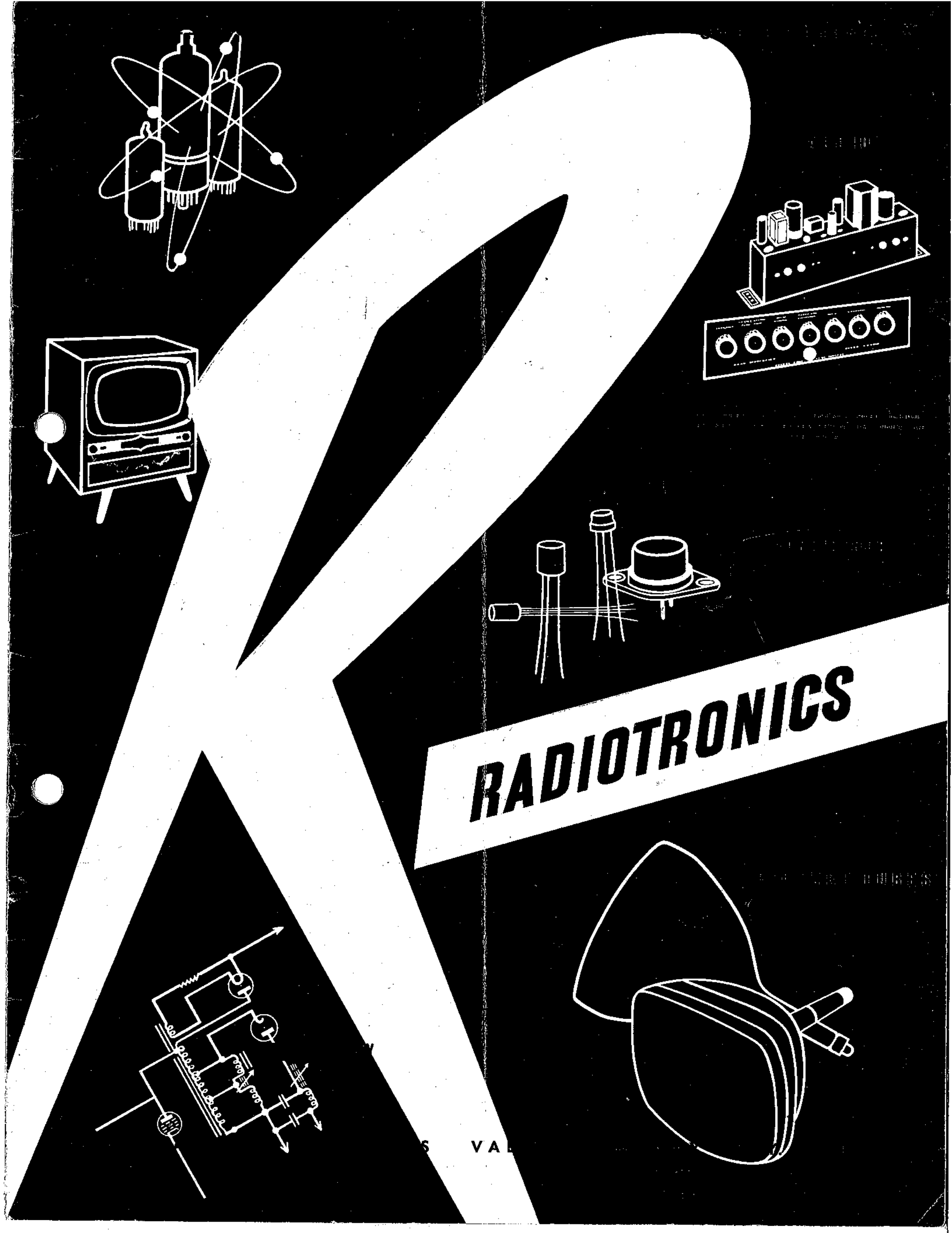
RADIOTRONICS

IN THIS ISSUE

EDITOR ...... **BERNARD J. SIMPSON**

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HIGH FIDELITY

PART 2
ACOUSTICS

INTRODUCTION

High fidelity or high quality sound systems are seldom listened to except indoors. Immediately the problem of transmission and reflection of sound arises. In all cases it is hoped to approach the ultimate, which is to have the sound reaching the ear from the loud-speaker system as near as possible in quality to that obtained from the original sound source. Acoustics is defined as "The Science of Sound" or, architectural conditions affecting the hearing of sounds throughout a room or hall.

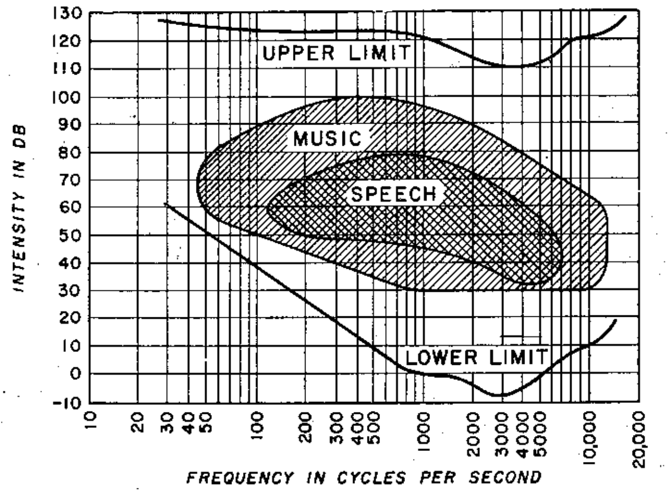


Fig. 9. Frequency and Intensity Ranges — Live Performance.

FREQUENCY AND INTENSITY RANGES OF SOUND

The sound created by a full orchestra in a large auditorium is much greater than could be comfortably listened to in the normal living room or den of the average home. An apartment dweller would not be at all sympathetic to a neighbor listening to a program at such volume levels. As has been previously mentioned, the ear is far from flat in response, and varies at different frequencies and volume levels. Figure 9 shows a comparison between music and speech frequency levels. It can be readily seen that music covers a much wider range of frequency and volume than does speech. The top and bottom hearing limit curves have also been included from the ear response curves discussed earlier (figure 7) in order to show how they enter the picture. When music is played at its average level the shaded areas representing the music and speech fall between the upper limit and lower limit curves, which shows that the ear of the average person would hear all frequencies if listening to the orchestra as it plays. As the music is recorded, naturally, all frequencies will be recorded on the tape and/or disc. If the tape or disc is played back at a level comparable to the original orchestra, all frequencies will be heard from the speaker by the average person. Now suppose the volume of the player is turned to a low level of intensity. What this actually does is to shift the shaded areas on the curve down to a lower average intensity level. As this occurs, it can be seen that certain portions of the shaded area fall outside and below the lower hearing limit, which means that a person will no longer hear those frequencies at the levels indicated. Therefore, the sound will no longer sound as it did when performed by the orchestra and heard directly. It can be seen in figure 10 that the bass will be attenuated much more than the high frequencies and the sound from the speaker will tend to be squeaky. In the modern high fidelity instrument, a certain amount of compensation can be included to improve this condition. This is accomplished by the use of a loudness control rather than a volume control. A loudness control is a modified volume con-

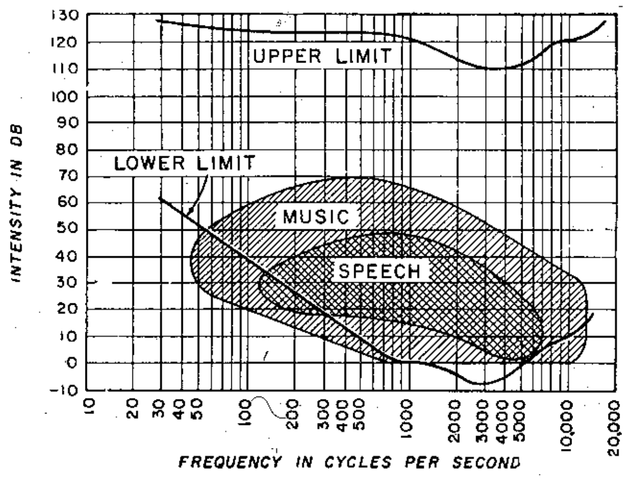


Fig. 10. Frequency and Intensity Ranges — Reproduction.

trol in which a calculated amount of tone control is inserted, so that a certain amount of high frequency attenuation is used to remove the squeakiness and the music will still appear balanced. This is not a cure-all. It can be done only within certain limits, since eventually the ear response will attenuate the lows so much, that as additional tone control is inserted, practically nothing will be left. Loudness control operation will be discussed later.

RELATIVE INTENSITIES OF SOUNDS AND NOISES

The definition of sound intensity is "the energy per second passing through a unit area of a progressive sound wave". It is proportional to the square of the amplitude of the vibrating particle. Loudness is the magnitude of the subjective response to the intensity of a sound. Therefore, there is no absolute loudness of a sound but only a difference in ratio between two sounds. As shown by the ear response curves, the sensation of loudness depends upon both the intensity and the frequency of the sound. Figure 11 shows graphically, both by physical sound intensity ratios and by decibels above the threshold of audibility, the relative intensities of different sounds and noises. It is interesting to note that the softest orchestral sounds are less in intensity than the room noise in the average city apartment.

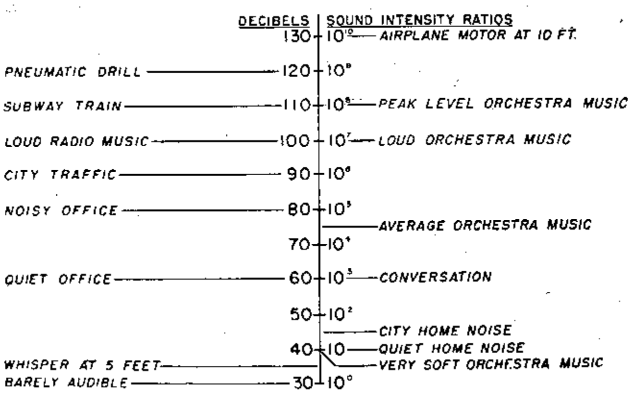


Fig. 11. Relative Intensities of Sound.

Also, the loudest orchestral intensities would be extremely objectionable to all in the neighborhood, if a record or radio were played at those levels in an average home. This plainly indicates why compensation is necessary (both in volume level, and because of that, in the volume control circuitry) when listening to music with any reproducing instrument.

From the previous discussion it can be seen that the response limits to the ear are somewhat wider than needed for the perception of most normal sounds. A critical listener can detect a change of one decibel in amplitude (in the mid-range between 100 cycles and 2000 cycles) and a change of three or four cycles per second in frequency. The average listener can invariably detect a change in amplitude of three decibels. One fact which is not shown by the previous curves, is that the ear and brain are able to localize the source of the sound with reasonable accuracy, by comparing the difference in intensity and the phase of the sound at the two ears.

The ear is also capable of detecting distortions of numerous kinds, which appear in very small amplitudes. The subject of distortion will be discussed later.

Because of these characteristics of the ear, it is important that a high-fidelity instrument be properly located in the listening area, and the treatment of this area is such that reverberation and reflections are controlled.

Even before starting to install a high-fidelity reproducing system, consideration should be given to the acoustics of the listening room. There are three major factors that affect the acoustics of a room. First, the size, second, acoustical quality (reflecting and absorbing characteristics), and third, the noise level of the area itself.

The size of a room largely determines the reverberation period. The room is actually an acoustic resonant cavity of fairly large dimensions, with many resonant frequencies. At frequencies of resonance, the sound is over-accentuated, while at other frequencies, the sound may be suppressed. The distance between two parallel walls will govern the amount of flutter and the frequency of the flutter. Flutter is the bouncing back and forth of sound between two parallel walls until it is attenuated to a point which is no longer objectionable.

REVERBERATION

The acoustical quality of a room is governed largely by the treatment of the walls, the finish of the walls, drapes, chairs, etc. For the best sound, the spatial pattern should be as diffused as possible at all frequencies, with no standing wave patterns and no point of excessive wave concentration. The amount of diffusion can be controlled by using the proper absorbing material, furniture, etc. Diffusion can also be obtained by the adding of irregularities to the walls. This will include such things as pictures, bric-a-brac, lamps, etc. The definition of reverberation is "re-echoed sound". In other words sound waves reach the listener through both direct and reflected paths as shown in figure 12. The sound intensity at the ear will build up, and at first only the sound following the direct path will be heard, then the sounds following longer and longer reflection paths will add to it.

After the sound stops at its source, the reflections still continue for a length of time dependent upon their path length. The speed of sound is 1056 feet per second, remember. The length of time between the stopping of sound at its source, and the stopping of the reflected sound is called the reverberation period.

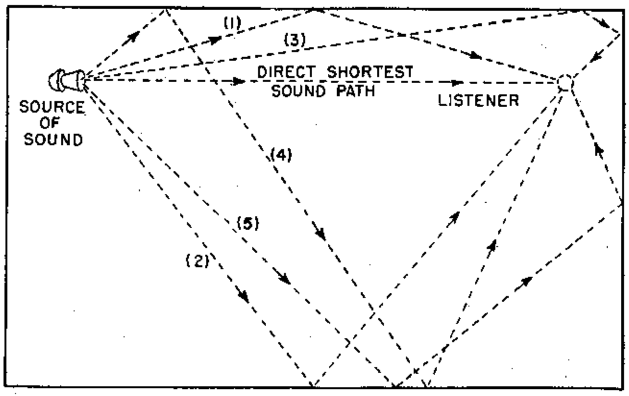


Fig. 12. Reverberation.

Another important factor in sound reproduction is the noise level of the listening room. This noise level must be minimized as much as possible, or until the noise level is not objectionable. Noise created by running equipment causing mechanical vibrations, must be stopped or greatly reduced. Sometimes this is a major problem. Electrical noise is often a still greater problem, as it can be carried along the power lines for some distance and radiate interference at various places along the way. If it is limited to the power line, a good line filter will usually clear the difficulty but if the electrical noise is the result of radiation it must be corrected at the source of interference.

Because of the foregoing considerations, the placement of the speaker system in a room is of the utmost importance. It is usually

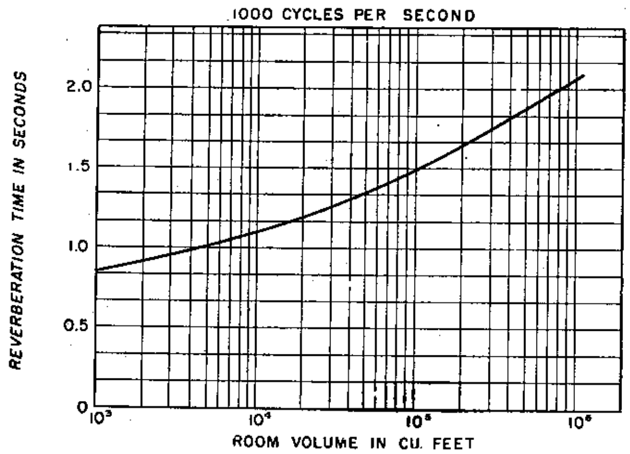


Fig. 13. Optimum Reverberation Time at 1,000 c/s.

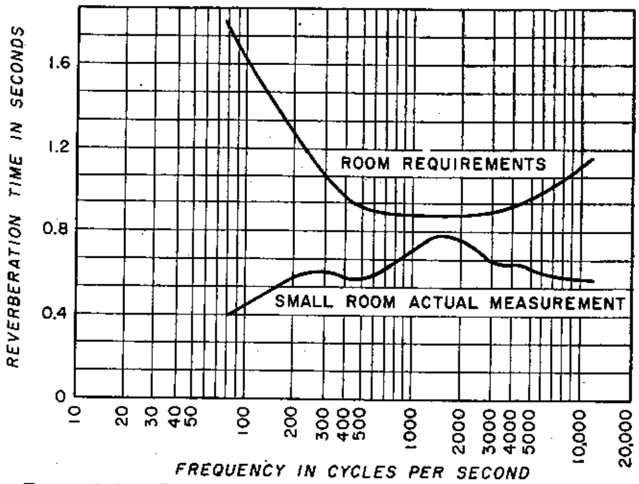


Fig. 14. Optimum Reverberation Time — Musical Reproduction.

easier to obtain good results by facing the speakers lengthways in the room, so that the wall towards which the speaker is projecting sound is as far away as possible.

The side walls of the room should be constructed of a material which does not reflect sound too readily, or be draped to a point where the reverberation is satisfactory. If overdone, that is by draping all walls, the room may be too "dead". The floor should be covered with a fairly thick rug to control the reflection between the floor and ceiling. Room resonances can usually be controlled by correct positioning of furniture to add diffusion where needed.

REVERBERATION TIMES

Over a period of years, listening tests have been made in all kinds and sizes of rooms. Figure 13 shows the reverberation time which has been found to be optimum in rooms of various sizes for a frequency of 1000 cycles per second.

OPTIMUM REVERBERATION TIME

The reverberation times for reproduced music should be less than for the same music if live, as the reproduced music already includes reverberation from the recording studio. Actually the reverberation time varies with frequency. At 100 cycles per second, shown in figure 14 at the top, it is almost twice that for 1000 cycles. At 5000 cycles, it is just slightly greater than 1000 cycles per second.

The bottom of figure 14 shows that for small rooms, much more reverberation is needed at the low frequencies than is available. Actually, this lack of reverberation (low frequency) has the effect of causing the sound in a small room to be deficient in bass. As reverberation also adds color, bass boost is not the complete solution to this problem. A good speaker system, a carefully chosen amount of bass boost, careful location of the instrument and furniture can help in overcoming this problem.

A NOVICE TRANSMITTER USING RADIOTRON 6146

This Clean-Cut Unit Employs Conventional Circuits and a Number of Features which will appeal to the Newly-Licensed, General-Class Operator

By F. S. Barkalow, W2BVS.
(RCA Tube Dept., Harrison, N.J.).

CQ WN

Every serious-minded, dyed-in-the-wool Novice will profit greatly by reading W2BVS' article. It was written for the Novice by an ex-Novice after much consultation with the many old-timers at RCA.

The rig with the "commercial" appearance is simply the result of applying a Novice's enthusiasm and ingenuity plus the old-timers' advice to a straightforward circuit. This transmitter was designed expressly for the Novice who is even now planning his future ham station. The design satisfies all of the present requirements of a good Novice transmitter, and already incorporates many of those inevitable changes and additions which usually result in the construction of a new rig.

GENERAL DESCRIPTION

The transmitter shown in Fig. 1 is an r-f unit, complete with power supply, for CW operation on 80, 40, and 20 metres. As shown in the schematic diagram Fig. 6, the valve line-up starts with a crystal controlled pentode oscillator using a 6V6-GT. This stage is coupled to a 6146 beam power final amplifier. This transmitter employs a common power supply for both the oscillator and the final, and features regulation of the oscillator plate voltage.

Another feature of general appeal is a tune-operate switch which increases the cathode resistance in the final amplifier during the initial tuning, thereby protecting the valve from accidental overloading. Also of interest is the use of a cathode-current (total valve current) milliammeter in the final; in the key-up position, this meter indicates grid drive directly. Keying is accomplished by means of

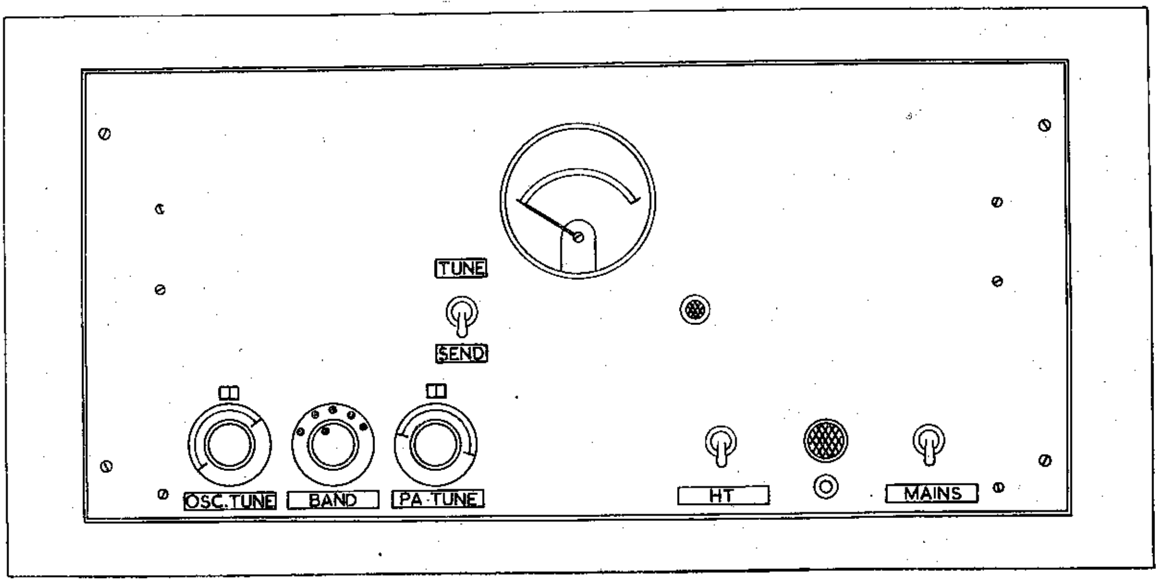


Fig. 1. Front panel layout of the novice transmitter.

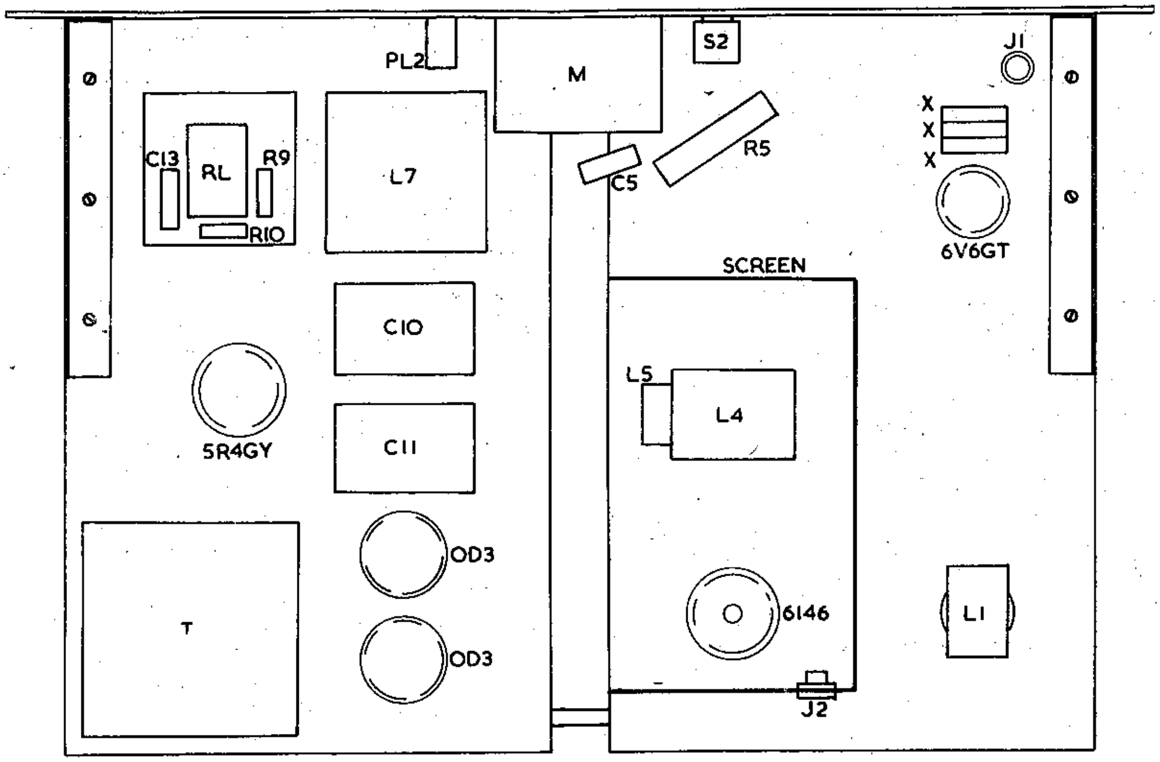


Fig. 2. Top of chassis layout. Although the use of voltage regulator valves in the power supply is highly recommended, they may be omitted if the beginner so desires; an alternative voltage divider network is described in the text.

a keying relay in the B+ lead of the 6146 final. For simplicity and low cost, plug-in coils and a crystal oscillator are employed. Frequency shifting is accomplished by means of crystal switching; however, a coaxial connector is provided for connection to an external VFO.

The power supply shown in Figures 2, 4 and 6 delivers 600 volts d.c., at currents up to 200 mA. A conventional circuit is employed except for the inclusion of a pair of OD3's to regulate the plate voltage for the oscillator valve.

The two voltage-regulator valves in series with variable resistor R13 are connected from B+ to ground to provide the 300 V. regulated source of plate voltage for the oscillator valve. If an unregulated source is desired, a resistive voltage divider may be substituted for the regulator valves and resistors R12 and R13 as shown in the schematic diagram. Note the addition of filter capacitor C12 at the junction of R8 and R11.

Resistor R12 discharges filter capacitors C1 and C2 when the power is turned off. The jumper in each of the regulator valves (be-

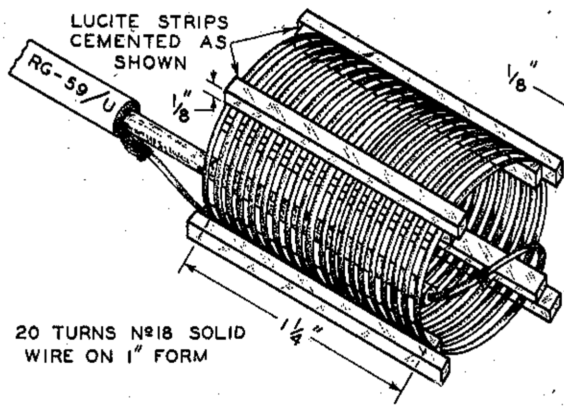


Fig. 3. Recommended method of connecting the coaxial transmission line to the antenna link. The additional Lucite or Perspex strips keep the link from touching the tank coil.

tween pins 3 and 7) is wired in series with the primary of the power transformer so that the transmitter cannot be operated if these valves are removed. Switch S4 opens the ground connection to the centre-tap of the high-voltage winding during stand-by periods. Indicator lamp PL2 will glow when S4 is closed.

Energizing voltage for the keying-relay coil (RL) is obtained from a 6.3 V. winding of the power transformer. This separate winding was used merely because it was available; the relay coil can be connected to the heater winding if a transformer having one heater winding is employed. The relay contact breaks the 600 V. d.c. B+ line to the final amplifier valve.

Capacitor C13 and resistors R9 and R10, mounted at the relay contacts, comprise a key-click filter. A metal cover (not shown in Fig. 2) shields the relay and keeps the contacts dust-free. This filtering and shielding plus the use of the external a.c. line filter (shown in Fig. 6) are worthwhile precautions to prevent TVI.

CONSTRUCTIONAL DETAILS

The r-f unit and the power supply are built on separate 3 by 8 by 12-inch chassis. These chassis are attached to a standard 8¾-inch relay-rack panel. A single 3 by 12 by 17-inch chassis can be used instead of the two smaller chassis; however, the adjacent sides of these two chassis form a centre partition which enables convenient mounting of the 6146 tank capacitor, shield, and bleeder resistors R12 and R13. This arrangement also enables the builder to construct either one or both of the units, depending upon whether or not a suitable power supply is available.

From left to right on the front panel (Fig. 1) are shown the oscillator tank tuning control C2, the crystal-selector switch S1, the final amplifier plate tuning capacitor C7, the plate-voltage switch S4, power-on indicator lamp PL1 (under which is located the key jack) and on the extreme right, the power-supply on-off switch. The tune-operate switch S2 is located above the final amplifier plate tuning control. To the right of S2, and above the plate-voltage switch, is located the plate-voltage indicator lamp PL2. The milliammeter located in the centre of the front panel indicates cathode current of the final amplifier.

All of the major components are shown and identified in the layout diagrams; the layout of parts was planned to permit simple wiring with short, direct leads. A common tie point should be used for all grounds in each stage. This practice, although not absolutely necessary for 80 metre operation, is recommended if this transmitter will be used for operation at higher frequencies.

The oscillator plate-tank capacitor and the r-f amplifier plate-tank capacitor are spaced from the chassis and supported by ceramic insulators because the stator and rotor of each capacitor is above ground potential by the B+ voltage. Fibre shafts and flexible couplings are employed to keep these potentials from existing at the tuning knobs.

The r-f amplifier plate-tank circuit is completely shielded from the grid circuit, both above and below the chassis, by two aluminium shields bent as shown in the diagrams, Figures 2 and 5. The base sleeve of the 6146 shields the input to the valve and isolates it from the output circuit. Pin 8, which is connected to the sleeve, must be grounded. Coupling the antenna to the final amplifier is accomplished by inserting a link L5, into the cold (B+) end of tank coil L4. This link is connected by means of a short piece of RG-59/U coaxial cable to the antenna connector J2 mounted on the shield which surrounds the final amplifier valve and coil.

A piece of ¾-inch sound-absorbing material is placed between the relay and the chassis to deaden the sound of the relay armature. A metal cover for the relay should be provided for the reasons given under "General Description". Check the inside dimensions of the cover to make certain that there is sufficient spacing to clear all parts of the relay.

ADJUSTMENT AND TUNING

Power Supply. Carefully check the power supply to make certain that it has been correctly wired and adjusted **before connecting it to the transmitter.** The only adjustment in the power supply will be the setting of the slider on resistor R13. (ALWAYS REMOVE THE LINE CORD FROM THE AC POWER SOURCE BEFORE ANY ADJUSTMENTS ARE MADE IN THE POWER SUPPLY). This adjustment can be made as follows: Insert a milliammeter between pin 2 of the lower regulator valve (Fig. 6) and ground, and adjust the slider for a current of 40 mA. Caution should be observed when the adjustable slider on this resistor is moved. Resistors of this type are wound with very fine wire which can be easily damaged by the slider contact. **Before attempting to move the slider from one point to another along the bleeder, loosen the slider set-screw and rotate the slider so that the contact moves on the vitreous enamel coating and not on the wires.** After this adjustment is completed, reconnect pin 2 of the regulator valve to ground.

Once the slider is set for this current of 40 mA, the oscillator plate voltage will be regulated at 300 V.; this regulation will be maintained provided that the current drawn by the oscillator plate valve does not exceed 35 mA. Under normal operating conditions, a purple glow is visible in the regulator valves; however, if the load current exceeds 35 mA, the glow will cease, thereby indicating a loss of regulation (this condition will occur if the 6V6-GT stops oscillating).

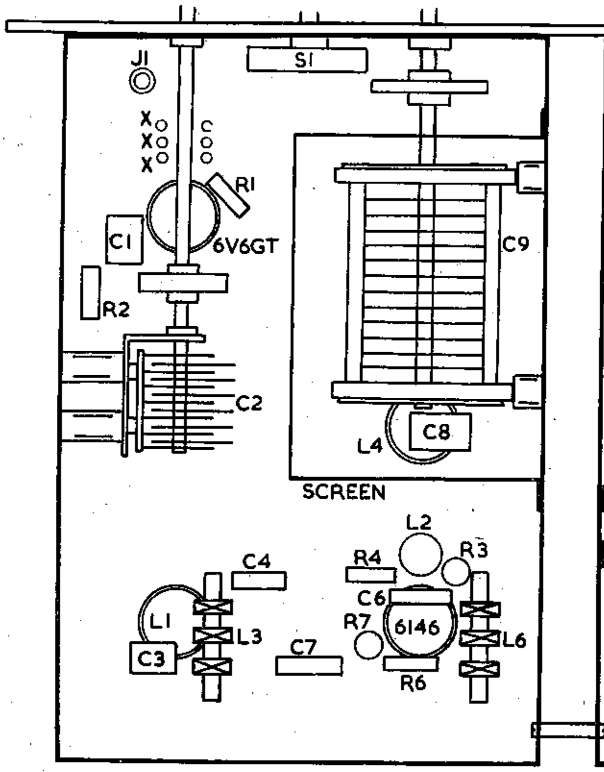


Fig. 5. Underchassis view of the r-f chassis. The coupling capacitor C4 is mounted edge-on to the chassis to minimise stray capacitance and avoid a waste of driving power.

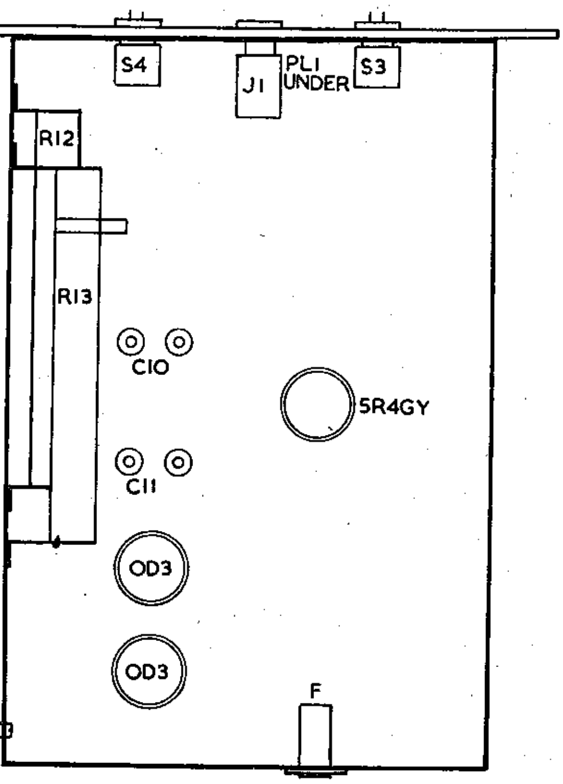


Fig. 4. Underchassis layout of the power supply.

Oscillator. Insert the 80 metre coils and a crystal for the 80 metre band. Before applying the power, make certain that the plate-voltage switch, S4, is opened. Turn on the supply and allow sufficient time for the heaters to warm up. Then apply plate voltage to the oscillator by closing the plate-voltage switch. With the key up, oscillation should take place as capacitor C2 is varied; oscillation will be evidenced by a small indication on the meter. The meter indicates grid current of the 6146 (approximately 3 mA) when the key is in the up position.* A ¼-watt neon lamp held near the oscillator plate coil will glow as a further indication of oscillation.

While capacitor C2 is varied, note that the grid current of the 6146 rises gradually until a peak is reached and then it cuts off suddenly and oscillation ceases. The correct setting of C2 is a point just before the peak is reached.

Final. When the tank circuit of an r-f amplifier valve is tuned off resonance, the plate current increases. Because the off-resonance plate current of the 6146 will be quite excessive, care must be observed in order to prevent damage to the valve and/or the meter.

To prevent damage to the 6146 and the meter while locating the resonant setting of ~~C8,~~ C.9 a tune-operate switch S2, is incorporated in the circuit. In the "TUNING" position of S2, a fairly high resistance (R4) is placed in series with the cathode resistor of the 6146 to limit the plate current to a safe value. With S2 in the "TUNING" position and with the antenna disconnected from link L5, the tank capacitor should be tuned for resonance.

After the resonant setting has been found, throw S2 to the "SEND" position to short out resistor R4; connect the antenna to the loosely coupled variable link L5. The tank capacitor ~~C7~~ C.9 should be readjusted for resonance. Check the 6146 plate current for this amount of antenna loading. The loading can be increased by moving the link further into the tank coil and retuning for resonance. (DO NOT ATTEMPT TO ADJUST THE LINK WITH THE POWER ON.) With 600 V. on the plate of the 6146, the loading can be increased up to a maximum plate current of 150 mA.† for an input of 90W. **Since the meter indicates**

* The meter indicates 6146 cathode current (total valve current) when the key is pressed.

† ICAS, Class C Telegraphy.

cathode current, it is necessary to subtract the control and screen-grid currents from the meter reading to obtain the plate-current value for a determination of the power input to the 6146. At the maximum input of 90 W. the screen current will be approximately 15 mA. with a recommended grid-No. 1 current of 3 mA.

Operation on 40 metres is possible with either a 40- or 80-metre crystal and a 40-metre oscillator tank coil. If an 80-metre crystal is used, the 6V6-GT functions as an oscillator-doubler. Similarly, 20-metre excitation for the 6146 is obtained by using a 40-metre crystal and tuning the plate circuit of the "oscillator" to 20 metres. The 6146 operates straight through on 80, 40, and 20.

It is desirable to have some means for the checking of the oscillator and final tank circuits to make certain that they are tuned to the desired bands rather than to harmonics. Either an absorption-type wavemeter or a grid-dip meter may be used for this purpose. It is well for the novice to remember that crystal control does not ensure the operator against outside-the-band operation. After making certain that C2-L1 and ~~C8~~ C.9-L4 are tuned to the desired bands, a wavemeter or a receiver should be used to check the output of the transmitter to determine whether harmonics are present.

TVI

This transmitter was operated on 80 metres with a half-wave doublet antenna fed with RG-59/U coaxial cable. Operation of the transmitter without the cabinet resulted in serious TVI on all channels on a set located 300 feet from the transmitter. Placing the transmitter in metal cabinet eliminated TVI completely. As a check a TV set was operated at a distance of four feet from the transmitter (with an indoor folded dipole); it was impossible to find any trace of TVI. Additional TVI precautions (such as the use of lead filters, a low-pass filter, cabinet alterations, etc.) may be necessary when this transmitter is operated on 40 or 20 metres.

Key clicks which were heard in both a receiver and a record player were eliminated by building a filter (see Fig. 6) and inserting it between the power supply line cord and the a.c. outlet.

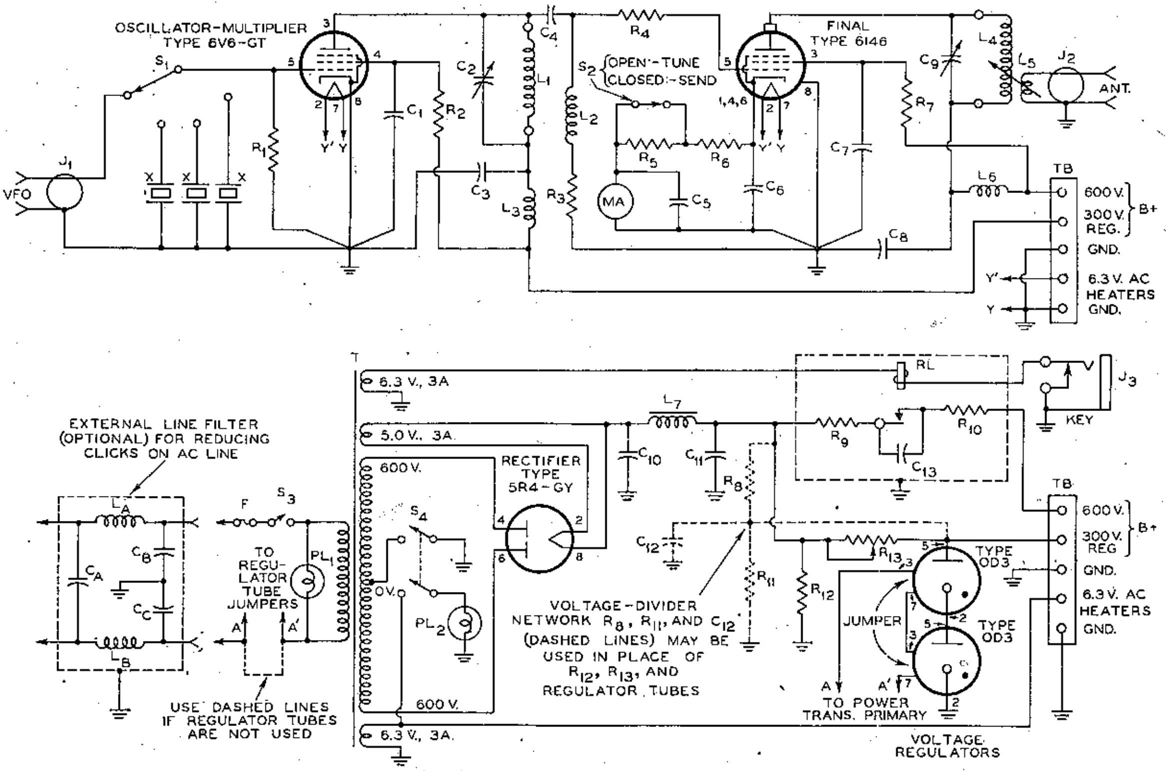


Fig. 6. Schematic diagram of the transmitter.

PARTS LIST

C1, C3, C5, C6: 0.005 μF, mica, 500 V.
C2: 100 μμF, variable, 1KV pk.
C4: 50 μμF, mica, 500 V.
C7, C8: 0.005 μF, mica, 1500 V.
C9: 150 μμF, variable, 3KV pk.
C10, C11: 4 μF, oil-filled, 1KVW.
C12*: 8 μF, electrolytic, 600 VW.
C13: 0.002 μF, mica, 1.5 KV.

R1, R2: 50 K-ohms, 1 W.
R3: 47 K-ohms, 2 W.
R4: 50 ohms, 1 W
R5: 750 ohms, 25 W.
R6: 50 ohms, 2 W.
R7: 25 K-ohms, 10 W.
R8*: 7.5 K-ohms, 50 W.
R9, R10: 50 ohms, 1 W.
R11*: 30 K-ohms, 50 W.
R12: 25 K-ohms, 75 W.
R13: 10 K-ohms, variable, 75 W.
L1: Oscillator plate coil see below.

L2, L3, L6: R-f choke, 2.5 mH.
L4: Final tank coil, see below.
L5: Link coil, see below.
L7: Filter choke, 6 H. at 200 mA.

M: Meter, 0-200 mA. F.S.D.

T: Mains transformer, 600-0-600 V., 200 mA.; 5V., 3A.; 6.3 V., 3 A.; 6.3 V., 3A.

*Components for alternative voltage divider.

WINDING DATA FOR COILS

The oscillator plate coil L1 and the PA tank coil L4 are plug-in type coils, and a separate set of coils is required for each of the bands to be covered. The dimensions of the coils will depend on the type of former chosen, and these notes are intended only as a guide to what is required. Some adjustment to the number of turns may be required to obtain the best results, and it may be advisable to wind slightly more turns than required, and then strip them off experimentally until the desired results are obtained.

OSCILLATOR PLATE COIL L1

A former approximately 1⅞" diameter is suggested for these coils, wound as follows. For the 80-metre coil, 36 turns of No. 22 d.s.c. wire close wound. For the 40-metre and 20-metre coils, 16 turns and 8 turns respectively of No. 18 t.c. wire wound to 2" long. The 40 and 20 metre coils may be made self-supporting. The number of turns should be increased approximately 5-10% if a 1" diameter former is used. If a smaller former still is used, the number of turns required will increase appreciably, approximately doubling the figures given for a ½" diameter former. To preserve a satisfactory L/C ratio in this circuit, the 80-metre coil should resonate with C2 approximately ¾ meshed, the 40-metre coil with the capacitor approximately ½ meshed, and the 20-metre coil with the capacitor approximately ¼ meshed.

PA TANK COIL L4

It is suggested that these coils be made self-supporting, with lucite strips cemented along the outside to keep the coil rigid, similar to the method used for L5. (See Fig. 3). Remember that L5 is required to be a sliding fit in L4. The difference in diameters may be made up by adjusting the height of the insulating strips cemented to the outside of L5. It is suggested that the L4 coils be wound on a 1½" inside diameter, as follows: For the 80-metre coil, 32 turns of No. 18 t.c. wire, 1⅜" long. For the 40-metre coil, 18 turns of No. 18 t.c. wire, 1¾" long, and for the 20-metre coil, 12 turns of No. 18 t.c. wire, 2" long.

LINK COIL L5

The construction of this coil is shown in Fig. 3. See also the remarks on this coil under L4 above.

ACKNOWLEDGEMENT

This article is reprinted with acknowledgement to RCA. The information on coil winding and Figs. 1, 2, 4 and 5 have been specially prepared for your assistance by the staff of Radiotronics.

See Notes on P.120 about application of 6146.

RADIOTRON 7027

BEAM POWER VALVE

FOR HIGH FIDELITY

AUDIO APPLICATIONS

Radiotron 7027 is a high-perveance beam power valve of the glass-octal type designed specifically for use in push-pull power amplifier circuits of high-fidelity audio equipment.

Featuring high power sensitivity and high stability, the 7027 is capable of delivering high power output at low distortion. For example, in push-pull Class AB_1 audio service, two 7027's operating with a plate voltage of 450 V., grid-No. 2 voltage of 350 V., and fixed grid-No. 1 voltage of –30 V., can deliver a maximum-signal power output of 50 W. with total harmonic distortion of only 1.5%.

In a push-pull class AB_1 circuit with grid-No. 2 feedback connection on the plate winding of the output transformer, it is possible to obtain a substantially lower ac-output terminal impedance with resultant higher damping factor than can be obtained with conventional pentode operation, and to maintain more constant power output with very low distortion over a wide range of load-impedance variations. For example, in such a circuit, two 7027's operating from a plate supply voltage of 410 V. and with a cathode-bias resistor of 220 ohms can deliver a maximum-signal power output of 24 W. with a total harmonic distortion of only 1.6%.

ELECTRICAL DATA:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts.
Current	0.9	amp.

CHARACTERISTICS, CLASS A_1 AMPLIFIER:

Plate Voltage	250	volts.
Grid-No. 2 (Screen-Grid) Voltage	250	volts.
Grid-No. 1 (Control-Grid) Voltage	–14	volts.
Plate Resistance (Approx.)	22500	ohms.
Transconductance	6000	μmhos.
Plate Current	72	mA.
Grid-No 2 Current	5	mA.

PUSH-PULL A-F POWER AMPLIFIER — CLASS AB_1

Pentode Connection

MAXIMUM RATINGS, Design-Centre Values:

PLATE VOLTAGE	450	max.	volts.
GRID-NO. 2 (SCREEN GRID) VOLTAGE	400	max.	volts.
CATHODE CURRENT:			
D.C.	110	max.	mA.
Peak	400	max.	mA.
PLATE DISSIPATION	25	max.	watts.
GRID-NO. 2 INPUT	3.5	max.	watts.
PEAK HEATER — CATHODE VOLTAGE:			
Heater negative with respect to cathode	200	max.	volts.
Heater positive with respect to cathode	200Δ	max.	volts

TYPICAL OPERATION WITH FIXED BIAS:

Values are for 2 valves.

Plate Voltage	330	400	450	volts.
Grid-No. 2 Voltage	330	300	350	volts.
Grid-No. 1 (Control Grid) Voltage°	–24	–25	–30	volts
Peak A-F Grid-No. 1 to Grid-No. 1 Voltage	48	50	60	volts
Zero-signal Plate Current	122	102	95	mA.
Max.-signal Plate Current	184	152	194	mA.
Zero-signal Grid-No. 2 Current	5.6	6	3.4	mA.
Max.-signal Grid-No. 2 Current	18.5	17	19.2	mA.
Effective Load Resistance (Plate to plate)	4500	6600	6000	ohms.
Total Harmonic Distortion	1	2	1.5	%
Max-signal Power Output	31.5	34	50	watts.

TYPICAL OPERATION WITH CATHODE BIAS:

Values are for 2 valves.

Plate-Supply Voltage	400	380	volts.
Grid-No. 2 Supply Voltage	300	380	volts
Cathode-Bias Resistor	200	180	ohms.
Peak A-F Grid-No. 1 to Grid-No. 1 Voltage	57	68.5	volts.
Zero-signal Plate Current	112	138	mA.
Max.-signal Plate Current	128	170	mA.
Zero-signal Grid-No. 2 Current	7	5.6	mA.
Max.-signal Grid-No. 2 Current	16	20	mA.
Effective Load Resistance (Plate to Plate)	6600	4500	ohms.
Total Harmonic Distortion	2	3.5	%
Max.-signal Power Output	32	36	watts.

MAXIMUM CIRCUIT VALUES°:

Grid-No. 1—Circuit Resistance:			
For fixed-bias operation	0.1	max.	megohm.
For cathode-bias operation	0.5	max.	megohm.

PUSH-PULL A-F POWER AMPLIFIER — CLASS AB_1

Grid No. 2 of Each Valve Connected to Tap on Plate Winding of Output Transformer

MAXIMUM RATINGS, Design-Centre Values:

PLATE AND GRID-NO. 2 (SCREEN GRID) SUPPLY VOLTAGE	450	max.	volts.
CATHODE CURRENT:			
D.C.	110	max.	mA.
Peak	400	max.	mA.
PLATE DISSIPATION	25	max.	watts.
GRID-NO. 2 INPUT	3	max.	watts.
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	200	max.	volts.
Heater positive with respect to cathode	200Δ	max.	volts.

TYPICAL OPERATION:

Values are for 2 valves.

Plate-Supply Voltage	410	volts.
Grid-No. 2 Supply Voltage	*	volts.
Cathode-Bias Resistor	220	ohms.
Peak A-F Grid-No. 1 to Grid-No. 1 Voltage	68	volts.
Zero-signal Cathode Current	134	mA.
Max.-signal Cathode Current	155	mA.
Effective Load Resistance (Plate to Plate)	8000	ohms.
Total Harmonic Distortion	1.6	%
Max.-signal Power Output	24	watts.

MAXIMUM CIRCUIT VALUE°:

Grid-No. 1—Circuit Resistance:
For cathode-bias operation ...... 0.5 max. megohm

Δ The d.c. component must not exceed 100 volts.

° The type of input coupling network used should not introduce too much resistance in the Grid-No. 1 circuit. Transformer or impedance-coupling devices are recommended.

* 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 43% of the plate signal voltage to grid No. 2 of each output valve.

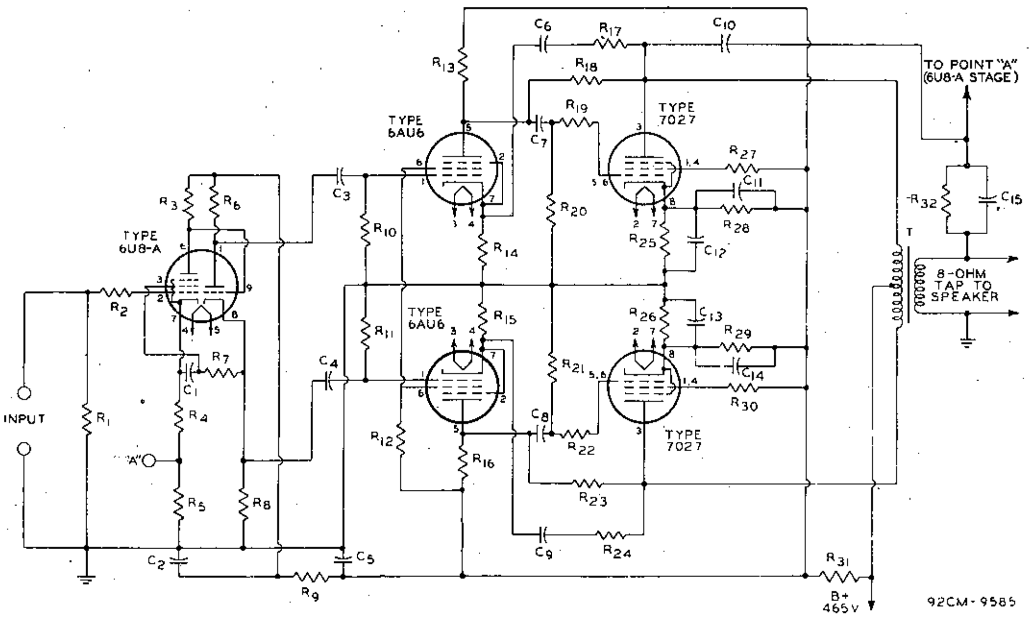


Fig. 1. High-Fidelity Amplifier Circuit Utilizing Type 7027.

C1: ...... 20 μF, 150 volts.
C2, C5, C11, C14: ...... 40 μF, 600 volts.
C3, C4: ...... 0.1 μF, 600 volts.
C6, C7, C8, C9: ...... 1 μF, 600 volts.
C10: ...... 56 μμF, 600 volts.
C12, C13: ...... 50 μF, 50 volts.
C15: ...... 120 μμF, 150 volts.
R1, R20, R21: 470000 ±10% ohms, ½ watt.
R2: ...... 10000 ± 10% ohms, ½ watt.
R3, R10, R11: 220000 ± 10% ohms, ½ watt.
R4: ...... 820 ±10% ohms, ½ watt.
R5: ...... 10 ±10% ohms, ½ watt.
R6: ...... 15000 ±10% ohms, 2 watts.
R7: ...... 180000 ±10% ohms, ½ watt.
R8: ...... 15000 ±10% ohms, 2 watts.
R9: ...... 10000 ±10% ohms, 2 watts.
R12: ...... 200000 ±10% ohms, ½ watt.
R13, R16: 150000 ±10% ohms, ½ watt.
R14, R15: ...... 680 ±10% ohms, ½ watt.
R17, R24: 120000 ±10% ohms, ½ watt.
R18, R23: ...... 330000 ±10% ohms, ½ watt.
R19, R22: ...... 10000 ±10% ohms, ½ watt.
R25, R26: ...... 425 ±10% ohms, 10 watts.
R27, R30: ...... 100 ±10% ohms, ½ watt.
R28, R29: 20000 ±10% ohms, 10 watts.
R31: ...... 1000 ±10% ohms, 10 watts.
R32: ...... 3900 ±10% ohms, ½ watt.
T = Output transformer for matching impedance of voice coil to 5000-ohm plate-to-plate valve load.

Amplifier Performance Specifications:
Sensitivity = 65 millivolts for 35 watts output;
Hum and Noise = 65 db below 35 watts;
Total Harmonic Distortion = less than 0.3% at any power output level up to 38 watts.

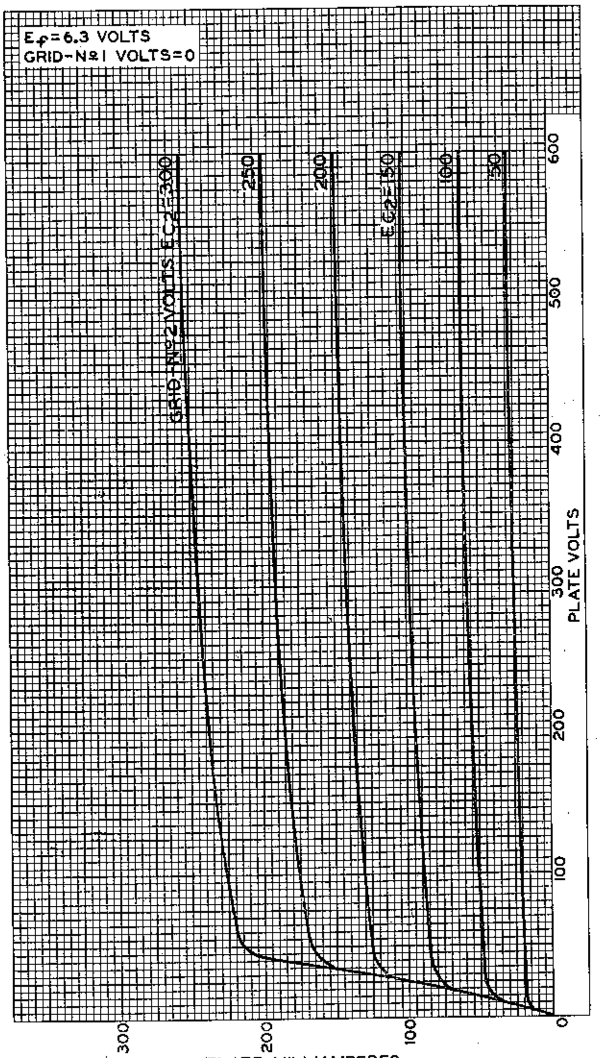
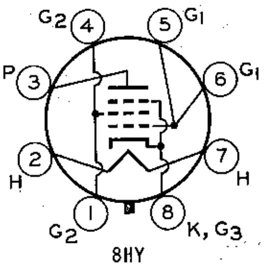


Fig. 2. Average Plate Characteristics of Type 7027.

SOCKET CONNECTIONS

Bottom View



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PIN 1 – GRID NO.2
PIN 2 – HEATER
PIN 3 – PLATE
PIN 4 – GRID NO.2
PIN 5 – GRID NO.1
PIN 6 – GRID NO.1
PIN 7 – HEATER
PIN 8 – CATHODE, GRID NO.3

OPERATING CONSIDERATIONS

The maximum ratings shown in the tabulated data for the 7027 are working design-centre maximums established according to the standard design-centre system of rating valves. Valves so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from a.c. or d.c. power-line supplies whose normal voltage, including normal variations, falls within ±10%.

The bulb becomes hot during operation. To ensure adequate cooling, therefore, it is essential that free circulation of air be provided around the 7207.

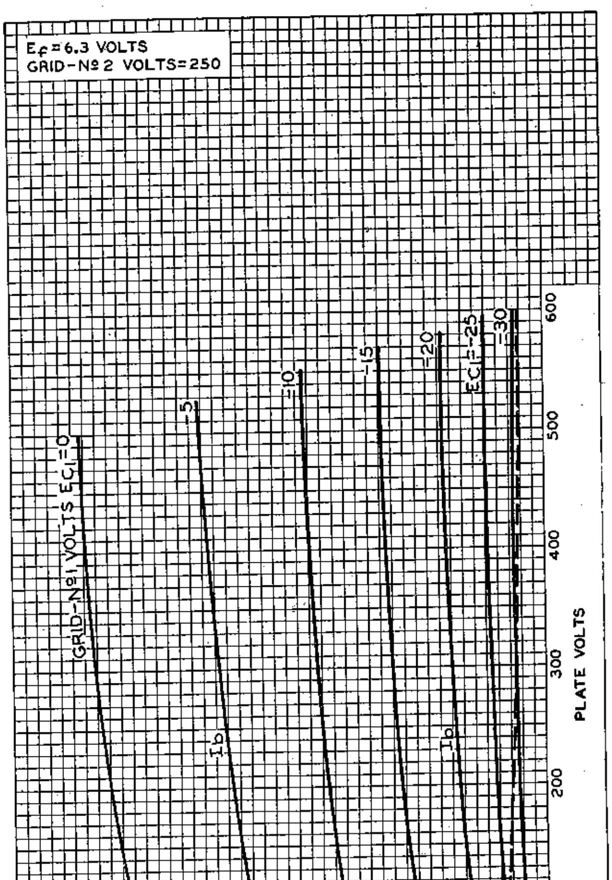

Fig. 3. Average Characteristics of Type 7027.

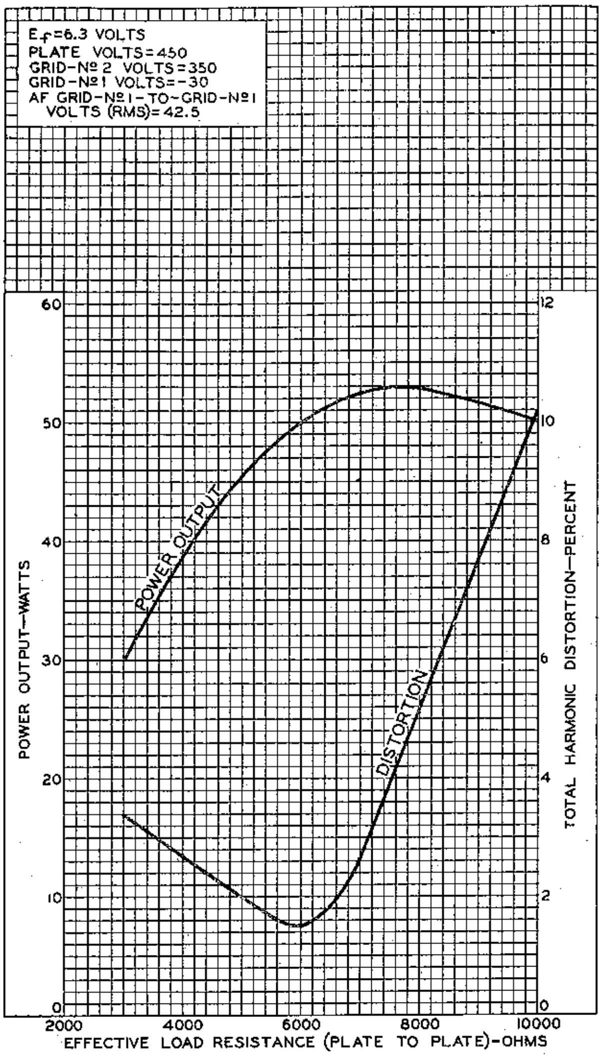

Fig. 4. Operation Characteristics of Type 7027 for Push-Pull Class AB, Pentode Connection.

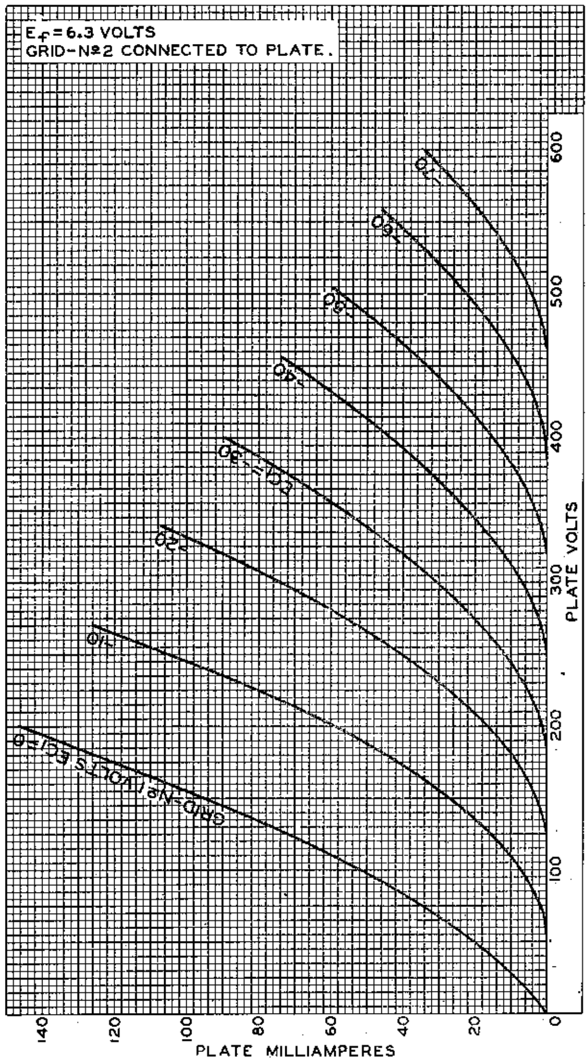

Fig. 5. Average Plate Characteristics for Triode Connection of Type 7027.

★ IN FUTURE ISSUES

LINEAR R-F POWER AMPLIFIERS.—— See P.107.

VISUALISING SWR.—— P.112.

BLOCKING OSCILLATOR SWEEP GENERATORS.—— P.163.

TRANSISTOR TRENDS AND DEVELOPMENTS.—— P.143.

A TRANSISTORIZED AMPLIFIER FOR RECORD PLAYERS

A 200 mW Output Battery-Operated Amplifier using Radiotron 2N217 or 2N408 Transistors.

This article describes a 3-stage, transistor audio amplifier specifically designed for use in battery-operated portable record players. The amplifier employs Radiotron 2N217 alloy-junction transistors and, when driven by a medium-output crystal or ceramic pickup and operated from a 9 V. supply, is capable of delivering 200 mW. output at the 10% distortion level. It has low distortion and good frequency response, and is compensated for the "New Orthophonic" recording characteristic developed by RCA and now almost universally employed for 45- and long-play recordings. The operating parameters used for the 2N217 transistors assure satisfactory performance at ambient temperatures up to 50°C.

This article also gives circuit changes which may be made to modify the frequency response, and describes the changes required when special considerations make it necessary that the amplifier operate satisfactorily at ambient temperatures above 50°C.

Provided that the ambient temperature is not allowed to rise above 45°C, Radiotron 2N408 transistors may be substituted for the 2N217. If this is done, then the upper curve in Fig. 5, labelled 50°C, should be read as 45°C when applied to the 2N408.

CIRCUIT DESCRIPTION

The amplifier circuit is shown in Fig. 1. The three stages—pre-amplifier, driver, and class B output stage—provide ample gain for use with crystal or ceramic pickups which deliver open-circuit output voltages of approximately 1 V. at 1000 c/s, and have capacitances in the order of 1000 $\mu\mu$F. Commercial pickups of this type usually have high-frequency characteristics which partially compensate for the "New Orthophonic" recording characteristic, and low-frequency characteristics which are easily corrected by the use of high-resistance terminations (see Fig. 2).

In this amplifier, substantially flat frequency response from pickups having the characteristics shown in Fig. 2 is obtained by the use of a 1-megohm resistor (R1) in series with the input to the first transistor.

The volume and tone controls for the amplifier are placed in the second stage and also serve as bias resistors. A log-taper potentiometer is used for the volume control in order to reduce the sensitivity of the control at low-volume settings. The tone-control circuit is designed so that adjustment varies the high-frequency roll-off point as well as the amount of high-frequency attenuation. This control is a linear potentiometer.

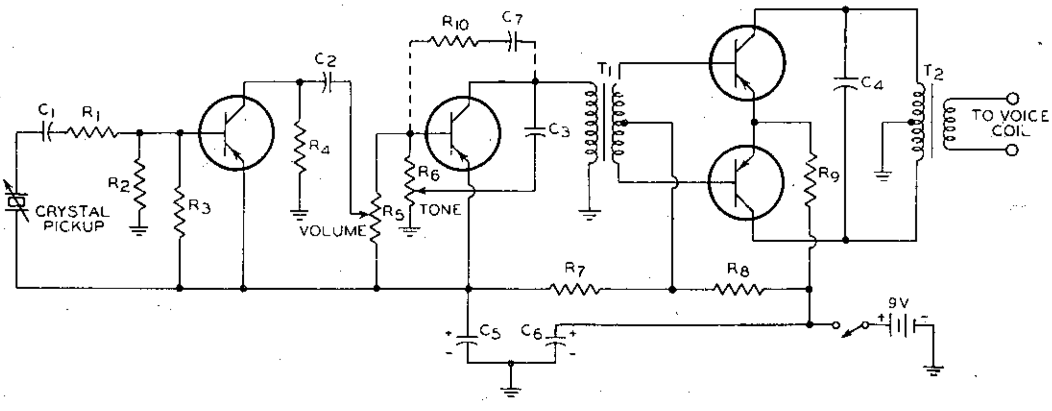

Fig. 1. Circuit of the transistor battery-powered record player amplifier.

In order to obtain the highest possible efficiency and power output, the output stage is operated under substantially class B conditions. The driver transformer (T1) has a primary-to-secondary impedance ratio of 3000 to 5000 ohms. Although a transformer having a higher primary impedance would provide more gain, the additional cost of such a transformer was considered unjustified because the available gain is more than adequate for the pickup used. Bias voltage for the output stage is obtained from a tap on the decoupling network for the first two stages. The 33-ohm

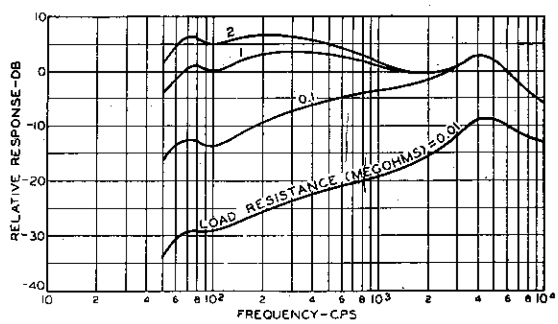

Fig. 2. Response of medium-output crystal pickup.

resistor (R9) in the common emitter circuit minimizes cross-over distortion and stabilizes the operating point for the output stage sufficiently to prevent thermal runaway at temperatures up to 50°C.

The output transformer (T2), when connected to the speaker voice coil, provides an effective load resistance (collector-to-collector) of 550 ohms. This transformer should be a high-efficiency type having a d.c. primary resistance as low as is economically feasible, because the available undistorted power output is reduced in proportion to the square of the d.c. voltage drop in the primary winding. The capacitor across the output transformer primary (C4) is used to minimize the "ringing" which tends to occur in a class B stage

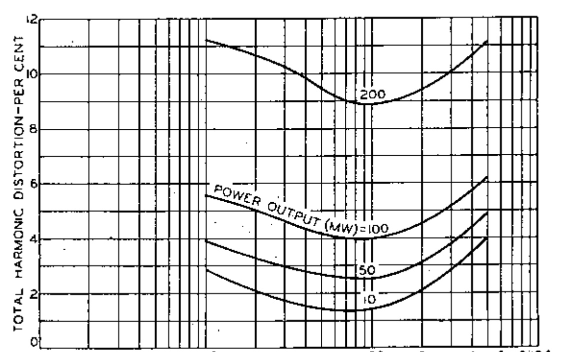

Fig. 4. Total harmonic distortion produced by the amplifier at various power levels.

when the output current switches from one half of the circuit to the other. The value of this capacitor is not critical and it may be made to serve a double purpose by the choice of a value which will reduce the effects of any high-frequency resonances in the pick-up.

CIRCUIT PERFORMANCE

The overall frequency response of the system (including a crystal pickup) to the RCA "New Orthophonic" Frequency-Test Record No. 12-5-51 is shown in Fig. 3. The drop in high-frequency response in the vicinity of 5000 c/s is due partly to the decrease in pick-

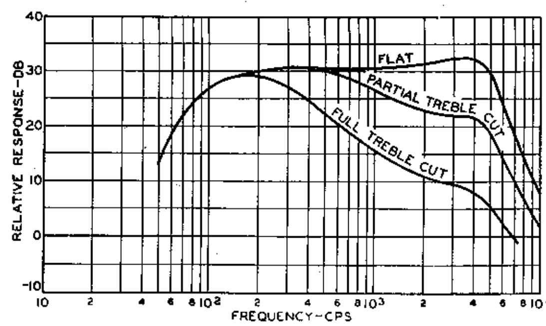

Fig. 3. Response of amplifier and crystal pickup.

up output in this region and partly to the by-passing effect of the capacitor across the output-transformer primary. The low-frequency response is determined by the time constant of the pickup capacitance and the terminating resistance (R1), and by the characteristics of the driver and output transformers.

Fig. 4 shows the total harmonic distortion contributed by the amplifier versus input-signal frequency at various output-power levels. Fig. 5 shows total harmonic distortion versus power output for different ambient temperatures.

The signal-to-noise ratio of the system is in the order of 55 to 60 db.

Fig. 6 shows the total current drawn by the amplifier from a 9 V. battery versus power

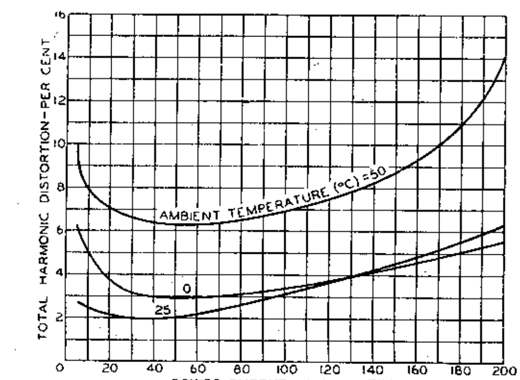

Fig. 5. Total harmonic distortion produced by the amplifier as a function of power output.

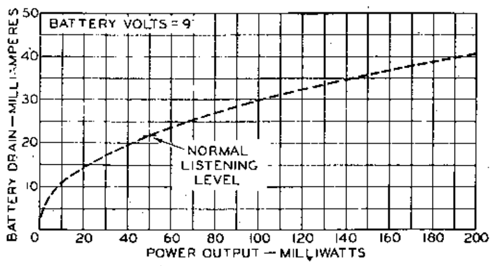

Fig. 6. Total current drawn by the amplifier as a function of power output.

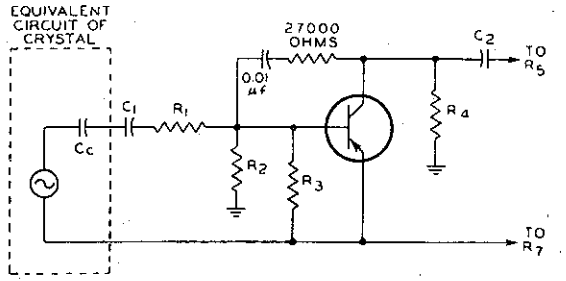

Fig. 7. Alternative input circuit for use with pickups having flat frequency-response characteristics.

output at an ambient temperature of 25°C. At the maximum rated output of 200 mW. the current drain for sinusoidal signal waveforms is approximately 41 mA., representing a power consumption of 0.369 W. At normal listening levels for speech and music (approximately 50 mW.) the amplifier draws only about 22 mA., representing a power consumption of 0.198 W. The amplifier will operate satisfactorily, although with reduced output, at reduced battery voltage. The total battery drain will, of course, depend upon the current drawn by the turntable motor. A typical 45-rpm, 6 V. motor draws 30 mA.

CIRCUIT MODIFICATIONS

If the amplifier is to be used with a pickup which faithfully follows the recording characteristic, correction for the "New Orthophonic" recording characteristic may be obtained without an appreciable reduction in overall gain by the use of the alternative input circuit shown in Fig. 7. The value of R1 will depend on the pickup capacitance and should be selected so that the time constant R1, Cc is 75 microseconds. When this alternative input circuit is used, the functions of the volume and tone controls in Fig. 1 should be reversed in order to minimize changes in overall frequency response with changes in the setting of the volume control. In this case the 100,000-ohm potentiometer (now the volume control) should have a logarithmic audio taper.

The low-frequency response of the amplifier may be improved by the addition of the 220,000-ohm resistor (R10) and 0.003 μF. capacitor (C7) shown connected by dashed lines across the second transistor in Fig. 1.

The amplifier can readily be modified for operation at ambient temperatures above 50°C. by a reduction in the base-to-emitter forward bias of each stage. The reduction should be at the rate of 0.002 V. for each degree by which the desired operating temperature exceeds 50°C, and may be obtained by (1) insertion of suitably bypassed resistors in the emitter leads of the first two stages; (2) a change in the bias circuit for the output stage so that the driver transformer centre tap is connected to a suitable point on a voltage divider directly across the 9 V. supply, instead of to a tap on the decoupling network.

PARTS LIST

C1: 0.01 μF.
C2. 1.0 μF.
C3: 0.002 μF.
C4: 0.04 μF.
C6. C5: 50 μF, 12 VW., electrolytic.
C7: 0.003 μF.
R1: 1 megohm, 0.5 W.
R2, R10: 220000 ohms, 0.5 W.
R3: 4700 ohms, 0.5 W.
R4: 1500 ohms, 0.5 W.
R5: Potentiometer, 5000 ohms, logarithmic audio taper.
R6: Potentiometer, 100,000 ohms, linear taper.
R7: 680 ohms, 0.5 W.
R8: 27 ohms, 0.5 W.
R9: 33 ohms, 0.5 W.
T1: Driver Transformer, primary impedance 3000 ohms, secondary impedance (base-to-base) 5000 ohms.
T2: Output Transformer, primary impedance (collector-to-collector) 550 ohms, secondary impedance to match speaker voice coil.

ACKNOWLEDGEMENT

This article is based on RCA Application Note AN 169, with acknowledgement to RCA.

NEW RCA TRANSISTOR RELEASES

RADIOTRON 2N578, 2N579, 2N580

These three new transistors of the germanium alloy PNP type are constructed in metal cases to JETEC No. T0-9 outline, and are specifically designed for use in high-current switching circuits of compact electronic computers and other "on-off" control circuits. Featuring a high maximum collector current rating of—400mA, the 2N578, 2N579 and 2N580, have respectively minimum DC current transfer ratios at the full collector current rating of 10, 20 and 30, and minimum alpha cut-off frequencies of 3, 5 and 10 Mc/s.

RADIOTRON 2N581, 2N583, 2N585

These three new germanium alloy junction transistors are specifically designed for use in medium-speed switching circuits of compact electronic computers. The 2N581 and 2N583 are PNP types, and the 2N585 an NPN type. The 2N581 and 2N583 are electrically identical, except that the 2N581 is in a metal case to JETEC outline No. T0-9 and the 2N583 case is to JETEC outline No. T0-1. The 2N585 is constructed in a metal case to the T0-9 outline.

The two PNP types have a maximum collector/base voltage rating of—18 volts, a maximum collector dissipation of 80 milliwatts at 25° C, and a typical current transfer ratio of 30 at a collector/emitter voltage of 0.3V and collector current of—20mA. The NPN type 2N585 has a maximum collector/base voltage rating of 25 volts, a maximum collector dissipation of 120 milliwatts at 25° C, and a typical current transfer ratio of 40 at a collector/emitter voltage of 0.2V and a collector current of 20mA.

RADIOTRON 2N582, 2N584

These two new transistors are germanium PNP alloy junction types specifically designed for use in high-speed switching circuits of electronic computers. The two types are electrically identical except that the 2N582 metal case has the JETEC outline No. T0-9, whilst that of the 2N584 is to outline No. T0-1. Both types feature a minimum alpha cut-off frequency of 14 Mc/s, and a minimum current transfer ratio of 40 with a collector current of—20mA. These features, in addition to careful control of the switching time, which is achieved by controlling the stored charge in the base region, contribute to the dependable performance of these transistors in high-speed switching circuits.

UNITED KINGDOM STANDARD FREQUENCY TRANSMISSIONS

The British Post Office commenced a limited programme of transmissions of standard radio frequencies from their Rugby station in 1950 under the call sign MSF. A continuous service was commenced in 1953 on frequencies of 2.5, 5 and 10 Mc/s. Modulation periods were provided by 1000 c/s tone and 1 c/s pulses. Monitoring of these standard frequency transmissions has always been carried out by the National Physical Laboratory.

A pamphlet entitled "MSF — Standard Frequency Transmissions from the United Kingdom" issued by the NPL describes the service, and also announces that the MSF frequencies are now based on the resonant frequency of the caesium atom. The frequency of 9, 192, 631, 830 c/s has been provisionally adopted as the resonant frequency. This frequency is a fundamental physical constant, free from small corrections and uncertainties associated with astronomical time, and the precise value of the frequency is based on the astronomical time for 1955.

Some years will be required to compare fully the accuracy of the astronomical and atomic units with the full accuracy of the atomic clock. This is because astronomical time must be averaged over a long period to eliminate errors and uncertainties of measurement. The MSF frequencies and modulation are maintained to $\pm$ 5 parts in 10^9, but are monitored to $\pm$ 1 part in 10^{10}, and continuous measurements are made at the NPL. The results of the laboratory monitoring are published monthly in "Electronic and Radio Engineer", but are given only to $\pm$ 1 part in 10^9 to allow for slight transmission and propagation errors.

AWV