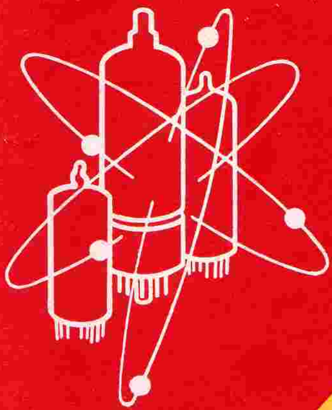
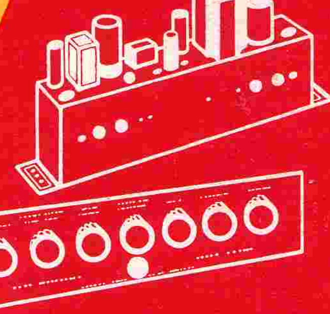
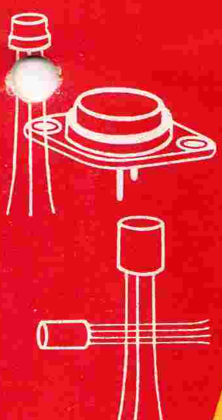






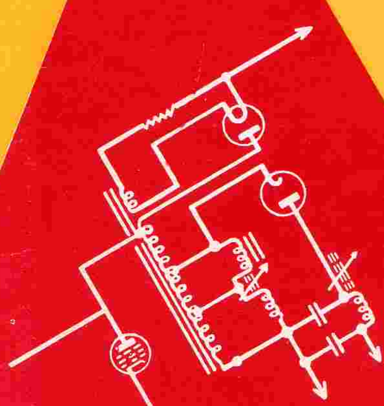
RADIOTRONICS

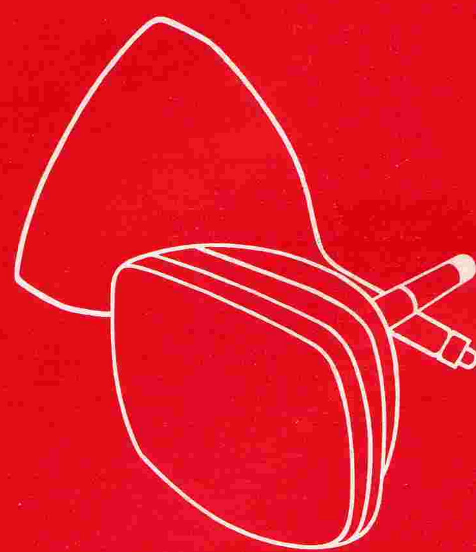
VOL. 24, No. 1 JANUARY, 1959

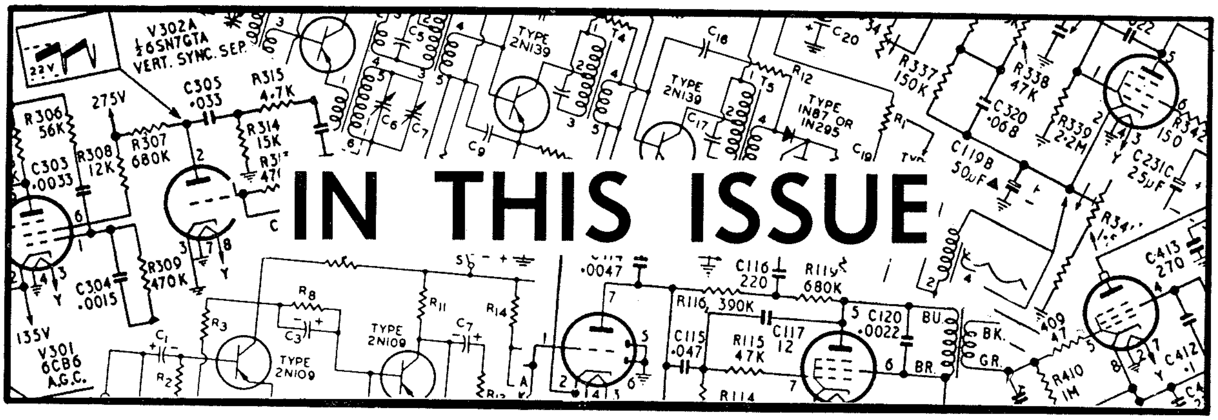
Price: One Shilling

AMALGAMATED WIRELESS VALVE COMPANY PTY. LTD.

Registered at the G.P.O., Sydney, for transmission by post as a periodical.







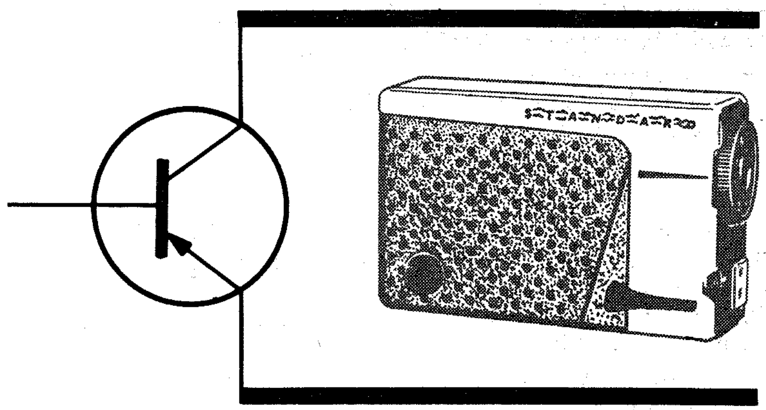
Radiotronics is published twelve times a year by the Wireless Press for Amalgamated Wireless Valve Company Pty. Ltd. The annual subscription rate in Australasia is 10/-, in U.S.A. and dollar countries $1.50, and in all other countries 12/6. Price of a single copy is 1/-.

Subscribers should promptly notify Amalgamated Wireless Valve Company Pty. Ltd., 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.

EDITOR ...... BERNARD J. SIMPSON

PRINTED BY THE CLOISTER PRESS, 45-49 GEORGE STREET, REDFERN

TRANSISTOR RADIO SERVICE TECHNIQUES



INTRODUCTION

This article is intended to help servicemen understand transistor radio operation and, by giving a detailed step-by-step service procedure, enable them to satisfy their customers with a minimum of work.

The material has been arranged under headings such as "dead", "weak", etc., corresponding to the customer's usual description when requesting service.

The many "service hints" listed in this publication should not be regarded as indicative of the amount of trouble to be expected. Many of the hints given are similar to everyday "run-of-the-mill" troubles found in thermionic valve radios and would not be mentioned except for the fact that transistor radios are a new experience for many servicemen.

By using an organised test procedure, transistor radio servicing can be made easy for the serviceman and satisfying to the customer. Throughout article, common-emitter type circuits are assumed, as these are the type that will be met.

TEST METHODS

The procedure to be used in servicing transistor radios is much the same as used with thermionic valve radios. They both employ the superheterodyne circuit, they both pick up a minute signal voltage on an antenna, amplify it and apply it to a loudspeaker.

The test procedure differs only because of the low impedances and the low voltages which are found in transistor radios.

TEST THE BATTERY FIRST. Do not perform any service work when operating the set using a weak battery. Do not accept any performance deficiency as being due to a weak battery unless it has been proven by comparison when using a strong battery.

Performance Indication by Listening

This is the quickest method of localising faults and should be used preliminary to any performance measurements.

Signal Tracing

Signal tracing is a method of servicing that is applicable to any communication circuit. Either signal tracing or the similar method of signal injection is well adapted to the servicing of transistor radios.

Signal level indication can be had by listening to the sound at the speaker, visual observation on an oscilloscope or, in some cases, measurement with an ac type of VTVM.

Voltage Measurement

Measurement of dc terminal voltages is just as applicable to the servicing of transistor radios as to the servicing of thermionic valve radios. The most important difference is in the magnitude of the voltages to be measured. The usual maximum terminal voltage which will be encountered in transistor radios is 9 volts. Bias (Base-Emitter) voltages are in the order of 0.05 to 0.2 of a volt.

Resistance Measurement

Although servicing by resistance measurement is one of the most common testing methods used with thermionic valve radios, this method has severe limitations when applied to the testing of circuits which contain transistors. Transistors will conduct an electrical current when the terminal voltage is supplied from an ohmmeter just as readily as when the voltage is supplied from the radio battery. Because of this transistor conductivity, misleading indications will be obtained and the transistors themselves can be permanently damaged by using resistance measurement.

If resistance measurements are to be made in a transistor radio, the transistors should be removed from the circuit to be tested. If the transistors are soldered in on a printed circuit board, it will be best to disconnect one terminal of the component to be tested.

Current Measurement

Individual current measurements are seldom made in the servicing of radios because of the difficulty in making such measurements. With battery operated radios, an overall current measurement is easily made and should be made to assist in diagnosing trouble.

Test Equipment Required

Refer to "Circuit Conditions and their Effect on Service Procedure" below.

SERVICE REQUIREMENTS

The customer's complaint must be met. It is, therefore, highly desirable to get information from the customer before doing any work on the radio. This is not always possible but an effort should be made to obtain the information.

The radia must be given a complete air test after service work is completed. This should be a listening test with the radio completely assembled.

Regardless of what the stated complaint may be, the following overall conditions should be checked:

(a) Condition of the battery (voltage with the set turned on).

(b) Overall current drain with no signal input (see table and manufacturer's data).

Total Battery Current (approx.)

Model *	No Signal	15 mw. out	50 mw. out.
"A"	8.6 ma	21 ma	33 ma
"B"	6.0	14	—
"C"	9.2	—	29
"D"	16	16	—
"E"	7.8	13	—
"F"	8.0	—	28

(c) Soldered connections. Turn radio on with maximum volume. While listening to the loudspeaker, gently wiggle all visible components with an insulated tool such as alignment tool.

(d) Sensitivity as determined by a listening test.

(e) Distortion as determined by a listening test.

CIRCUIT CONDITIONS AND THEIR EFFECT ON SERVICE PROCEDURE

Circuit Impedances

In thermionic valve radios, both the input (grid) and output (plate) circuits are high impedance. A common practice to determine whether or not a circuit is "alive", is to touch a finger to various points and listen for possible effects on sound emanating from the speaker.

In transistor radios, the input (base) circuit has very low impedance. The output (collector) circuit has medium impedance. The "finger test" method described above will provide no indication in a transistor radio. Figure 1 is an illustrated comparison of the circuit impedances.

* Figures are given for six typical transistorized portables.

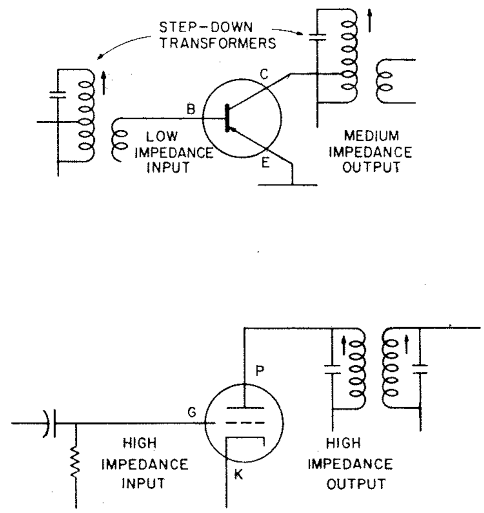


Figure 1 — Comparison of Impedances in Transistor Radios vs. Thermionic Valve Radios.

Since the circuits in a transistor radio are not high impedance (except oscillator and antenna tank circuits), it is not necessary to use low-capacity probes in conjunction with oscilloscopes.

Impedance matching in transistor radios is more critical than in thermionic radios. For this reason, only exact replacement oscillator coils, antennas, if transformers, volume controls, audio transformers and speakers should be used in servicing transistor radios.

Transformers (audio and if) used in transistor radios generally have a step-down ratio and when signal tracing, a very pronounced signal voltage loss will be encountered between primary and secondary. Because of the extremely low signal voltages present at the base input of transistors, a high-gain oscilloscope is required for gain measurements.

DC Voltages at Transistor Terminals

The maximum terminal voltage normally encountered in portable transistor radios is 9 volts. With p-n-p transistors the collector voltage and the base voltage are both negative in respect to the emitter. With n-p-n transistors both voltages are positive.

Just as with thermionic valves, a small voltage at the input of a transistor is used to control the output current. But this small voltage (base-emitter bias voltage) is in the order of only 0.05 volt to 0.2 volt. The operation of a transistor with 0.05 volt bias where 0.1 volt is specified will result in distortion. Figure 2 illustrates the voltage relationships to be expected at the terminals of transistors.

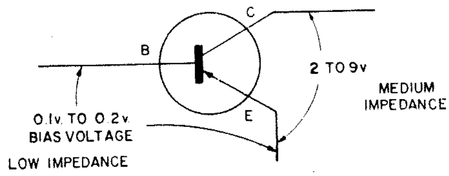


Figure 2 — Normal Operating Voltages (P-N-P Type of Transistor)

Just as with thermionic valve radios, meter sensitivity is also quite important. Voltmeters used in servicing transistor radios should have a sensitivity of 20,000 ohms per volt or better and have a low range scale which will enable reading of base-emitter bias voltages to an accuracy of ± 0.03 volt.

Transistor Currents and Bias Voltages

In a thermionic valve, as the negative bias voltage is increased, the plate current decreases. In a transistor, as the bias voltage (base-emitter) is increased, the collector current increases. Collector current cut-off occurs when the bias is reduced to zero. Figure 3 illustrates this current/voltage relationship.

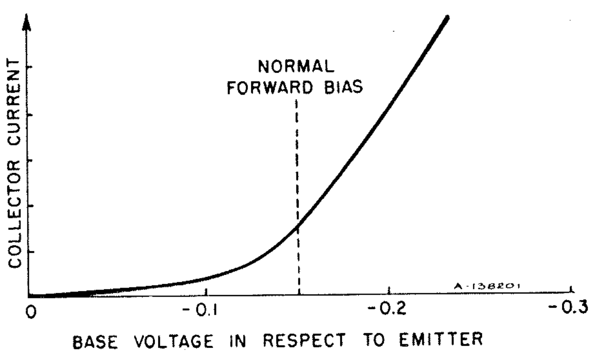


Figure 3 — Bias Voltage vs. Collector Current (P-N-P Type of Transistor)

In transistor radios using push-pull "Class B" output, the battery current varies widely with signal. In one typical model the battery current is 8 ma with no signal and 29 ma with 50 mw output.

A current condition with all transistors but not found in thermionic valve radios is that a small current flows in the signal input circuit (base-emitter). This current, although only a small fraction of the collector current, varies with base-emitter bias in the same manner as collector current. This relationship is illustrated in Figure 4.

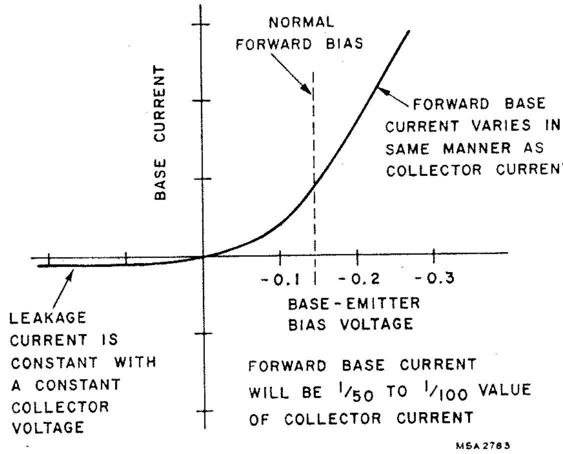


Figure 4 — Base Current vs. Bias Voltage (P-N-P Type of Transistor)

When the base-emitter voltage is reduced to zero, a slight reverse current flows in the base-emitter circuit. This is internal leakage from the collector which is at normal potential.

Total battery current is readily measured on transistor radios. Comparison with normal values published in the service data is of great assistance in troubleshooting.

AGC System

On some transistor radios an "overload diode" is used to reduce the sensitivity on strong signals. The agc voltage changes the current in the 2nd if transistor and thus increases the dc voltage across the overload diode. This causes the diode to conduct and reduce the gain of the if transformer. Figure 5 is a simplified diagram of the voltage relationships in an "overload diode" circuit. If agc voltage were used to control the gain of transistors themselves, the transistors might be driven to "cut-off" on strong signals — distortion would result.

Signal Tracing Equipment

Because of the extremely low signal voltages present at the base input of transistors a high-gain oscilloscope is required for gain measurements. Because of frequent distortion problems which have been encountered, an oscilloscope is also very desirable for the purpose of observing waveform. Many types of signal tracer in common use for signal tracing several years back, can also be employed for signal tracing in transistor radios. An ac type of VTVM can be used for signal tracing in the audio circuits of transistor radios.

When using signal tracing in a transistor radio, it should be remembered that all transformers, from the antenna coil to the output transformer, are step-down type and a great reduction in signal voltage can be expected between the collector

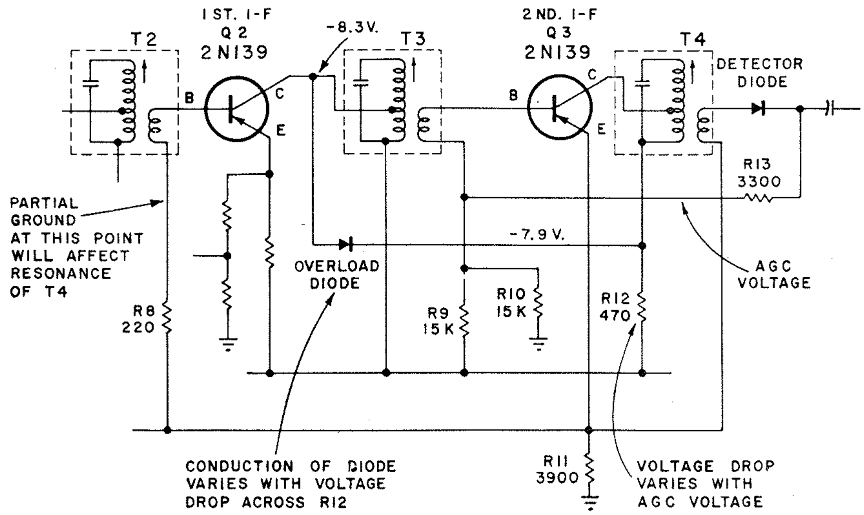


Figure 5 — Overload Diode System of AGC

of one transistor and the base of the following transistor. The ratios to be expected are illustrated in Figure 6.

TEST PROCEDURE WHEN SET IS "DEAD"

1. Turn the set on and check battery voltage. Under usual conditions the battery will continue to operate the set until its voltage under normal load has dropped to two-thirds of its rated voltage when new. Try a new battery if there is any doubt.

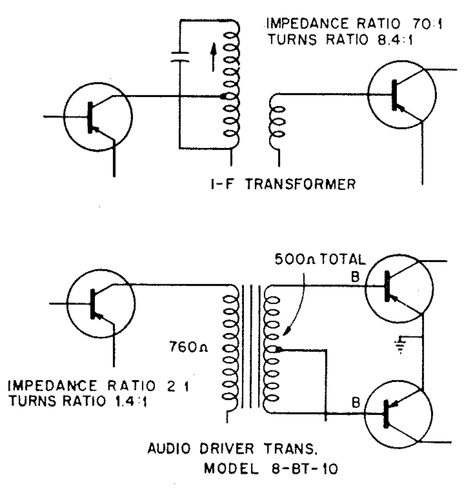


Figure 6 — Transformer Ratios used in Transistor Radios

2. If the battery is satisfactory, hold the set up to your ear and turn the on-off switch "on" and "off". Clicks should be heard through the speaker. No clicks could mean an open voice coil of the speaker or an open connection at the earphone jack.

3. Determine if the oscillator circuit is operative. The usual method is to remove the chassis from the case and check at the converter transistor using an oscilloscope. However, oscillator operation can be determined by bringing the transistor radio close to any other AM radio which is operating and tuned to a broadcast station between 1100 Kc and 1600 Kc. Turn the transistor radio on and turn its tuning dial from one end to the other end. If the oscillator circuit in the transistor radio is working, a heterodyne squeal will be heard on the AM radio when the transistor radio is tuned to 455 Kc below the broadcast station frequency. (Example: Broadcast station at 1400 Kc and transistor radio at 945 Kc. This condition is true even if the audio section of the transistor radio is dead.)

4. If the oscillator is working and a click was heard in the speaker, (a) connect the ground lead of a signal generator to either battery lead, (b) set the signal generator to 455 Kc (with audio modulation), (c) set the signal generator to give high output, (d) connect a capacitor (.01 to .1) in series with the high-side signal generator lead, (e) turn the transistor radio on and touch the free end of the capacitor to the terminals of each component in the transistor radio to determine where a signal can be heard and where it cannot be heard. By referring to the schematic diagram and the

component layout in the service data, determine where the signal can and cannot be heard; the point of signal stoppage can thus be isolated to one particular stage.

Because of the low-impedance circuits used in transistor radios, the "finger touch" method of checking used with thermionic valve radios will not provide any indication of circuit conditions in a transistor radio.

A "click" testing method applicable to transistor radios and illustrated in Figure 7 is as follows:

(a) Attach one lead of a resistor (12,000 ohms to 15,000 ohms) to one end of a test lead.

(b) Connect one end of the test lead to positive (+) battery terminal (may or may not be "ground").

(c) Touch the free end of the resistor to transistor terminals, starting with the output stage, while listening for "clicks" in the speaker.

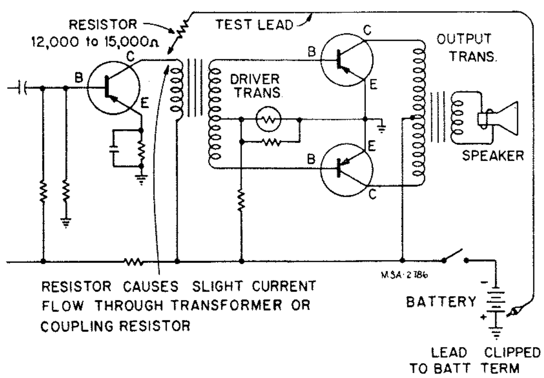


Figure 7 — "Click" Probe for use in Checking Transistor Radios

5. Having determined in what part of the circuit the signal stoppage occurs, use a voltmeter to measure the voltages at the transistor in the suspected stage.

Open resistors, improperly soldered (cold joint or rosin joint) connections and shorted capacitors are the most likely causes of incorrect voltages.

The most important voltage is the base-to-emitter voltage. This will (except for the converter) be 0.1 to 0.2 volts; this voltage on the converter transistor will be approximately 0.05 volts. The polarity will depend upon the transistor type.

6. If satisfactory voltage indications are obtained, the trouble will most likely be (a) an improperly soldered connection at an if transformer or at a capacitor, or (b) an open capacitor. Improperly soldered connections can most easily be located by probing with a plastic alignment tool and even a tooth pick.

7. To make a circuit isolation of a component on a printed circuit board without removal of either terminal, with a sharp knife, cut through the printed wiring leading to that component as illustrated in Figure 8. This wiring break is easily bridged afterwards with a soldering iron.

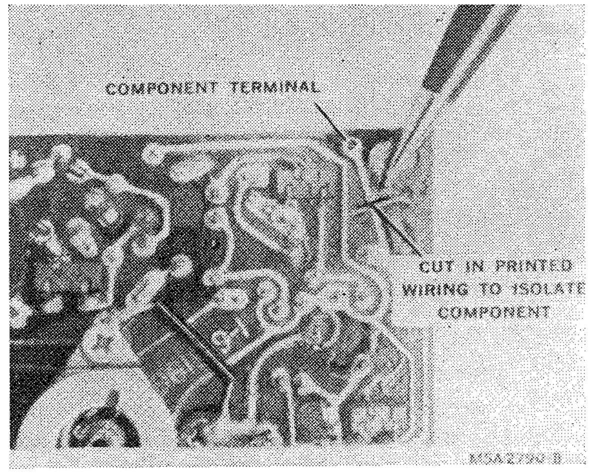


Figure 8 — Component Isolation on Printed Circuit Board

TEST PROCEDURE WHEN SET IS "WEAK"

USE A NEW BATTERY AND GIVE THE SET AN AIR TEST TO DETERMINE WHETHER THE FAULT IS IN THE AUDIO SECTION OR IN THE RF/IF SECTION.

If a set has low rf/if sensitivity, it may provide loud volume on strong nearby stations but distant stations will be weak or not heard at all.

If a set has a low audio sensitivity, it will have weak volume on all stations with little change between nearby stations and distant stations unless the rf/if sensitivity is also low.

2. Using a signal generator set at 455 Kc with audio modulation, probe the various points in the set to note where there is a lack of gain. Keep the signal generator output low to avoid misleading indications caused by overloading; use only enough signal to provide an audible indication.

3. When using the signal generator connected to the oscillator section of the tuning gang, peak the if transformers — it takes only a couple of extra minutes.

DO NOT USE PRESSURE TO HOLD THE ALIGNMENT TOOL IN THE CORE SLOT. THE CORE CAN BE FORCED OUT OF POSITION IF EXCESS PRESSURE IS APPLIED. When a core is forced out of position it may be necessary to replace the transformer.

When the resonance peak is reached, there should be a very definite decrease in the output with only one-quarter turn of the core in either direction. A transformer having a broadly resonant peak should be repaired or replaced. See "Test Procedure When Set Has Low RF/IF Gain" below for description of an unusual condition. Sometimes a poor connection will be found at a transformer terminal lug.

4. After localizing the trouble to be in either the audio or rf/if sections, use the procedure outlined in:

(a) TEST PROCEDURE WHEN SET HAS LOW AUDIO GAIN.

(b) TEST PROCEDURE WHEN SET HAS LOW RF/IF GAIN.

TEST PROCEDURE WHEN SET HAS LOW AUDIO GAIN

1. Use a signal generator having audio modulation to localize defect as described in preceding section "Test Procedure When Set is Weak". Remember that all transformers are step-down.

2. Measure voltages at the audio transistors, paying particular attention to the base-emitter bias voltage. This voltage should be between 0.1 volt and 0.2 volt; the base is negative with respect to the emitter. Low voltage decreases sensitivity and high voltage will cause high current drain. Distortion will also be caused by a low-voltage condition.

3. Leaking by-pass capacitors have sometimes been found to have a partial short-circuit. This lowers all voltages in the rf/if and 1st audio sections and lowers overall sensitivity. A preliminary voltage check at the filter capacitors will show if this condition exists.

4. Measure the dc resistance of audio transformers. A frequent cause of low audio gain has been internally shorted turns in the primary of the driver transformer used in models with Class B output stages. Gain tests by signal injection may not readily disclose this trouble. Measurement of the primary dc resistance of this driver transformer has proven to be a reliable test. If it measures 10% below the manufacturer's figure in the service data, it should be replaced without further question. Before making resistance measurements, either the transistor should be removed or the transformer lead should be disconnected.

5. Loose rivets at the volume control terminals may cause either low audio sensitivity or inability to turn the volume down. The best remedy is to replace the control. Soldering the terminal to the rivet has sometimes been effective; it doesn't hurt to try it if the control would otherwise be scrapped.

6. Poorly soldered connections in the audio section may cause low volume. Wiggling components with a insulated alignment tool will often disclose such connections if they should exist.

7. Electrolytic capacitors are used as coupling (or blocking) capacitors in the audio circuit. Low capacity units will cause low audio sensitivity. Check by shunting with another capacitor of approximately equal size.

8. A check of the overall audio gain against the manufacturer's data may be made.

In all cases, the high side of the signal generator should be isolated by use of a series capacitor 0.25 mf or larger. The specified input voltage is to be measured at the specified connection point and not at the signal generator output terminals. The signal generator ground should be connected to the circuit ground of the transistor radio.

TEST PROCEDURE WHEN SET HAS LOW RF/IF GAIN

1. Check if alignment — this normally should be done when making preliminary tests with a signal generator. Refer to preceding sections "Test Procedure When Set is Weak". The following are if alignment suggestions.

(a) Where there is only one core to each if transformer, in some cases two peaks may be reached, one peak being higher than the other. Refer to the service data.

(b) Where a transistor stage shows low gain, shunt each by-pass capacitor in that stage with another capacitor to detect open capacitors. An open by-pass capacitor in the circuit of that transformer could give an unsatisfactory peaking condition.

(c) If a transformer can not be peaked at if, the trouble can be due to a defective transformer or to a defective transistor (if or converter) — try replacing transistor and try resoldering transformer terminal connections before replacing transformer.

2. If if alignment does not restore if sensitivity, measure transistor terminal voltages. Pay particular attention to the base-emitter voltage of the if transistors. This voltage should be approximately 0.15 volts; low voltage (0.1 volt) will lower sensitivity and high voltage (0.2 volt) will cause high current drain.

Although voltages may vary widely without greatly affecting stage gain, the voltages should all have the same proportion of variation. The bias voltages are the most difficult to measure but must not be neglected. If a large voltage discrepancy is found it will be necessary to remove transistors before making resistance measurements in localizing the trouble.

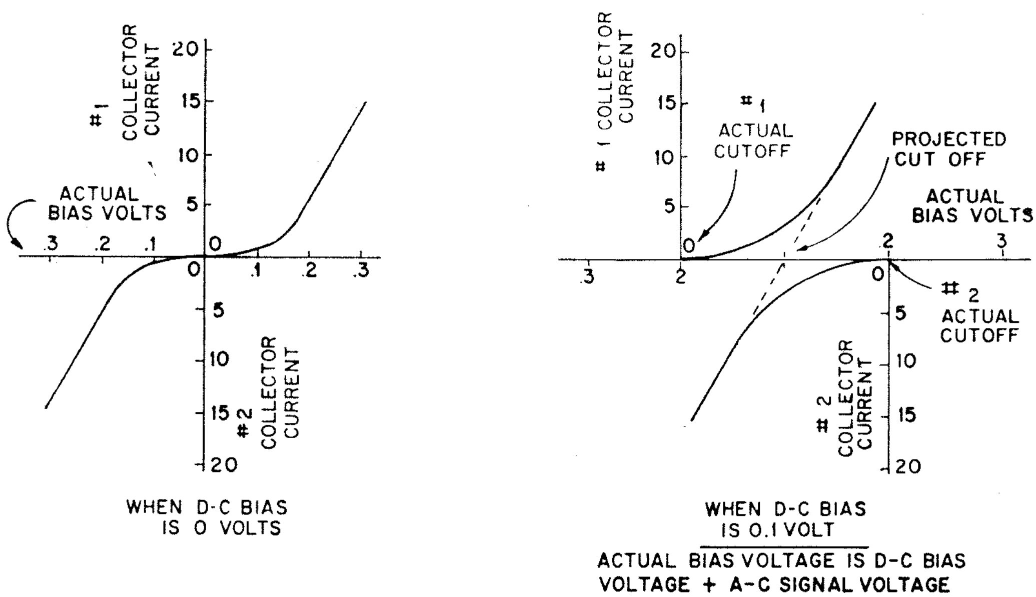


Figure 9 — Crossover Distortion in Class B Circuit due to Improper Bias Voltage.

3. On radios using an "overload diode", the dc voltage across the diode determines the point at which it starts to conduct and thereby reduce the gain. Incorrect voltages may cause the diode to conduct with low signal input.

4. Leaking by-pass capacitors have sometimes been found to have a partial short-circuit. This lowers all voltages in the rf/if and 1st audio sections and lowers overall sensitivity. A proliminary voltage check at the filter capacitors will show if this condition exists.

5. If the if transformers all peak properly and the set still shows low rf/if sensitivity, check the oscillator alignment. This may be done by setting the tuning dial close to 600 Kc and away from any station and adjusting the core of the oscillator coil for maximum noise. This is very effective when near a fluorescent light. If adjustment of the oscillator coil gives much improvement, proceed with a complete realignment following the procedure outlined in the service data.

6. Other possibilities of low rf/if sensitivity are as follows:

(a) Incorrect transistor — if type 2N139 is used in place of specified type 2N140, conversion gain will be down and oscillator section may fail to operate when battery voltage is down slightly.

(b) Detector diode reversed — output is down slightly. Check by noting polarity of agc voltage at the diode source. On models which use n-p-n transistors in the if stages, the agc line voltage at the diode will become more negative (or less positive) in respect to circuit ground with signal increase. On all other models, using p-n-p transistors, the polarity will be reversed.

(c) Antenna rod winding shorted at end connection — disconnect and measure resistance.

TEST PROCEDURE WHEN SET IS "DISTORTED"

Distortion as described below is generally regarded as amplitude distortion in which sounds are mushy.

1. For accurate determination of the existance and the origin of distortion in any radio receiver, there is no substitute for the use of an oscilloscope and signal generator. After finding out where the distortion originates, a voltage check (especially bias voltage) will assist in pin-pointing the trouble.

2. Amplitude distortion is most often caused by improper terminal voltages on the audio transistors. The first thing is to check the terminal voltages (including the battery itself) with the set turned on. Try a new battery if voltages are low.

3. The collector-emitter voltages are comparatively easy to read; see service data for specified values.

4. The base-emitter voltage on "Class B" pushpull transistors should be 0.08 volts to 0.12 volts. Low voltage will cause a form of amplitude distortion known as "Crossover distortion" and is most noticeable on low volume. This condition is illustrated in Figure 9. If the bias voltage cannot

be accurately measured, the collector currents can be measured with a milliammeter in series with a transformer lead. Proper bias results in a total no-signal current of between 1.5 and 2ma in the two output transistors.

5. For minimum distortion, matched output transistors should be used in push-pull output stages. Matching may be checked by measuring audio output voltage with an oscilloscope across each half of the output transformer. Equal voltage output should be had from matched transistors if a constant audio signal is injected at the volume control.

6. Where improper voltages are found, they are most often the result of resistors having changed value. The natural procedure, after having isolated the source of distortion to two or three resistors, is to measure the suspected parts and replace the defective one. Accurate measurement of resistance in a transistor circuit requires that THE TRANSISTOR IN THAT CIRCUIT MUST BE REMOVED BEFORE USING THE OHMMETER. Transistors will conduct current from the ohmmeter even if the power supply battery is removed. An alternative to removal of the transistor, is to disconnect one end of the suspected resistor and apply the ohmmeter in such a way that a transistor will not be in the circuit to be measured.

To isolate a component on a printed circuit board without removal of either terminal, cut through the printed wiring leading to that component with a sharp knife as illustrated in Figure 8. This wiring break is easily bridged afterward with a soldering iron.

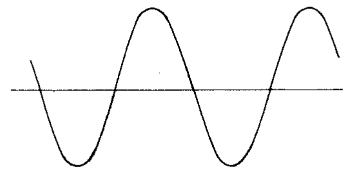
7. There is a possibility of distortion in the diode detector circuit if a slight forward dc bias is not applied to the diode. With no signal input, there should be approximately 0.1 volt across the detector diode as measured with a VTVM; the voltage will increase directly with signal increase (see Item 8 which follows).

8. An overload diode is used in most of these transistor radios to reduce the gain of an if transformer with signal increase. If this diode is open or connected in reverse, the if transistors will be overloaded on strong signals. This diode will normally limit the signal applied to the detector diode, holding it relatively constant with a wide range of signal input level. Incorrect terminal voltages at the diode terminals will change the point at which the overload diode starts to conduct. The 2nd if transistor may thus become overloaded before the diode starts its limiting action.

Use a signal generator and apply if to the oscillator section of the gang condenser and observe the waveform with an oscilloscope at the detector diode using different levels of signal input. The waveform should be an undistorted sine wave at all input levels. The comparison between an undistorted and a distorted sine wave is illustrated in Figure 10.

TEST PROCEDURE WHEN SET HAS REGENERATIVE "SQUEAL"

Regenerative squeal or oscillation in most cases is caused by a high resistance connection in the "common ground" circuit. All "ground" connections must be of lower resistance than similar connections in thermionic valve radios because of the low impedances of transistor circuits.



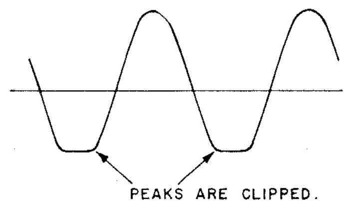


Figure 10 — Undistorted Sine Wave vs. Distorted Sine Wave.

As described above, "ground" connections mean not only visible metal-to-metal connections but also the internal ac impedance of capacitors.

The first step in correcting a regenerative squeal condition is to eliminate all possibility of high resistance metal-to-metal visible connections.

If the first step does not eliminate the regenerative condition, it will be necessary to check the items described in the following text.

1. High internal battery resistance. A new battery corrects the trouble.

2. High resistance riveted battery connections.

3. High resistance connections at chassis mountings. This condition is evidenced by a change in the frequency and intensity of the squeal when mounting screws are first loosened and then tightened.

4. The mounting lugs of if transformers are sometimes used for ground inter-connections. Loose lugs can result in intermittent regeneration. This condition may be detected by slightly pressing on the sides and top of the if transformer cans. Solder a jumper wire between the two mounting lugs of each can.

5. Low value filter capacitors.

6. High resistance connection at electrolytic capacitor terminals. This has the same effect as low capacity.

7. An if transistor having exceptionally high gain may cause regeneration on weak signals. This condition can sometimes be corrected by interchanging if transistors. Realignment is advisable after any change of transistors in the if circuit.

8. If an incorrect type transistor is used, regeneration may occur. Check for use of correct type of transistor.

TEST PROCEDURE WHEN SET IS "INTERMITTENT"

The first step is to localize where and under what conditions the signal interruption takes place.

1. Measure the battery voltage with the set turned on. Under usual conditions the battery will continue to operate the radio until its voltage under load has dropped to two-thirds of its rated voltage when new.

2. Use an insulated alignment tool or similar object to probe and slightly wiggle every component to search for poorly soldered connections. Resolder any suspected connection. Slightly flex the circuit board, speaker and tuning condenser to search for intermittent open circuits and/or short circuits due to excess solder.

3. To locate a break in printed wiring, use the points of a pair of long-nose pliers or other tool to bridge a suspected break location. Go over suspected wiring with soldering iron and solder.

4. Look for excess solder that may make contact only when set is placed in its case.

5. If the preceding physical examination does not enable the trouble to be localized, it will be necessary to use signal tracing or signal injection to localize the fault.

(With acknowledgements to RCA)

CURRENT RANGE OF EEV TV CAMERA TUBES

IMAGE ORTHICONS

TYPES 5820 and 6474

These 3" types were previously known as P-816 and P-817 respectively. They now incorporate the "burn-resistant dynode" and "dynode burn" as an operational hazard will be less troublesome. The target mesh is now Superfine 750 tpi.

TYPE 6849

This 3" image orthicon is a new addition to the range, and is intended for light industrial use.

TYPES P-807 and P-809

These types are 3" image orthicons of the "field mesh" type. They carry provisional Jetec registration as 7293 and 7294 respectively. P-807 is intended for monochrome work, whilst the P-809 with high capacitance target is intended for colour applications.

TYPE 7295

Improvements to the target structure of this 4½" image orthicon have resulted in an increase in signal/noise ratio of some 3 db. Microphony and edge effect are also reduced in magnitude. The slight parabolic shading which was a feature of earlier tubes when operated over the knee has also been considerably reduced. This type was previously known as P-811.

TYPE P-812

This 4½" image orthicon is a fairly recent addition to the range. It is a high capacity version of the 7295, and has received very favourable comment as a studio tube. It is not recommended for universal OB work. The P-812 has been installed in standards converters in Britain with considerable success, and is giving excellent results in telerecordings.

TYPE P-822

This new 4½" image orthicon has a higher capacitance target than the 7295 (P-811). This change has the advantage of reducing noise level, edge effects and halo, and increasing the straight portion of the light/signal transfer characteristic.

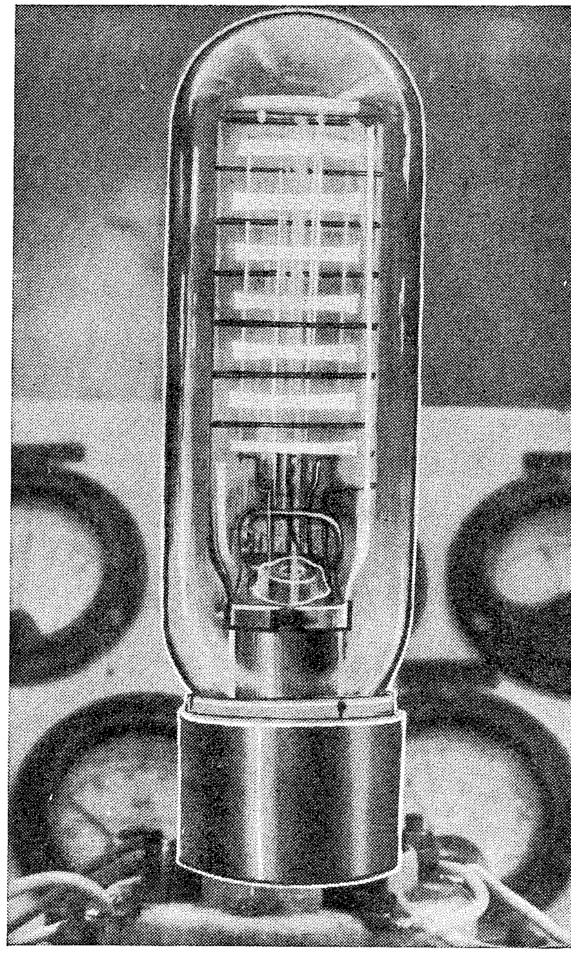
This tube is particularly suited to studio productions where some measure of control over scene illumination enables the full benefits of the higher target capacitance to be realised. Tube sensitivity is more than adequate for normal daylight pickup. Operational sensitivity is in the region of f5.6 at 25 ft-lamberts, with an average signal/noise ratio of 39 db.

VIDICONS

TYPES 6198 and 6326

These 1" vidicons were previously known as P-810 and P-813 respectively. The 6198 is intended for use in industrial cameras, whilst the 6326 is primarily intended for film pickup applications.

RADIOTRON AV25 DEMONSTRATION TRIODE



DESCRIPTION

The Radiotron AV25 is a simple triode intended for educational use. It features open construction, rendering clearly visible the oxide-coated filament strands, the ladder-like grid, and the plate, which is coated with a phosphor which fluoresces green under electron bombardment. Variations in grid voltage produce changes in the pattern of the electron beam striking the plate, which shows as luminous areas. Thus grid control of the electron beam, even to cutoff, may be demonstrated. In the photograph the plate fluorescent pattern was obtained with zero grid bias.

GENERAL DATA

Electrical

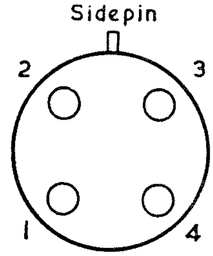
Filament Voltage	6.0 volts ac or dc
Filament Current	1.6 amperes
Fluorescent Screen Colour	Green

Mechanical

Mounting Position	Vertical
Maximum Overall Length	$7\frac{7}{8}$"
Maximum Seated Height	$7\frac{1}{2}$"
Maximum Diameter	$2\frac{1}{2}$"
Plate Dimensions	$2\frac{7}{8}$" x $1\frac{1}{2}$"
Bulb	T18
Base	Medium metal-shell Jumbo 4-pin bayonet.

Bottom View of Base

Pin 1	Grid
Pin 2	Filament
Pin 3	Plate
Pin 4	Filament



Maximum Ratings	**DC Operation**	**AC Operation**
Plate Voltage	300 volts	275 volts rms
Grid Voltage*	± 180 volts	± 150 volts rms

Typical Operation and Characteristics		
Plate Voltage	250 volts	200 volts rms
Grid Voltage at Min. Coverage*	— 110 volts	— 90 volts rms
Grid Voltage at Max. Coverage*	+ 140 volts	+ 115 volts rms
Amplification Factor (μ)	3	
Plate Resistance (r_p)	5000 ohms	
Transconductance (g_m)	600 μmhos	
Plate Current (at max. coverage)	110 ma	50 ma rms

*Phase of the grid voltage with respect to the plate voltage is designated by the sign. Minimum coverage or "cutoff" occurs when the shadows cast by the grid wires just overlap. Maximum coverage occurs when the same shadows just disappear.

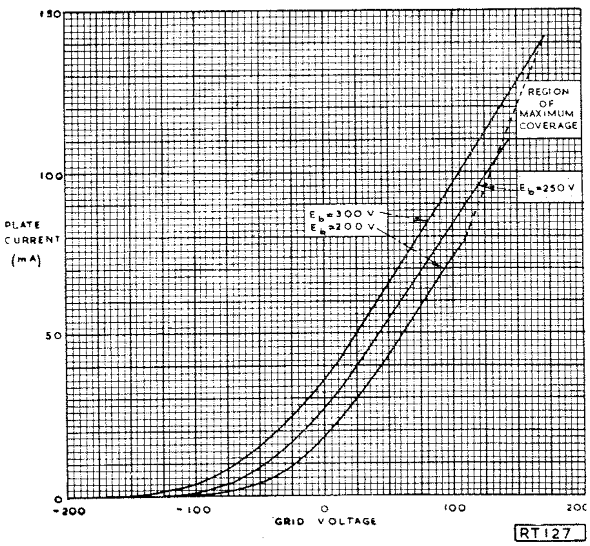


Fig. 1. Plate Characteristics of AV25 Operated in a DC Circuit.

DC OPERATION

DC operating characteristics for the AV25 are given in Fig. 1 for three different plate voltages.

Operation near maximum plate voltage and maximum coverage is not recommended for extended periods. Fatigue in the fluorescent coating, shown by the appearance of a dark region on the plate, is due to excessive plate dissipation. The resulting loss in definition is only temporary and may be remedied by lowering the plate current and allowing the tube to cool for several minutes.

A suitable circuit is given in Fig. 3. In switch position 1 variation of the grid control gives a positive grid voltage range. In switch position 2 variation of the grid control gives a negative grid voltage range with respect to the filament.

Provision of the ammeter and voltmeters is an optional refinement.

AC OPERATION

AC operating characteristics of the AV25 are given in Fig. 2. The fluorescent intensity is greater at higher plate voltages, and this makes for better viewing in brightly lit locations. If ac is fed direct to the plate, the peak voltage determines the brightness, but the low rms current keeps plate dissipation down, and temporary fatigue of the phosphor is unlikely to occur, even for prolonged operation at "full coverage."

In addition, the required ac circuitry is simple and cheap, no rectified plate voltage supply being required. AC operation is therefore recommended because of both better brightness and cheaper components.

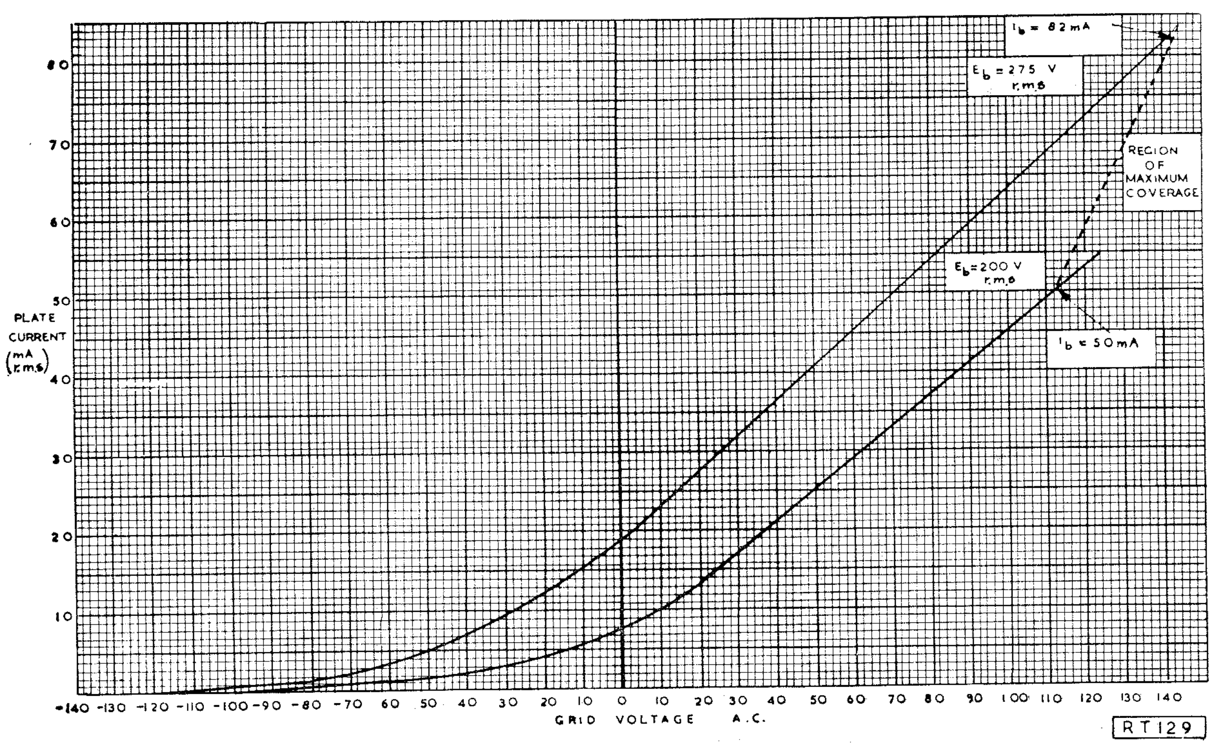


Fig. 2. Plate Characteristics of AV25 Operated in an AC Circuit.

A suitable ac circuit is shown in Fig. 4. An ordinary transformer having secondary rated at 275 volts, 80 ma per side, is adequate.

The phase of the grid voltage relative to that of the plate, and its magnitude, depend on the position of the tapping on the grid control potentiometer. When the tapping is above the centre, the grid voltage is in phase with the plate voltage. When the tapping is below the centre point, the voltages are 180° out of phase. These conditions correspond to zero, positive and negative grid voltage in the dc case.

INSTALLATION AND USE

The AV25 should be mounted in an upright position. Definition and contrast are considerably improved if stray ambient light is avoided. Fig. 5 shows a suitable showcase which will both shield the tube from stray light and house the circuitry.

Fatigue of the phosphor, previously mentioned, should be avoided if best definition is to be obtained. Excessive shock must be avoided because of the delicate filament construction.

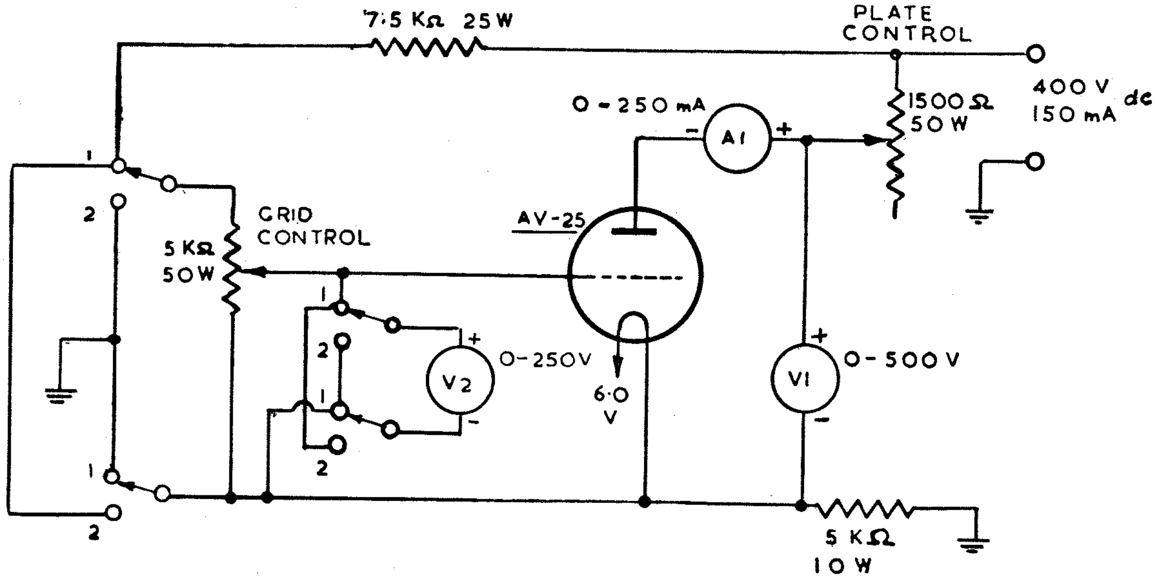


Fig. 3. Typical Circuit for Demonstrating the Radiotron AV25 using Direct Supply Voltage.

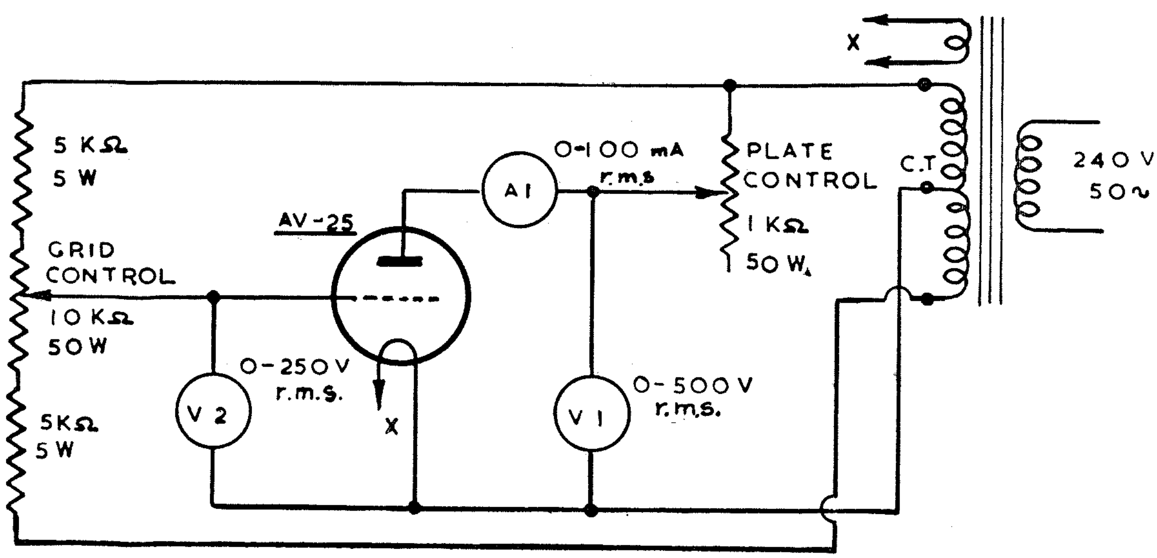


Fig. 4. Typical Circuit for Demonstrating the Radiotron AV25 using Alternating Supply Voltages.

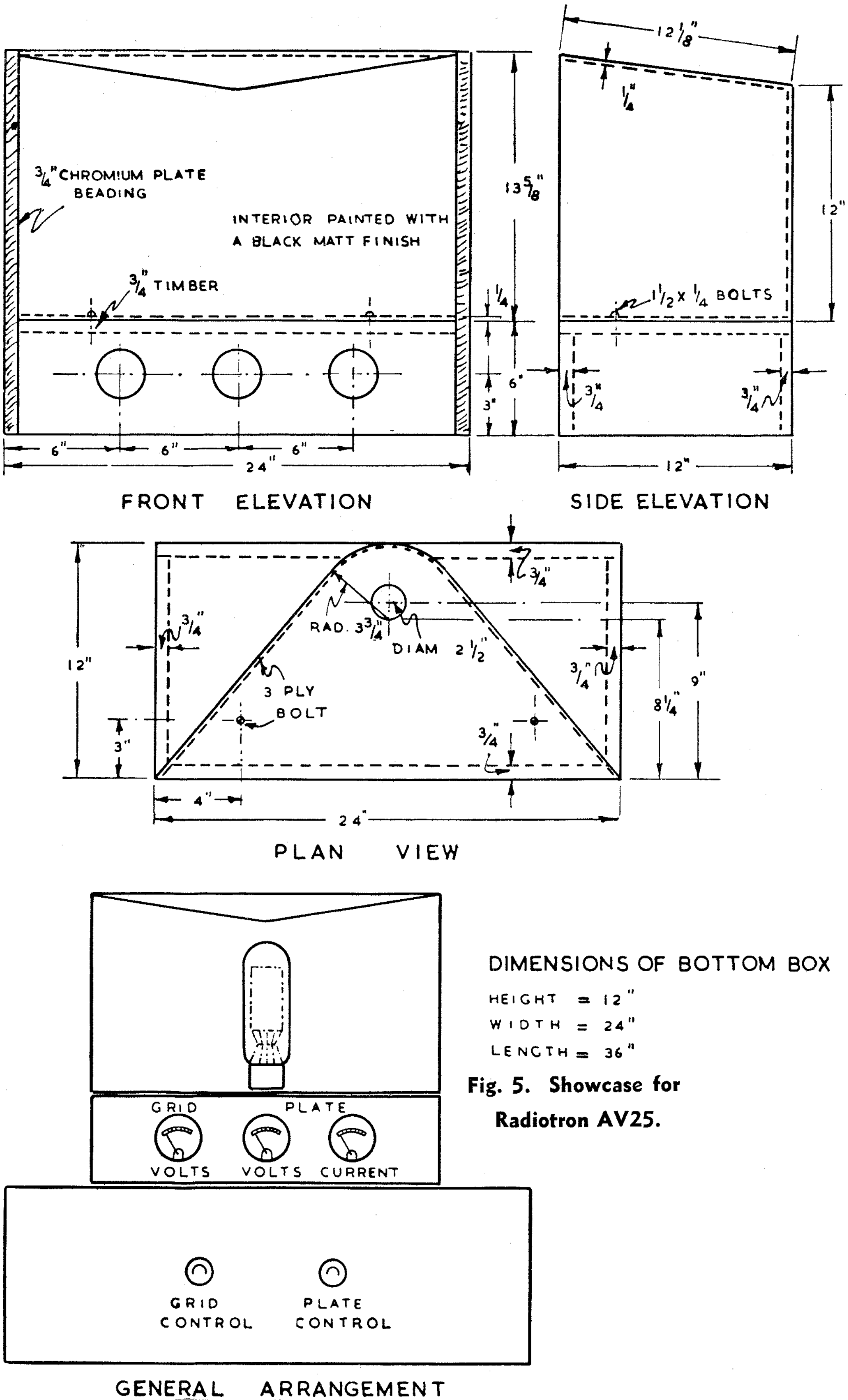


Fig. 5. Showcase for Radiotron AV25.

high fidelity HI FI 6973 hi fi 6973 amplifiers using radiotron 6973

This article describes the application of the 6973 beam power valve designed for use in the output stages of high-fidelity audio amplifiers. Two amplifier circuits are given: a moderate-cost circuit providing a power output of 15 watts at a total harmonic distortion of less than 0.4 per cent., and a low-cost circuit providing a power output of 10 watts at a total harmonic distortion of less than 0.5 per cent. and 15 watts at less than 4 per cent. distortion. Technical data on the 6973 was given in the January, 1958 copy of "Radiotronics".

Moderate-Cost Amplifier

Fig. 1 shows the circuit of an amplifier using 6973's with fixed bias in the output stage, and the pentode and triode units of a 6U8-A in the input voltage amplifier and phase-splitter stages, respectively. This amplifier employs 20 db of inverse feedback between the speaker voice-coil winding and the input amplifier cathode, has no adjustments or critical components, and provides exceptionally fine performance at moderate cost. It can deliver a maximum-signal power output of 15 watts (actual power delivered to a resistive load) with less than 0.4 per cent total harmonic distortion (see Fig. 2). Its frequency-response characteristic, shown in Fig. 3, is flat over the entire audio spectrum, and down less than 2 db at 10 and 80,000 cycles per second. It has a sensitivity of 1.2 volts rms for full output, a damping factor of 12, and an extremely low noise level (combined hum and noise with input circuit open are 75 db below 15 watts).

Fixed bias for the 6973's is obtained simply and inexpensively from a half-wave rectifier circuit supplied by a capacitance-resistance voltage divider across one side of the high-voltage winding. Capacitors C_2, C_6, and C_7 are used to improve the stability of the amplifier at the higher audio frequencies. The values shown for these capacitors may require modification to suit the particular output transformer used.

Low-Cost Amplifier

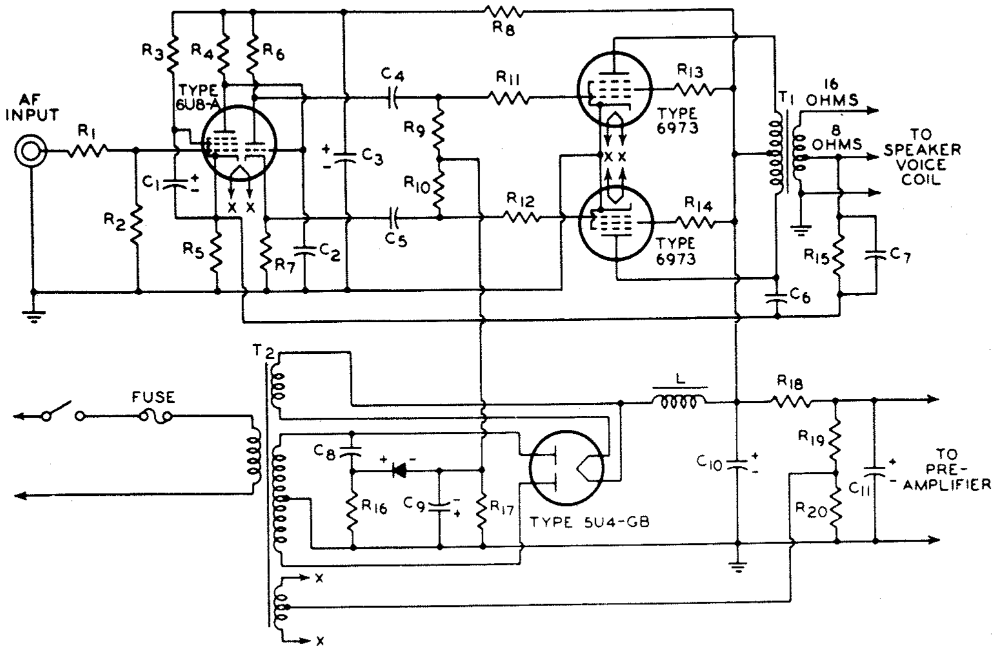
Fig. 4 shows the circuit of an amplifier using 6973's with cathode-resistor bias, and a 12AX7 as an input voltage amplifier and "floating paraphase" phase inverter. It requires substantially fewer components than the amplifier shown in Fig. 1, employs approximately 14 db of overall inverse feedback, and provides very good performance at low cost. This amplifier can deliver a maximum-signal power output of 10 watts (actual power delivered to a resistive load) with less than 0.5 per cent. distortion, and 14 watts

---

EDITOR'S NOTE

In the high fidelity circuit of Fig 1, three components may have to be of different values from those shown, to suit the particular output transformer used. They are C2, C6 and C7. C2 is intended to adjust the time constant of the 6U8-A pentode stage and so provide critical damping. C6 is intended to prevent instability resulting from the portion of the 6U8-A plate current which flows through T_1 secondary. C7 provides feedback phase correction at high frequencies. Final values for these components may need to be verified experimentally. Similar remarks apply to the low-cost circuit of Fig. 4, where components R6, C2 and C7 may need to be selected experimentally.

It is suggested that the Radiotron 6CZ5, in current production for TV sets, may be used in lieu of the 6973. The two valves are similar, except that the 6973 ratings are slightly higher, the valve is specifically tested for audio applications, and there is a slight difference in the base arrangements. Although the 6CZ5 is primarily intended for use in TV vertical deflection service, there is no reason why satisfactory results should not be achieved in an af amplifier, provided the ratings are observed.



C_1: 2 μf, 450 v., electrolytic	R_6 R_7: 15,000 ohms + 5%, 2 watts
C_2: 15 μμf, 400 v., mica or ceramic	R_8: 3900 ohms, 2 watts
C_3 C_{11}: 40 μf, 450 v., electrolytic	R_9 R_{10}: 220,000 ohms, 0.5 watt
C_4 C_5: 0.1 μf, 600 v., paper	R_{11} R_{12}: 1000 ohms, 0.5 watt
C_6: 6.8 μμf, 600 v., mica or ceramic	R_{13} R_{14}: 100 ohms, 0.5 watt
C_7: 180 μμf, 400 v., mica or ceramic	R_{15}: 6800 ohms, 0.5 watt
C_8: 0.02 μf, 600 v., paper	R_{16}: 15,000 ohms, 1 watt
C_9: 100 μf, 50 v., electrolytic	R_{17}: 68,000 ohms, 0.5 watt
C_{10}: 80 μf, 450 v., electrolytic	R_{18}: 4700 ohms, 2 watts
F: Fuse, 3 amperes, 150 volts	R_{19}: 270,000 ohms, 1 watt
L: Filter choke, 3 henries, 160 ma., 75 ohms, Triad type C13X or equivalent	R_{20}: 47,000 ohms, 0.5 watt
R_1: 10,000 ohms, 0.5 watt	SR: Selenium rectifier, 20 ma., 135 volts rms
R_2: 470,000 ohms, 0.5 watt	T_1: Output transformer for matching speaker voice-coil impedance to 6600-ohm plate-to-plate tube load, Stancor type A8056 or equivalent
R_3: 820,000 ohms, 0.5 watt	T_2: Power transformer, 360-0-360 volts rms, 120 ma., Stancor type PC 8410 or equivalent
R_4: 240,000 ohms, 0.5 watt	
R_5: 680 ohms, 0.5 watt	

Fig. 1 — Circuit of high fidelity amplifier using 6973's with fixed bias.

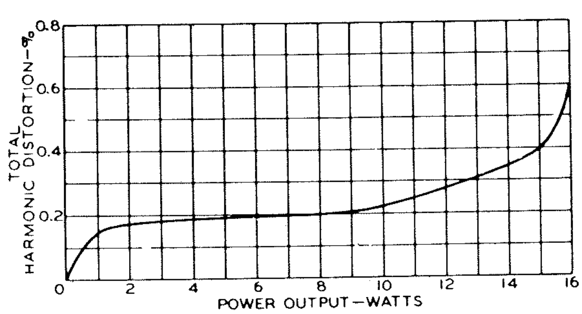


Fig. 2 — Total harmonic distortion produced by the amplifier shown in Fig. 1, as a function of power output.

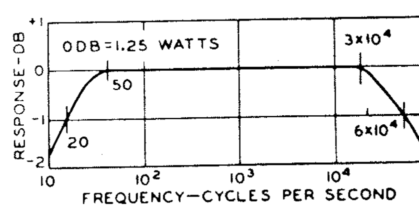
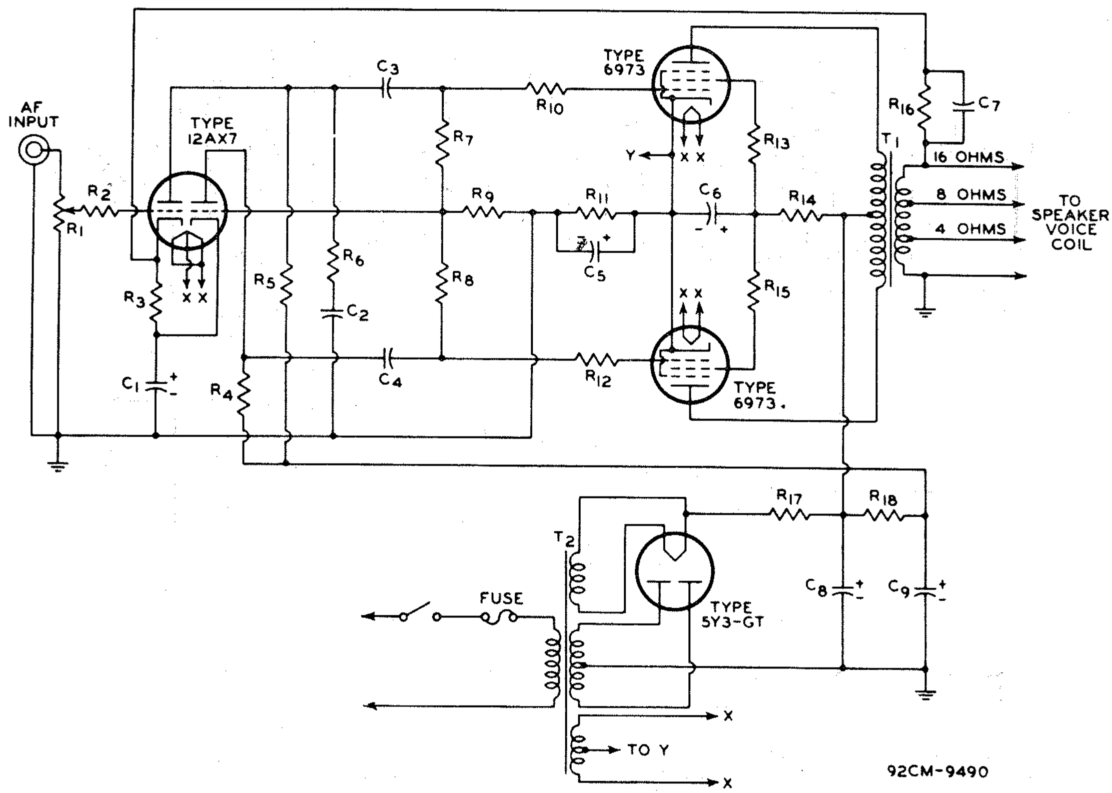


Fig. 3 — Frequency-response characteristic of the amplifier shown in Fig. 1.



C_1: 50 μf, 10 v., electrolytic
C_2: 680 μμf, 400 v., mica or ceramic
C_3 C_4: 0.1 μf, 600 v., paper
C_5: 50 μf, 50 v., electrolytic
C_6: 30 μf, 450 v., electrolytic
C_7: 1000 μμf, 400 v., mica or ceramic
C_8 C_9: 40 μf, 450 v., electrolytic
Fuse: 2 amps, 150 v.
R_1: Volume control, 500,000-ohm potentiometer, audio taper
R_2: 10,000 ohms, 0.5 watt
R_3: 100 ohms, 0.5 watt
R_4: 120,000 ohms, 0.5 watt
R_5: 100,000 ohms, 0.5 watt
R_6: 4700 ohms, 0.5 watt
R_7: 220,000 ohms, 0.5 watt
R_8: 270,000 ohms, 0.5 watt
R_9: 47,000 ohms, 0.5 watt
R_{10} R_{12} R_{16}: 1000 ohms, 0.5 watt
R_{11}: 240 ohms, 2 watts
R_{13} R_{15}: 47 ohms, 0.5 watt
R_{14}: 3300 ohms, 0.5 watt
R_{17}: 68 ohms, 0.5 watt
R_{18}: 3900 ohms, 1 watt
T_1: Output transformer for matching speaker voice coil impedance to 8000-ohm plate-to-plate tube load, Triad type S31A or equivalent
T_2: Power transformer, 300-0-300 volts rms, 120 ma, Thordarson type T22R05 or equivalent

Fig. 4 — Circuit of high-fidelity amplifier using 6973's with cathode-resistor bias.

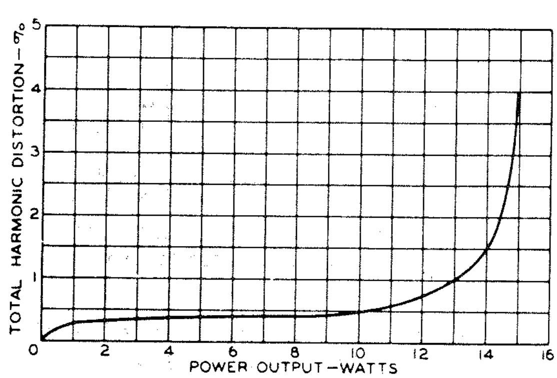


Fig. 5 — Total harmonic distortion produced by the amplifier shown in Fig. 4, as a function of power output.

with only 1.5 per cent. distortion (see Fig. 5). It has very good frequency-response characteristics (see Fig. 6), and a sensitivity of 1.7 volts rms for full (15 watts) output. Combined hum and noise level input circuit open are 75 db below 15 watts. The values used for the stabilizing components (R_6, C_2 and C_7) should be chosen to match the characteristics of the output transformer.

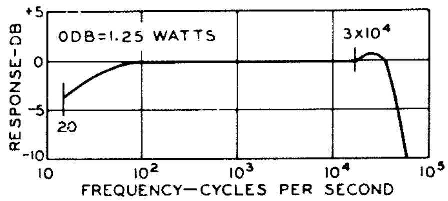


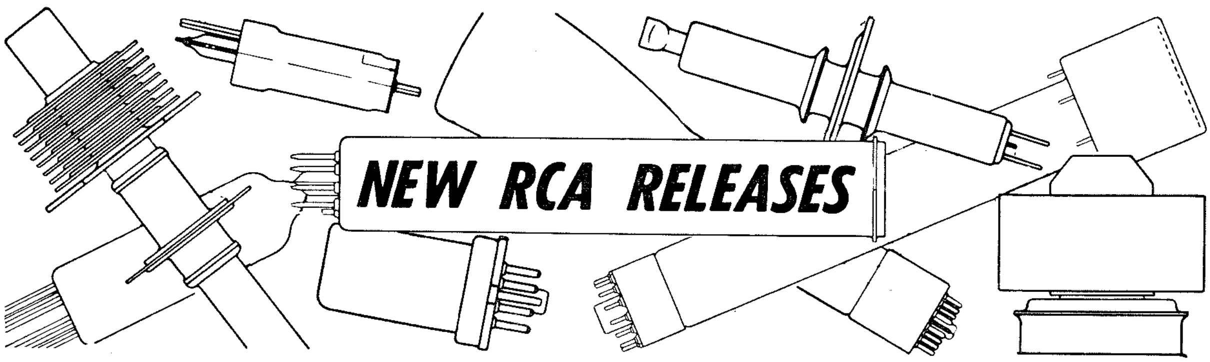
Fig. 6 — Frequency-response characteristics of the amplifier shown in Fig. 4.

The feedback connections for both amplifiers should be made between the points shown in the circuit diagrams, regardless of the typs used for the speaker connections.

Other Applications

Because of its high grid-No. 2 voltage rating, the 6973 is particularly suitable for use in grid-No. 2- feedback ("ultra-linear") type amplifier circuits. In this type of circuit the screen grid of each 6973 is connected to a tap on the plate of the output transformer and contributes a portion of the useful power output. A class AB_1 amplifier stage using the grid-No. 2-feedback connection, has substantially lower output impedance and better regulation under varying load conditions than one using the conventional pentode connection. A disadvantage, however, is the higher cost of the output transformer required.

(With acknowledgements to RCA)



RADIOTRON 1N1763, 1N1764

These two units are the first of a broad line of diffused-junction silicon rectifiers for use in the power supplies of electronic equipment.

The maximum ratings of the 1N1763 are 400 volts peak inverse, 140 volts rms supply, 500 ma dc forward current. The maximum reverse current at 400 volts peak inverse is 100μa at 25°C.

The maximum ratings of the 1N1764 are 500 volts peak inverse, 175 volts rms supply, 500 ma dc forward current. The maximum reverse current at 500 volts peak inverse is 100μa at 25°C.

RADIOTRON 2N373, 2N374

The 2N373 and 2N374 are two new drift transistors of the germanium p-n-p alloy type, specifically designed for use in domestic battery-operated AM receivers. The very low feedback capacitance, exceptional stability and excellent uniformity of characteristics make these transistors especially useful where simplification of circuit design and high stage gain are primary considerations.

The Radiotron 2N373 is designed specifically for 455 Kc if amplifier applications, and can produce a useful power gain of 34 db without a neutralising network. Where maximum power gain is required with a neutralising network, the 2N373 can provide a useful power gain of 39 db. The 2N374 is similar to the 2N373, but has characteristics which meet the requirements of converter and mixer-oscillator applications in AM broadcast receivers. The 2N374 provides a useful power gain of 40 db at the centre of the band.

RADIOTRON 2N176, 2N351, 2N376

These three transistors are alloy-junction power transistors of the germanium p-n-p type intended for use in Class A and Class B push-pull power output stages of af amplifiers, particularly those in car radio receivers. In Class A amplifier service at a mounting-flange temperature of 80°C and a dc supply voltage of -14.4v, the 2N176 has a maximum-signal power output of approximately 2 watts with a power gain of 35.5 db; the 2N351, 4 watts at 33.5 db; and the 2N376, 4 watts at 35 db.

AWV