here is the rms transverse velocity of the pickup stylus as it conforms to the modulated grooves on a recording. The velocity is therefore dependent on two factors, frequency and peak amplitude of the recording. The figure quoted as recorded velocity in specifying cartridge output takes care of these two factors. Recording levels vary with different makes and types of record. An average level would probably be of the order of 5 centimetres per second, with instantaneous peaks around 20 centimetres per second.

Load Impedance

Still thinking of a pickup as a generator, and remembering that the impedances of generator and load must be equal for maximum transfer of energy (maximum efficiency), we need to know the load impedance of the pickup. This allows us to arrange that the input impedance of the amplifier has a value suitable for the pickup. In the case of low impedance pickups working into valve amplifiers, this may involve the use of a transformer.

Where high-impedance units are concerned however, it is easy to meet this requirement by choosing the appropriate value of load resistor for the pickup. Some departure from the recommended value is permissible, but adherence to the optimum value within ±10% seems a reasonable rule to follow.

Don't forget that some pickups require a fairly elaborate equalizing network which must present the required load to the pickup. Always follow the pickup or cartridge manufacturer's recommendations on these points.

Tracking Pressure

Tracking pressure, expressed in grammes, is the weight required to keep the stylus in contact with the groove walls in the recording. It is important to realise just what importance this value can have. First of all we have two extremes, one where the weight is too high and excessive record wear results, and one where the weight is too low, resulting in poor tracking, distortion and extra wear. Note that both conditions result in extra wear. This is easy to understand where heavy tracking weights are used but not so obvious in the case of too-light weights.

A stylus which is loaded too lightly will not track correctly; it will tend to ride out of the groove and bounce against the walls rather than following them accurately. When a stylus bounces in this way, the pressures exerted against the walls of the grooves is far beyond any normal tracking pressures. Complete breakdown of the wall can result, producing "jumping" and "skipping" of passages.

It follows of course that somewhere between the two extremes is an optimum value, and this is the figure quoted in the specification. Direct comparison of tracking weights is not possible. One cannot say for example that a cartridge with a tracking pressure of 2 grammes is necessarily better than one with a pressure of 7 grammes, nor will the lighter pressure necessarily produce less record wear. The important thing is to follow the makers' recommendations on tracking pressure. Most pickup arms for use with detachable cartridges have provision for adjustment of tracking pressure.

Compliance

This property is expressed in the cartridge specification as a number multiplied by 10^{-6} centimetres per dyne, for example, 5×10^{-6} cm/dyne. By definition, compliance is the ratio of the displacement of a body to the applied force, or in simpler terms, how much the cartridge moves when a specified push is applied. Where a cartridge is concerned it relates the sideways movement to force applied by modulations on the record grooves. Compliance is the opposite of "stiffness."

It follows that compliance (related to a cartridge) is the ability of the cartridge to follow the groove modulations. A stereo cartridge must respond to both vertical and lateral movement, and a stereo component therefore has specified for it both vertical and lateral compliance. It will readily be seen that, among other things, compliance (or the lack of it) will affect record wear.

In specifying compliance, the force applied is expressed in dynes. A dyne is the force which, acting on one gramme of mass, produces an acceleration of one centimetre per second. The higher the compliance figure quoted, the "better" the pickup, with reservations. For example, the compliance figure does not take into account the total permissible or available deflection of the cartridge. It would be possible for example for a high-compliance cartridge to have a very small total deflection, and thus be unable to deflect sufficiently to track and play the more heavily-modulated grooves. This state of affairs is of course not likely to occur with a reputable maker, but serves to put the compliance figure into perspective.

Dynamic Mass

Having mentioned compliance and the force necessary to move a certain mass, the next item of data concerns a rarely-quoted property, the dynamic mass. When the cartridge responds to the modulated record grooves, not all the cartridge follows the intricate variations, but only the stylus and certain portions of the cartridge, depending on its type. The portion of the cartridge which does follow the modulations is referred to as the dynamic mass. The property is expressed as a weight, usually in grammes or fractions thereof.

It will readily be seen that the lower the dynamic mass, the less inertial resistance will be offered to changes in motion imposed by modulations on the record grooves. A cartridge with lower dynamic mass may therefore be expected, other things being equal, to follow the modulated grooves easier and more faithfully. Unfortunately this interesting property is rarely quoted, and if a figure is given, it is not always as useful as it could be due to a wide divergence of views on methods of arriving at the quoted figure. It is not a case of simply weighing the moving parts of the cartridge, because the stylus tip is the point under consideration, this being where the deflecting force is applied. The property will also be affected by the method of suspending the moving parts in the cartridge. One definition of dynamic mass is that mass which, if concentrated at the stylus point, would possess the same inertia as that of the moving system.

HUM IN AUDIO AMPLIFIERS

Much has been written in the past on the subject of hum in audio amplifiers, and there is consequently a large bibliography available to those who wish to make a study of the subject. The average constructor or audiophile needs only a basic knowledge of the subject however, sufficient to put him on his guard in constructing and using hifi amplifiers. Let us start by listing the major causes of hum.

Induced hum. This heading covers hum due to leakage flux from the power transformer, filter chokes and other iron-cored components handling 50 cps power. It could include the turntable motor if placed sufficiently close to the amplifier. Poor layout can be the trouble here. Hum can be induced into just about any part of the circuit.

Hum due to lack of filtering. This is possibly the type of hum with which we are most familiar. It is due to unfiltered ripple on the B+ supply line, and is due to either insufficient filtering or the failure of one of the filter capacitors. In new equipment it may be due to poor design in the power pack. Ample design data is given in the "Radiotron Designer's Handbook."

Electrostatically-coupled hum. This arises from electrostatic coupling between points carrying ac potentials and low-signal-level portions of the amplifier circuit. Here again poor layout can be the cause.

Valve hum. This is generally referred to as heater hum, and is caused by ac voltages induced into the signal circuits from the valve heaters. This problem arises as a rule only in the low-level stages of the amplifier, usually only the first stage.

Before going on to mention a few of the ways of reducing hum, it is assumed that the ac leads to the heaters and pilot lamp are twisted and that the wiring for low level points is kept as far as possible away from them. If no centre-tap is available on the heater winding of the transformer, two half-watt 68-ohm resistors may be connected in series across the heater circuit, the centre point being earthed.

Of course it is necessary to observe all the rules of good wiring practice, using shielded wiring when necessary, with the shield earthed to the chassis. The chassis itself and any associated equipment such as record changer or record player should be thoroughly earthed. If a pre-amplifier is mounted on the same chassis as a main amplifier and power transformer, the problem is much the same but intensified.

The procedure which has been found helpful in reducing hum to low levels is to begin by reducing leakage-flux hum from the power transformer. This is mainly 50 and 150 cps hum. The effects of transformer leakage flux are usually negligible except when a steel chassis is used. In the latter case a simple cure is to isolate the transformer magnetically from the steel chassis, using brass bolts and spacers to lift the transformer at least ¼" above the chassis. This device is inexpensive, and there are good reasons for adopting it in all cases.

When the power transformer is isolated from the chassis, if the hum does not decrease to a sufficiently low level, it might sometimes be beneficial to re-orient the transformer with respect to the choke and other components, using the position giving least hum.

In most cases it is not necessary to isolate the filter choke magnetically from the chassis, although this should be beneficial. In the case of both transformer and chokes, screening may be employed using such materials as mumetal, but this should only be necessary in exceptional cases.

Having reduced the hum due to leakage flux to a satisfactory low level, the next approach is to make a large improvement in the filtering by connecting a large capacitor, of say 250μf, between B+ and ground. If this makes a substantial improvement better filtering is called for. In most cases the effect will be slight, and nothing need be done in this direction. This hum is almost entirely 100 cps when the rectification is full-wave.

The majority of remaining hum is usually due to electro-static coupling, particularly with fairly-low-level stages on the same chassis as the power supply. The cure is to place an electrostatic screen either around the points of high ac potential or around the low level stages. Points which could be watched in this regard are the mains socket, mains switch and fuse. The electrostatic screen may consist of a strip of steel or aluminium with a width of about ¼" less than the height of the chassis. It may be mounted with a small gap between the chassis and the strip to allow the wiring to pass underneath. Rearrangement of some of the components may be necessary to make a tidy job of the screen. A good place for the screen in a conventional push-pull amplifier is immediately preceding the phase-splitter.

Measurement of the hum should be made both with and without the screen. If the improvement is worthwhile, either the screen may be retained or the components and wiring may be modified to reduce the hum due to this cause.

Back in 1952 the U.S. National Bureau of Standards carried out a limited investigation of heater hum. This showed that by a suitable choice of valves and circuitry heater-induced hum (50 cps) in ac-operated low-level amplifiers can be reduced to less than 4 microvolts, whereas carelessness in selection and construction of the amplifier and its components may result in heater-hum levels of over 500 microvolts.

Hum is not significantly affected by normal variations of components such as plate and screen resistors, by-pass capacitors, and so on. In general it was found that the lowest hum figures were obtained in amplifiers using either a triode or pentode with by-passed cathode, heater grounded through an adjustable potentiometer ("hum-dinger" arrangement), and with low grid-circuit impedance.

Without the cathode by-pass capacitor, hum was of course much greater; a sufficiently large by-pass capacitor is obviously desirable for all low-hum applications. Return of the heater circuit through an adjustable potentiometer connected across the heater supply, when adjustment was optimum, reduced the hum to as little as 1/20 or even 1/50 of the initial value. Returning the heater circuit through 45 volts, either positive, or negative but preferably positive, reduced hum somewhat in most cases. Increased grid circuit resistance tended to give greater hum in triodes, while in pentodes hum in general either showed no change or else decreased with increased resistance.

SECOND HARMONIC DISTORTION

Calculating Distortion

A formula is available* for the calculation of second harmonic distortion from a knowledge of the relative lengths of the upper and lower portions of the load-line. In the diagram, the operating point is at Q and the loadline is EQC. If there is no second harmonic distortion, EQ will be equal in length to QC, but in all practical cases with triodes, and in the majority of cases with pentodes, there will be a certain amount of second harmonic. The formula given in the Radiotron Designer's Handbook is

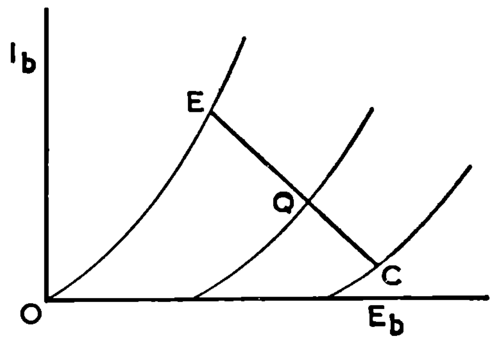
$$\text{\% second harmonic } H_2 = \frac{EQ - QC}{2\,(EQ + QC)} \times 100$$

This may be put into a form more convenient for operation on a slide rule, using the ratio EQ/QC as a basis —

$$H_2 = \frac{\dfrac{EQ}{QC} - 1}{2\,\dfrac{EQ}{QC} + 1} \times 100$$

An example will show how simple this becomes with a slide rule:—

* "Radiotron Designer's Handbook," 4th Edition, p282.



$$\text{If } EQ/QC = 1.2$$
$$\text{Then } EQ/QC - 1 = 0.2$$
$$\text{and } EQ/QC + 1 = 2.2$$
$$\therefore H_2 = \frac{0.2}{2 \times 2.2} \times 100$$
$$= 4.55\%$$

The procedure may be carried out by a single operation on the slide rule which is considerably more rapid and more accurate than referring to a curve showing the relationship between second harmonic and EQ/QC, although the latter is helpful in giving a general picture of the relationship.

Measuring Second Harmonic Distortion with a Milliammeter

It is well known that second harmonic distortion in a power valve causes the dc plate current to rise from no signal to maximum signal. It is not so well known that this may be used as an accurate measurement of the distortion, at least with Class A triodes where the higher order harmonics are small.

It may readily be shown* that

$$H_2 = 71 \triangle I_b\sqrt{(R_L/P_o)}$$

or $$\triangle I_b = 0.014 H_2\sqrt{(P_o/R_L)}$$

Where H_2 = percentage second harmonic
I_b = rise in plate current in amperes
R_L = load resistance in ohms
and P_o = power output in watts at maximum signal.

For example, a valve operates as a single-ended amplifier with $R_L = 2500$ ohms, $P_o = 3.5$ watts and $H_2 = 5\%$. Using the equation above we find that $\triangle I_b = 0.0026$ ampere = 2.6 ma.

The same method may be applied to push-pull amplifiers to give the second harmonic distortion in each valve, although this is effectively balanced out by the push-pull operation.

* Using equations (3) and (10) on page 549, and equation (11) on page 551 of Radiotron Designer's Handbook, 4th ed.

NEW RELEASES

EEV K347

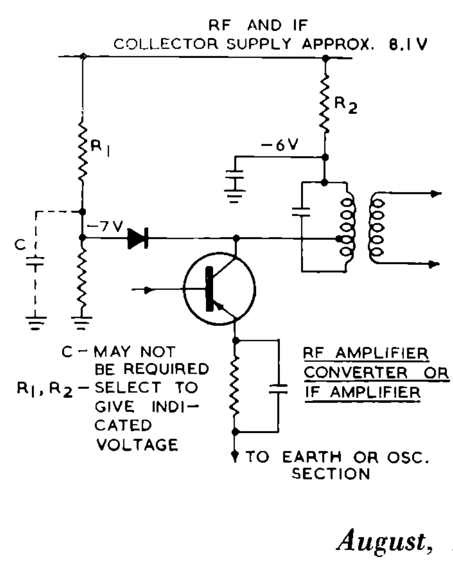
The EEV K347 is a forced-air cooled magnetically-focused klystron, and under typical operating conditions will deliver a peak output power of 600 Kw with a gain of 33db. The three cavities of the valve are separate from the vacuum envelope, and mechanical tuning over the frequency range 580 to 615 Mc is effected by means of sliding plungers. The cavities, focusing coils and electromagnet frame are supplied separately.

EEV K361

The EEV K361 low-voltage reflex klystron is designed specifically for use in doppler speed measuring systems where reliable performance with minimum routine attention are primary requirements. Typical applications include an equipment produced by the Westinghouse Brake and Signal Company for automatically controlling the speed of loose-shunted rolling stock in railway marshalling yards, and in Police 'radar' doppler speed measuring systems. Mechanical tuning of this klystron is effected, over the frequency range of 10700 to 10725 Mc, by a single screw tuner intruding into the cavity. The K361 has a minimum output power of 20 mw and is fitted with a coupler type UG-40 A/U for connecting to No. 16 waveguide (0.9 inch x 0.4 inch internal dimensions).

DIODE AVC IN TRANSISTOR PORTABLES CORRECTION

We regret that the circuit presented on page 109 of "Radiotronics" Vol. 25 No. 5 (May 1960) was incorrect, in that the right-hand side of the diode should be connected to the transistor collector, instead of to the bypass capacitor. The corrected circuit is shown below.



EEV IN OUTER SPACE RESEARCH —

The radio telescope at Bonn University Observatory will shortly be used for an intensive investigation into the temperatures prevailing in intersteller gas. This new outer space research programme, under the direction of Professor Becker, assisted by Herr Heinz G. Muller, is another example of new application for travelling wave tubes manufactured by EEV. Special dual-channel amplifying equipment, using two low noise type N1017 TW tubes in cascade in each channel, has been supplied to the University by Marconi's Wireless Telegraph Company Limited.

The radio telescope, a parobolic mirror of 83 ft. diameter mounted on a pyramidal tower about sixty feet high, scans the sky picking up the cosmic continuum radiation emanating from galactic and extra-galactic radio sources under observation. The signals in the neigbourhood of the hydrogen line frequency (1420 Mc) are amplified by one pair of TW tubes, the other pair being used to amplify reference-noise signals from a resistor at a known temperature.

The outputs from the two amplifying channels are detected, integrated and compared and the effective cosmic temperature determined; from these, data contour maps are prepared. So accurate has the system proved in initial tests that a discrimination of 0.1°K has been achieved.

— AND AT THE INTERNATIONAL IEA EXHIBITION

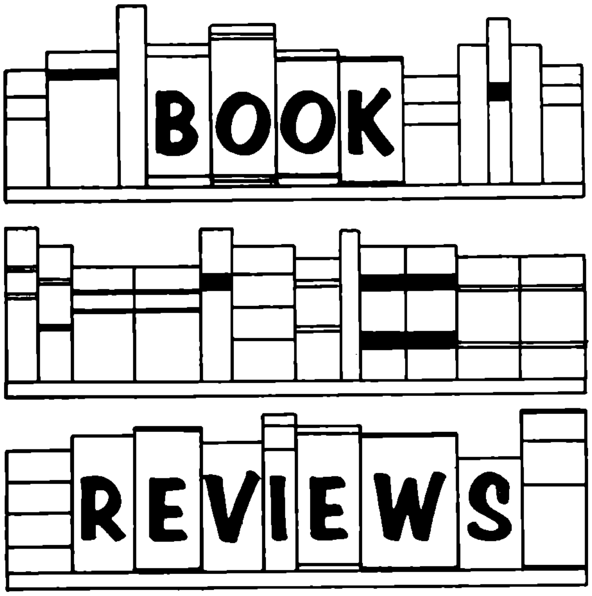
(INSTRUMENTS, ELECTRONICS, AUTOMATION)

The English Electric Valve Co. Ltd. had a wide selection of valves and electronic tubes on display including several being shown for the first time at the IEA Exhibition. The devices shown included two new klystrons, the K361 reflex klystron used in doppler speed-measuring systems for railway and police applications, and the K352 S-Band klystron amplifier developed for use in linear accelerators and long range radar applications.

The EEV type M565 high-power magnetron and the types N1036, N1037 parametric amplifiers are of interest to radar engineers. The parametric amplifiers are suitable for use in any low-noise receiver application such as radar head amplifiers or radio astronomy, and one of the advantages of this type of tube is its ability to withstand enormous signal overloads without damage.

The image orthicon X-Ray image amplifier tube which has been specially designed for use with extremely low-dosage-rate X-Ray equipment was also shown. This tube operates from an extremely low level light source and permits the X-Ray image to be presented on a normal television monitor for recording on cine film or multiple display etc.

REMEMBER!
CLOSING DATE FOR 1961 SUBSCRIPTIONS IS DECEMBER 1st, 1960



"CALL BOOK 1960," New Zealand Association of Radio Transmitters, Inc. Size 9½in. x 7in., 72 pages.

Call books are almost indispensable items on the "Ham" bookshelf. Whilst this book lists amateurs in New Zealand and is of particular interest to operators in that country, Hams in Australia and in fact any others who are particularly interested in ZL contacts will find this book a useful addition. The listing of call signs and addresses is supplemented with lots of useful data which turn a simple call book into a handy reference. By the way, the call book shows how really well organized the ZL's are, a matter for congratulation.

"TELEVISION EXPLAINED," 7th edition, W. E. Miller and E. A. Spreadbury, Iliffe and Sons Ltd. Size 8½in. x 5in., 192 pages, plus 10 pages of art plates, 90 figures.

This book assumes a knowledge of the ordinary sound radio receiver, but no previous knowledge of television circuits. It is non-mathematical, written in simple language, and comprehensively illustrated by many diagrams and photographs. It will prove of great assistance to all students of television, to radio service engineers who wish to embark upon television work and want to understand the principles and circuits involved, and to knowledgeable owners of television receivers who would like to understand the working of their sets.

This book is naturally orientated towards TV practice in the UK, but the fundamentals of course still apply. This seventh edition includes an additional chapter on combined TV and FM receivers, that is, with additional facilities for the reception of high fidelity FM sound broadcasting. This is becoming an increasingly popular arrangement in the UK, where an impressive number of such stations has been installed.

"APPLICATIONS OF ELECTRONICS," B. Grob and M. S. Kiver, McGraw-Hill Book Co. Inc., Size 9in. x 6in., 625 pages, 479 figures.

Back in October of last year we reviewed the first volume of a two-volume package presenting an introduction to the entire field of electronics. ("Basic Electronics," B. Grob, McGraw-Hill). Now the second volume has been released. The quality of this volume well supports the favourable remarks made in October. The first volume dealt largely with fundamentals; the second volume shows how they are applied. Once again, mathematics is used sparingly, and transistor circuits are well covered.

All modern circuit applications and equipment are covered, ranging through entertainment equipment to industrial, military and navigational equipment, and including several topics normally found only in specialised books. The interesting layout of these two books, previously mentioned in relation to the first of the series, make them outstandingly suitable for both group and private study.

"RADIOTRONICS"

BACK NUMBERS

Back numbers of "Radiotronics" prior to May, 1960, are out of print, and it is anticipated that by the time this issue reaches readers, the May and June issues for 1960 will also be exhausted.

HIGH FIDELITY AMPLIFIER CIRCUITS

This article has been prepared to provide hobbyists, electronic technicians, and others interested in construction of high-fidelity amplifier systems with laboratory-tested circuits, which can provide superior performance at moderate cost. These systems employ valve types designed especially for use in high-fidelity applications, and include the most recent developments in circuit design. The article discusses the performance requirements of a high-fidelity amplifier system, describes the functions of the various amplifiers, preamplifiers, and control units which are usually employed, includes construction hints, and provides voltage charts to facilitate checking the equipment. The article contains circuits for three power amplifiers having power outputs of 15, 30, and 50 watts, a bass-and-treble tone control amplifier, preamplifiers for use with magnetic phonograph pickups, a preamplifier for use with a magnetic-tape pickup head, and a microphone preamplifier. Also included are circuits for a two-channel mixer, and a balancing unit for stereo systems. The tone-control amplifier, preamplifiers, and mixer have matching gain and output characteristics which permit them to be used singly, or in various combinations with any of the three power amplifiers. Each power amplifier circuit includes a power-supply which can be used to supply the heater and B+ requirements of a complete audio system.

PERFORMANCE REQUIREMENTS

The performance capabilities of a high-fidelity amplifier are usually given in terms of its frequency response, total harmonic distortion, intermodulation distortion, maximum power output, and noise level.

To provide high-fidelity reproduction of audio programme material, an amplifier should have a frequency response which does not vary more than 1 db over the entire audio spectrum. General practice is to design the amplifier so that its frequency response is flat within 1 db from a frequency below the lowest to be reproduced to one well above the upper limit of the audible region.

Harmonic distortion and intermodulation distortion produce changes in programme material which may have adverse effects on the quality of the reproduced sound. Harmonic distortion causes a change in the character of an individual tone by the introduction of harmonics which were not originally present in the programme material. Harmonic distortion is expressed as a percentage of the output power. For high-fidelity reproduction total harmonic distortion should not be greater than about 1% at the desired listening level.

Intermodulation distortion is a change in the waveform of an individual tone as a result of interaction with another tone present at the same time in the programme material. This type of distortion not only alters the character of the modulated tone but may also result in the generation of spurious signals at frequencies equal to the sum and difference of the interacting frequencies. Intermodulation distortion, like harmonic distortion, is expressed as a percentage of the output power and should be less than 2 per cent at the desired listening level. In general, any amplifier which has low intermodulation distortion will have very low harmonic distortion.

The maximum power output which a high-fidelity amplifier should deliver depends upon a complex relation of several factors, including the size and acoustical characteristics of the listening area, the desired listening level, and the efficiency of the loudspeaker system. Practically, however, it is possible to determine amplifier requirements in terms of room size and loudspeaker efficiency.

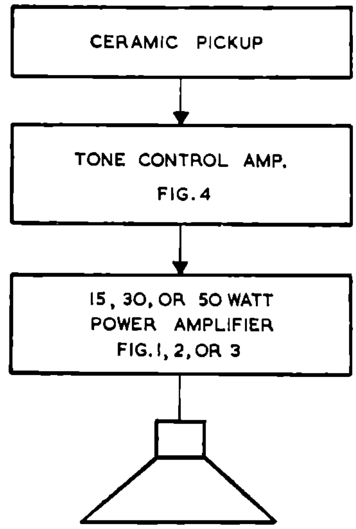
The acoustic power required to reproduce the loudest passages of orchestral music at concert-hall level in the average-size living room is about 0.4 watt. Because high-fidelity loudspeakers of the type generally available for home use have an efficiency of only about 5 per cent the amplifier should therefore be able to deliver a power output of at least 8 watts. Since many wide-range loudspeaker systems, particularly those using frequency-divider networks, have efficiencies of less than 5 per cent, amplifiers used with such systems must have correspondingly larger power outputs.

The noise level of a high-fidelity amplifier determines the range of volume the amplifier is able to reproduce — that is, the difference (usually expressed in decibels) between the loudest and softest sounds in programme material. Since the greatest volume range utilized in electrical programme material at the present time is about 60 db, the noise level of a high-fidelity amplifier should be at least 60 db below the signal level at the desired listening level.

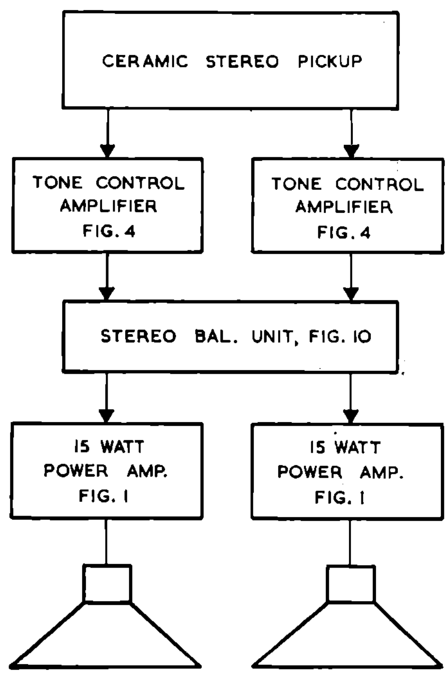
CIRCUITS

FIFTEEN-WATT AMPLIFIER

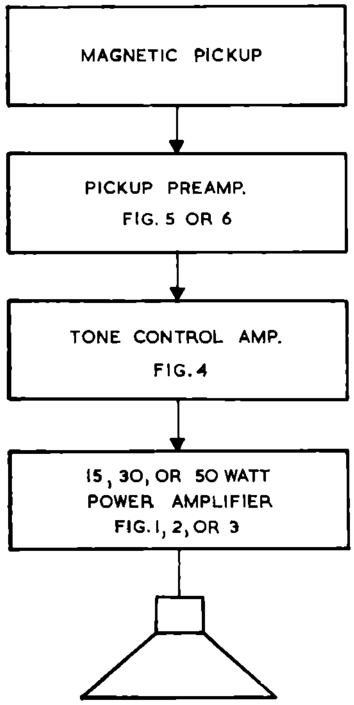
The high-fidelity power amplifier shown in Fig. 1 can deliver 15 watts with less than 0.4 per cent total harmonic distortion and less than 1.5 per cent intermodulation distortion. It has a frequency response which varies less than + 0.5 db from 20 cps to 60,000 cps, and a sensitivity of 1.2 volts



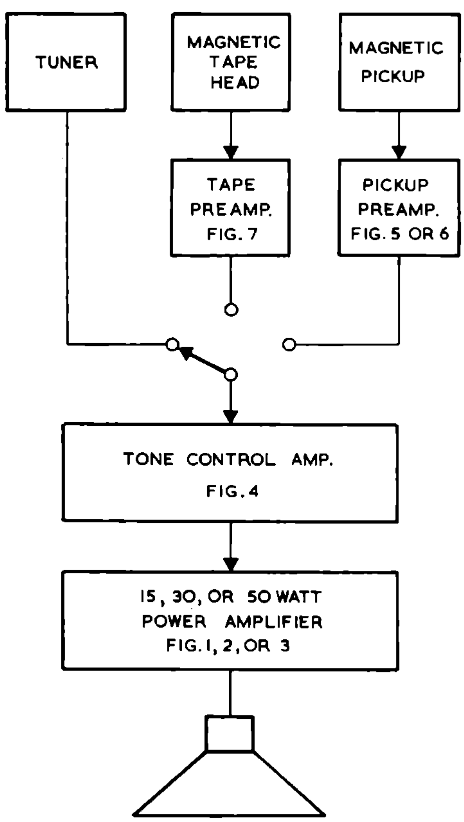
SIMPLE HIFI MONAURAL RECORD REPRODUCING SYSTEM



STEREOPHONIC VERSION OF THE SYSTEM SHOWN ABOVE. TONE CONTROLS IN THE TWO CHANNELS MAY BE GANGED.



MONAURAL RECORD REPRODUCING SYSTEM USING MAGNETIC PICKUP.



SYSTEM FOR HIFI REPRODUCTION OF MONAURAL RECORDINGS, TAPE RECORDINGS AND BROADCAST PROGRAMMES.

rms for 15 watts output. Total hum and noise with input shorted is 84 db below 15 watts.

This amplifier incorporates several design features which permit it to provide excellent performance with relatively inexpensive components. Features responsible for the very low hum and noise level are the use of a 7199 low-noise triode-pentode in the input and phase-splitter stages, a choke-capacitor filter in the B-supply circuit, and the application of a positive voltage to the valve heaters to minimize hum due to heater cathode leakage.

The features responsible for the low distortion and excellent frequency-response characteristics of this amplifier are the use of 6973 beam power valves operated under class AB_1 conditions with fixed bias in the output stage, the use of direct coupling between the input and phase-splitter stages, and the use of inverse feedback from the voice-coil winding of the output transformer to the cathode of the input amplifier stage. In addition to its excellent performance capabilities and low cost, this amplifier is extremely compact, and therefore, is particularly suitable for use in stereophonic systems.

THIRTY-WATT AMPLIFIER

The high-fidelity power amplifier shown in Fig. 2 can deliver 30 watts output with less than 0.7 per cent total harmonic distortion and less than 1.5 per cent intermodulation distortion. The frequency response of this amplifier is flat within $\pm$ 0.5 db from 15 cps to 40,000 cps. The total hum and noise with the input shorted is 85 db below 30 watts. Sensitivity is 1 volt rms input for 30 watts output. The amplifier is similar in design to the 15-watt amplifier shown in Fig. 1, except that it uses 7027-A beam power valves in the output stage, and a resistive network in the negative leg of the B-supply rather than a separate rectifier to supply the fixed bias voltages for the output valves. The amplifier is also provided with a hum-balancing adjustment in the heater circuit.

FIFTY-WATT AMPLIFIER

The high-fidelity power amplifier shown in Fig. 3 is capable of outstanding performance at moderate cost. This four-stage amplifier can deliver 50 watts output with less than 0.1 per cent total harmonic distortion and less than 1 per cent intermodulation distortion; and has a frequency response flat within $\pm$ 0.5 db from 10 cps to 50,000 cps. Sensitivity is 0.4 volt rms input for fifty watts output. The total hum and noise is 70 db below 50 watts.

This amplifier, like the 15-watt and 30-watt high-fidelity amplifiers shown in Figs. 1 and 2 uses a 7199 low-noise triode-pentode as an input amplifier and phase-splitter, but has a push-pull driver stage using 6CB6 sharp-cutoff pentodes, and incorporates several other features which contribute to its superior performance. These features include the use of a 450-volt plate supply and a 400-volt electronically regulated grid-No. 2 supply for the 7027-A beam power valves in the output stage; the use of inverse-feedback loops from the plates to the grids of the output valves, from the plates of the output valves to the cathodes of the driver valves, and from the voice-coil winding of the output transformer to the cathode of the input amplifier.

Additional features are the operation of all heaters at a positive voltage with resect to ground and use of a balancing adjustment (R30) in the heater-supply circuit to minimize hum, a grid-No. 2-voltage adjustment (R39), a grid-No. 1 bias adjustment (R33) for the 7027-A output valves and an ac-balance adjustment (R17) which may be used to balance the outputs of the push-pull stages. Instructions for making the ac-balance adjustment are given adjacent to Fig. 3.

TONE-CONTROL AMPLIFIER

Fig. 4 shows a high-fidelity two-stage tone-control amplifier using a 7025 low-noise twin triode. This amplifier has non-interacting bass and treble controls which can be adjusted to provide up to about 16 db boost or attenuation at 30 cps, and up to about 16 db boost or attenuation at 15,000 cps. With the bass and treble controls set at their mid-range positions, the frequency response of the amplifier is flat within ± 1 db from 30 cps to 15,000 cps. The amplifier has an over-all voltage gain of approximately 2.5, and is designed to be used immediately ahead of any of the power amplifiers shown in Figs. 1, 2, and 3, or any power amplifier having similar characteristics. For operating convenience, the volume control on the power amplifier may be physically located on the tone-control chassis. In this case, it is advisable to insert a 1-megohm resistor in place of the volume control on the power amplifier.

If partial compensation for the reduced high- and low-frequency sensitivity of the ear at low volume levels is desired, the volume-control potentiometer may be replaced by a "loudness control."

REPRODUCTION OF PHONOGRAPH RECORDS AND MAGNETIC-TAPE RECORDINGS

The frequency range and dynamic range which can be recorded on a phonograph record or on magnetic tape depend on a complex relation of several factors, including the composition, mechanical characteristics, and speed of the record or tape, the electrical and mechanical characteristics of the recording equipment, and other factors which are outside the scope of this article. To achieve wide frequency and dynamic ranges, manufacturers of commercial recordings use equipment which introduces a non-uniform relationship between amplitude and frequency. This relationship is known as a "recording characteristic." To assure proper reproduction of a high-fidelity recording, therefore, some part of the reproducing system must have a frequency-response characteristic which is the inverse of the recording characteristic. Most manufacturers of high-fidelity recordings use the RCA "New Orthophonic" (RIAA) characteristic for discs and the NARTB characteristic for magnetic tape.

The location of the frequency-compensating network or "equalizer" in the reproducing system will depend on the types of recordings which are to be reproduced and on the pickup devices used.

A ceramic high-fidelity phonograph pickup is usually designed to provide proper compensation for the RIAA recording characteristic when the pickup is operated into the load resistance specified by its manufacturer. Since this type of pickup also has relatively high output (0.5 volt to 1.5 volts), it does not require the use of either an equalizer network or a preamplifier, and can be connected directly to the input of a tone-control amplifier and/or power amplifier of the type described in this article.

A magnetic high-fidelity phonograph pickup, on the other hand, usually has an essentially flat frequency-response characteristic and very low output (1 millivolt to 10 millivolts). Since a pickup of this type merely reproduces the recording characteristic, it must be followed by an equalizer network as well as by a preamplifier having sufficient voltage gain to provide the input voltage required by the tone-control amplifier and/or power amplifier. Many current designs include both the equalizing and amplifying circuits in a single unit.

A high-fidelity magnetic-tape pickup head, like a magnetic phonograph pickup, reproduces the recording characteristic and has an output of only a few millivolts. This type of pickup device, therefore, must also be followed by an equalizing network and preamplifier, or by a preamplifier which provides "built-in" equalization for the NARTB characteristic.

PREAMPLIFIERS

Figs. 5 and 6 are circuits of preamplifiers for use with high-fidelity magnetic phonograph pickups.

Both preamplifiers are equalized for the RCA "New Orthophonic" (RIAA) recording characteristic, have similar voltage-gain characteristics, and use valves having exceptionally low hum and noise. These valves are designed especially for use in high-fidelity equipment operating at low signal levels. The two-stage preamplifier circuit shown in Fig 5 uses 7025 twin triode, and has a voltage gain of about 150. This preamplifier has a high-impedance output, and is recommended for use when the preamplifier is constructed on the same chassis as the power amplifier and/or tone-control amplifier. The preamplifier may also be used at distances of up to six feet from the amplifier without effect on its frequency response provided the capacitance of C8 is reduced by approximately 30 $\mu\mu$f for each foot of shielded cable used for the af connection between the preamplifier and the following amplifier.

The three-stage preamplifier circuit shown in Fig. 6 uses a 5879 low-noise sharp-cutoff pentode as an input amplifier, one unit of a 7025 as a voltage amplifier, and the other unit of the 7025 as a cathode-follower output amplifier. This preamplifier has a voltage gain of approximately 180, and low-impedance output. Because of the low impedance output the preamplifier may be installed at distances up to 50 feet from the following amplifier without effect upon its frequency-response characteristics.

Fig. 7 is the circuit of a preamplifier for use with a high-fidelity magnetic-tape-pickup head. This preamplifier is essentially the same as that shown in Fig. 6 except that its frequency response is equalized to provide the NARTB playback characteristic.

Fig. 8 shows the circuit of a one-valve preamplifier for use with a high-fidelity, high-impedance crystal or dynamic microphone. This amplifier uses a 5879 low-noise sharp-cutoff pentode in a conventional circuit with high-impedance output, has a voltage gain of approximately 70, and a flat frequency response over the audio range. Because of its high output impedance this preamplifier should be constructed on the same chassis as the power amplifier and/or tone-control amplifier.

MIXER

Fig. 9 shows the circuit of a high-fidelity mixer which can be used to combine audio-frequency programme material from two sources. In this circuit each mixer control is preceded by a one-stage voltage amplifier using one unit of a 7025 low-noise twin-triode and is separated from the common load resistor by a resistance-capacitance network. These features provide "high-level" mixing to minimize noise during adjustments, a very high degree of isolation between the two signal channels, and more than sufficient voltage gain to overcome the losses in the mixing potentiometers and isolating networks. The common 390,000-ohm load resistor may be used as the input resistor for the following tone-control amplifier or power amplifier.

Each section of the mixer can provide a voltage gain of about 7, and can handle an input signal of about 0.2 volt (200 millivolts) rms without overloading.

AMPLIFIER CONSTRUCTION

The results achieved from any high-fidelity amplifier system depend to a large degree upon the skill and care with which the system is constructed. Improper placement of transformers, other components, and wiring, and attempts to achieve excessive compactness, can easily result in instability, oscillation, hum, and other operating difficulties, as well as in damage to components by overheating. It is important, therefore, that construction of high-fidelity amplifier systems be undertaken only by persons who have had some experience in the layout, mechanical construction, and wiring of audio equipment.

It is impractical to give specific construction data for the various amplifiers and other units described in this article, because the best arrangement for each unit or combination of units will depend upon the requirements of the user. It is possible, however, to list some general considerations which should be observed in the construction of any high-fidelity amplifier system.

Any amplifier having two or more stages should be constructed with a straight-line layout so as to provide maximum separation between the signal input and output circuits and terminals. Power-supply connections, particularly those carrying ac, should be isolated as far as possible from signal connections, especially from the input connection Signal-carrying conductors, even when shielded should not be cabled together with power-supply conductors. Internal wiring for ac-operated valve heaters, switches, pilot-light sockets, and other devices, should be twisted and placed flat against the chassis. All connections to the ground side of the circuit in each unit should be made to a common bus of heavy wire. This bus should be connected to the chassis only at the point of minimum signal voltage—i.e., at the signal-input terminal of the unit, as shown by the ground symbol in the circuit diagrams.

All internal wiring handling signal voltages should be as short as possible, and as far as possible away from the chassis to minimize losses at the higher audio frequencies due to stray shunt capacitance. All connections between units should be made with shielded cable having a capacitance of not more than 30 $\mu\mu$f per foot.

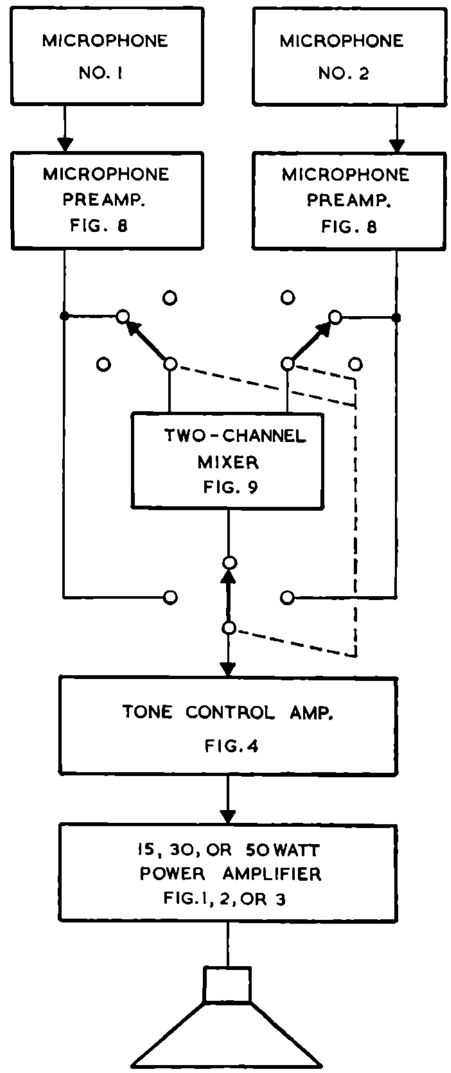
The power amplifiers and power-supply units described dissipate large amounts of heat and, therefore, should be constructed and installed in such a manner as to assure adequate ventilation for the valves and other components.

A beam power valve or rectifier should be separated by at least $1\frac{1}{2}$ valve diameters from any other valve or component on the same side of the chassis.

Power amplifiers and power-supply units which are to be installed horizontally (that is, with valves vertical) in cabinets or on shelves should be provided with mounting feet, perforated bottom covers, and a number of small holes around each valve socket to permit relatively-cool air to enter from below and provide ventilation for the under side of the chassis and valves.

If a power amplifier, tone-control amplifier, and one or more preamplifiers are to be constructed on the same chassis, the mechanical layout should be planned so that the circuits operating at the lowest signal levels are farthest from the output stage and power supply. Amplifier units which normally operate at comparable signal levels but are not used simultaneously—such as preamplifiers for tape pickup heads and magnetic phonograph pickups—usually may be installed side by side on the same chassis without danger of interaction. Units which operate simultaneously, however—such as the channels of a stereophonic system—should not be installed side by side on the same chassis without careful consideration to placement of components and wiring, and the possible use of shielding, to prevent interaction.

When an amplifier, preamplifier, mixer or other unit requiring heater power is located more than five or six feet from its power-supply unit, the heater-current conductors in the power-supply cable must be large enough to assure that each valve receives its rated heater voltage. In cases where very large heater currents or very long power-supply cables are involved, it may be desirable to install a heater-supply transformer on or near the amplifier unit. If such a transformer is installed on or near a preamplifier for a magnetic-tape pickup head, a magnetic phonograph pickup, or a dynamic microphone, the transformer should be completely shielded and carefully positioned to prevent its field from inducing hum in the pickup device.



SYSTEM FOR MIXED OR INDIVIDUAL OPERATION OF TWO MICROPHONES.

VALVES FOR HIGH FIDELITY AUDIO APPLICATIONS

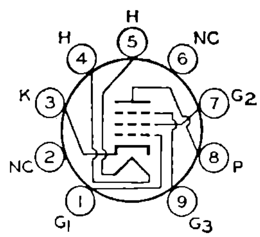
TYPE	Name	GENERAL DATA: Electrical: Cathode Volts	GENERAL DATA: Electrical: Cathode Amps.	GENERAL DATA: Mechanical: Maximum Dimensions Inches: Length	GENERAL DATA: Mechanical: Maximum Dimensions Inches: Diam.	MAXIMUM RATINGS †: Plate Volts	MAXIMUM RATINGS †: Grid-No. 2 Volts	MAXIMUM RATINGS †: Plate Dissipation Watts	MAXIMUM RATINGS †: Grid-No. 2 Input Watts	MAXIMUM RATINGS †: Peak Heater-Cathode Volts
5879	Sharp-Cutoff Pentode	6.3	0.15	2 3/16	0.875	300	150	1.25	0.25	+90 / −90
						250	—	1.5	—	+90 / −90
6973	Beam Power Tube	6.3	0.45	3 1/16	0.875	440	330	12	2	+200▲ / −200
						410	—	12	1.75	+200▲ / −200
7025	High-Mu Twin Triode	6.3 / 12.6	0.3 / 0.15	2 3/16	0.875	330	—	1.2	—	+200▲ / −200
7027-A	Beam Power Tube	6.3	0.9	4 5/8	1.63	600	500	35	5	+200▲ / −200
						600	—	35	4.5	+200▲ / −200
7199	Medium-Mu Triode—Sharp-Cutoff Pentode	6.3	0.45	2 3/16	0.875	330	—	2.4	—	+200▲ / −200
						330	165	3	0.6	+200▲ / −200

▲ **The dc component must not exceed 100 volts.**

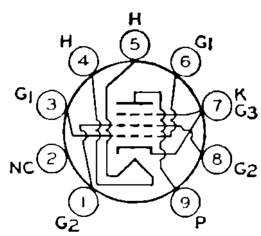
† **Types 6973, 7025, 7027-A and 7199 on a Design-Maximum basis; type 5879, on a Design-Centre basis.**

Socket Connections

Bottom View



5879

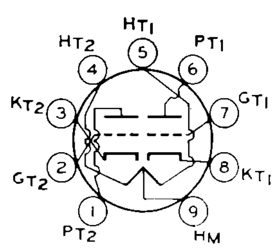


6973

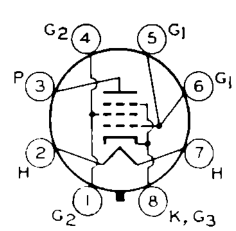
SERVICE		Plate Supply Volts	Grid-No. 2 Supply Volts	Cathode Resistor Ohms	Grid Volts	AC Plate Resistance Ohms	Transconductance Micromhos	Amplification Factor	Peak AF Grid-to-Grid Volts	Plate Current Ma.	Grid-No. 2 Current Ma.	Load Resistance (Plate-to-Plate) Ohms	Total Harmonic Distortion %	Power Output Watts	TYPE
Values to right give operating conditions and characteristics for indicated use. In push-pull service, values are for two tubes		TYPICAL OPERATION AND CHARACTERISTICS													
Class A₁ Amplifier	Pentode Conn.	250	100	—	—3	2000000	1000	—	—	1.8	0.4	Grid No. 3 tied to cathode			5879
	Triode Conn.•	100 250	— —	— —	—3 —8	17000 13700	1240 1530	21 21	— —	2.2 5.5	•Grids-No. 2 & 3 tied to plate				
Push-Pull Class AB₁ Amplifier	Fixed Bias	250 350 400	250 280 290	— — —	—15 —22 —25	— — —	— — —	— — —	30 44 50	105 106 107	16 14 13.7	8000 7500 8000	2 1.5 2	12.5 20 24	6973
	Cathode Bias	300 310	300 310	230 270	— —	— —	— —	— —	48 55	96 92	14 14	5500 6000	2 4	15 17	
Push-Pull Class AB₁ Amplifier•	Fixed Bias	375	*	—	—33.5	•Grid No. 2 of Each Tube Connected to Tap on Plate Winding of Output Transformer			67	95	—	12500	1.5	18.5	
	Cathode Bias	370	#	355	—				62	84	—	13000	1.2	15	
Class A₁ Amplifier	Each Unit	100 250	— —	— —	—1 —2	80000 62500	1250 1600	100 100	— —	0.5 1.2	Equivalent Hum & Noise Voltage (Referred to grid) = 1.8 μ volts rms, average.				7025
Push-Pull Class AB₁ Amplifier	Fixed Bias	400 450 540	300 350 400	— — —	—25 —30 —38	— — —	— — —	— — —	50 60 76	152 194 220	17 19.2 21.4	6600 6000 6500	2 1.5 2	34 50 76	7027-A
	Cathode Bias	400 380 425	300 380 425	200 180 200	— — —	— — —	— — —	— — —	57 68.5 86	128 170 196	16 20 20	6600 4500 3800	2 3.5 4	32 36 44	
Push-Pull Class AB₁ Amplifier•	Cathode Bias	410	#	220	—	•Grid No. 2 of Each Tube Connected to Tap on Plate Winding of Output Transformer			68	155	—	8000	1.6	24	
Class A₁ Amplifier	Triode Unit	215	—	—	—8.5	8100	2100	17	—	9	Equivalent Hum & Noise Voltage (Referred to grid)		10 μ volts rms, median		7199
	Pentode Unit	100 220	50 130	1000 62	— —	1000000 400000	1500 7000	— —	— —	1.1 12.5			35 μ volts rms, median		

* Obtained from taps on the primary winding of the output transformer. The taps are located on each side of the centre tap (B+) so as to apply 50 per cent of the plate signal voltage to grid No. 2 of each output valve.

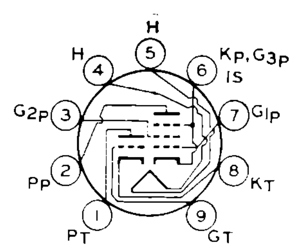
Obtained from taps on the primary winding of the output transformer. The taps are located on each side of the centre tap (B+) so as to supply 43 per cent of the plate signal voltage to grid No. 2 of each output valve.



7025



7027-A



7199

15-WATT AMPLIFIER

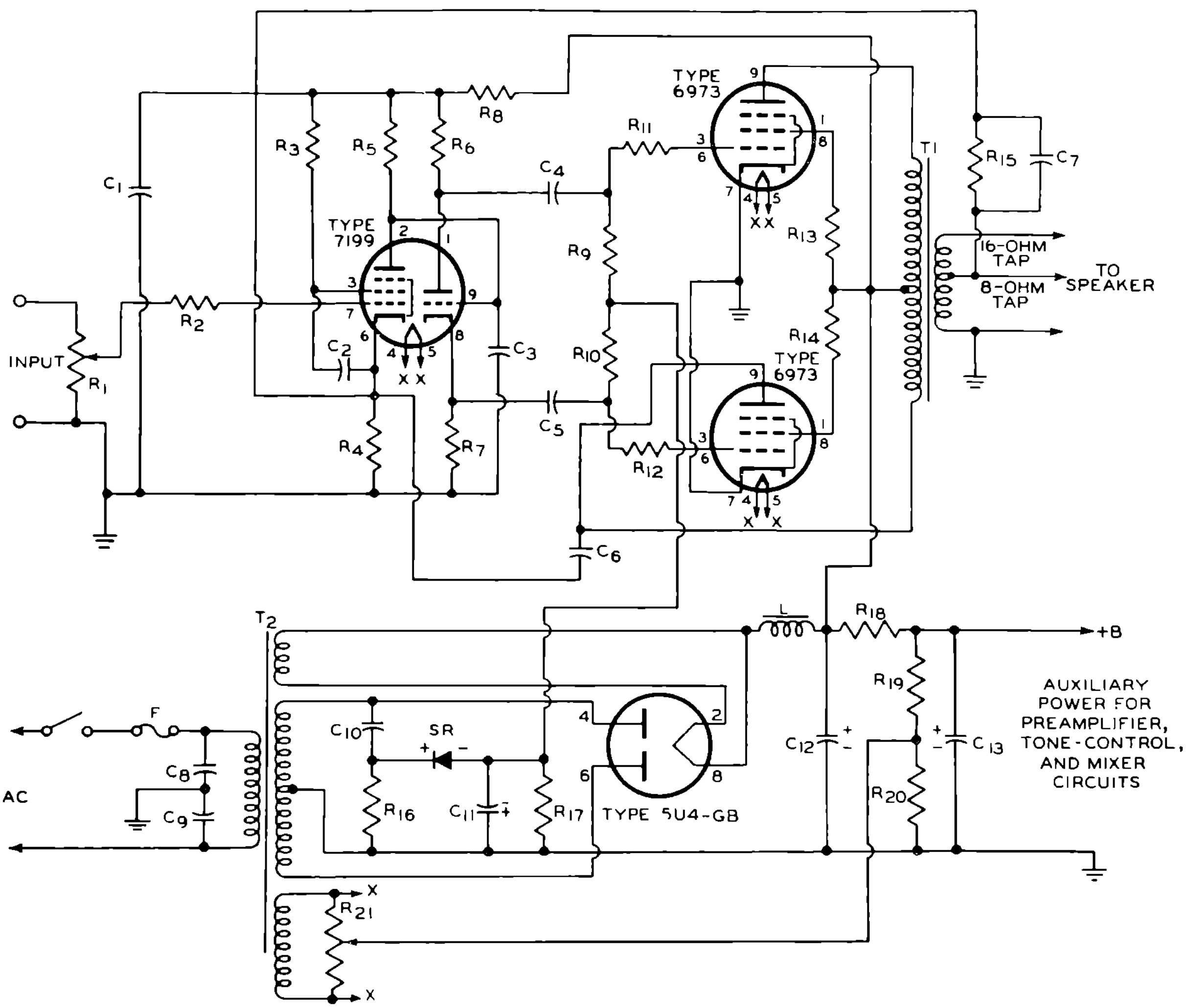


Fig. 1

PERFORMANCE SPECIFICATIONS

Sensitivity: 1.2 volts rms for 15 watts output;

Hum and Noise: 84 db below 15 watts with input shorted;

Frequency Response: Flat $\pm\frac{1}{2}$ db from 20 cps to 60000 cps;

Total Harmonic Distortion: 0.4% at 15 watts;

Intermodulation Distortion: 1.5% at 15 watts.

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
5U4-GB	—	+305	—	360 ac	—	360 ac	—	+305	—
6973	+300	—	−25	+50	+50	−25	0	+300	+295
7199	+210	+78	+40	+50	+50	+1	0	+85	+78

All voltages ±20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

HUM-BALANCE ADJUSTMENT

Short-circuit the audio-input terminals of the amplifier. Connect the amplifier to the ac line and adjust the hum-balance potentiometer (R21) for minimum hum from the loudspeaker.

PARTS LIST

C1: 40 μf, 450 volts
C2, C4, C5: 0.25 μf
C3, C6: 3.3 $\mu\mu$f, 600 volts
C7: 150 $\mu\mu$f
C8, C9: 0.05 μf, 600 volts
C10: 0.02 μf, 600 volts
C11: 100 μf, 50 volts
C12: 80 μf, 450 volts
C13: 40 μf, 450 volts
F: Fuse, 3 amperes
L: Filter Choke, 3 h., 160 ma., 75 ohms or less
R1: Potentiometer, 1 megohm
R2: 10000 ohms
R3: 0.82 megohm
R4: 820 ohms
R5: 0.22 megohm
R6, R7: 15000 $\pm$5% ohms, 2 watts
R8: 3900 ohms, 2 watts
R9, R10: 0.1 megohm
R11, R12: 1000 ohms
R13, R14: 100 ohms
R15: 8200 ohms
R16: 15000 ohms, 1 watt
R17: 68000 ohms
R18: 4700 ohms, 2 watts
R19: 0.27 megohm, 1 watt
R20: 47000 ohms
R21: Potentiometer, 100 ohms
SR: Selenium Rectifier, 20 ma., 135 volts rms
T1: Output Transformer for matching impedance of voice coil to 6600-ohm plate-to-plate load.
T2: Power Transformer, 360-0-360 volts rms, 120 ma.

NOTE

All resistors 0.5 watt, $\pm$10%, unless specified.
All capacitors 400 volts, unless specified.

30-WATT AMPLIFIER

PERFORMANCE SPECIFICATIONS

Sensitivity: 1 volt rms for 30 watts output;

Hum and Noise: 84 db below 20 watts with input shorted;

Frequency Response: Flat $\pm$ 0.5 db from 15 cps to 40000 cps;

Total Harmonic Distortion: 0.7% at 30 watts;

Intermodulation Distortion: 1.5% at 30 watts.

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
5U4-GB	—	+400	—	375 ac	—	375 ac	—	+400	—
7027-A	+390	0	+390	+390	−30	−30	0	0	—
7199	+280	+105	+45	0	0	+1.1	0	+115	+105

All voltages $\pm$20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

HUM-BALANCE ADJUSTMENT

Short-circuit the audio-input terminals of the amplifier. Connect the amplifier to the ac line and adjust the hum-balance potentiometer (R19) for minimum hum from the loudspeaker.

PARTS LIST

C1: 25 μf, 50 volts
C2: 22 $\mu\mu$f, 600 volts
C3: 80 μf, 600 volts
C4, C5: 0.25 μf, 600 volts
C6: 0.01 μf, 600 volts
C7, C8: 0.05 μf, 600 volts
C9, C11: 40 μf, 600 volts
C10: 100 μf, 50 volts
C12: 20 μf, 450 volts
F: Fuse, 3 amperes
R1: Potentiometer, 1 megohm
R2: 10000 ohms
R3: 220000 ohms
R4: 820 ohms
R5: 10 ohms
R6: 180000 ohms
R7: 15000 $\pm$5% ohms, 2 watts
R8: 15000 $\pm$5% ohms, $\frac{1}{2}$ watt

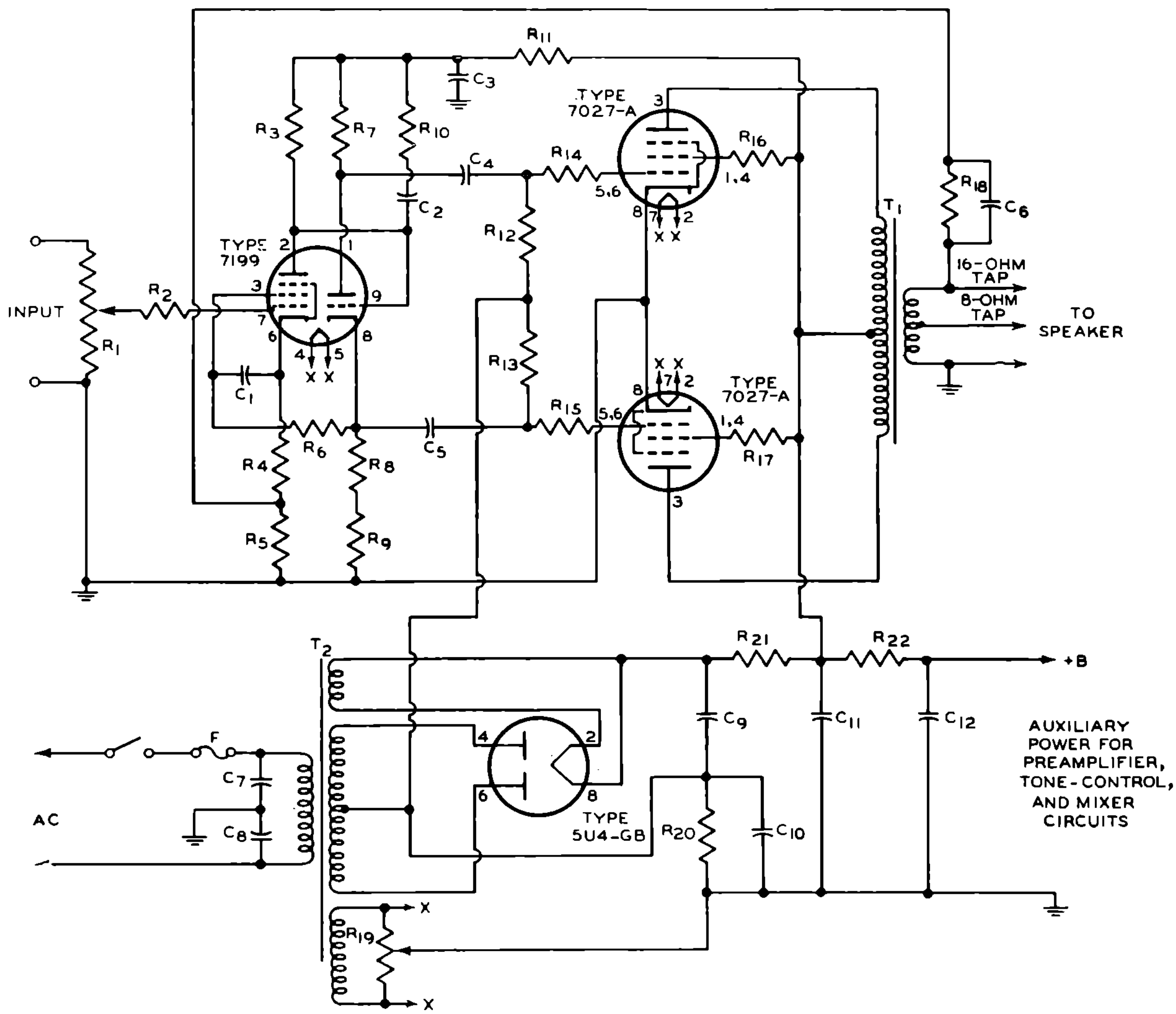


Fig. 2

R9: 1000 ohms
R10: 22000 ohms
R11: 2000 ±10% ohms, 2 watts
R12, R13: 100,000 ohms
R14, R15: 1000 ohms
R16, R17: 56 ohms
R18: 270 ohms
R19: Potentiometer, 100 ohms, ½ watt

R20: 220 ±10% ohms, 10 watts
R21: 50 ±10% ohms, 10 watts
R22: 10,000 ±10% ohms, 2 watts
T1: Output Transformer for matching impedance of voice coil to 5000-ohm plate-to-plate load.
T2: Power Transformer, 375-0-375 volts rms, 160 ma.

NOTE

All resistors 0.5 watt, ±10%, unless otherwise specified.

All capacitors 400 volts unless otherwise specified.

50-WATT AMPLIFIER

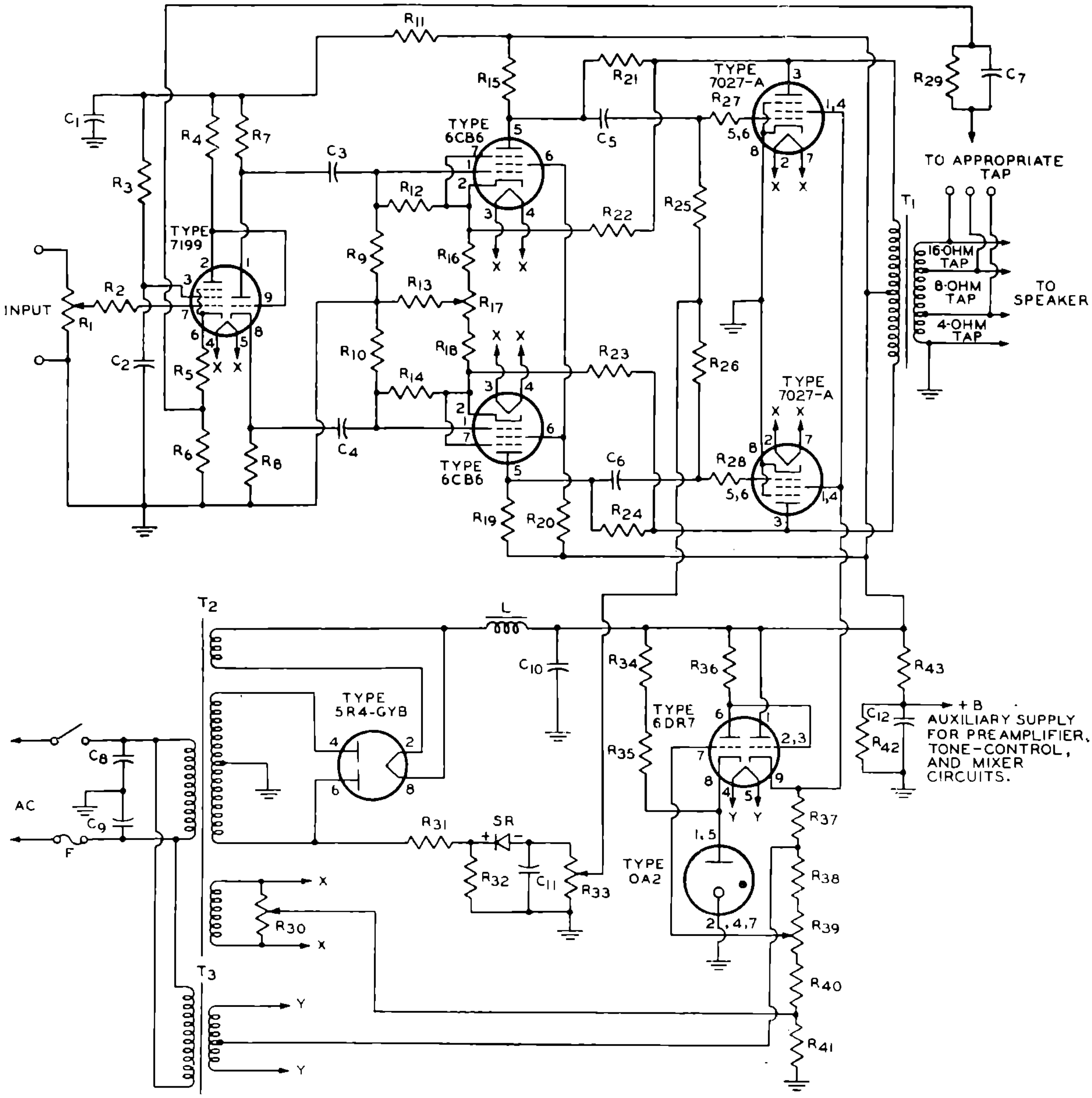


Fig. 3

PERFORMANCE SPECIFICATIONS

Sensitivity: 0.4 volts rms for 50 watts output;

Hum and Noise: 70 db below 50 watts with input shorted;

Frequency Response: Flat ± 1 db from 10 to 50000 cps;

Total Harmonic Distortion: 0.1% at 50 watts;

Intermodulation Distortion: 1% at 50 watts.

PRELIMINARY ADJUSTMENTS

To avoid possible damage to the valves and components in the output stage of the 50-watt power amplifier shown in Fig. 3, and to mininize hum, the following adjustments should be made before this amplifier is placed in operation.

(1) Remove the 5R4-GYB rectifier from its socket and connect a dc voltmeter between B minus and the junction of R25 and R26, with the positive lead of the meter on B minus. Set the meter on a range which provides a full-scale reading of at least 50 volts.

(2) Connect the amplifier to the ac power line and adjust the bias-control potentiometer (R33) until the meter reads 40 volts. Disconnect the amplifier from the power line, and remove the meter.

(3) Set the dc voltmeter to a range which provides a full-scale reading of at least 500 volts, and connect it between B minus and Pin 9 of the 6DR7 socket, with the negative lead of the meter on B minus. Connect the loudspeaker to the audio-output terminals of the amplifier. Replace the 5R4-GYB rectifier in its socket.

(4) Connect the amplifier to the ac line, and, after approximately one minute, adjust the grid-No. 2-voltage-control potentiometer (R39) until the meter reads 400 volts. Disconnect the amplifier from the ac line and remove the meter.

(5) Short-circuit the audio-input terminals of the amplifier. Connect the amplifier to the ac line and adjust the heater-balance potentiometer (R30) for minimum hum from the loudspeaker.

(6) Remove the short circuit from the audio-input terminals of the amplifier and set the volume control at its maximum clockwise (maximum-volume) position. Adjust the ac-balance control (R17) for minimum hum from the loudspeaker.

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
0A2	+150	0	—	0	+150	—	0	—	—
5R4-GYB	—	+460	—	600 ac	—	600 ac	—	+460	—
6CB6	+3	+6	+65	+65	+175	+120	+6	—	—
6DR7	+460	+360 to +400	+360 to +400	+250	+250	+360 to +400	+125 to +150	+150	+400
7027-A	+400	+65	+450	+400	−40	−40	+65	0	—
7199	+335	+110	+55	+65	+65	+1.3	0	+120	+110

All voltages ±20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

PARTS LIST

C1, C2: 40 μf, 450 volts
C3, C4: 0.02 μf
C5, C6: 1 μf
C7: { 4-ohm tap; 0.002 μf; 8-ohm tap; 0.0015 μf; 16-ohm tap; 0.001 μf }
C8, C9: 0.05 μf, 600 volts
C10: 20 μf, 600 volts
C11: 100 μf, 150 volts
C12: 40 μf, 450 volts
F: Fuse, 5 amperes
L: Filter Choke, 8 h., 250 ma., 60 ohms or less
R1: Potentiometer, 0.5 megohm
R2: 4700 ohms
R3: 0.82 megohm
R4: 0.22 megohm
R5: 820 ohms
R6: 10 ohms
R7, R8: 15000 ohms, 2 watts
R9, R10: 1.5 megohms
R11: 33000 ohms, 2 watts
R12, R14: 1.3 megohms
R13: 47 ohms
R15, R19: 0.15 megohm
R16, R18: 390 ohms
R17: 500 ohms
R20: 0.15 megohm, 1 watt
R21, R24: 0.33 megohm, 1 watt
R22, R23: 0.12 megohm, 2 watts
R25, R26: 0.1 megohm
R27, R28: 4700 ohms
R29: { 4-ohm tap; 600 ohms; 8-ohm tap; 820 ohms; 16-ohm tap; 1200 ohms }
R30: Potentiometer, 100 ohms
R31: 0.12 megohm
R32, R34, R35, R37: 33000 ohms, 2 watts
R33: Potentiometer, 50000 ohms
R36: 0.27 megohm, 1 watt
R38: 10000 ohms, 1 watt
R39: Potentiometer, 25000 ohms, 2 watts
R40: 15000 ohms, 2 watts
R41: 12000 ohms, 2 watts
R42: 0.22 megohm, 2 watts
R43: 22,000 ohms, 2 watts
SR: Selenium Rectifier, 20 ma., 135 volts rms
T1: Output transformer for matching impedance of voice coil to 5000-ohm plate-to-plate load.
T2: Power transformer, 600-0-600 volts rms, 200 ma.
T3: Filament transformer, 6.3 volts centre-tapped, 1 ampere.

NOTE

All capacitors 400 volts, unless otherwise specified.
All resistors 0.5 watt, ±10%, unless otherwise specified.

TONE CONTROL AMPLIFIER

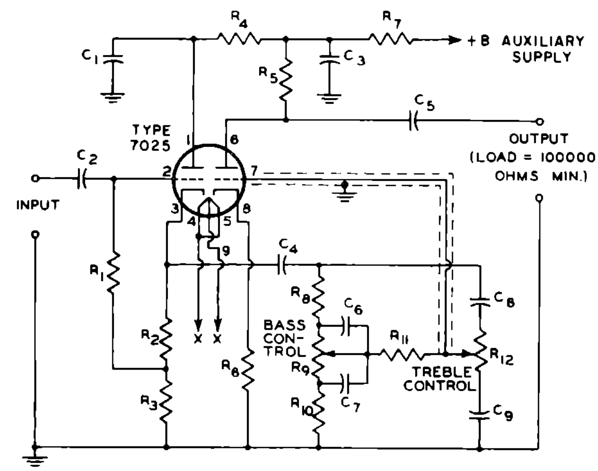


Fig. 4

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
7025	+240	+16	+17.5	*	*	+165	0	+1	*

All voltages ±20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

* This voltage will vary with the type of power amplifier used, as follows: 15 watt (Fig. 1), +50 volts; 30 watt (Fig. 2), zero volts; 50 watt (Fig. 3), +65 volts.

PERFORMANCE SPECIFICATION

Sensitivity: 0.5 volt rms for output of 1.25 volts with controls set for flat response.

Control: +16db bass and treble boost, –16db bass and treble cut.

PARTS LIST

C1: 20 μf, 450 volts
C2: 0.047 μf
C3: 20 μf, 450 volts
C4: 0.1 μf
C5: 0.22 μf
C6: 0.0022 μf
C7: 0.022 μf
C8: 220 μμf
C9: 0.0022 μf
R1: 0.47 megohm
R2: 1500 ohms
R3: 15000 ohms
R4: 22000 ohms
R5: 0.1 megohm
R6: 1000 ohms
R7: 15000 ohms
R8: 0.1 megohm
R9: Bass-Control Potentiometer, 1 megohm
R10: 10000 ohms
R11: 0.1 megohm
R12: Treble-Control Potentiometer, 1 megohm

NOTE

All resistors — 0.5 watt, ±10%, unless otherwise specified.
All capacitors — 400 volts, unless otherwise specified.

The Audio Manufacturer's Group of the British Radio Electrical Manufacturer's Association has issued a Provisional Specification for Methods of Measuring and Expressing the Performance of Audio Frequency Amplifiers. At the time of going to press comments are being studied preparatory to the issue of a complete specification. It is hoped to have more to say of this in future issues.

PREAMPLIFIER FOR MAGNETIC PICKUP

(RIAA EQUALIZATION)

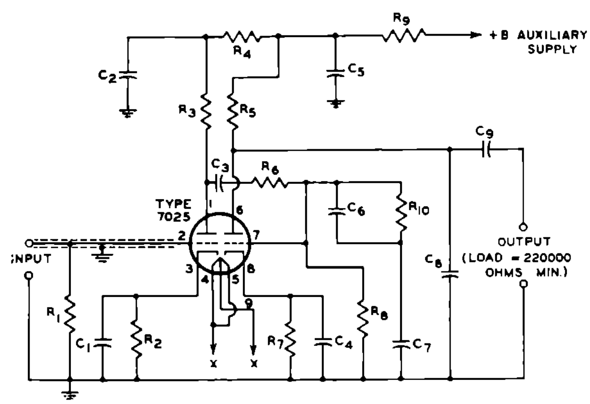


Fig. 5

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
7025	+195	0	+1.5	*	*	+210	0	+1.6	*

All voltages ±20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

* This voltage will vary with the type of power amplifier used, as follows: 15 watt (Fig. 1), +50 volts; 30 watt (Fig. 2), zero volts; 50 watt (Fig. 3), +65 volts.

PERFORMANCE SPECIFICATION

Sensitivity: 3 millivolts rms for output of 0.55 volt at frequency of 1000 cps.

PARTS LIST

C1: 25 μf, 25 volts
C2: 20 μf, 450 volts
C3: 0.1 μf
C4: 25 μf, 25 volts
C5: 20 μf, 450 volts
C6: 0.0035 μf
C7: 0.01 μf
C8: 180 $\mu\mu$f
C9: 0.22 μf
R1: Value depends on type of magnetic pickup used. Follow pickup manufacturer's recommendations.
R2: 2700 ohms
R3: 0.1 megohm
R4: 39000 ohms
R5: 0.1 megohm
R6: 0.47 megohm
R7: 2700 ohms
R8: 0.68 megohm
R9: 15000 ohms, 1 watt
R10: 22000 ohms

NOTE

All resistors 0.5 watt, ±10% unless otherwise specified.
All capacitors 400 volts, unless otherwise specified.

REMEMBER!

CLOSING DATE FOR 1961 SUBSCRIPTIONS IS DECEMBER 1st, 1960

PREAMPLIFIER FOR MAGNETIC PICKUP

(RIAA EQUALIZATION)

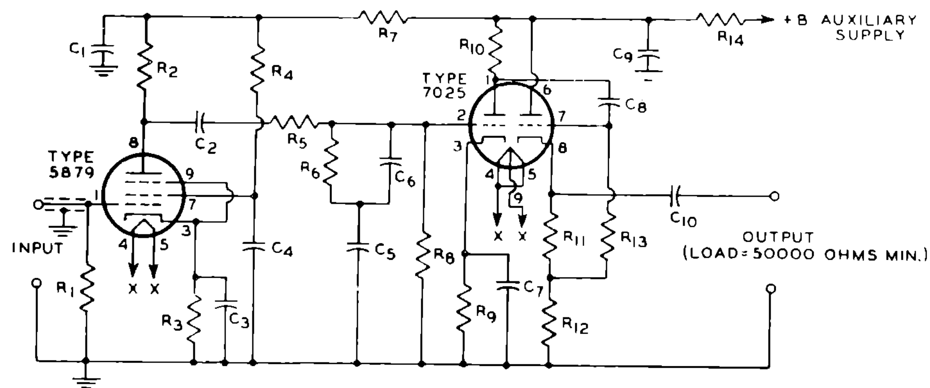


Fig. 6

PERFORMANCE SPECIFICATION

Sensitivity: 3 millivolts rms for output of 0.54 volt at 1000 cps.

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
5879	0	—	+1.8	*	*	—	+75	+95	+1.8
7025	+190	0	+1.3	*	*	+285	+17	+19	*

All voltages ±20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

* This voltage will vary with the type of power amplifier used, as follows: 15 watt (Fig. 1), +50 volts; 30 watt (Fig. 2), zero volts; 50 watt (Fig. 3), +65 volts.

PARTS LIST

C1: 40 μf, 450 volts
C2: 0.1 μf
C3: 25 μf, 25 volts
C4: 0.22 μf
C5: 0.02 μf
C6: 0.005 μf
C7: 25 μf, 25 volts
C8: 0.022 μf
C9: 40 μf, 450 volts
R1: Value depends on type of magnetic pickup used. Follow pickup manufacturer's recommendations.
R2: 100000 ohms
R3: 1000 ohms
R4, R5: 0.47 megohm
R6: 15000 ohms
R7: 22000 ohms
R8: 0.68 megohm
R9: 1500 ohms
R10: 100000 ohms
R11: 1500 ohms
R12: 15000 ohms
R13: 0.47 megohm
R14: 4700 ohms

NOTE

All resistors 0.5 watt, ±10%, unless otherwise specified.
All capacitors 400 volts, unless otherwise specified.

PREAMPLIFIER FOR TAPE HEAD

(NARTB EQUALIZATION)

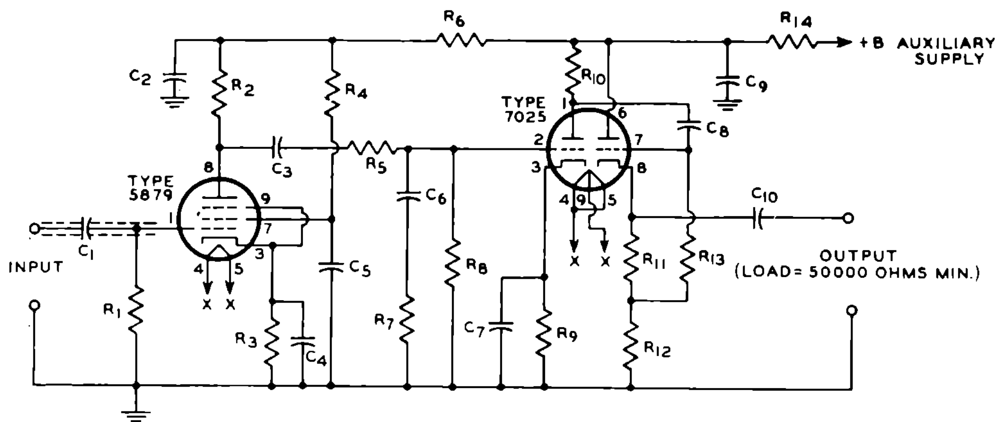


Fig. 7

PERFORMANCE SPECIFICATION

Sensitivity: 3 millivolts rms for output of 0.55 volts at 1000 cps.

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
5879	0	—	+1.8	*	*	—	+75	+95	+1.8
7025	+190	0	+1.3	*	*	+285	+17	+19	*

All voltages ±20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

* This voltage will vary with the type of power amplifier used, as follows: 15 watt (Fig. 1), +50 volts; 30 watt (Fig. 2), zero volts; 50 watt (Fig. 3), +65 volts.

NOTE

All resistors 0.5 watt, ±10%, unless otherwise specified.
All capacitors 400 volts, unless otherwise specified.

PARTS LIST

C1: 0.047 μf
C2: 40 μf, 450 volts
C3: 0.1 μf
C4: 25 μf, 25 volts
C5: 0.22 μf
C6: 0.015 μf
C7: 25 μf, 25 volts
C8: 0.022 μf
C9: 40 μf, 450 volts
C10: 0.47 μf
R1: 1 megohm
R2: 0.1 megohm
R3: 1000 ohms
R4: 0.47 megohm
R5: 0.22 megohm
R6: 22000 ohms
R7: 3300 ohms
R8: 3.3 megohms
R9: 1500 ohms
R10: 0.1 megohm
R11: 1500 ohms
R12: 15000 ohms
R13: 0.47 megohm
R14: 4700 ohms

PREAMPLIFIER FOR LOW-OUTPUT MICROPHONES

PERFORMANCE SPECIFICATION

Sensitivity: 3 millivolts rms for output of 220 millivolts

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
5879	0	—	+1.8	*	*	—	+78	+98	+1.8

All voltages ±20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

* This voltage will vary with the type of power amplifier used, as follows: 15 watt (Fig. 1), +50 volts; 30 watt (Fig. 2), zero volts; 50 watt (Fig. 3),

PARTS LIST

C1: 25 μf, 25 volts
C2: 0.047 μf

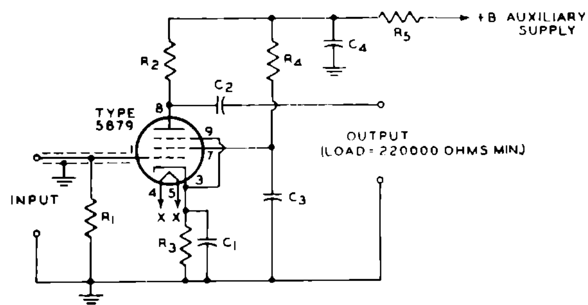


Fig. 8

C3: 0.22 μf
C4: 40 μf, 450 volts
R1: 2.2 megohms
R2: 0.1 megohm
R3: 1000 ohms
R4: 0.47 megohm
R5: 22000 ohms

NOTE

All resistors 0.5 watt, ±10%, unless otherwise specified.
All capacitors 400 volts, unless otherwise specified.

TWO-CHANNEL MIXER

PERFORMANCE SPECIFICATION

Sensitivity: 3 millivolts rms for output of 20 millivolts

PARTS LIST

C1: 0.1 μf
C2, C3: 47 μμf
C4: 25 μf, 25 volts
C5: 0.1 μf
C6: 20 μf, 450 volts
R1: Value depends on output load required for previous stage or type of input device. Should not exceed 2.2 megohms.
R2: 0.47 megohm
R3: Volume Control Potentiometer, 0.5 megohm
R4: 0.1 megohm
R5: 1000 ohms
R6: 0.47 megohm
R7: Same as R3
R8: 0.1 megohm
R9: Same as R1
R10: 22000 ohms

NOTE

All resistors 0.5 watt, ±10%, unless otherwise specified.
All capacitors 400 volts, unless otherwise specified.

DC VOLTAGE MEASUREMENT CHART

TYPE	PIN NUMBER								
	1	2	3	4	5	6	7	8	9
7025	+185	0	+1.5	*	*	+185	0	+1.5	*

All voltages ±20% measured from pin to ground with no signal input, using AWA Voltohmyst or similar instrument.

* This voltage will vary with the type of power amplifier used, as follows: 15 watt (Fig. 1), +50 volts; 30 watt (Fig. 2), zero volts; 50 watt (Fig. 3), +65 volts.

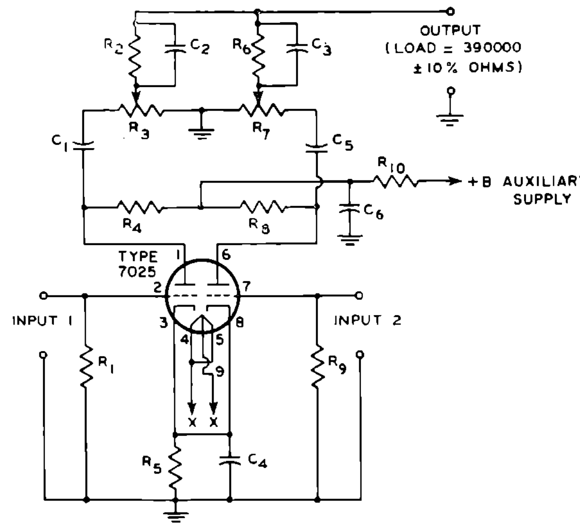


Fig. 9

STEREO BALANCE UNIT

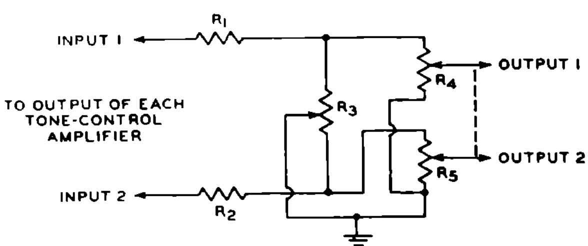


Fig. 10

PARTS LIST

R1, R2: 0.1 megohm
R3: Balance - Control Potentiometer, 0.5 megohm, linear taper.
R4, R5: Volume-Control Potentiometers, ganged, 1 megohm, audio taper.

NOTE

All resistors 0.5 watt, ±10%.

ADJUSTMENT OF THE STEREO BALANCING UNIT

For proper operation of a stereo system, the output levels of the two channels should be equal. A typical method for balancing the two channels follows:—

1. Connect the output of a monaural signal source, such as an audio signal generator or a test record, to both the right and left channel inputs. Use a frequency of 1000 cps as a test frequency.
2. Set the ganged volume-control potentiometers (R4 and R5) to provide a comfortable listening level.
3. Measure the ac voltage developed across the voice coil of the speaker in each channel, with a VTVM.
4. Adjust the balance-control potentiometer (R3) so that the voltages across both voice coils are equal.

(With acknowledgements to RCA)

AWV