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RADIOTRONICS

Volume 17 March 1952 No. 3

See Pages 48
& 107 for data notes.

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RADIOTRONICS

Volume 17 **March, 1952** **Number 3**

By the way—

The April issue will include an article on hum in audio amplifiers, an explanation of signal-to-noise ratio figures used in receiver comparisons and a full description of a 50 Mc/s all-miniature receiver.

The article on pickup tracking in this issue points out, amongst other things, the undesirability of the average individual interfering with the damping of a pickup in an endeavour to improve its frequency response.

Under "New RCA releases" the use of the word "ULTOR" will be noticed. "ULTOR" is defined as the electrode, or the electrode in combination with one or more additional electrodes connected within the tube to it, to which is applied the highest d.c. voltage for accelerating the electrons in the beam prior to its deflection.

Your attention is drawn to the availability of the latest 1952 edition of the A.W.V. Radiotron Receiving Valve Manual, This replaces the Characteristic Chart, NOT the Valve Data Book, which it merely supplements. See page 60 for further details.

No one likes having his name or address misspelt on his mail. If there is anything wrong with the address on your Radiotronics envelope, please make the correction, cut out and return the address stencil to us.

Changes of address should be notified promptly. Should a subscriber fail to receive an issue for any reason, this should be brought to our notice as soon as possible. Owing to the limited printing of each issue, supplies of back issues cannot be guaranteed. Subscribers are also reminded to advise the Post Office of any address change so that mail can be forwarded to the new address.

Information published in Radiotronics concerning new RCA releases is intended for information only, and present or future Australian availability is not implied.

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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 $1.25; and in all other countries 11/-. Price of a single copy 1/-.

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4th Edition.

Radiotron Designer's Handbook

See P.68-A for Chapters' Contents summary.

The success of the third edition is indicated by world sales in excess of 280,000 copies, and by its translation into Polish. It was written to satisfy the need for a concise and reliable handbook giving information much of which was not generally available from radio engineering text books.

Since it was first published in 1940, the science of radio receiver and amplifier design has advanced enormously. One of the problems of a radio designer to-day is the immense number of articles in periodicals, which require an elaborate indexing system as well as a large reference library. Many of these periodicals have limited circulation, particularly outside their country of origin, and are not always available except from the libraries of the larger organizations.

Not only so, but these articles also require careful sifting, to determine the accuracy of the author's statements. Up to the present time no radio text book or reference handbook has covered the subject of radio receiver and audio amplifier design in the detailed manner required by the designer.

The general principles are covered again and again, but the books do not go far enough to solve the many detailed problems facing the designer.

Fourth edition

The fourth edition of the Radiotron Designer's Handbook, which will be available in Australia about May-June, 1952, is more than an ordinary new edition. The whole work has been completely rearranged and re-written to suit the needs of to-day. It is nearly four times the size of the third edition, and is very much more embracing in its treatment of the various subjects. In fact, it covers the ground more comprehensively than any other book published anywhere in the world. In order to do so, it has been necessary to restrict the subject matter to A-M and F-M receiver design, audio frequency amplifiers and reproduction from gramophone discs, without including television — which to-day would require a large book on its own. Even so the book covers a total of 1,500 pages of 8 point typeface. The book is the product of Mr. Langford-Smith (editor and part author) and nine other authors, while the checking of the accuracy of the material has been done by a total of 23 engineers.

Moreover the treatment is essentially practical, being written by engineers who are themselves engaged in receiver design. The essential theory is given in concise form, with every possible aid towards its ready application.

The handbook is a comprehensive and nearly self-sufficient work of reference, for the assistance of those who design radio receivers, whether professional engineers or amateurs. That is to say, while extensive references and bibliographies are given, they will not normally need to be used by the design engineer, except for very advanced or highly specialized matters.

The chapter on mathematics and that on networks both commence from an elementary (or rather "basic") level so that engineers whose theory is rather "rusty" can refresh their knowledge. These two chapters have been carefully planned to include everything necessary for a proper understanding of the theory in the whole of the Handbook.

All chapters begin at an elementary level, but (with a few exceptions) the technical level rises and becomes more specialized in the later sections. However, even in the elementary portions, much care has been taken to retain accuracy and to avoid misunderstanding. Any reader with limited technical knowledge may commence with any chapter or any section and carry on until he has reached his limit. A qualified engineer will find the more specialized information which he requires arranged for his convenience. In all cases the index should be used for reference purposes, since it has been made as complete and helpful as is practicable.

The new handbook follows quite a different arrangement to that of the previous edition, being divided into seven parts covering — The Radio Valve; General Theory and Components; Audio Frequencies; Radio Frequencies; Rectification, Regulation, Filtering and Hum; Complete Receivers; Tables, Charts and Sundry Data.

The radio valve

This includes a short elementary introduction to the radio valve, followed by an extensive and detailed chapter on valve characteristics, giving a substantial amount of original material. Finally, there is a long and detailed chapter on valve testing, which also brings in allied subjects such as the maximum permissible value of grid resistor. Much of this information has never before been published.

General theory and components

There is a valuable basic chapter on the theory of networks, followed by a description of the characteristics of resistors and capacitors. A valuable chapter on the design of iron-cored transformers and inductors, both a-f and power, gives much information not available in book form, including a number of charts. A chapter on basic mathematics was included, commencing from elementary level, but including all the mathematics required for an intelligent use of the handbook.

One of the most important, and largest, chapters is that on negative feedback, which is the most complete treatment of the subject ever published, lished, apart from the highly specialized textbook by Bode.

An elementary chapter on wave motion and the theory of modulation is followed by the theory of tuned circuits, a chapter on the calculation of inductance, and another on the design of radio frequency inductors.

The rest of the book — apart from the last chapter — covers the design of radio receivers and audio amplifiers.

Audio frequencies

A long and detailed chapter on voltage amplifiers is followed by another on power amplifiers. These are followed by a chapter on fidelity and distortion, covering this subject very completely. This treatment of audio frequency fidelity is unique and will be of the greatest interest to those concerned with high fidelity reproduction. Another chapter covers tone compensation and tone control, followed by another on volume expansion, compression and limiting.

One of the largest chapters is on reproduction from disc records, covering the field more comprehensively than any other known single source, and includes much information of the greatest value both to home users and broadcast studio engineers. The wide interest in reproduction from records should make this very popular. Another chapter covers microphones, pre-amplifiers, attenuators and mixers, followed by one on units for the measurement of gain and noise (i.e. the decibel, phon, etc.).

The chapter on loudspeakers has been brought absolutely up to date by the incorporation of the latest information on enclosed cabinet and vented baffle loudspeakers, together with the design of horns, multiple units and distortion in loudspeakers. Finally there is a chapter on matching, extension loudspeakers, multiple systems and cross-over networks.

Radio frequencies

This section is introduced by a chapter on aerials and transmission lines, followed by the design of radio frequency amplifiers, oscillators, frequency conversion, tracking, intermediate frequency amplifiers, detection and a.v.c., reflex amplifiers, limiters and automatic frequency control.

Rectification, etc.

There is a chapter on rectification, one on filtering and hum, another on vibrator power supplies and finally one on current and voltage regulators.

Complete receivers

A descriptive chapter on types of receivers is followed by two valuable chapters on the design of A-M and F-M receivers. Finally there is a detailed chapter on receiver and amplifier tests and measurements.

Sundry data

This is unusually embracing, and also includes data on American and English Standards for components, etc.

A complete list of chapter and section headings will be included as a supplement to the next issue of Radiotronics.

"Advanced Theory of Waveguides", by L. Lewin. Published by Iliffe and Sons Limited, November, 1951. Size 8¾″ x 5½″. 192 pages, 54 diagrams. Cloth bound.

Waveguide theory has attracted considerable attention, especially during the last ten years, from many research workers both in Britain and in the United States. This book sets out the various methods that have been found successful in treating the types of problems arising in work on the subject.

It is assumed that the reader is familiar with the essentials of the theory and practice of waveguides, while a knowledge of advanced mathematics is also required, for without it this branch of micro-wave study must inevitably remain a closed book.

Waveguides in general having already been comprehensively reviewed in numerous other works, the author has here selected for discussion a number of topics as representative of the field in which the micro-wave engineer is at present engaged. Although many of the examples are concerned with the rectangular waveguide, it is considered that, with a thorough understanding of the methods employed, the reader will be able to apply the general principle to most of the cases that are likely to be encountered in practice.

Contents:

Foreword. Preface. Electromagnetic Theory and its Application to Waveguides. Cylindrical posts in Waveguides. Diaphragms in Waveguides. The Tuned Post and The Tuned Window. Waveguide Steps, T-junctions and Tapers. Radiation From Waveguides. Propagation in Loaded and Corrugated Guides. Bibliography. Index.

Our copy with the compliments of the publisher.

New RCA Releases

Radiotron 16ADP7 is a 16-inch oscillograph tube of the metal-shell type utilizing magnetic focus and magnetic deflection. It is designed especially for radar indicator service, but it is also useful in general oscillographic applications where a temporary record of electrical phenomena is desired.

Because of the long persistence of its P7 phosphor, the 16ADP7 is particularly useful where either low-speed non-recurring phenomena or high-speed recurring phenomena are to be observed. Furthermore,

(Continued on page 56)

A Method of Determining the Tracking Capabilities of a Pickup

By H. E. Roys *

Introduction

A pickup that is used for the purpose of reproducing disc records relies upon the mechanical contact between groove and stylus tip for actuation of the stylus. For, in order to obtain faithful reproduction, it is necessary that the stylus "track" or maintain good mechanical contact with, and exactly follow the undulations of the recorded groove. Where we are dealing with lateral recordings, and these form the bulk of the records in use to-day, we are primarily concerned with the contact between stylus and groove side walls as illustrated by Fig. 1-A. When the groove changes laterally from a mean position due to the modulation, it is the side walls of the groove that exert a side thrust upon the stylus to make it follow. If the vertical force is low, the stylus will climb the side wall as illustrated in Fig. 1-B, and then the effectiveness of the pinch of the "V" shaped record groove is lost and poor tracking and distortion results.

Tracking has been a problem even from the beginning of disc recording, when the usual vertical force was one half a pound instead of one half an ounce. For it is only by using adequate vertical force that the stylus can be held in the groove and maintain good mechanical contact with the side walls. The tracking problem still exists to-day even though vast strides have been made in the reduction of pickup mechanical impedance with a resulting improvement in tracking. Fine groove reproduction with a small stylus tip requires low vertical force if a minimum of record and stylus wear is wanted.

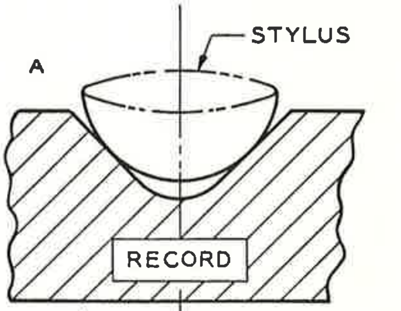

FIG. 1a. This shows an ideal "fit" between stylus and groove side walls

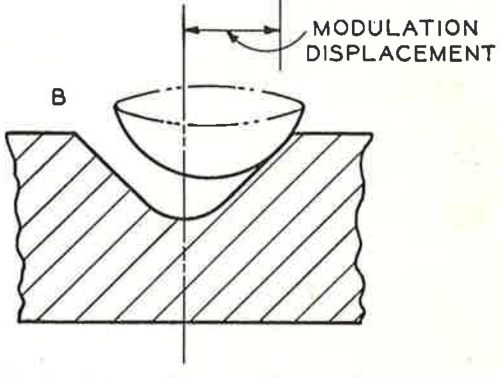

FIG. 1b. When the groove is displaced laterally from the mean position due to modulation, the tip, if the mechanical impedance of the pickup is high, will climb the side wall of the groove and an increased vertical force is needed to hold it in the groove.

Method of measurement

Since the tracking capabilities of a pickup depend upon its mechanical impedance, a measure of the mechanical impedance is also an evaluation of its ability to faithfully follow the recorded groove.

Determining the mechanical impedance is not a simple measurement nor is it completely adequate. For example, practically all of the pickup and tone arm combinations tend to climb the groove side walls, rattle and even skip out of the groove at tone arm resonance, and although skipping is not common at the high frequency resonance, changes in response at resonance can be noted unless sufficient vertical force is used, see Fig. 2. The mechanical impedance is high at the two resonant points and usually the vertical force has to be increased several times over its normal value in order to keep the pickup stylus firmly in the groove. Yet listening tests indicate that the quality of reproduction is acceptable with the lighter force. This may be so due to the fact that the mechanical impedance between the resonance frequencies is low, and it is throughout this region that the peak energies of speech and music are encountered, so that although the tracking requirements may be severe, the vertical force requirement is not great.

The intermodulation method of distortion analysis appears to be a good method of studying the tracking capabilities of a pickup, especially when using frequencies of 400 and 4000 cycles. For these frequencies lie between the two resonant frequencies of the pickup system and are located in

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* **Engineering Products Department,
R.C.A. Victor Division,
Camden, N.J.**

the region where high peak energies of speech and music are normally encountered. The method is sensitive, and yet the measurements are simple and easy to make. In addition, measurement equipment is not absolutely necessary, as a great deal of useful information can be obtained by simply listening to the reproduction of the test record. In fact, the test record is probably the most valuable item of the test.

The test records

For tracking studies, 78 and 45 RPM records cut by Mr. R. C. Moyer of our Indianapolis Plant are used. These were cut at different levels up to 10 db above an assumed normal recording value. Levels as low as minus 6 db were also included so that an overall range in 2 db steps, from − 6 to + 10 db is available when using the 78 RPM record and from − 4 to + 10 db with the 45 RPM record.

The two frequencies were combined in the normal manner for the intermodulation signal, 400 cycles for the low frequency and 4000 cycles for the high with the 4000 cycle tone 12 db below the 400 cycle signal in level. The 0 db or normal level for the 45 RPM record was made approximately 3 db lower than the 78 RPM value in accordance with the general practice of cutting fine groove records at a reduced level in order to avoid cutting into adjacent grooves and also to minimize tracing distortion. The peak value of the 0 db or normal levels as measured by the optical pattern method, while the pressings were being rotated (a necessity where two frequencies are combined in order to obtain an accurate evaluation of the pattern width) was measured to be 6 centimetres a second for the 45 RPM record and 8.7 centimetres a second for the 78 RPM record. The maximum peak recorded levels attained is about 27 and 18 centimetres a second for the 78 and 45 RPM records respectively. It is difficult to determine just what peak levels are encountered in phonograph records, but it is believed that the levels on the test records are adequate for pickup tracking studies. The RCA 45 RPM record system design is based upon a maximum recording level of approximately 14 centimetres a second.

Both records were cut with a stylus having a tip radius of less than 0.0005 inch, so a fine groove pickup having a tip radius of 0.001 inch can be used with either record. The 78 RPM record,* 12-5-39, has a groove wide and deep enough to accommodate pickups that have a tip radius of 0.003 inch such as normally used for 78 RPM reproduction. The 45 RPM record,* 12-5-37, has a narrow groove suitable only for reproduction with a pickup having a 0.001 inch tip radius.

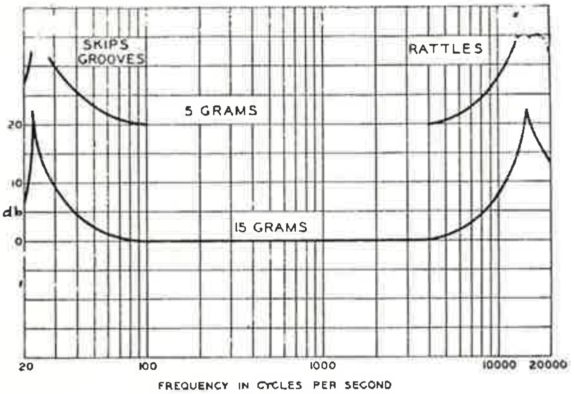


FIG. 2. Frequency response characteristic taken by the variable speed method. The peak at the low frequency end is due to tone arm resonance and the one at the high frequency end, due to pickup resonance. Mechanical impedance characteristic is similar to this in shape

Test procedure

Intermodulation test frequencies of 400 and 4000 cycles have been found to be particularly useful for studies of distortion in disc recording and reproducing systems. Fig. 3 shows a block diagram of the equipment* we have been using and also illustrates what the test signal, a combination of two frequencies, looks like on an oscilloscope and also how the distortion appears as modulation of the

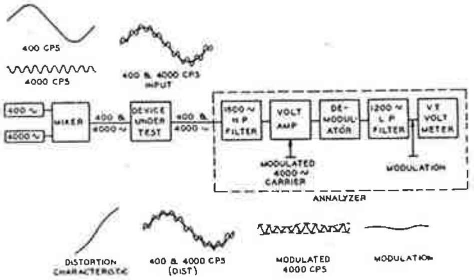


FIG. 3. The block diagram shows the function of the components of the equipment. The sine wave figures illustrate the appearance of the test signal, and how distortion shows up as amplitude modulation of the 4000 cycle test tone

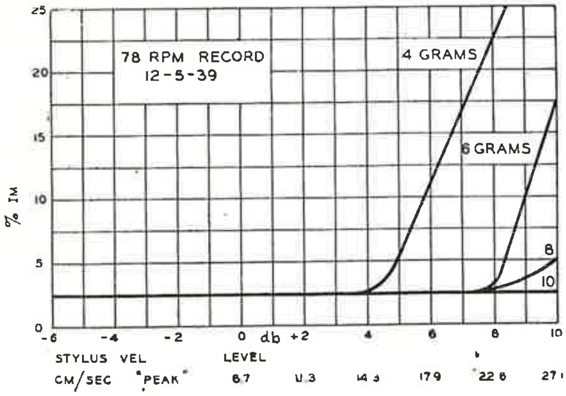


FIG. 4. Distortion curves obtained with the RCA MI-11874 magnetic pickup, illustrating its tracking capabilities and improvement obtained as the vertical force is increased.

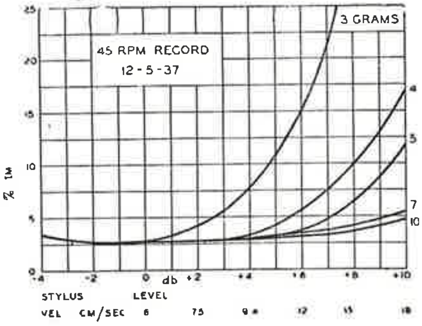


FIG. 5. Characteristics obtained with MI-11874 pickup when using the 45 rpm test record.

*** Refer Radiotronics, Vol. 16, No. 4, P. 74 for further details.**

4000 cycle carrier.

In determining the tracking capabilities of a pickup either the 45 or 78 RPM intermodulation record is played while using various vertical forces and the distortion is measured for each different recorded level. The results when plotted give a set of curves such as illustrated in Fig. 4. In general, the distortion is low for the low values of recorded signal, but at some higher level an abrupt change is encountered and the distortion increases rapidly as the recorded level is raised. Increasing the vertical force shifts the breaking point to a higher recorded level and by using sufficient vertical force, good tracking can be obtained at the highest levels available on the record.

Where the distortion appears abruptly and increases so rapidly with recorded level, it appears permissible to define good tracking in terms of vertical force and the recorded level where the break occurs.

Fig. 5, however, gives the results obtained with the 45 RPM record, and shows the breaking point with resulting rise in distortion to be less abrupt than obtained with the 78 RPM record. This makes it difficult to determine good tracking as defined above and it may be necessary to establish some value of intermodulation, such as 10 per cent. for example, as the limiting value. Then for the pickup illustrated in Fig. 5 with a vertical force of 5 grams, good tracking can be expected for recorded levels up to about 17 centimetres a second.

Ten per cent. intermodulation when using test frequencies of 400 and 4000 cycles, is a figure that has been arrived at after many careful listening tests over a wide range system as the value at which tracing distortion becomes perceptible. It is the value that has been used to establish the inner recorded diameter of RCA's 45 RPM records. Good correlation has been obtained between measurements and listening tests, and more recent tests indicate that the intermodulation method is as equally useful in determining the tracking capabilities of pickups.

When making tracking measurements, it is often advisable to listen to the output of the test record in order to detect any irregularities that may occur due to record eccentricity or wobble causing a once-around variation in distortion at turntable speed (due perhaps to excessive friction in the tone arm bearings). Such variation may be so slight that it does not register on the meter, especially if the meter is sluggish in action, and hence, may be overlooked unless listening tests are made.

When making comparison tests with records containing music, the pickup will usually appear to track better than indicated by the intermodulation test records. In such cases it is possible that the peak velocity on the music record is not as high as expected or that its duration is so short that tracking distortion is not readily apparent. If a number of tests are made, especially while using a wide range system so that tracking distortion can be readily detected, it is believed that on the average, the agreement will be found to be good between measurements and listening tests.

Effect of damping

It is the usual practice in pickup design to incorporate some mechanical resistance to smooth out the resonant peak of the pickup. The effect of the damper is usually judged by frequency response measurements. During tracking studies it was noted that the damping material can have a detrimental effect upon tracking. A sliver of viscoloid between the stylus and the case of the pickup, used for the tracking tests of Fig. 4, gave the results shown in Fig. 6. The sliver was small and had little effect upon the response characteristic, but the effect upon the tracking capabilities was such that the intermodulation increased from about 6 to 16 per cent. at a recorded level of 27 centimetres per second.

A large stiff block of viscoloid was tried in the same location with another pickup and the results with and without the damper are shown in Fig. 7.

FIG. 6 (below). A small piece of viscoloid when applied for mechanical damping caused this change in tracking capabilities.

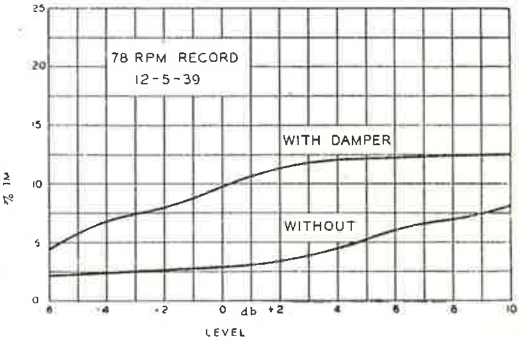
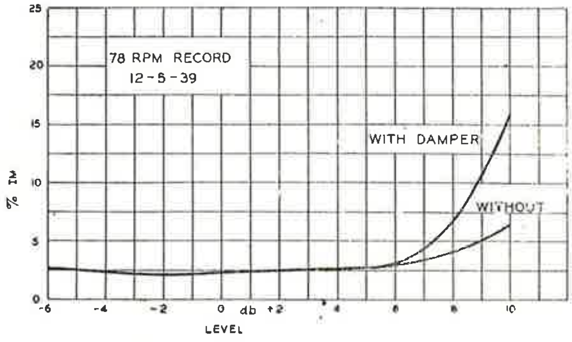
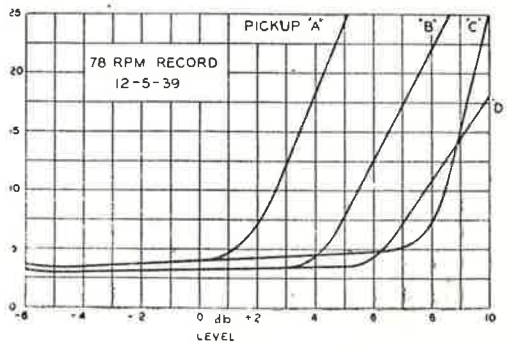


FIG. 7 (at left below). A larger piece of viscoloid had a detrimental effect upon tracking throughout entire recorded range.

FIG 8 (at right below). Comparison of pickups of different types and construction. Curve "D" was obtained with the RCA MI-11874 pickup





In this case the damper block was so stiff that it affected the tracking capabilities even at the lowest recorded levels. This is an unusual example, but it serves to illustrate that the damper block should be added with care, and the effect upon tracking as well as frequency response should be investigated.

Pickups of different design

Several pickups of different design were investigated for tracking capabilities. The same vertical force was used and the results are shown in Fig. 8. Two of the pickups were of the same type with minor changes in construction but considerable difference in the amount of damping material that was used. One pickup used no damping material, and another used a moderate amount. The pickup that used the greatest amount of damping material exhibited the poorest tracking capabilities, confirming the results of our tests as given above.

Conclusions

1. The intermodulation method of distortion analysis appears to be valuable in determining the tracking capabilities of a pickup. By reproducing intermodulation frequencies that have been recorded at different levels, the necessary value of vertical force needed to insure proper tracking can be easily determined.

2. Measurement equipment, although needed for a careful analysis, is not essential, as much useful information can be obtained by listening to the output of the test record.

3. Damping material so commonly used in pickup construction in order to obtain smooth response characteristics may adversely affect the tracking capabilities of the pickup and therefore should be investigated carefully and used judiciously.

See P.107
for full data

RADIOTRON 6AE8

Triode-Hexode Converter

Another Australian-made Miniature

The Australian-made Radiotron triode-hexode converter 6AE8, is the miniature successor to the X61M which has proved so popular with receiver manufacturers. It is mounted on the standard 9-pin miniature base, and abbreviated characteristics are indicated below. Further data and curves will appear later.

GENERAL DATA

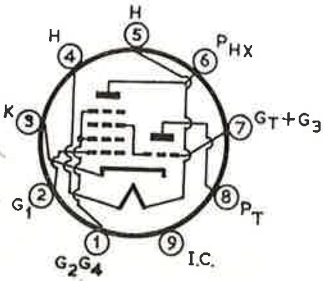
Electrical:—

Heater, for unipotential cathode

Voltage (a.c. or d.c.)	6.3 volts
Current	0.3 ampere

Mechanical:—

Mounting position	Any
Maximum overall length	$2\frac{3}{16}$"
Maximum seated height	$1\frac{15}{16}$"
Maximum diameter	$\frac{7}{8}$"
Bulb	T-6-$\frac{1}{2}$
Base	Small Button Noval 9-pin



Bottom view.

Pin 1 — Grid Nos. 2 & 4.
Pin 2 — Grid No. 1.
Pin 3 — Cathode.
Pin 4 — Heater.
Pin 5 — Heater.
Pin 6 — Plate.
Pin 7 — Grid No. 3 & Triode Plate.
Pin 8 — Triode Plate.
Pin 9 — Internal Connection.

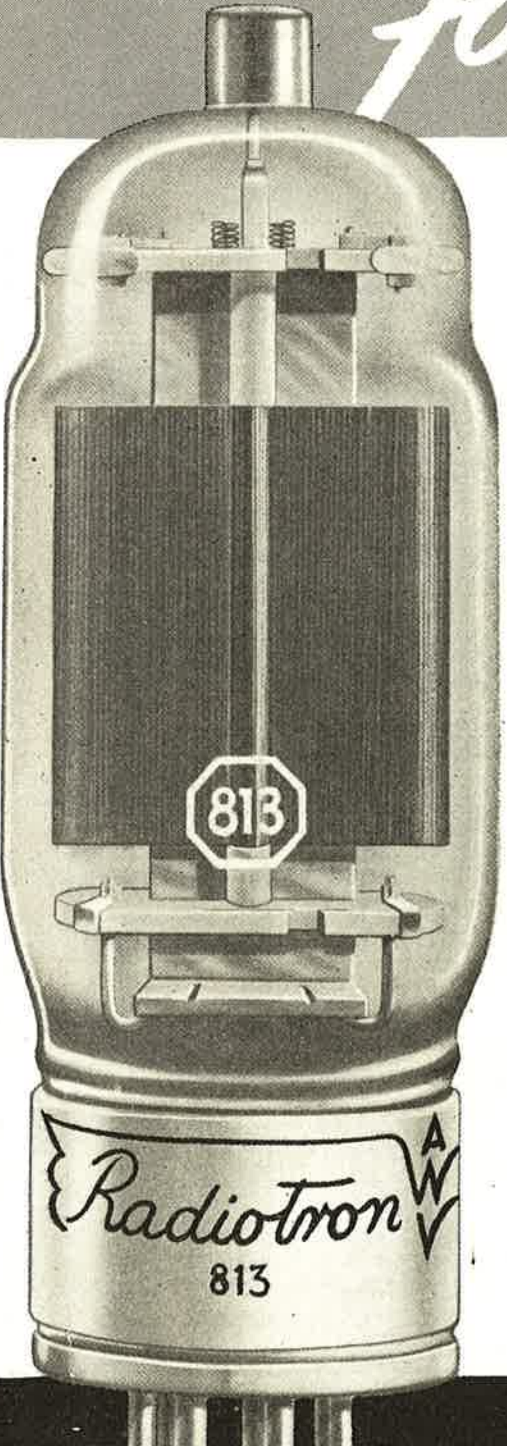
CONVERTER SERVICE

Typical operation:

Hexode Plate Voltage	250 volts
Hexode Screen Voltage	85 volts
Hexode Control Grid Voltage	–2 volts
Conversion Conductance	750 μmhos
Hexode Plate Resistance	2 megohms
Triode Plate Voltage*	100 volts
Triode Grid Current	300 μA
Triode Grid Resistor	30,000 ohms

* Supplied through a 30,000 ohm resistor from 250 volts.

AWV HEADLINERS *for HAMS*



HERE IT IS OM—

The latest technical data on Radiotrons in common use by amateurs and others working in the low-power field.

Look in here for —

- Data on new types such as 811-A, 812-A, 5618, 5651 and 5763.
- Operating conditions for frequency-multiplier service.
- Grid-current and effective grid-resistance valves for modulators.
- Socket connection diagrams for all types.
- Data on the following Australian-made Radiotrons, OC3, OD3, 2E26, 810, 813, 833-A, 866-A.

With the latest design improvements, high-quality materials plus uniform characteristics, new AWV valves are always your best buy. Look for the familiar red, white and blue Radiotron carton.

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AMALGAMATED WIRELESS VALVE COMPANY PTY. LTD.
47 YORK STREET, SYDNEY, N.S.W. AUSTRALIA

DESCRIPTIONS OF "HAM" TYPES

Type	Name	Filament or Heater (H)		Max. Dimensions Inches		Interelectrode Capacitances μμf			Amplification Factor	Max. Frequency for Full Input Mc/s	Max. ICAS☐ Ratings (Class C Telegraphy)	
		Volts	Amps.	Length	Diam.	Grid-Plate	Grid-Cathode	Plate-Cathode			Screen Input Watts	Plate Input Watts
0A2	Miniature Voltage Regulator	Cold Cathode		$2\frac{5}{8}$	$\frac{3}{4}$	Glow-discharge types for regulating voltages to oscillators (ECO or XTAL types), oscillator power supplies, to stabilize bias voltages, and for spark-over protection.						
0A3	Voltage Regulator			$4\frac{1}{8}$	$1\frac{9}{16}$							
0B2	Miniature Voltage Regulator			$2\frac{5}{8}$	$\frac{3}{4}$							
0C3	Voltage Regulator			$4\frac{1}{8}$	$1\frac{9}{16}$							
0D3	Voltage Regulator			$4\frac{1}{8}$	$1\frac{9}{16}$							
2D21	Miniature Gas Thyratron	6.3(H)	0.6	$2\frac{1}{8}$	$\frac{3}{4}$	80 watts in grid-controlled full-wave circuit.						
2E26	Beam Power Amplifier	6.3(H)	0.8	$3\frac{21}{32}$	$1\frac{5}{16}$	0.20■	13.0	7.0	6.5●	125	2.5	40
4-65A	VHF Power Tetrode	6.0	3.5	$4\frac{3}{8}$	$2\frac{3}{8}$	0.08	8.0	2.1	5 ●	50	—	—
4-125A/ 4D21	VHF Power Tetrode	5.0	6.5	$5\frac{11}{16}$	$2\frac{7}{8}$	0.05	10.8	3.1	6.2●	120	—	—
4-250A/ 5D22	Power Tetrode (Forced-Air Cooled)	5.0	14.5	$6\frac{3}{8}$	$3\frac{9}{16}$	0.12	12.7	4.5	5.1 ●	75	—	—
5R4-GY	Full-Wave Vacuum Rectifier	5.0	2	$5\frac{5}{16}$	$2\frac{1}{16}$	140 watts in full-wave choke-input circuit.						
802	Transmitting Pentode	6.3(H)	0.9	$5\frac{3}{4}$	$2\frac{1}{16}$	0.15■	11.0	6.8	7.3●	30	6	33
807	Beam Power Amplifier	6.3(H)	0.9	$5\frac{3}{4}$	$2\frac{1}{16}$	0.2■	12.0	7.0	8●	60	3.5	75
810	Transmitting Triode	10.0	4.5	$8\frac{3}{4}$	$2\frac{9}{16}$	4.8	8.7	12.0	36	30	—	750
811-A	Transmitting Triode	6.3	4	$6\frac{21}{32}$	$2\frac{7}{16}$	5.6	5.9	0.7	160	30	—	260
812-A	Transmitting Triode	6.3	4	$6\frac{21}{32}$	$2\frac{7}{16}$	5.5	5.4	0.77	29	30	—	260
813	Beam Power Amplifier	10.0	5	$7\frac{1}{2}$	$2\frac{9}{16}$	0.25■	16.3	14.0	8.5●	30	22	500
815	Twin Beam Power Amplifier	6.3 12.6(H)	1.6 0.8	$4\frac{9}{16}$	$2\frac{3}{8}$	0.22■	14.0	8.5	6.5●	125	4.5*	75*
816	Mercury-Vapor Rectifier	2.5	2	$4\frac{11}{16}$	$1\frac{9}{16}$	400 watts in full-wave choke-input circuit.						
826	Transmitting Triode	7.5	4	$3\frac{11}{16}$	$2\frac{3}{8}$	3.0	3.0	1.1	31	250	—	130
829-B	Twin Beam Power Amplifier	6.3 12.6(H)	2.25 1.125	$4\frac{5}{16}$	$2\frac{3}{8}$	0.12■	14.5	7.0	9●	200	7*	120*
832-A	Twin Beam Power Amplifier	6.3 12.6(H)	1.6 0.8	$3\frac{5}{16}$	$2\frac{3}{8}$	0.07 ■	8.0	3.8	6.5 ●	200	5*	36*
833-A	Transmitting Triode	10.0	10	$8\frac{13}{16}$	$4\frac{19}{32}$	6.3	12.3	8.5	35	30	—	1500
866-A	Mercury-Vapor Rectifier	2.5	5	$6\frac{9}{16}$	$2\frac{7}{16}$	1500 watts in full-wave choke-input circuit.						
2050	Gas Thyratron	6.3(H)	0.6	$4\frac{1}{8}$	$1\frac{9}{16}$	80 watts in grid-controlled full-wave circuit.						
5618	Miniature Transmitting Pentode	6.3° 3.0#	0.23° 0.46#	$2\frac{5}{8}$	$\frac{3}{4}$	0.24	7.0	5.0	—	100	2	7.5
5651	Miniature Voltage-Reference Tube	Cold		$2\frac{1}{8}$	$\frac{3}{4}$	Voltage stability is such that voltage fluctuations at any current value within the operating current range (1.5 to 3.5 ma) are less than 0.1 volt.						
5763	Miniature Beam Power Amplifier	6.0	0.75	$2\frac{5}{8}$	$\frac{7}{8}$	0.3 ■	9.5	4.5	16	175	2	15§
8005	Transmitting Triode	10.0	3.25	$6\frac{11}{16}$	$2\frac{7}{16}$	5.0	6.4	1.0	20	60	—	300
8025-A	UHF Transmitting Triode	6.3	1.92	$4\frac{15}{16}$	$2\frac{5}{32}$	3.0	2.7	0.4	18	500	—	50

CLASS B MODULATORS

Values shown in bold face type are for Intermittent Commercial and Amateur Service (ICAS).
Values shown in light face type are for Continuous Commercial Service (CCS).

Type	Max. DC Plate Volts	Max DC Plate Current Ma.	Max. DC Plate Input Watts	Max. Plate Dissipation Watts	Typical Operating Conditions (Two Tubes)									
					DC Plate Volts	Zero-Signal DC Plate Current Ma.	Max.-Signal DC Plate Current Ma.	DC Grid Volts	Max.-Signal DC Grid Current Ma.	Peak AF Grid-to-Grid Volts	Plate-to-Plate Load Ohms	Effective Grid-Resistanceϕ (Per Tube) Ohms	Max.-Signal Grid Driving Power Watts	Max.-Signal Power Output Watts
807	750	120	90	30	500 600 750	6 10 15	240 240 240	0 0 0	25 25 25	555 555 555	4000 5050 6650	7100 7100 7100	5.3 5.3 5.3	70 90 120
	Audio driving signal fed to grid No. 2. Grid No. 1 tied to grid No. 2 through 20000-ohm resistor (2 watts).													
810	2500 2750	250 250	425 510	125 175	2000 2250	60 70	420 450	−50 −60	50 50	345 380	11000 11600	1480 1380	10 13	590 725
811-A	1250 1500	175 175	165 235	45 65	1250 1500	50 32	216 313	0 −4.5	52 58	145 170	12400 12400	675 820	3.8 4.4	235 340

☐ ICAS = Intermittent Commercial and Amateur Service.

§ Values shown are for Continuous Commercial Service.

● Grid-screen mu-factor.

* Total for tube.

■ Maximum.

ϕ At crest of cycle. One half of the secondary of the driver transformer when working into the effective grid resistance should reflect to the driver tubes an impedance of not less than and preferably higher than the recommended load impedance of the driver tubes.

° For series filament arrangement, filament voltage is applied between pins No. 1 and No. 7. The grid-No. 1 voltage is referred to pin No. 1, and grid-No. 3 is connected to pin No. 1.

For parallel filament arrangement, filament voltage is applied between pin No. 5 and pins No. 1 and No. 7 connected together. The grid-No. 1 voltage is referred to pin No. 5 and grid-No. 3 is connected to pin No. 5.

FREQUENCY MULTIPLIERS

Values shown in bold face type are for Intermittent Commercial and Amateur Service (ICAS).
Values shown in light face type are for Continuous Commercial Service (CCS).

Type	Max. DC Plate Volts	Max. DC Plate Current Ma.	Max. Plate Dissipation Watts	Max. DC Grid-No. 1 Volts	Max. DC Grid-No. 1 Current Ma.	Typical Operation in Doubler Service ø										
						Plate		Grid-No. 2			Grid-No. 1				Approx. Grid-No. 1 Driving Power Watts	Approx. Carrier Power Output Watts
						DC Volts	DC Current Ma.	DC Volts••	Dropping Resistor Ohms	DC Current Ma.	DC Volts	Bias Resistor Ohms	DC Current Ma.	Peak RF Volts		
2E26	**600**	**85**	**13.5**	**−175**	**3.5**	**600**	**55**	**185**	**37500**	**11**	**−75**	**25000**	**3**	**92**	**0.23**	**20**
807	**750**	**100**	**30**	**−200**	**5**	**750**	**90**	**250**	**91000**	**5.5**	**−90**	**18000**	**5**	**110**	**0.45**	**40**
5618	300	30	5	−125	3	300	25	75	41000	5.5	−125	68000	1.85	160	0.75	4.2
	Tripler to 80 Mc/s→					300	25	75	41000	5.5	−125	68000	1.85	160	0.75	3.4
5763	300	50	12	−125	5	300	40	250	12500	4	−75	75000	1.0	95	0.6	3.6
	Tripler to 175 Mc/s→					300	35	237.5	12500	5	−100	100000	1.0	120	0.6	2.8

RECTIFIERS, THYRATRONS

Type	Max. Peak Forward Anode Volts	Max. Peak Inverse Anode Volts	Max. Peak Anode Current Amps.	Operating Conditions (Full-Wave Choke-Input)		
				AC Plate-to-Plate Supply Volts	Approx. DC Output Volts to Filter	Max. DC Output Current Amps.
RECTIFIERS °°						
5R4-GY	—	2800	0.65♦	1900	750	0.175
816	—	7500	0.5	5300	2390	0.25
866-A	—	2000 10000	2.0 1.0	1410 7070	635 3180	1.0 0.5
THYRATRONS °°						
2D21	650	1300	0.5	Max. Av. Cathode Amps., 0.1		
2050	650	1300	1.0	Max. Av. Cathode Amps., 0.1		

GLOW-DISCHARGE TUBES

Type	Approx. DC Starting Volts	Operating Conditions			
		Min. DC Anode—Supply Volts	Approx. DC Operating Volts	Regulation for Specified Current Range	
				Ma.	Volts
VOLTAGE-REGULATOR TYPES					
OA2	156	185	151	5 to 30	2
OA3	100	105	75	5 to 40	5
OB2	115	133	108	5 to 30	1
OC3	115	133	108	5 to 40	2
OD3	160	185	153	5 to 40	4
VOLTAGE-REFERENCE TYPES					
5651	107	115	87	1.5 to 3.5	3

Note 1: G caps nearer base; P caps nearer bulb tip.

ø Typical values shown for the 2E26 and 807 are for operation at 15 Mc/s; for the 5618, 80 Mc/s; for the 5763, 175 Mc/s.

♦ Per plate.

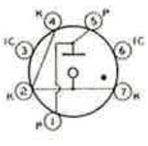
•• Obtained from a separate supply or from the plate-voltage supply with a voltage divider; or through a series resistor of value shown. Under key-up conditions, the screen voltage must not exceed the maximum rated plate voltage.

°° Filaments should be allowed to come up to operating temperature before plate voltage is applied. For average conditions the delay is approx. 10 sec. except for the 866-A which should have a 30-sec. delay period.

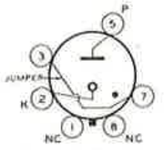
BOTTOM VIEWS OF SOCKET CONNECTIONS

KEY TO TERMINAL DESIGNATIONS

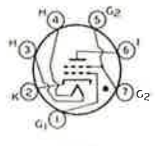
BC = Base Sleeve	H = Heater	IS = Internal Shield	NC = No Connection
F = Filament	H_M = Heater Mid-Tap	K = Cathode	P = Plate (Anode)
F_M = Filament Mid-Tap	IC = Internal Connection—Do not Use	● = Gas-Type Tube	S = Shell
G = Grid			U = Unit



OA2 OB2 5651



OA3 OC3 OD3



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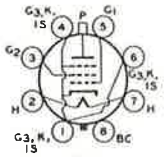

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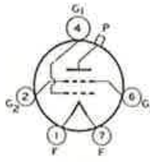

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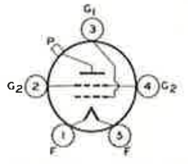

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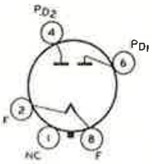

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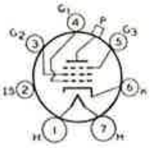

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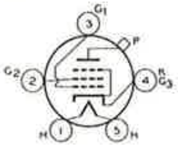

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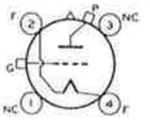

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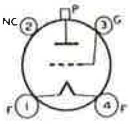
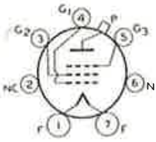


811-A 812-A 8005



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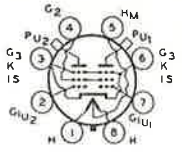

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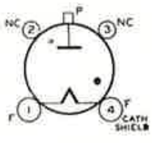
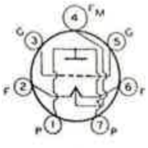


816 866-A



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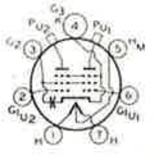

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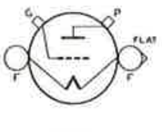

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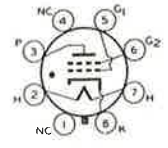

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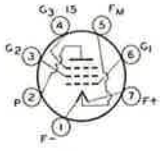

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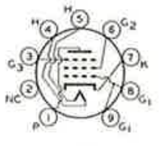

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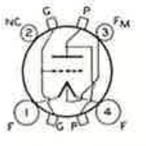


8025-A See Note 1

CLASS C AMPLIFIERS AND OSCILLATORS

Values shown in bold face type are for Intermittent Commercial and Amateur Service (ICAS).
Values shown in light face type are for Continuous Commercial Service (CCS).

Type	Class of Service	Max. DC Plate Volts	Max. DC Plate Current Ma.	Max. Plate Dissipation Watts	Max. DC Grid-No. 1 Current Ma.	Typical Operating Conditions										
						Plate		Grid-No. 2			Grid-No. 1				Approx. Grid-No. 1 Driving Power Watts	Approx. Carrier Power Output Watts
						DC Volts	DC Current Ma.	DC Volts••	Dropping Resistor Ohms	DC Current Ma.	DC Volts	Bias Resistor Ohms	DC Current Ma.	Peak RF Volts		
2E26	Phone	400	60	6.7	3.5	400	50	160	32000	7.5	−50	20000	2.5	60	0.15	13.5
		500	60	9	3.5	500	54	180	35500	9	−50	20000	2.5	60	0.15	18
	Code⧫	500	75	10	3.5	500	60	185	28500	11	−40	13500	3	50	0.15	20
		600	85	13.5	3.5	600	66	185	41500	10	−45	15000	3	57	0.17	27
4-65A	Phone	2500	120	45	—	2500	108	250	—	16	−150	—	8	235	1.9	225
	Code	3000	150	65	—	3000	115	250	—	20	−90	—	10	170	1.7	280
4-125A/ 4D21	Phone	2500	200	85	—	2500	152	350	—	30	−210	—	9	360	3.3	300
	Code	3000	225	125	—	3000	167	350	—	30	−150	—	9	280	2.5	375
4-250A/ 5D22	Phone	3200	275	165	—	3000	225	400	—	30	−310	—	9	365	3.2	510
	Code	4000	350	250	—	4000	312	500	—	45	−225	—	9	303	2.46	1000
802 †	Phone	400	40	6.7	7.5	400	35	195	12000	17	−40	27000	1.5	55	0.1	8
		500	40	8	7.5	500	40	245	17000	15	−40	27000	1.5	55	0.1	12
	Code	500	60	10	7.5	500	45	250	20800	12	−100	50000	2.0	155	0.25	16
		600	60	13	7.5	600	55	250	22000	16	−120	50000	2.4	165	0.3	23
807	Phone	475	83	16.5	5	475	83	225	50000	5	−85	21300	4	110	0.4	27.5
		600	100	25	5	600	100	275	50000	6.5	−90	22500	4	115	0.4	42.5
	Code	600	100	25	5	600	100	250	50000	7	−45	12800	3.5	65	0.2	40
		750	100	30	5	750	100	250	85000	6	−45	12800	3.5	65	0.2	50
810	Phone	1600	210	85	70	1600	210	—	—	—	−200	4000	50	370	17	250
		2000	250	125	75	2000	250	—	—	—	−350	5000	70	550	35	380
	Code	2000	250	125	70	2000	250	—	—	—	−160	4000	40	330	12	375
		2500	300	175	75	2500	300	—	—	—	−180	3000	60	350	19	575
811-A	Phone	1000	125	30	50	1000	115	—	—	—	−55	1200	45	150	6.1	88
		1250	150	45	50	1250	140	—	—	—	−120	2700	45	250	10	135
	Code	1250	175	45	50	1250	140	—	—	—	−50	1100	45	140	5.7	135
		1500	175	65	50	1500	173	—	—	—	−70	1750	40	175	7.1	200
812-A	Phone	1000	125	30	35	1000	115	—	—	—	−110	3400	33	220	6.6	85
		1250	150	45	35	1250	140	—	—	—	−115	3300	35	240	7.6	130
	Code	1250	175	45	35	1250	140	—	—	—	−90	3000	30	200	5.4	130
		1500	175	65	35	1500	173	—	—	—	−120	4000	30	240	6.5	190
813 ‡	Phone	1600	150	67	25	1600	150	300	43000	30	−160	13500	12	250	2.7	180
		2000	200	100	30	2000	200	350	41000	40	−175	11000	16	300	4.3	300
	Code	2000	180	100	25	2000	180	400	36000	45	−120	12000	10	205	1.9	275
		2250	225	125	30	2250	220	400	46000	40	−155	10000	15	275	4	375
815	Phone	325	125	13.5	7	325	123	165	10000	16	−45	11250	4	112△	0.2	30
		400	150	20	7	400	150	175	15000	15	−45	15000	3	116△	0.16	45
	Code	400	150	20	7	400	150	145	15000	17	−45	10000	4.5	116△	0.23	44
		500	150	25	7	500	150	200	17500	17	−45	13000	3.5	112△	0.18	56
826	Phone	1000	125	45	40	1000	95	—	—	—	−160	4000	40	320	11.5	70
	Code	1000	140	55	40	1000	130	—	—	—	−70	2000	35	183	5.8	90
829-B	Phone	600	212	21	15	600	112	200	15500	26	−70	8700	8	160△	0.6	50
		600	212	28	15	600	150	200	13300	30	−70	5800	12	172△	0.9	70
	Code	750	240	30	15	750	120	200	16200	34	−50	6300	8	120△	0.45	65
		750	240	40	15	750	160	200	18300	30	−55	4600	12	140△	0.8	87
832-A	Phone	600	68	10	6	600	36	200	25000	16	−65	25000	2.6	150△	0.16	17
	Code	750	90	15	6	750	48	200	37000	15	−65	23000	2.8	150△	0.19	26
833-A	Phone	2500	400	200	100	2500	335	—	—	—	−300	4000	75	460	30	635
		3000	400	250	100	3000	335	—	—	—	−240	3400	70	410	26	800
	Code	3000	500	300	100	3000	415	—	—	—	−200	3600	55	360	20	1000
		3300	500	350	100	3000	335	—	—	—	−160	2300	70	310	20	800
5618	Code#	300	30	5	3	300	25	75	32000	7	−45	30000	1.5	65	0.2	5.4
5763	Code°	300	50	12	5	300	50	250	10000	5	−60	22000	3	80	0.35	8
8005	Phone	1000	160	50	45	1000	160	—	—	—	−195	7000	28	350	9	115
		1250	200	75	45	1250	190	—	—	—	−195	7000	28	350	9	170
	Code	1250	200	75	45	1250	190	—	—	—	−115	3800	30	240	6.5	170
		1500	200	85	45	1500	200	—	—	—	−130	4000	32	255	7.5	220
8025-A	Phone	800	65	20	20	800	40	—	—	—	−105	10000	10.5	145	1.4	22
	Code	1000	80	30	20	1000	50	—	—	—	−90	6400	14	130	1.6	35

Phone = Class C Plate-Modulated Telephone Service.
Code = Class C Telegraph or FM Telephone Service.

‡ All typical operating conditions shown for this type are with grid-No. 3 connected to mid-point of ac-operated filament or to negative end of dc-operated filament.

† Max. dc grid-No. 3 volts = 200. All typical operating conditions shown for this type utilize +40 volts on grid No. 3.

•• In Code Service grid-No. 2 voltage is obtained from a separate supply, or from the plate-voltage supply with a voltage divider, or through a series resistor of value shown. Under key-up conditions, the grid-No. 2 voltage must not exceed the maximum rated plate voltage except for the 813 in which case the grid-No. 2 voltage must not exceed 800 volts. In Phone Service grid-No. 2 voltage is obtained preferably from a separate source modulated with the plate supply, or from the modulated plate supply through a series resistor of value shown.

⧫ Tube may be operated at 160 Mc/s in CCS service with 13 watts output at 300 plate volts, and at 160 Mc/s in ICAS service with 16.5 watts output at 350 plate volts.

\# Typical values shown are for operation to 40 Mc/s. For 80 Mc/s operation values are the same except for driving power of 0.3 watt and power output of 5.2 watts.

° Typical values shown are for operation at 50 Mc/s.

△ Peak rf grid-to-grid volts.

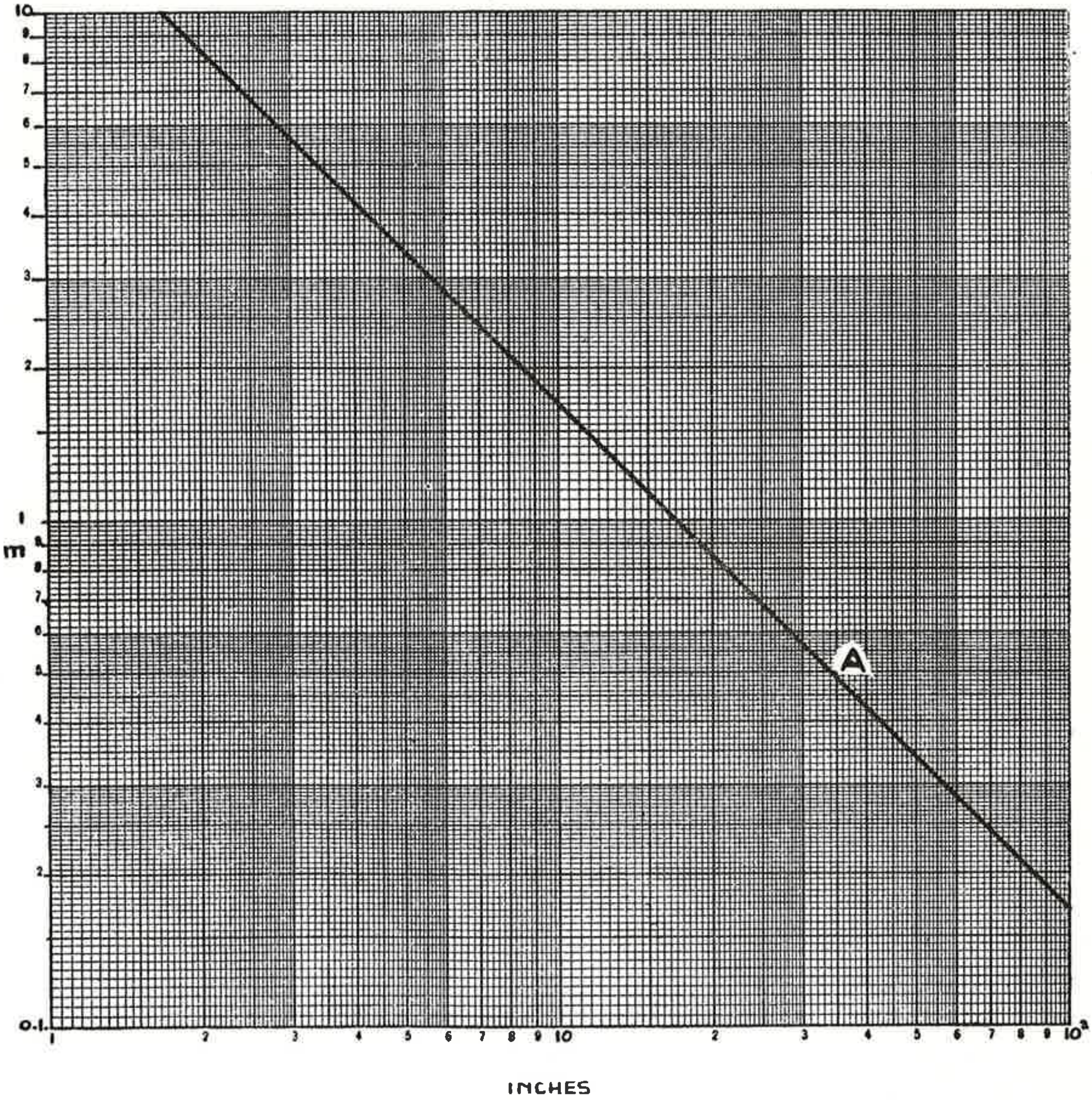
Typical driver unit.

PUBLIC ADDRESS HORNS

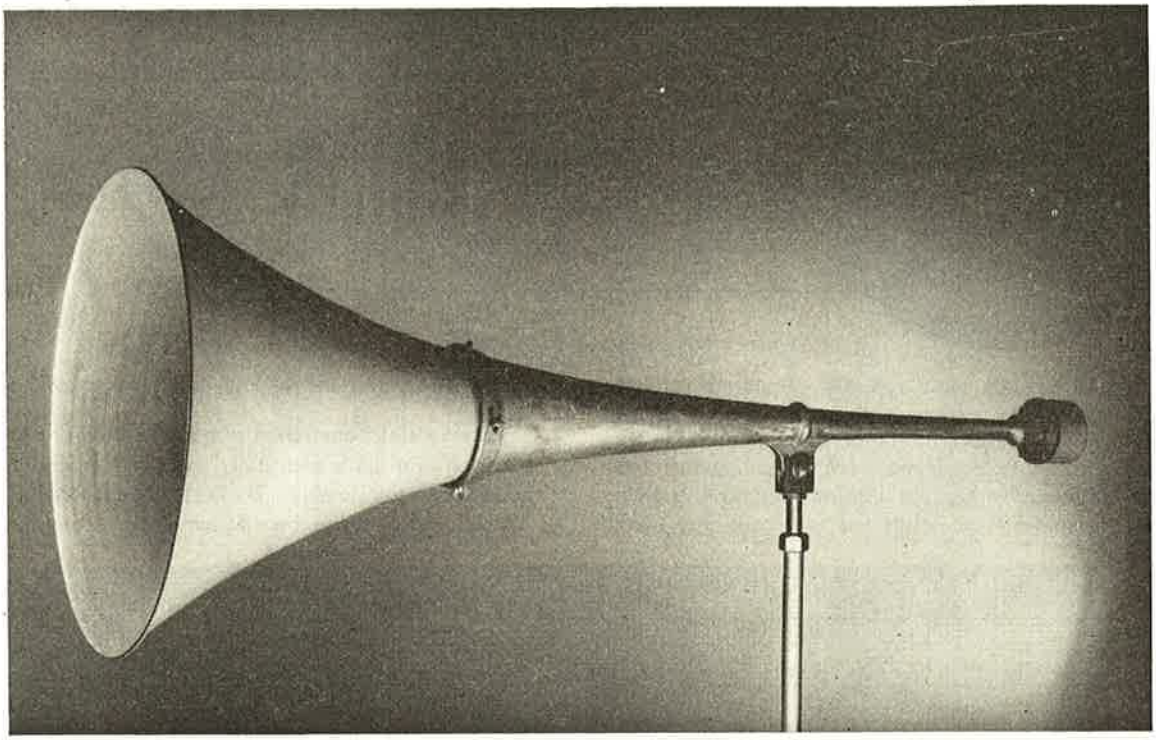
By I. C. Hansen

Several readers have recently requested information concerning exponential horns and as it was felt that this subject might be of general interest, a brief outline is presented here. Mathematics have been deliberately kept to a minimum; graphs being used to enable those interested to obtain the desired data without the aid of log. tables or a slide rule.

Exponential horns with a mouth diameter not less than the minimum mentioned later will operate with good efficiency down to a lower limit known as the "cut-off frequency". This latter is determined solely



A — Expansion Ratio, m, versus distance in inches between two points on horn axis where diameter doubles.



Typical public address horn fitted with driver unit and mounted on stand.

by the rate at which the horn cross-sectional area increases, with increase in horn length. The rate of increase is called the "expansion ratio" or "flaring constant".

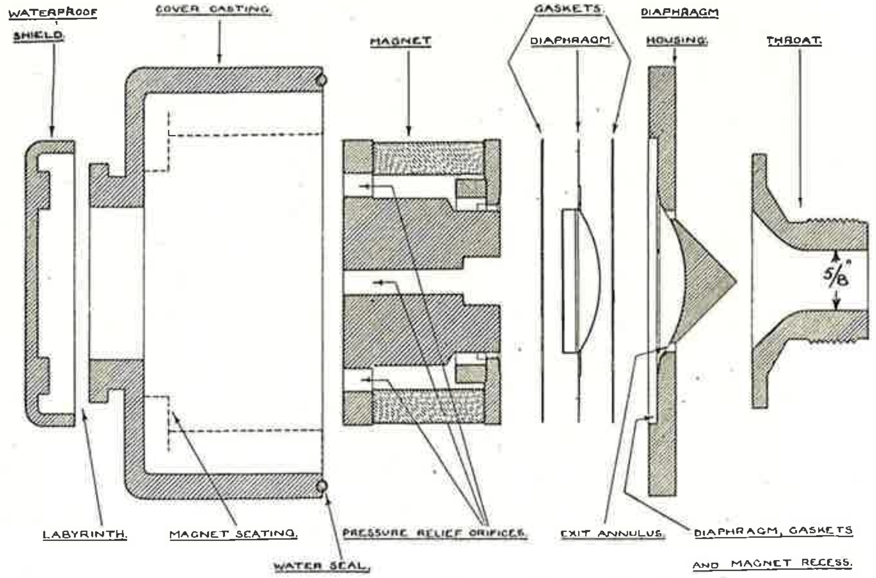
To determine this constant for an existing horn, choose a point near the throat and measure the horn diameter. Then measure the axial distance from that point to another nearer the mouth where the diameter has exactly doubled. Reference to curve A will show the expansion ratio m, then from curve B the cut-off frequency can be found.

In general, for best results with public address horns, the audio input to the driver unit should be restricted to a frequency about 1.2 times the cut-off frequency.

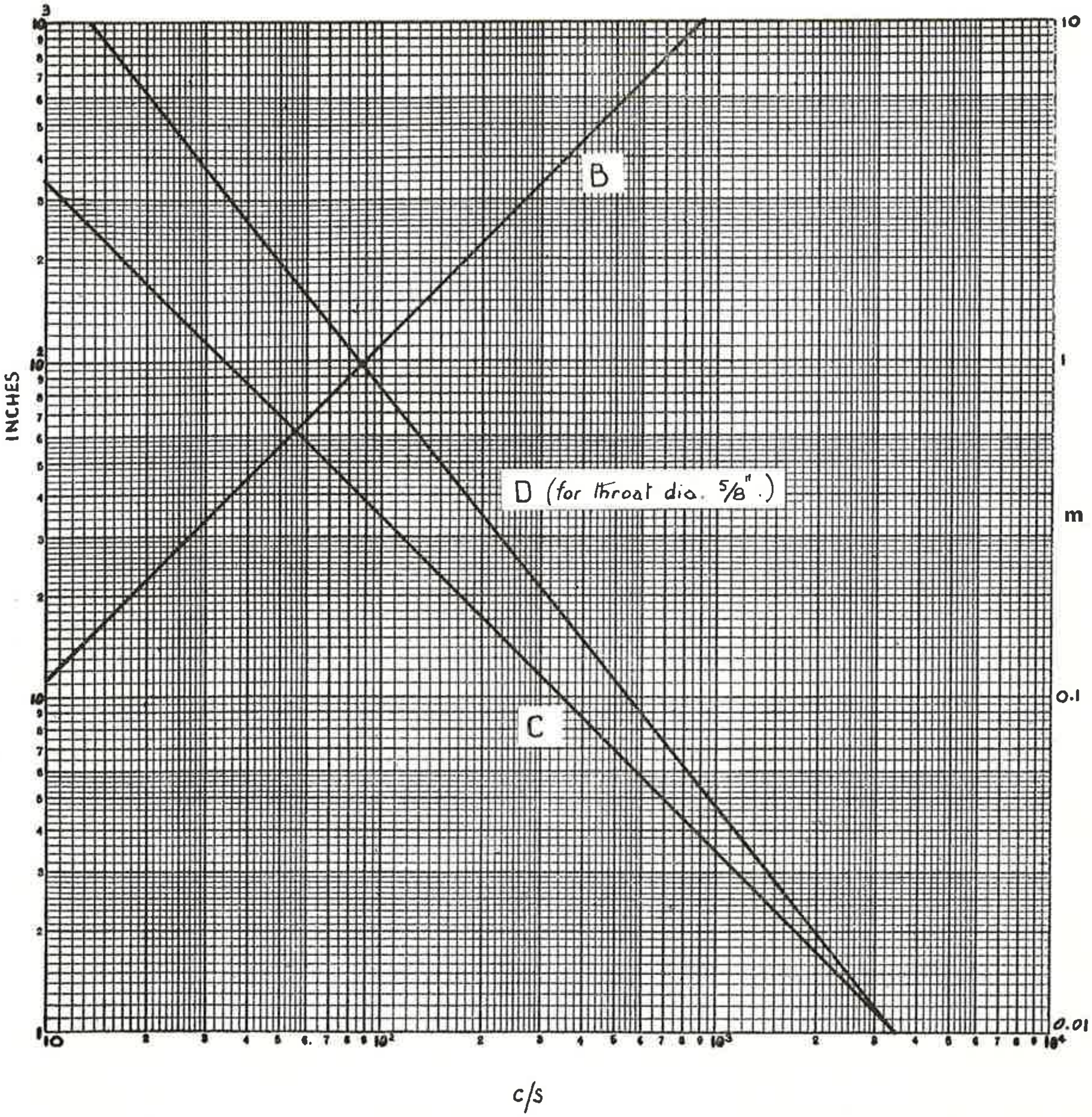
The minimum mouth diameter is at least a quarter (preferably a third) wavelength of the cut-off frequency. Curve C based on a quarter wavelength will show the minimum mouth diameter for a given cut-off frequency. Knowing the expansion ratio, the horn length for a desired mouth diameter can then be determined if the throat diameter is known. This can be readily ascertained by examining the driver unit and for most of these in local use, this throat measurement is $\frac{5}{8}''$. A good example of a driver unit in general use is the Reslo S.U. 10 which is illustrated here.

In a typical case it may be necessary to know the cut-off frequency of a horn, about which no data is available other than that it is used in conjunction with, for example, a Reslo S.U. 10 unit.

A quick measurement on the horn shows that at a selected point the diameter is 4 inches, while it



Sectional view of driver unit illustrated on preceding page.



B — Cut-off frequency versus m. C — Mouth diameter versus cut-off frequency. D — Horn length versus cut-off frequency.

has increased to 8 inches at a point 10 inches nearer the mouth. Reference to curve A shows that, in this case, the expansion ratio is 1.7 and this from curve B indicates a cut-off frequency of approximately 150 c/s.

As a check on the horn length and mouth measurements, curve C shows that the minimum mouth diameter should be 22.5 inches and the horn length from curve D, 50 inches, both based on a cut-off frequency of 150 c/s. Dimensions of commercial horns will probably exceed these by a small amount, 10-25%, to improve the performance of the unit; but provided the horn is not smaller than estimated, it should function satisfactorily down to the cut-off frequency. It should be emphasised that this frequency is determined by the expansion ratio rather than by length or mouth diameter.

Should the mouth and length of an existing horn be smaller than necessary for a measured expansion ratio and cut-off frequency, it would be highly desirable, to avoid reflection and other unwanted effects, to limit the lowest audio frequency input to a frequency higher than the cut-off frequency. This higher frequency could be calculated from the information given earlier, namely that the mouth diameter should be greater than a quarter wavelength of the lowest input signal. As a guide, a quarter wavelength at 100 c/s is 34 inches.

Thus in the case just quoted, had the mouth diameter of the horn measured 17 inches instead of the minimum recommended of 22.5 inches, it would be good practice to limit the low frequency input to 200 cycles. Methods of doing this will be taken up in a later article.

New RCA Releases

(Continued from page 44)

two or more phenomena can be observed simultaneously on the screen by means of a suitable switching arrangement.

Featured in the 16ADP7 is a limiting aperture at the end of the electron gun to produce a sharper, rounder spot on the screen, and hence greater effective resolution, especially at high values of beam current. This feature is particularly significant in those applications where pulse-modulated operation causes high grid-No. 1 drive and resultant high beam current.

The high-quality faceplate of the 16ADP7 is made of Filterglass to provide increased contrast between the trace and the background. Also, the faceplate with its relatively flat surface facilitates the use of an external, transparent, calibrated scale.

Radiotron 7TP4 is a directly viewed, 7-inch, cathode-ray tube intended for monitor service in connection with theatre-television systems, industrial television equipment, and portable broadcast equipment. It has a $5\frac{3}{8}''$ x $4''$ picture size.

Utilizing electrostatic focusing, the 7TP4 features an electron gun of improved design to provide high resolution and good uniformity of focus over the entire picture area. Furthermore, focus can be maintained automatically with variation in line voltage and with adjustment of picture brightness.

Other features of the 7TP4 include a large, relatively flat screen area in relation to tube diameter, and a metal-backed fluorescent screen which not only improves picture contrast and brightness but also eliminates the need for an ion-trap magnet.

Radiotron 7MP14 is a new, seven-inch cathode-ray tube of the magnetic-deflection and magnetic-focus type having a medium-long-persistence, cascade (two-layer) screen. It is intended primarily for those oscillographic applications, such as radar indicator service, where grid No. 1 is pulse-modulated at high frequency to provide a temporary record of electrical phenomena.

Because of its medium-long persistence of a little over a minute, the 7MP14 is particularly useful where either low- and medium-speed non-recurring phenomena or high-speed recurring phenomena are to be observed. It can be operated with scanning frequencies as low as 30 cycles per second without excessive flicker; and with a yellow filter, with much lower scanning frequencies.

Like its companion 7MP7 which replaces the 7BP7A in new equipment design, the 7MP14 utilizes a limiting aperture at the end of the electron gun to provide greater effective resolution especially when the tube is operated at high beam current as in pulse-modulated service. Other features of the 7MP14 include a faceplate of television quality, a neck diameter of $1\frac{7}{16}$ inches, and a 5-pin duodecal base.

Radiotron 17HP4 is a 17-inch, all-glass, rectangular picture tube utilizing Low-Voltage Electrostatic Focus — a design feature which makes it possible to obtain the voltage for the focusing electrode from the low-voltage d.c. supply of the receiver. The required focusing-electrode voltage is only 0 to 2.5 per cent. of the ultor voltage.

The focusing electrode in the 17HP4 has its own base-pin terminal to permit choice of focusing voltage for best results. When fixed focus is used, the designer can set the focusing voltage at a value which will give good results for his particular combination of ultor and grid-No. 2 voltages. If somewhat better performance is desired, he can provide for adjustment of the focusing voltage. With either method, focus can be maintained automatically with variation in line voltage and with adjustment of picture brightness.

Using a design in which the cathode is not connected to any other electrode, the 17HP4 retains the advantage of low input capacitance when employed in a cathode-drive circuit. Also, since the focusing electrode is not connected internally to grid No. 2, the 17HP4 has the advantage of permitting reduction in focusing voltage as grid-No. 2 voltage is raised — a necessary relationship for optimum focus.

The 17HP4 has a Filterglass faceplate; an external conductive bulb coating; an ion-trap gun requiring an external, single-field magnet; a design-centre maximum ultor-voltage rating of 16000 volts; and a screen size of $14\frac{3}{8}''$ x $11\frac{1}{16}''$.

Radiotron 5893 is a new, medium-mu, "pencil-type" triode intended particularly for use in grounded-grid service as a plate-pulsed oscillator at frequencies up to 3300 Mc. In such service, it is capable of giving a useful peak power output of 1200 watts.

The 5893 is also useful in low-power mobile transmitters as a cw oscillator, rf power amplifier, or frequency doubler at frequencies up to 1000 Mc. As an unmodulated class C rf power amplifier utilizing grounded-grid circuit under ICAS conditions, the 5893 is capable of delivering a useful power output of about 6 watts at 1000 Mc.

Featured in the 5893 is an improved "pencil-type" construction which not only meets the requirements of a good uhf tube as to minimum transit time, low lead inductance, and low interelectrode capacitances, but also provides other desirable features such as small size, light weight, low heater wattage, good thermal stability, and convenience of use in circuits of the coaxial-cylinder, line, or lumped-circuit type. Effective isolation of the plate circuit from the cathode circuit of the 5893 in grounded-grid service is made possible by the grid flange.

The "pencil-type" design employs a coaxial-electrode structure of the double-ended metal-glass type in which the plate cylinder and the cathode cylinder, each only $\frac{1}{4}$ inch in diameter, extend outward on opposite sides of the grid flange. The overall length of the structure is only $2\frac{5}{16}$ inches.

Type 5879

Low-noise Miniature Pentode for Audio Amplifier Service

By D. P. Heacock *
and R. A. Wissolik *

A major requirement for a tube in the input stage of a high-gain audio amplifier is that it generate little extraneous signal. Unless such signals are originally very small, the amplification of these signals by the succeeding stages may result in an objectionable amount of noise output. This extraneous output can be broken down into three general types of disturbance — hiss, hum, and microphonics. Hiss may be defined as the undesired output generated by thermal effects in the resistive component of a control-grid circuit, plus the shot and leakage effects in a tube. Hum is the unwanted audio signal caused by coupling between the a.c. heater supply and some other part of the circuit. Microphonics is the output caused by changes in the spacing between tube elements. This microphonic effect may, in extreme cases, produce a sustained output due to regenerative feedback between the loudspeaker system and the microphonic tube.

In addition to low-noise quality, an input tube for an audio amplifier should have relatively high gain. Small physical size is also desirable, and cost should be comparable to that of standard receiving types. RCA type 5879 is a tube designed to have these features.

The 5879 is a sharp-cutoff pentode having characteristics similar to those of type 6J7. It is a single-ended tube with a miniature envelope and a nine-pin base. The major electrical characteristics of the tube are given in Table 1.

The ratings of the tube permit its use either as a pentode or as a triode-connected pentode. The pentode characteristics of the tube are such that high gain may be obtained in resistance-coupled amplifier circuits. With a plate-supply voltage of 150 volts or more, a gain of greater than 100 can be obtained. When triode operation is desired, the triode amplification factor of 21 is adequate to provide moderate gain.

In the design of the 5879, every effort was made to incorporate all features which minimize the production of any type of tube noise. As mentioned above, hiss is one of the primary sources of noise. One component of hiss is the noise caused by the resistive element associated with the grid circuit of the input tube. This noise voltage is produced by the random motion of electrons in conductors and is generally referred to as the noise due to thermal agitation. This noise is distributed uniformly over the entire frequency spectrum. A similar hiss-type of noise is caused by the random emission of electrons from the surface of the cathode. Hiss is also produced by leakage effects between the various elements of the tube.

TABLE 1

Major electrical characteristics for the 5879 sharp-cutoff pentode.

Maximum Ratings	**As Pentode**	**As Triode***	
Plate Voltage	300	250	max. volts
Grid-No. 2 Voltage	150	—	max. volts
Grid-No. 2 Supply Voltage	300	—	max. volts
Grid-No. 2 Input	0.25	—	max. volts
Plate Dissipation	1.25	1.5	max. volts
Characteristics			
Plate Voltage	250	250	volts
Grid-No. 2 Voltage	100	—	volts
Grid-No. 1 Voltage	−3	−8	volts
Amplification Factor	—	21	
Plate Resistance	2 Meg.	13,700	ohms
Transconductance	1,000	1,530	µmhos
Plate Current	1.8	5.5	mA
Grid-No. 2 Current	0.4	—	mA

*** With grids No. 2 and No. 3 connected to plate.**

Little can be done in the design of the tube to minimize noise due to the first two causes because random fluctuations are inherent whenever there is a flow of current. However, hiss due to random leakage between tube elements is reduced in the 5879 by several structural features. An extra mica is used as a shield between the tube mount and the getter in order to prevent metallic getter particles from settling on the tube-mount micas when the getter is flashed. Furthermore, the processing of the tube is carefully carried out at low temperatures in order to prevent the vaporization of metallic parts and subsequent condensation of the vapor upon the micas of the tube. In addition, the micas are sprayed with a rough aluminium-oxide coating in order to lengthen any possible leakage paths between the tube elements. Finally, the cathode is designed to operate at a relatively low temperature to minimize vaporization of cathode material throughout the life of the tube.

Causes of hum

Hum in a tube is usually caused by one or more types of coupling — inductive, capacitive, or con-

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*** Tube Dept., R.C.A., Harrison, N.J.**

ductive — between the heater and other parts of the tube structure. Inductive (magnetic) hum may result if the heater design is such that an alternating magnetic field is produced inside the tube structure. Electrons in the tube will be deflected by such a field, and a modulation of the plate current at a rate of 60 or 120 cycles per second may result. In type 5879, hum is minimized by the use of a double-helical heater. In this heater design, two interwound helical coils carrying opposing currents occupy essentially the same space. The magnetic field produced by one helix is opposed by the field of the other, and the magnetic field round the heater is therefore virtually eliminated. In addition, the heater current required by the tube is reduced to as low a value as practical in order to further reduce magnetic effects.

Hum may also be caused by capacitive coupling between the heater and other elements of a tube. Very little of this coupling is present in a tube electrode structure because the cathode acts as an electrostatic shield between the heater and the other elements. Most of the coupling is caused by capacitance between the stem leads of a tube. In the 5879 a great reduction in this capacitance has been accomplished through proper design of the stem and arrangement of the base pins. The basing of the tube (Fig. 1) is such that one base pin not connected to any active element inside the tube is provided between the base pins for both grid and heater, and plate and heater. These pins may be grounded to serve as electrostatic shields between the heater pins and the grid and plate pins. Furthermore, since the cathode and screen are frequently at a.c. ground potential, the pins for these elements then serve as additional shields between the grid and plate pins and the heater pins.

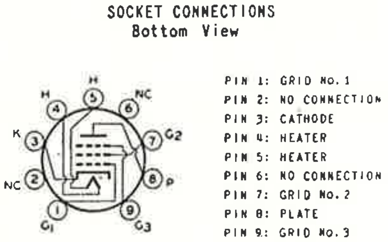

Fig. 1. Socket connections for 5879.

The basing of the tube lends itself conveniently to the triode connection since the screen, suppressor, and plate are brought out on adjacent pins in the base. Moreover, the grid and plate pins are sufficiently separated to permit the grid-to-plate capacitance to be maintained at a low value. The nine-pin noval base is used in this type so that all the above features could be suitably provided.

Conductive coupling between the heater and other tube elements exhibits itself most commonly as a leakage current between the heater and cathode of the tube. If a cathode resistor is used which is inadequately bypassed for the hum frequency, the leakage current will produce a voltage across the cathode impedance and a hum component will be present in the output of the tube. Because the heater insulation has a nonlinear resistance characteristic, the voltage produced across the cathode impedance is rich in harmonics which are clearly audible. Unfortunately, heater-cathode leakage cannot be completely corrected by basic design, but must be kept to a suitably low value by continuous process control during manufacture. It is necessary to use as pure a material as possible for the heater insulation; care must be taken not to chip or damage the heater coating during the assembling of the tube; and finally, the tube must undergo suitable processing after sealing and exhaust.

Microphonic effects minimized

Microphonic effects in a tube are caused by vibration of tube elements. This motion produces a momentary change in the spacing of the tube elements and thereby causes a variation in the plate current. In the 5879 these effects are minimized by many design features.

First, there is a close tolerance on holes in the mount support micas and the diameter of the holes is such that a tight fit is obtained with the tube elements. Second, two micas are used at the top and two at the bottom of the mount structure. Because the micas are never exactly the same, the effective diameter of the hole in the micas is smaller when two micas are used and the tube elements are more firmly wedged into place. Third, an inverted, pinched, welded cathode assembly is used (Fig. 2). The cathode has an emboss directly below the top mica. The cathode above the mica is pinched flat and welded so as to wedge it tightly into the top mica and prevent motion of the cathode at this point. The bottom of the cathode cannot be held tightly because the cathode must be free to expand. The cathode tab, however, serves to restrain motion of the cathode at this point. Fourth, the tube is designed with a short mount structure. Because the distance between the top and bottom micas is relatively small, the rigidity of the tube elements is increased. Motion of the tube parts in the centre of the mount is thereby restricted. Fifth, the spacing between the grid and cathode is relatively wide. Because the plate current varies inversely as the square of the distance between grid and cathode, a given displacement of the grid will produce less

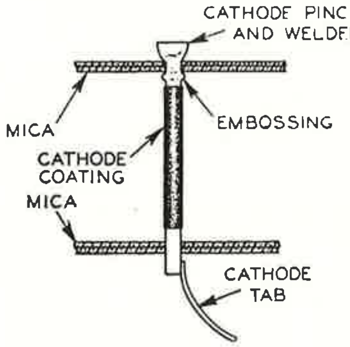

Fig. 2. Diagram of inverted, pinched and welded cathode assembly employed.

plate-current variation in a wide-spaced tube than in a close-spaced tube.

Many standard receiving tubes use one or several of these features in order to obtain certain desirable performance characteristics. In type 5879, however, the design has been concerned solely with the production of a good tube for audio service without particular regard for other, more general applications. Thus, it has been possible to incorporate all of these features into a single tube capable of giving superior audio performance. Production tests on the tubes serve mainly to reject "wild" tubes having characteristics unlike those of the majority of the product. The yield of good tubes from the final production test is high and, as a result, the cost of the tube is relatively low and the quality of the out-going product is good. Some equipment manufacturers attempt to select good audio tubes from regular receiving types, but this procedure usually results in low yield, high testing costs, and complications due to the difficulty of supplying suitable tube replacements. Use of the 5879 eliminates the need for this costly expedient.

Test equipment and procedures

In order to check the performance characteristics of the 5879, it is tested triode-connected, in the first stage of a high-gain audio amplifier. The triode connection is chosen so that leakage currents in the screen or suppressor circuits can be detected in the output of the tube. The grid resistor is 100,000 ohms in value and bias is provided by a cathode resistor. Tests can be made with this resistor unbypassed or bypassed with a 40-microfarad capacitor. Both a.c. and d.c. heater supply voltages are available, and the ground point of the a.c. supply can be varied by means of a potentiometer across the heater transformer. A shock-mounted standard phenolic socket with a grounded centre eyelet is used. Good wiring practice is observed in the wiring of the preamplifier, but no special shielding is employed.

For hiss tests, an overall system bandwidth of 13 Kc/s is used. For hum tests, the bandwidth is restricted to that range of 40-380 c/s so as to pass only the heater supply frequency and its major harmonics. The microphonic test is made with full bandwidth. For this test, a weighted arm is dropped on to the preamplifier chassis in order to excite the tube. The kinetic energy possessed by this arm, at the instant of impact, is about 0.01 foot pounds.

Test data

A distribution of the microphonic output of the tube based on tests of 100 tubes selected at random from regular production is shown in Fig. 3. The abscissa indicates the peak noise output of the tube caused by the impact of the arm on the chassis, expressed in microvolts referred to the grid of the tube under test. The ordinate indicates the percentage of tubes in the lot reading less than the corresponding abscissa value for microphonic output. The median value of microphonic output is about 42 microvolts.

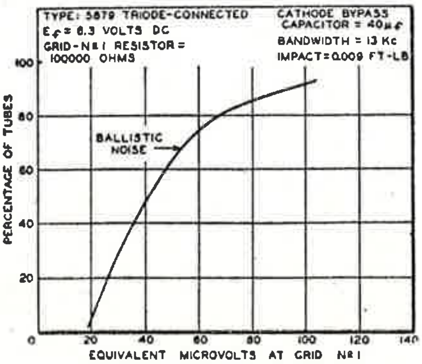

Fig. 3. Distribution of tube microphonic output.

The noise output due to hiss is shown in Fig. 4. For these data, the tube is operated with a d.c. heater in order to eliminate hum. The data are taken for both triode and pentode connection. The pentode connection gives rise to somewhat more hiss because of noise produced by random variations in the division of the current between the plate and screen (partition noise). The curves do not approach zero because the thermal agitation noise produced in the 100,000-ohm grid resistor is about 3.8 microvolts when the amplifier bandwidth is 13 Kc/s.

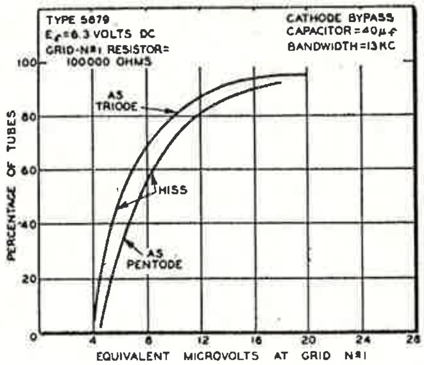

Fig. 4. Curves showing noise output due to hiss.

Fig. 5 shows hum data taken with a typical circuit for medium-priced audio equipment. One side of the a.c. heater supply is grounded and the cathode resistor is bypassed. For this test, the grid resistance is made equal to zero to eliminate hum due to capacitive coupling between the heater and the control grid. The hum present is caused in part by an imperfect bypass of the cathode resistor. Some magnetic hum is also present. An additional hum voltage is caused by coupling between the heater and the grid when a grid-circuit impedance is used. The magnitude of this voltage is proportional to the grid circuit impedance. For example, with a resistor of 100,000 ohms in the grid circuit of the 5879, an additional hum voltage of about four microvolts results.

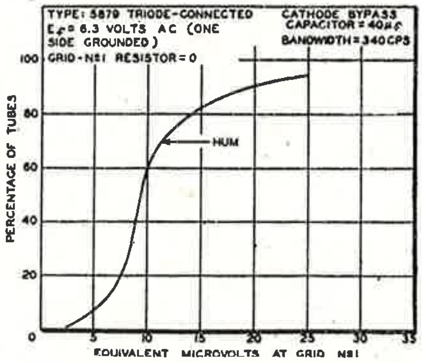

Fig. 5. Hum data taken with typical circuit for medium-priced audio equipment; one side a.c. heater grounded, cathode bypassed.

In some applications, the tube may be operated with an unbypassed cathode resistor. Such operation is definitely not recommended in low level audio equipment because of the hum produced by heater cathode leakage. Fig. 6 illustrates the effect of operating the tube with one side of the heater supply grounded and the cathode resistor unbypassed.

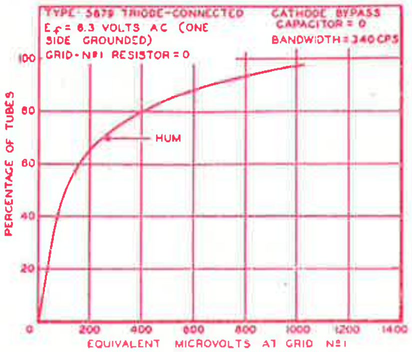

Fig. 6. Effect of operating tube with one side of heater supply grounded and cathode resistor unbypassed.

The hum is increased 20 to 50 times over the hum present with the cathode bypassed. If it is absolutely essential that the tube be operated with an unbypassed cathode resistor, several expedients can be used to reduce hum. First, the heater supply should be centre-tapped. The centre tap, in effect, forms part of a bridge circuit in which leakage currents from one-half of the heater to the cathode are opposed by out-of-phase leakage currents from the other half of the heater. As a further expedient, the centre tap should be returned to some point in the power supply which is 20 to 50 volts positive with respect to the cathode.

The beneficial effect of this connection is based on the fact that the leakage current through the heater-cathode insulation increases only slightly after a certain value of applied voltage is exceeded (Fig. 7). If no bias is provided, a.c. heater voltage impressed across the insulation causes a relatively large a.c. current. If the a.c. heater voltage is superimposed on a d.c. bias, it causes only relatively small variations in the total current; i.e., the a.c. (hum) component will be small. The use of a centre-tapped heater transformer with heater bias will reduce the hum on most tubes to a value of 20 microvolts or less referred to the grid of the tube.

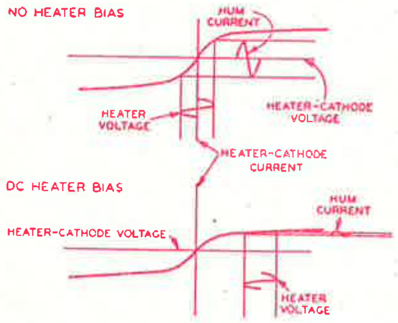

Fig. 7. Effect of d.c. heater bias to reduce hum.

Minimum hum

For amplifier design in which hum must be kept to an absolute minimum, the cathode resistor should be bypassed in order to minimize hum due to heater-cathode leakage. In addition, the heater supply should be provided with an adjustable a.c. ground by means of a low resistance potentiometer across the heater winding. The arm of the potentiometer should be returned to a d.c. heater bias source. This variable heater ground will permit the capacitive coupling between the heater and the grid to be balanced out. In addition, when the potentiometer is adjusted for minimum hum output, a small hum-bucking signal, either positive or negative, is fed into the grid to oppose any other minor sources of hum in the amplifier. Fig. 8 indicates that when these steps have been taken the median value of hum is less than 4 microvolts.

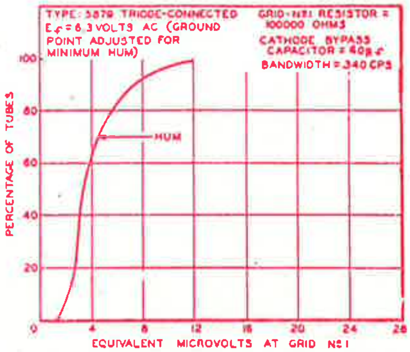

Fig. 8. Medium hum value is less than 4 microvolts with all precautionary measures.

NEW RADIOTRON RECEIVING VALVE MANUAL

The new enlarged 1952 edition of the Radiotron Receiving Valve Manual will soon be ready for distribution. This 32 page book replaces the earlier Characteristic Chart last published in 1951.

A feature of previous editions which is returned, is the convenient grouping of valve characteristics and related socket diagrams on the same page.

The manual is divided into three sections which are as follows:—

(a) Complete RCA range
(b) Additional RCA and AWV types
(c) Other manufacturers' types marketed in Australia.

It is felt that the latter section will be of considerable use to servicemen and others as the manual will now be much more nearly complete than earlier editions.

Advance orders for the new manual are now being accepted and copies will be mailed in rotation as soon as supplies are received.

The price of this 11″ x 8½″ publication is 2/- post free.

It is hoped to make an announcement concerning a new Radiotron Valve Data Book later in the year.