41.

RADIOTRONICS

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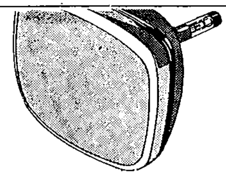
AMALGAMATED WIRELESS VALVE COMPANY PTY. LTD.



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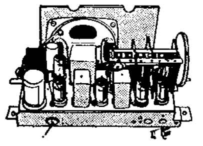

EDITOR .... **A. J. GABB**, B.Sc. (Syd.), A.M.I.R.E. (Aust.)

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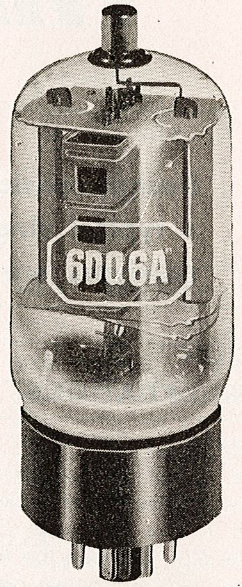
Subscribers should promptly notify Amalgamated Wireless Valve Company Pty. Ltd., 47 York Street, Sydney, and also the local Post Office of any change in address, allowing one month for the change to become effective.

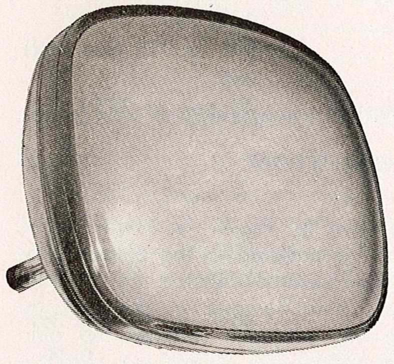
NEW RADIOTRON RELEASES

RADIOTRON 6DQ6A



BEAM POWER VALVE. Radiotron 6DQ6A is a high-perveance beam power valve of the glass-octal type designed especially for use as a horizontal deflection amplifier in high efficiency deflection circuits of television receivers.

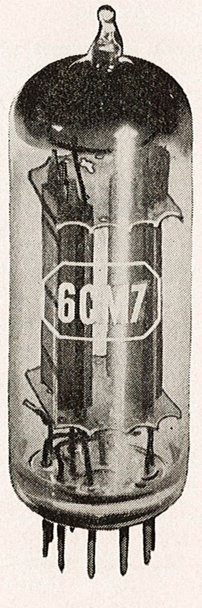
Designed with a large reserve of power capability, this valve has a maximum cathode current of 140 milliamperes, a maximum grid-No. 2 dissipation of 3 watts, a maximum grid-No. 2 voltage of 200 volts, a maximum d.c. plate voltage (including boost) of 700 volts. These features, together with a high operating ratio of plate current to grid-No. 2 current, make possible the design of an efficient horizontal-deflection circuit in which the valve can deflect fully picture tubes having deflection angles in excess of 90 degrees.



RADIOTRON 21ALP4A

PICTURE TUBE. This is a 21 inch, 90 degree electrostatic picture tube of rectangular glass construction. The face plate is spherical and is made of neutral gray glass which minimizes internal reflections and improves picture contrast. The 21ALP4A has an external conductive coating, and aluminized screen for increased picture brightness. The electrostatic-focus gun has improved focus quality, better focus over a wide range of operating voltages, and its performance is less affected by changes in anode voltage, brightness, and screen voltage.

RADIOTRON 6CM7



Radiotron 6CM7 is a medium-mu dual triode of the 9-pin miniature type containing two dissimilar triodes in one envelope. It is intended especially for use as a vertical deflection oscillator and vertical deflection amplifier in television receivers.

Unit No. 1 is designed for use as a conventional blocking oscillator in vertical deflection circuits. It has a maximum d.c. plate voltage current rating of 20 milliamperes, and a maximum plate dissipation rating of 1.25 watts.

Unit No. 2 of the 6CM7 is a high-perveance triode designed especially for use as vertical deflection amplifier. These features enable unit No. 2, in suitable circuits, to fully deflect picture tubes having deflection angles up to 90 degrees and operating at ultor voltages up to 20,000 volts.

VIDEO-AMPLIFIER

USING RADIOTRON 12BY7

Design considerations, circuit description and performance data for a typical single stage video amplifier suitable for commercial TV receivers are given.

by P. G. GONDA, A.S.T.C., M.I.R.E. (Aust.)

DESIGN CONSIDERATIONS.

General.

The circuit is considered a compromise — particularly suited to the Australian TV standards — between the following factors: gain, peak output, sync compression,* rise time, freedom from ringing simplicity and adaptability to various layouts.

Load Capacitance.

Adaptability was achieved by making provision for a load capacitance of 30 pF. As the actual maximum load is unlikely to exceed 25 pF, a fixed capacitor can be added to bring the total load capacitance to 30 pF.

Coupling to Picture Tube.

The three basic alternatives currently used are as follows:

(a) d.c. coupling;

(b) a.c. coupling with d.c. restoration;

(c) a.c. coupling.

The main advantage of a.c. coupling is simplicity of contrast control without affecting picture brightness or adding the stray capacitance associated with a potentiometer (approximately 15 pF). The main disadvantage, of course, is loss of the d.c. component of the video signal, which conveys background brightness.

Whilst textbooks consider the presence of correct d.c. component at the picture tube essential, overseas experience has shown that the background brightness in any particular programme is constant to such a degree that the brightness control has to be adjusted only once (e.g., when tuning in). As a result, approximately 90% of the 1956 models in the U.S.A. (including those in the "de-luxe" class) use a.c. coupling without d.c. restoration.

BRIEF SPECIFICATIONS.

Optimum Input	4V p-p, negative going, d.c. coupled to video detector.
Maximum Output	120V p-p.
Sync Compression	3.6 db at max. output.
Maximum Gain	30 times.
Frequency Response	6 db at 3.5 Mc/s.
Rise Time	0.16 μsec.
Overshoot	6% or 0% (see text).
Undershoot	0%.
H.T. Power Consumption	40 mA at 275V.

CIRCUIT DESCRIPTION.

General.

The circuit, as shown by Fig. 1, is of the series shunt peaked type, a.c. coupled to the picture tube cathode with contrast control effected by the unbypassed 200 ohms potentiometer in the cathode circuit. Increasing the resistance reduces the gain of the stage due to an increase in bias and negative current feedback.

Soundtrap.

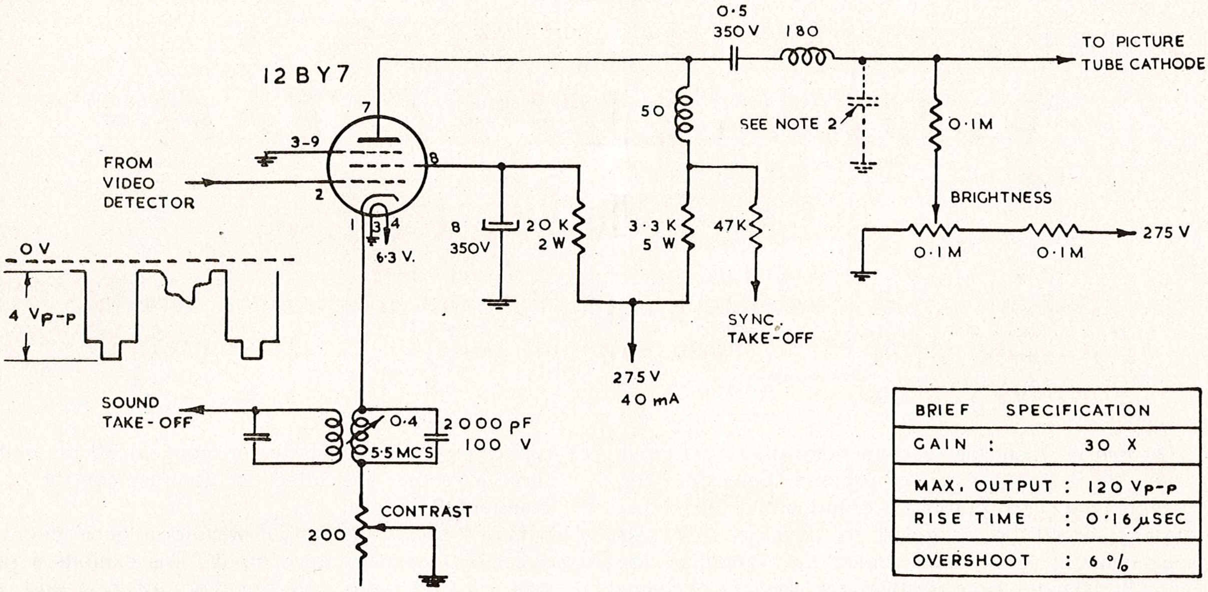
The 5.5 Mc/s soundtrap is in the cathode circuit because the ringing contributed is considerably less than that by a plate trap, when both are adjusted for the same attenuation. The actual attenuation produced is of the order of 30 db, which is reduced to 23 db when the cathode potentiometer is adjusted for minimum contrast.

The Q of the trap coil should be of the order of 15 for the above attenuation.**

As there is considerable power gain from the amplifier grid to cathode, the circuit will lend itself to the technique of replacing one stage of sound i-f amplication by the video amplifier, e.g. by inductive coupling of a parallel resonant circuit tuned to 5.5 Mc/s to the trap. The difference in sound i-f and video amplifier cathode impedance levels will yield useful voltage gain.

* *For the purpose of this article, sync compression is defined as* $20 \log \dfrac{\text{sync to peak-to-peak ratio at input.}}{\text{sync to peak-to-peak ratio at output.}}$

** *For simple design procedure, see K. Hillman's "Design Chart for Selective Cathode Trap", Electronics, July, 1956.*



NOTE 1
ALL CAPACITANCES IN MICROFARADS
ALL RESISTANCES IN OHMS
ALL INDUCTANCES IN MICROHENRIES
UNLESS OTHERWISE STATED

NOTE 2
TOTAL LOAD CAPACITY
SHOULD BE 30±3 pF FOR
OPTIMUM TRANSIENT RESPONSE

NOTE 3
ALL RESISTORS ½ W AND
ALL CAPACITORS 600 V
UNLESS OTHERWISE SPECIFIED

Fig. 1. Video Amplifier Circuit.

CIRCUIT PERFORMANCE.

General.

Whilst the layout is not critical, normal engineering practices — such as minimising stray capacitances and making the distance between input and output components as large as possible should be observed.

Electrode Dissipations.

Table 1 lists the 12BY7 plate and screen dissipations under various input conditions and as a function of H.T. supply variations. It will be observed that the H.T. supply can be raised to almost 300 V before the maximum design centre rating is exceeded.

Contrast Control Range.

As indicated by Fig. 3 (D) a contrast range of 15 db is obtained using a 200 ohm potentiometer. This is more than adequate, and a greater range would render the action unnecessarily coarse.

H T	OUTPUT	SYNC. COMP.
300	•——•——•	•- - - •- - - •
275	x——x——x	x- - - x- - - x
250	————	- - - - - - - -

Linearity and Overload Characteristics.

Fig. 2 shows overload characteristics as a function of supply voltage variation, measured with a negative going composite video input. Peak-to-peak output and sync compression versus input level at various H.T. supply voltages and at maximum and minimum contrast setting are plotted. As shown, even at 250 V H.T., 100 V p-p output can be obtained. This is ample to drive normal picture tube and sync circuits.

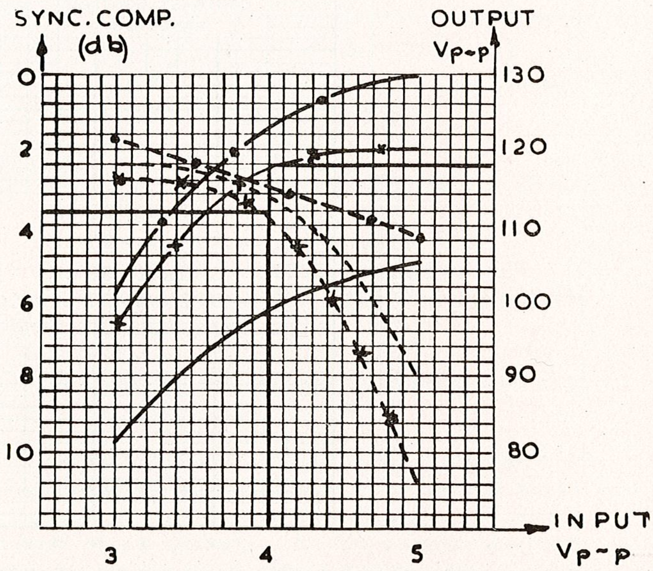


Fig. 2. Family of curves showing Sync Compression and Maximum Output v. Input to Grid.

TABLE 1

H.T.	INPUT	SCREEN DISSIPATION MAX. 1.1W.	PLATE DISSIPATION MAX. 6.5W.
250	0	0.8	4.7
250	—1V d.c.	0.8	4.7
250	4V p-p*	0.8	4.3
275	0	1	5.6
275	—1V d.c.	1	5.4
275	4V p-p*	1	5.4
300	0	1.2	6.9
300	—1V d.c.	1.2	6.5
300	4V p-p*	1.2	6.4

As can be seen, the recommended operating input level (4 V p-p) is a compromise between sync compression and output. Consequently the a.g.c. system should be designed to develop 4 V p-p maximum at the video detector. Amplified or amplified/keyed a.g.c. systems are capable of maintaining this level within ± 10% for the full range of normally encountered signal levels (50 μV—300 mV). Simpler a.g.c. systems may require pre-set adjustment on installation of the receiver.

Frequency Response.

Fig. 3-curve A shows the frequency response, which is 6 db down at 3.5 Mc/s. Whilst the Australian TV standards do permit a wider video bandwidth, this has been used to accommodate the gradual cut-off characteristics required for good transient response with complete absence of ringing.

Curves B and C show the effect of ± 5 pF load capacitance variation from the nominal 30 pF whilst curve D shows the effect of contrast control.

Transient Response.

Fig. 4 shows the output waveform generated by a 250 Kc/s square wave input. This exhibits a rise time of 0.16 μsec., an overshoot of 6% and no ringing. Whilst the overshoot is normally considered desirable, as it creates the illusion of improved resolution, some designers may prefer a response without overshoot. If the load capacitance is increased to 33 pF and the inductance of the series peaking coil reduced to 170 μF, the overshoot will be eliminated, as shown by Fig. 5.

Figures 6 and 7 show the effect of varying load capacitance ± 5 pF from the normal 30 pF.

To illustrate circuit action, Figures 8 and 9 show the transient response with the series and shunt circuits, respectively, removed.

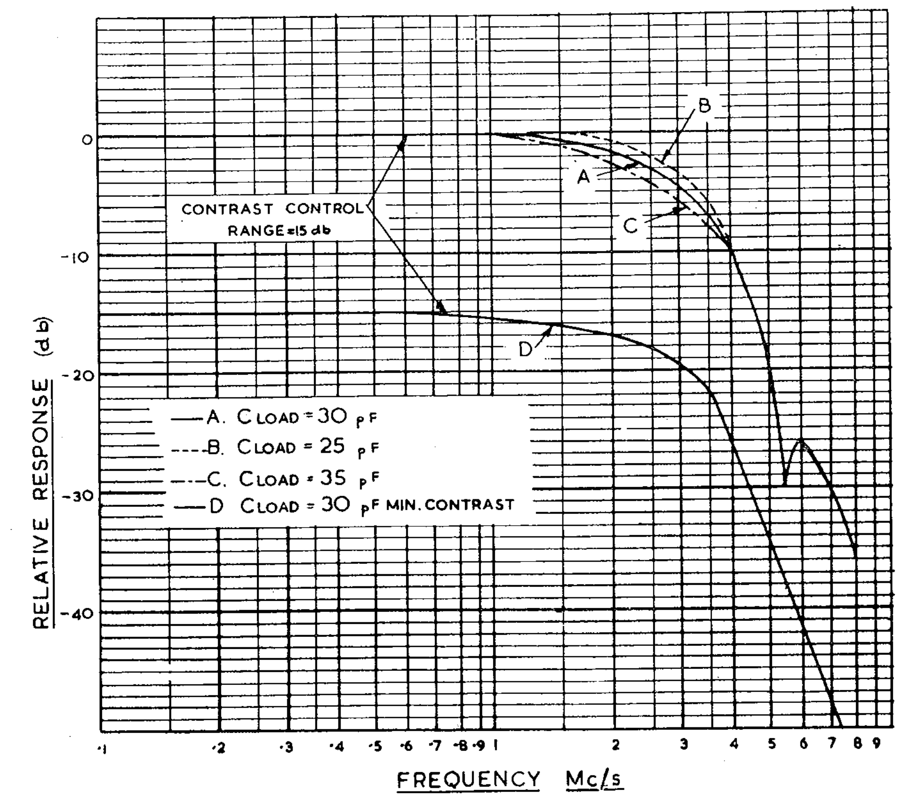


Fig. 3. Frequency Response.

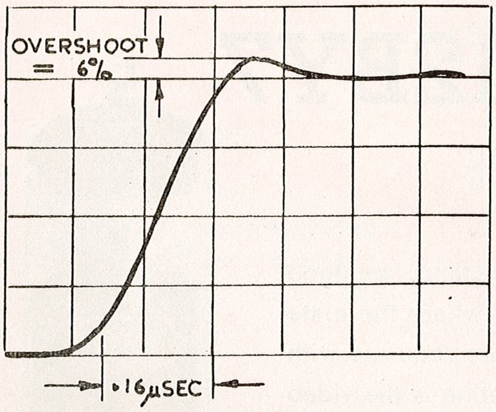


Fig. 4. Normal Transient Response.

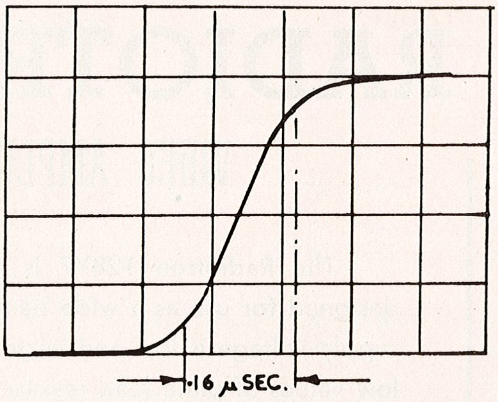


Fig. 5. Transient Response; components adjusted for no overshoot.

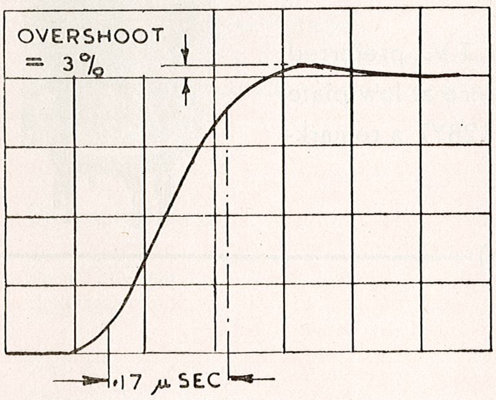


Fig. 6. Transient Response: load capacitance 5 pF above normal.

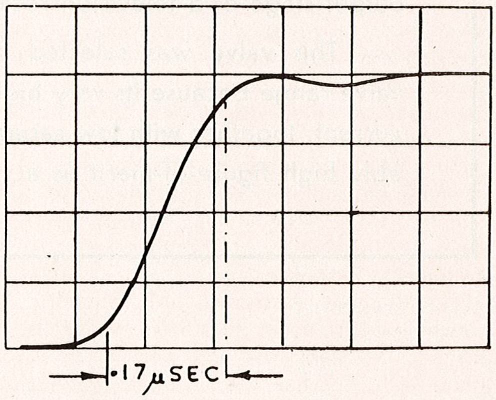


Fig. 7. Transient Response: load capacitance 5 pF below normal.

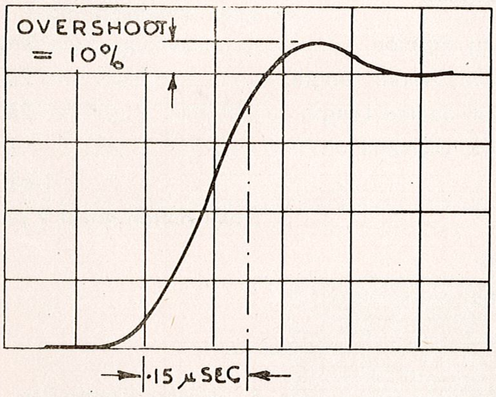


Fig. 8. Transient Response: series peaking coil removed.

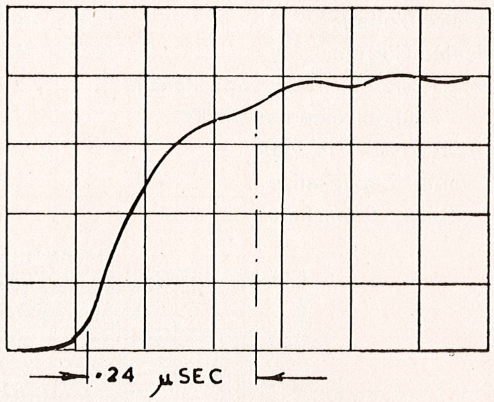


Fig. 9. Transient Response: Shunt peaking coil removed.

Test Pattern Performance.

An RCA Test Pattern ("Indian Head") signal (10 Mc/s bandwidth) was fed to an experimental amplifier as described above, using a series peaking coil of 180 µH inductance. The total load capacitance was adjusted to 30 pF and the output observed on a 17HP4B aluminised picture tube.

The pattern showed very slight overshoot without undershoot (one white line on horizontal black-to-grey transitions). This, however, was only visible from a distance less than 1 foot, and therefore can be considered insignificant.

CONCLUSIONS — APPLICATIONS.

The circuit should be applicable to any commercial TV design where:—

(a) A H.T. supply of not less than 250 V at 40 mA is available.

(b) The r-f and i-f gain is sufficient to produce a negative going video signal of 4 V p-p at the video detector.

(c) The video detector can be directly coupled to the video amplifier grid.

Acknowledgments are due to Mr. R. McMaster of Amalgamated Wireless (Australasia) Limited for his helpful criticism and to Mr. E. Pietor, at A.W.V. Applications Laboratory, for his valuable assistance is carrying out the numerous measurements required for this article.

RADIOTRON 12BY7

VIDEO AMPLIFIER PENTODE

The Radiotron 12BY7 is a high transconductance pentode designed for use as a wide band video amplifier, where the plate supply voltage is low and large output voltages are required with low values of plate load resistor. Such an application is the video output stage of a television receiver.

This valve was selected for the Radiotron T.V. preferred valve range because its very high mutual conductance at low plate current, together with low capacitances, give the 12BY7 a remarkably high figure-of-merit as a video amplifier.

(tentative data)

GENERAL DATA

	Series	Parallel	
Heater Voltage	12.6	6.3	volts
Heater Current	0.3	0.6	amp
Direct Interelectrode Capacitances (without external shield):			
Grid No. 1 to Plate		0.055	μμF
Input Capacitance		11.1	μμF
Output Capacitance		3.0	μμF

Mechanical:

Mounting Position	any
Maximum Overall Length	2⅝″
Maximum Seated Length	2⅜″
Maximum Diameter	⅞″
Bulb	T-6½
Base	Small button noval 9 pin

Socket Connections

(bottom view)

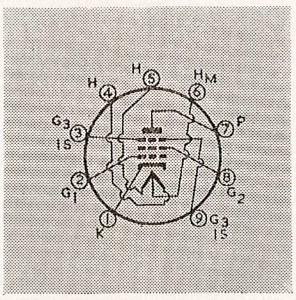
Pin 1. Cathode

Pin 2. Grid No. 1

Pin 3. Grid No. 3, Internal Shield

Pin 4. Heater

Pin 5. Heater



Pin 6. Heater Centre-Tap

Pin 7. Plate

Pin 8. Grid No. 2

Pin 9. Grid No. 3, Internal Shield

Maximum Circuit Value:

Grid No. 1 Circuit Resistance:	
For cathode-bias operation	1 max. megohm
For fixed-bias operation	0.25 max. megohm

CLASS A1 AMPLIFIER

Maximum Ratings:

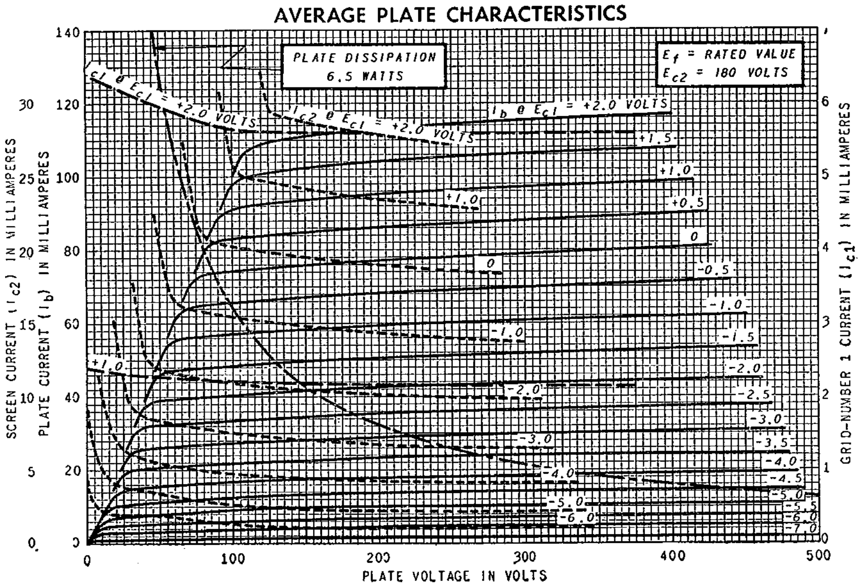
Plate Supply Voltage	300	max.	volts
Grid No. 3 (Suppressor) Voltage	0	max.	volts
Grid No. 2 (Screen) Voltage	175	max.	volts
Grid No. 1 (Control-Grid) Voltage:			
Negative Bias Value	50	max.	volts
Positive Bias Value	0	max.	volts
Grid No. 2 Input	1	max.	watt
Plate Dissipation	6.25	max.	watts
Peak Heater-Cathode Voltage:			
Heater negative with respect to cathode	200	max.	volts
Heater positive with respect to cathode	200*	max.	volts

Characteristics:

Plate Voltage	250	volts
Grid No. 3	Connected to cathode at socket	
Grid No. 2 Voltage	150	volts
Cathode-Bias Resistor	68	ohms
Plate Resistance (approx.)	90000	ohms
Transconductance	12000	μmhos
Plate Current	25	mA
Grid No. 2 Current	6	mA
Grid No. 1 Bias for plate current of 20 μA	—10	volts

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

AVERAGE PLATE CHARACTERISTICS



NEW RCA RELEASES

NEW U.H.F. BEAM POWER VALVES WITH CERAMIC-METAL SEALS

Radiotron 6816 and 6884 are the designations of two new, very small forced-air-cooled beam power valves designed for use as u.h.f. power amplifiers, oscillators and frequency multipliers as well as a-f power amplifiers and modulators in compact mobile and fixed equipment. Differing only in their heater voltage and current, these new types have a maximum plate dissipation rating of 115 watts in modulator service and in cw service. In the latter service, they can be operated with full ratings to 1200 Mc/s and with reduced ratings to 2000 Mc/s. They have a maximum overall length of 1.920", a maximum diameter of 1.265", and a weight of only 2 ounces each.

Because of their high power sensitivity and high efficiency, the 6816 and 6884 can be operated with relatively low plate voltage to give large power output with small driving power.

The design of these new valves utilizes a coaxial electrode structure featuring "one piece" construction, i.e., each electrode, its support, and its gold-plated external contact surface are formed in one piece. This type of construction facilitates accurate assembly of the electrodes and provides low-inductance, high-conductivity paths to the electrodes themselves. The respective electrode contact surfaces are insulated from each other by low-loss ceramic bushings which permit tube operation with seal temperatures as high as 250°C. Efficient cooling of the plate is effected by a forced-air-cooled, integral radiator.

The coaxial-electrode structure with its ring-type ceramic-metal seals having graduated diameters makes the 6816 and 6884 particularly useful in either coaxial-cylinder cavity or parallel-line circuits. Because the design permits effective isolation of the plate from the cathode, these types are especially suitable for operation in cathode-drive circuits at the higher frequencies in their operating range.

RADIOTRON 6849 IMAGE ORTHICAN FOR INDUSTRIAL APPLICATIONS

Radiotron 6849 is a television camera valve designed especially for use in industrial and scientific-research television application involving extremely low light levels.

Because the 6849 combines extremely high sensitivity with a spectral response approaching that of the eye, it is capable of extending the range of human vision by amplifying low-intensity light images so that the eye can see details in the amplified images when they are brightly displayed on a television picture valve.

When used in a standard television system and with proper low-noise amplifiers, the 6849 can produce signal information with illumination on the photocathode as low as 0.00001 foot-candle.

RADIOTRON 5636 "PREMIUM" SHARP-CUTOFF PENTODE

The Radiotron 5636 "premium" sharp-cutoff pentode is intended for military and critical industrial applications.

The 5636 features two separate control grids each having a sharp-cutoff characteristic. It is intended for use in gated amplifier circuits, delay circuits, mixer circuits at frequencies up to 400 Mc/s, and in gain-controlled amplifier circuits. This valve is rated for service at altitudes up to 60,000 feet without pressurised equipment.

The 5636 has a unipotential cathode and utilizes flexible leads. The cathode is provided with two lead terminals to permit separation of the input and output circuit returns and to facilitate isolation of the input and the output circuits.

The design of this valve incorporates a compact structure in which special attention has been given to features which enable it to resist shock and vibration. As a result of its structural design, this tube is characterised by small spread in electrical characteristics, reduced microphonic effect, and long life under conditions of frequent on-off switching.

The 5636 is manufactured under rigid controls and undergoes rigorous tests to insure its "premium" quality.

RADIOTRON 6894 AND 6895 HALF-WAVE MERCURY-VAPOR RECTIFIER VALVES

Radiotron 6894 and 6895 are new half-wave, mercury-vapour rectifier valves intended for use in high-voltage rectifier circuits designed to supply dc power with good regulation to broadcast transmitters and industrial types of equipment. The ratings of these types are such as to make them companion valves to the Radiotron 5563-A mercury-vapor thyratron.

Alike except for their bases, the 6894 and 6895 are capable of withstanding a maximum peak inverse anode voltage of 20,000 volts. Each can deliver a maximum peak anode current of 11.5 amperes and a maximum average anode current of 2.5 amperes in quadrature operation.

Three 6894's or 6895's in a half-wave, three-phase circuit with in-phase operation are capable of supplying up to 51 kilowatts at a d.c. voltage up to about 9,500 volts; or six of them in a series, three-phase circuit with quadrature operation can supply up to 143 kilowatts at a d.c. voltage up to about 19,000 volts.

The 6894 and 6895 may be used in existing equipment as direct replacements for the types 575-A and 673, respectively. For new equipment design, the 6894 and 6895 offer new d.c. output voltage and power capabilities in comparison with the 575-A and 673.

TECHNICAL LIBRARY

"ELECTRONIC COMPUTERS"

Edited by T. E. Ivall, published by Iliffe & Sons Ltd. First Edition 1956.

This book is a non-mathematical coverage of the whole field of computers. The initial chapters trace the evolution of computers and then discuss the general principles of their operation. Both analogue and digital computers are analyzed in turn and the application of each is outlined.

With the advent of automation in factory and office alike, the computer has assumed growing importance. The whole approach adopted in the publication of this volume has been to present an interesting and instructive survey to technicians, business executives and engineers outside the field of computers.

Much of the material included has already appeared in "Wireless World". Its integration into this comprehensive volume is to be commended.

The liberal use of diagrams and photographs adds to the ease of reading.

The final chapter deals with "computers of the future". One cannot help but agree that the development of the electronic computers will have far-reaching effects in the automation of industry, commerce and science.

(A.J.G.)

"R.C.A. RECEIVING TUBE MANUAL, RC-18"

Published by Tube Division, Radio Corporation of America, Harrison, N.J. 8⅜ x 5⅜ inches, 352 pages.

The new R.C.A. RECEIVING TUBE MANUAL, RC-18, like the preceding editions, is the most comprehensive and authoritative book of its type in the industry. Revised, expanded, and brought up to date, the Manual contain technical data on more than 575 receiving valves, and more than 75 picture tubes.

The new RECEIVING TUBE MANUAL covers basic valve theory and application information in the same easy-to-understand style and used in previous editions. The section on Application has been expanded to include a description of television applications such as tuner circuits, video amplifiers, sync circuits, a.g.c. circuits, and deflection systems. Other sections include information on generic valve types, interpretation of valve data, and electron-valve installation.

The Receiving-Tube Classification Chart is arranged to facilitate rapid selection of R.C.A. types according to their family class, functions, and filament or heater voltages. Types having similar characteristics and the same heater or filament voltage are bracketed.

Technical data on picture tubes are tabulated in a Characteristics Chart to permit quick comparison of the features of individual types. Basing diagrams are given on accompanying pages for ease of reference.

The section on Circuits covers such typical applications as superheterodyne, superregenerative, and short-wave receivers, A-M and F-M tuners, various types of amplifiers, a code-practice oscillator, a 6-station intercom, and high-fidelity audio amplifier circuits including a low-distortion input amplifier stage, a two-stage input amplifier using cathode-follower (low-impedance) output, a bass and treble tone-control amplifier stage, and a complete 10-watt hi-fi amplifier.

"SOUND REPRODUCTION"
By G. A. BRIGGS

Published by the Wharfedale Wireless Works. Third Edition 1954.

Many will have read earlier books by Mr. Briggs ("Loudspeakers" has been widely used and appreciated). Readers will now enjoy yet another meeting with this gentleman.

This work commences with a lively discussion on Hi Fi and progress to the fundamentals of speaker reproduction. Oscillograms of frequency responses of typical speakers are presented to illustrate their resonances and the means of overcoming them by using vented enclosures, labyrinths, resonators and similar baffles manners oscillograms of transient response and intermodulation distortion are shown to indicate their origin and effect upon reproduction.

Much detail is written around room accoustics and the shortcomings of the ear. A chapter dealing with "Speaker Cross-over Networks" gives constructional details likely to satisfy any possible requirement.

In conclusion, the author adds a very comprehensive treatise on gramophone records covering such problems as "cleaning of records" to "records with square-wave modulation".

The author has shown his greatness in writing a book which appeals to anyone interested in good quality reproduction. It will be welcomed by the beginner in this field as well as by those of high academic standing.

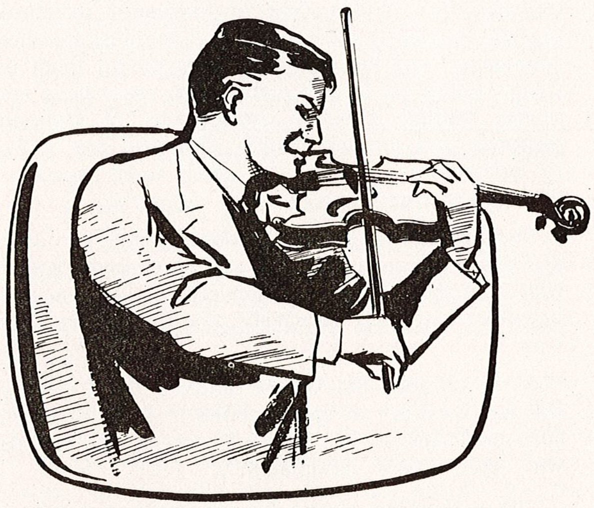
(J.W.E.)

THE ART OF BAFFLING

By ANTONY DOSCHEK*

The popular and technical literature of high fidelity shows an amazing amount of design and engineering information for the construction of loudspeaker enclosures. While many of the described methods are oversimplified, some are overelaborated and misleadingly mathematical. I use "misleadingly" in the sense that we are led to believe that rigorous mathematical research will infallibly produce a good speaker enclosure. There is no doubt that an exhaustive mathematical survey would help our understanding of the behaviour of a given loudspeaker in a given cabinet, and therefore would enable us to build a second enclosure with some assurance that a similar speaker would sound well in it. But no such "exhaustive" survey has yet been made, so far as I know, and if it were to be, its optimal application would always be restricted to the limits of the normal and wholly acceptable variations and tolerances of engineering materials.

Although Stradivarius had no oscilloscope nor audio generator at hand, he adapted, nevertheless, design principles of indisputable if inexplicable scientific validity to the construction of his violins—arriving at his refinements through experiment and listening. It took this master builder nearly one thousand tries before he came close to finalizing his designs. Yet we are given to believe that a well-oiled slide rule and sufficient "screwing and gluing" will spawn a reproducer capable of bringing any Strad right into the living room, with "full tonal realism", of



course. Further, this marvel also will be able to sound like any and every voice of the orchestra and chorus, or a speaking voice, or any one or several of an infinite variety and combination of random noises. Frankly, the degree to which this actually has been accomplished is impressive—but the end, or the end result, is not yet.

Assuming that we start with a virtually distortionless tape or disc and an aggregation of first-rate, compatible components leading up to the loudspeaker itself, we can feel that our problem has been consolidated to one of simply utilizing the speaker to its best advantage in an acoustically good listening room. Therefore we decide to mount the loudspeaker in such a way that no enclosure coloration will interfere with the perfection of its performance—as indicated by the manufacturer's representation of its response curve. We therefore choose the true "infinite baffle" wall mounting, being careful to (1) exhaust the rear of the cone into the outdoors, (2) reinforce the studding with masonry to insure a minimal vibration of the section of wall framing the speaker, (3) fair-off the mounting ring to minimize edge effects, and (4) close the windows and doors to keep out interfering sounds. Then we listen—at first with pure joy, then with stirrings of doubt, finally with disenchantment. The duration of the aforementioned three phases of emotion depends entirely upon the experience and critical competence of the listener; indeed, the second or third phase may never develop for some favored innocents.

What has happened? We re-examine the speaker response curve—using proper techniques and instruments—and find that the manufacturer has not misrepresented his data and that, furthermore, the deviations from the norm are well within the limits of perceptibility for the "standard observer". Therefore we rule out response variation and distortion at our level of listening. The driving components check out well, the room furnishings are acoustically favourable, we are in a state of good physical and mental health, and we have reserved this time for nothing but critical listening: yet the reproduction does not "live".

Actually nothing has happened that was not predictable—especially through hindsight. We have precisely what we started out to contrive: a practically perfect reproducer of what went into the microphone. By definition, it is a device to re-create the sound of musical instruments, and it has been painstakingly tailored to avoid the very properties that all musical instruments have, e.g., resonance and characteristic timbre. Our demand has been met: the speaker does not impart any coloration of its own to what is being reproduced. Therefore the trouble must lie elsewhere, perhaps with the logic informing our demand, which may have been too narrow. Perhaps we were too ready to assume that we

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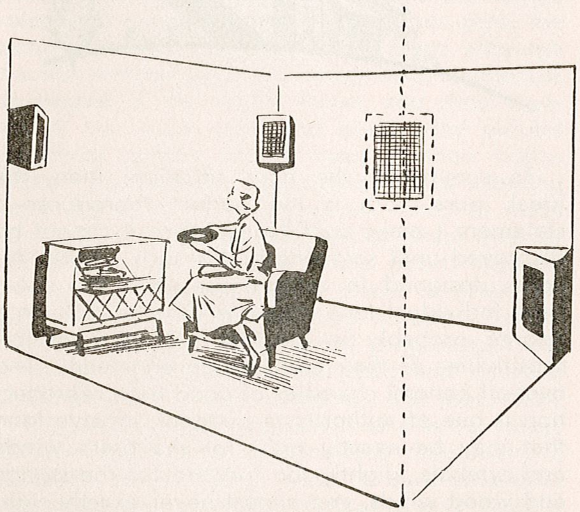
knew exactly what happens among the enormously complex, interlocked functions of creating, re-creating, and perceiving musical sounds. In the matter of pitch, alone, there is the factor that the loudness of a note will vary its pitch even though its frequency remains the same. For example, frequencies above 1,000 cps. will rise in pitch as loudness increases, while those below 1,000 cps. will lower in pitch. We also know that the human ear has its own characteristic distortions, and that these are affected by its listening environment. Therefore there is every likelihood that the Philharmonic-in-Carnegie Hall will sound quite different to us from the Philharmonic-at-home with superimposed Carnegie Hall acoustics. One thing, then, that we obviously ignored in our planning was a factor we may call dimensions of listening.

Hence we decide that one step in the right direction might be to enlarge the area of the sound source, so as to randomize the sound field in our room, since almost no musical sources are truly directional. We do not hesitate to install a system of several loudspeakers, since



we have been told that the ear is not greatly disturbed by minor phase distortions and, indeed, this gives us at once noticeably more realistic reproduction. As a matter of fact, it gets to be almost pretty good; especially if we have managed to keep our transients clean. On paper, then, we still have an ideal reproducer but, in fact, we are beginning to turn our listening room into a kind of musical instrument in its own right. Although any speaker of standard cone (or mouth) area is capable of exciting room resonances, these resonances, which exist simply because of the fixed volume and configuration of the enclosed air and its vibratile boundaries, are excited more strongly by several speakers operating in phase and they therefore become more audible, because of the greater cone-to-air coupling efficiency of many in-phase cones. The direction of the radiated sound, too, has been randomized to a great extent, and the system sounds impressive at medium and high levels. The quality of the pianissimos, however, will depend upon the sensitivities of the individual speakers.

N.B.—If the author seems too grudging about according to infinite baffle mountings whatever virtues they may possess, this is only because the author's company manufactures no electrical components or loudspeakers, as yet, and therefore has nothing to sell the infinite baffle adherents—except free advice. In the circumlocutions to follow, concerning horns and box enclosures, one will note that the attitude is considerably less improbitory.

It is said that the acoustical horn is the most perfect sound transducer (with the exception of the "ideal earphone"), and this opinion is certainly substantiated by the theory and mathematics of the device. Some of this acclaim, however, is accorded because of its efficiency, a property with which we need not be overly concerned in home reproducing systems. On the negative side we have its strong directional characteristic—part of the stuff of which its efficiency is composed—and the fact that a horn is no horn unless it is a true acoustical horn by definition. By this we mean that the disability of a horn for high quality musical reproduction rests entirely on the embodiment in it of **all** the design factors which constitute a true acoustical horn: namely, the correct relationships of throat and mouth areas and of length and flare; the effective combination of such individual sections in stages; the cross-sectional and longitudinal configuration: the acoustical stiffness of the material of construction; and the highly critical volume and geometry of the sound cell and its driver coupling ratio. Slighting of any of the rigid requirements of the above named design factors will result in a hornlike instrument which is in fact not a true horn and is, furthermore, apt to adulterate the beauty of musical tone in a most vicious way.

Although any of the constantly expanding mathematical curves may be employed as a basis for horn design, it appears that the exponential function serves the purpose best in the low frequency region of the spectrum.

An acoustical horn has a very definite set of relationships among its throat and mouth areas, its flare rate and characteristic, and its length—not to mention certain restrictions governing its cross-sectional shape. Unless these design relationships are maintained in its construction, the horn will exhibit colorations and acoustical anomalies more objectionable than almost any other type of speaker enclosure is apt to produce. The "ideal" acoustical horn for the reproduction of the full range of musical sounds is an exponentially expanding straight duct, of a length dependent upon its throat area and a mouth area of not less than 400 square feet—over 21 feet on each side of a square mouth! Such a horn will reproduce a 16-cycle sine wave with good conversion efficiency, absence of any inherent colorations if the material of construction is absolutely rigid and acoustically nonabsorbent, and will exhibit no reactances of its own for any frequencies of the audible spectrum higher than 16 cps.

The popular abbreviated horn, therefore, is a horn**like** instrument. When its abbreviation is extreme, its sounds come out "trombonish" in quality, and have clearly audible sharp reactance peaks and troughs, especially in the low frequency portion of the spectrum. Admittedly, this applies only to the shortest of the short bass-reinforcing horns and even here it is partially compensated for in practice, sinch such "horns" usually are part of front-and-rear radiating systems, and the front radiation is usually somewhat improved by this mounting. Although the sound from such modifications of the horn principle may be glamorous and impressive, there is a strong flavour of artificiality in it, and many tonal subtleties are completely mired down.

The aforesaid applies chiefly to the low-frequency performance of modified horns of intricately folded construction and inadequate mouth area. Before going on to examine the situation in the mid- and high-frequency regions of the spectrum, one myth more must be dissected: that "the corner of the room acts as an extension of the horn mouth." This is (nearly) true in only one special case: namely, if we place one horn-loaded loudspeaker, or a group of several direct-radiating cones, whose effective radiating areas total about **28 square feet,** approximately 50 inches along the normal axis of the corner, we will have converted our listening room into an exponential horn of about 30 cps. cut-off frequency. To be sure, the corner of a room nearly always will augment bass and increase loudness by limiting sound radiation to the solid angle equivalent to one-eighth sphere, but this does not make a true acoustical horn out of a room corner; the reinforcement is haphazard, as often bad as good.

The exponential, the hyperbolic, and other shapes of horn have important application to the reproduction of the mid-range and the high-frequency portion of the spectrum. Because of the much higher cut-off frequency here, the horn can be straight—not folded—and have its full value of required mouth area without being impractically large. Assuming the perfection of its sound cell design, and quality of its driver, only two factors remain to qualify its performance: (1) its directionality—which can be successfully overcome for home listening by acoustical lenses or diffractors, and (2) the acoustical stiffness of its construction. This latter requirement for really good reproduction has been ignored by many manufacturers on the theory that so little energy is expended in the mid-range spectrum that almost any practical material should contain and propagate the wave envelope successfully. Nothing can be more wrong. To a musically trained ear, the differences in the sound of identically designed horns driven by identical drivers but made of dissimilar materials is immediately and strikingly apparent. If the material out of which the horn body is cast or fabricated can be made to vibrate, it will impart a distinct coloration of its own to the sound: if it is rigid and has the property of high internal damping as well—glass is rigid but shows low internal damping, ceramic is rigid but shows very high internal damping—it will impart no coloration to the sound of the horn. Also, the quality of all the small metal or phenolic drivers that I have listened to has seemed edgy or brittle: my personal preference being the six- or eight-inch paper cone driver loaded by a ceramic or cast cement horn. Compression loaded horn tweeters, which are useful and even necessary in high-level industrial systems, are usually "steely" and not so svelte as high quality cones or electrostatics for listening in relatively small rooms.

To summarize the horn situation, then, the ideal, pure horn is the perfect reproducer—a statement I make confidently, since it cannot be disproved until someone builds such a horn. All horns designed in compromise with this ideal have individual tone character or coloration, to a degree probably in keeping with the musical sensitivities of their own design engineers. The over-all general character of good horn reproduction is one of authority: a pungent, incisive tone that may be exactly right for the brass winds and cymbals, slightly too forward for the strings and wood winds, and almost never exactly right for bass drums and pipe organs. The presence-effect of good horns is always striking, and this makes them particularly effective in the reproduction of both singing and speaking voices.

A third general classification of loudspeaker enclosure systems comprises the various box types. Actually, these can be separated into three categories in themselves: (1) sealed off "infinite baffles" which absorb the back radiation of the speaker in an air volume so large that it contributes little or nothing to the stiffness of the loudspeaker cone suspension, (2) smaller "infinite baffle" enclosures which are rear vented through a wide-band acoustical muffler system intended to absorb rear cone radiation while affording high air compliance, and (3) tuned and untuned phase inverters or modified Helmholtz resonators. The first two categories, at their best, sound like true "infinite baffles" in that they contribute nothing of their own timbre or coloration to the programme material. Boxes of the third category do impart a definite tone character of their own to what is being reproduced. It is this very property of the Helmholtz resonators that has earned them variously the reputation of being both the worst and the best systems in common use. To the author's way of thinking, the fact that such a violent controversy exists is the highest recommendation for considering the phase inverter very seriously, since it means that a very wide variety of performance results can be achieved by experimentation with this basic design.

Guided by knowledge and experience, it is possible for the builder to construct phase inverter enclosures with almost any desired output response, with precisely the right speaker installed.

Almost any variation of the Helmholtz resonator design, within the broad compass of its theoretical requirements, contributes some change to the character of the reproduction, and it is this property of the phase inverter that makes it a first cousin to the string quintet and the human voice, and a close relative to the organ pipe, the wood winds, and the brass winds; since, although it is not perhaps generally recognized, resonances developed in the mouth, throat, and chest cavaties of the wood wind and brass wind players contribute greatly to the tones of their instruments. Furthermore, any auditorium or listening room shows its own resonances. Any of these can be, to some extent, imitated by phase inverter enclosures, and therefore it is a poorly thought out opinion that condemns phase inverters on the basis of the fact that they introduce "artificial" resonance in the recorded programme. As a matter of fact, a well-designed and damped phase inverter is much smoother, and lends itself to the satisfactory reproduction of a wider range of tone colors and combinations than many a "stripped down" horn. And its own coloration very often adds a lifelike musical quality missing in infinite baffles or truncated horns. Call it distortion if you will: it is distortion purposefully calculated to compensate for the shortcomings of living rooms, point-source reproduction, and ears.

The complaint of many who have built or bought phase inverter enclosures is that they produce a "boominess", or "ringing" or "boxy" quality. This can happen. It is altogether a matter of designing and adjusting the enclosure to a particular type of speaker. Much of this can be done in the original planning and computation, but much of it must be arrived at through empirical testing and analytical listening.

As an aid in this listening, the author often takes a speaker enclosure outdoors, under substantially free-field conditions, and alternately listens to it and to a good pair of earphones. Under this treatment, many an enclosure has shown off its shortcomings, and a few have demonstrated "tone quality" that positively enhanced the musical quality of the programme.

Far too much emphasis has been placed upon quantitative values in reproducer performance and not enough upon the qualitative aspects. We measure the range of the response curve, its degree of deviation from a norm at several frequencies, its polar pattern. We measure efficiency. In short, we seem to be interested principally in how much sound we are getting instead of what kind of sound—again on the pseudological premise that the "degree" should determine the "kind", since the "kind" already has been established by the original programme. But although such studies are fundamental to good design, they are only fundamental. The hidden danger is that our conclusions may be based upon studies so fundamental that they do not describe what we are seeking at all. For example, the sine wave has long been, and still is, the acousticians' favorite probe for exciting a loud-speaker enclosure to measure its response. The use of the sine wave, of course, is predicated on the knowledge that the complex music wave is composed largely of sine waves—and so it is in fact.

The sine wave curve can be expected to show the sine wave response of an enclosure. But what about the "complex response" of that same enclosure? Some who know will certify that the complex response of an enclosure is quite unlike its sine response. One can go even further, to say that the response will vary as the kind and degree of "complexity".

Radiation pressure test results obtained with various "kinds" of excitation wave forms—sine waves, square and rectangular waves, saw-tooth and triangular waves, warble frequencies, white- and grey-noise patterns, and sweeps—show significant differences in speaker enclosure output response even when the unit of measurement is a common denominator. This means that the enclosure and its driver react differently to different stimuli. A likely explanation of this phenomenon is the variable excitation of a cluster of overtones, or partials, called "formants". The formant series of overtones is known to be a determinant factor in the tone quality of virtually all musical instruments; its exact position in the spectrum of the instrument is a criterion of the instrument's so-called carrying quality as well.

Actually, the development of the science and art of sound reproduction has progressed so far toward perfection, and at such a furious pace of late, that our evaluations of what is desirable or undesirable can be expressed only in necessarily controversial, subjective terms. There is no doubt that the future holds conclusions from the many laborious psycho-acoustic studies now being carried on which will "explain" our reactions to tone quality and even, perhaps, the musical art itself.

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