RADIOTRONICS

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Volume 19 **October 1954** **Number 10**

New Standard Playback Curve

by F. Langford-Smith

The leading American phonograph manufacturers have agreed on a new standard playback curve which will be used for all new records throughout the industry. This has been standardized by the Record Industry Association of America Inc., the Audio Engineering Society (new AES curve) and NARTB (transcription) and is being used by R.C.A. (New Orthophonic), American Columbia, American Decca and M-G-M.

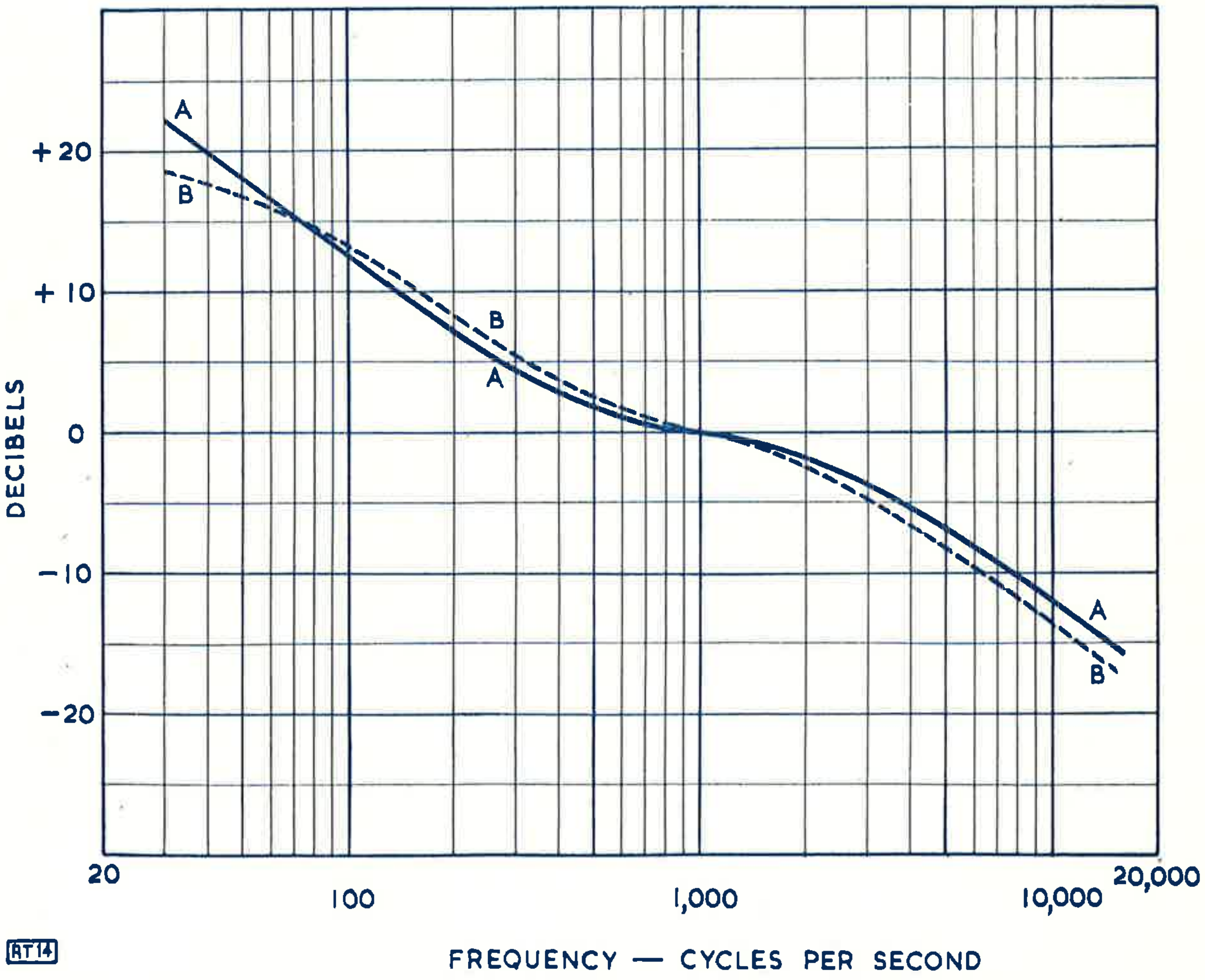


Fig. 1. A. Old AES Standard Playback Curve. B. New RIAA-AES-NARTB-RCA New Orthophonic Standard Playback Curve.

The new curve (B in Fig. 1) differs slightly from the older AES characteristic (Ref. 1) shown by the solid curve A in Fig. 1, but the difference between them is less than 2 db except at frequencies below 40 c/s, so that the effect of playing new records on the old equalization characteristic, or vice versa, is slight. Above 1000 c/s the new curve is identical with the 75 microsecond pre-emphasis curve used in FM broadcasting.

The history and details of the new curve are given in a very readable article by Moyer (Ref. 2).

Suggested equalizing circuits for incorporation in a gramophone are shown in Figs. 2 and 3 for triode and pentode respectively (Ref. 2).

REFERENCES

1. Radiotron Designer's Handbook, 4th ed., p. 439, Fig. 17.15A.
2. Moyer, R. C., "Evolution of a recording curve", Audio Eng. 37.7 (July, 1953) 19. Gives early history and R.C.A. New Orthophonic curve.
3. "New standard record curve", Radio Electronics 25.5 (May, 1954) 63. Shows new RIAA-NARTB-RCA New Orthophonic curve and also old Columbia LP, old London ffrr (Decca), old AES and old R.C.A.

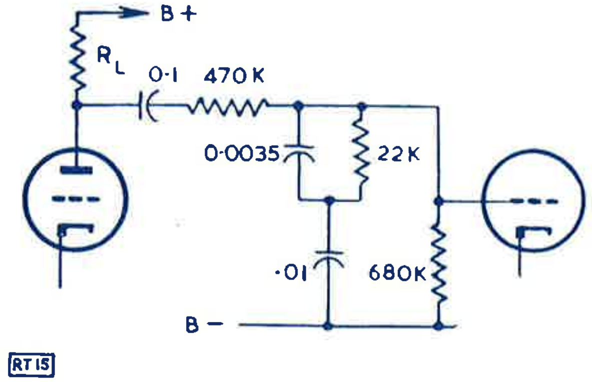


Fig. 2. Triode Equalizing Circuit.

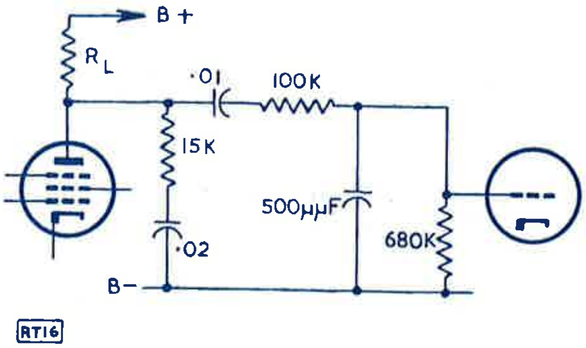


Fig. 3. Pentode Equalizing Circuit.

New RCA Releases

Radiotron–6BC4 is uhf medium-mu triode of the 9-pin miniature type utilizing a very short bulb. It is designed for use as an rf amplifier in the cathode-drive circuits of UHF television tuners covering the frequency range of 470 to 890 megacycles per second.

The 6BC4 has a transconductance value of 10,000 micromhos. This feature permits high gain and reduced equivalent noise resistance. In addition, this tube has low lead inductance, low lead resistance, and good isolation within the tube between the load circuit and the input circuit.

Other design features of the 6BC4 include silver-plated base pins to reduce losses due to skin effect at the ultra-high frequencies, four grid terminals to permit reduced lead inductance and lead resistance in circuit applications, and a short mount structure utilizing small parts to provide low interelectrode capacitances.

The gas phototube **Radiotron–6405/1640** is designed for use in industrial applications critical as to microphonics and sensitivity gradient. Among such applications are electronic beverage-inspection equipment and ampul-inspection equipment.

The spectral response of the 6405 is characterized by high sensitivity to red and near-infra-red radiant energy. Because of its spectral response, the 6405 is especially suitable for use with an incandescent light source.

Radiotron–6417 is a general-purpose transmitting beam power tube of the heater-cathode type intended for use in compact, low-power mobile and portable transmitters and in emergency communications equipment operating directly from 12-volt storage batteries. It can also be used in the low-power stages of larger fixed station transmitters. The 6417 can be operated with full input up to 50 megacycles per second and with reduced input up to 175 megacycles per second.

Because of its high transconductance, and a plate characteristic favourable to the generation of a high harmonic output, the 6417 is particularly useful in the doubler and tripler stages of transmitters. Because of its high perveance, this tube can supply high power output at relatively low supply voltages. These features in addition to its high power sensitivity make the 6417 especially useful as an rf power amplifier, frequency multiplier, oscillator (VFO or crystal), and as a vhf driver tube for larger tube types.

Featured in the design of the 6417 are heavy control-grid support rods and two control-grid base-pin connections which provide cooler grid operation: a cathode with a large area to supply the high peak currents required for multiplier service; and a 12.6-volt heater which can be conveniently operated from a storage battery.

RADIOTRON AV-34

Vacuum Gauge Tube (Thermocouple type)

*by V. Anthony, B.Sc.**

This article describes the AV-34 thermocouple vacuum gauge. The mode of operation is discussed and physical and electrical characteristics are given together with a calibration curve for dry air covering the pressure range 1 mm to 10^{-3} mm of mercury. Typical circuits with components listed are given for either a regulated or unregulated mains supply voltage.

GENERAL DATA

ELECTRICAL

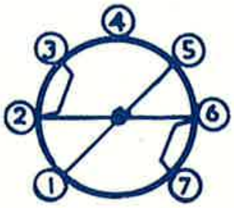
Maximum rating

Heater current .... 300 mA (RMS)

Typical characteristics

Heater current	140 mA	250 mA
Approx. heater resistance ...	1.8 ohms	2.20 ohms
„ couple EMF ...... at zero pressure.	10 mV	22 mV

Bottom View.



Pin 1: Couple —

Pin 2: Heater

Pin 3: Heater

Pin 4: No Connection

Pin 5: Couple +

Pin 6: Heater

Pin 7: Heater

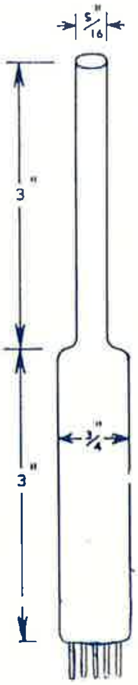
Base: Miniature Button 7-pin

The AV-34 is provided with a lead glass tubulation which can be sealed directly to similar glasses. Connection to either a hard glass or metal vacuum system can be made by:—

(a) Wax joint;

(b) Graded glass seal;

(c) Metal-glass seal.



Dimensioned Outline.

Because this gauge is small it may be used in confined spaces and its small volume results in rapid response to pressure changes.

The AV-34 consists essentially of a Eureka-Nichrome thermocouple junction welded to the mid-point of a platinum heater wire. The heater temperature is dependent on the following factors:—

(a) Radiation losses;

(b) Conduction losses through the connecting leads;

(c) Conduction losses through the surrounding gas.

Over the pressure range of 1 mm to 10^{-3} mm of mercury, only the last factor is significant. The gas conductivity is a function of the density and therefore of the pressure of the surrounding gas. Thus the thermocouple E.M.F. which is determined by the heater temperature is a measure of the surrounding gas pressure.

* **Power Valve Section, Amalgamated Wireless Valve Company, Ashfield.**

A basic circuit for the gauge is shown in figure 1. The required heater current (I_H) is set by the variable resistance (R_1). The series meter resistance (R_2) must be chosen to ensure full scale deflection of the microammeter (M_2) at zero pressure. At pressures greater than zero the couple output will be less and the meter will read less than full scale deflection due to the lower temperature of the heater wire.

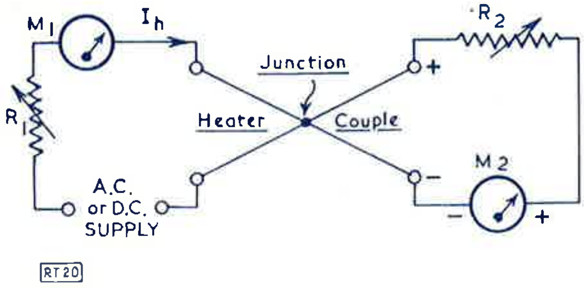


Fig. 1. Basic gauge circuit.

In figure 2 calibration curves for dry air are given covering two separate values of heater current. The lower value (140 mA) is more suitable over the pressure range 10^{-3} mm to 10^{-1} mm of mercury whereas above 10^{-1} mm of mercury pressure the higher value (250 mA) is the better. These curves are for dry air only in an average gauge and differences between individual gauges may be up to 20%. This accuracy is adequate for general vacuum work particularly as the gauge covers the large pressure range of 1 mm to 10^{-3} mm of mercury.

A complete circuit for the gauge is given in figure 3. A suitable transformer (T) is one used in electric bell systems; a 240 volt primary giving a secondary output of approximately 8 volts. It is recommended that an 8 mV, 50 ohm meter movement (M_2) be used in the couple circuit.

The value of the series meter resistance (R_2) is specified by the manufacturer for each gauge (assuming that the above meter movement is used). Other meters may be used having a sensitivity of less than 8 mV full scale deflection, but a different value of R_2 than that specified by the manufacturer must be used. It is possible to check the heater current with the meter M_2 by a suitable switching arrangement and so eliminate M_1.

The couple output is sensitive to changes in heater current, a 10% change in the latter giving approximately 12% variation in couple output. With an unregulated supply voltage, frequent adjustment of the heater current may be necessary. This can be reduced by use of the circuit shown in figure 4 which incorporates two OC3 voltage regulator tubes. The resistance, R_1, shown must be adjusted to limit the peak current through the OC3's to less than 40 The heater current waveform in this circuit is not sinusoidal and an RMS ammeter (of the moving iron, dynamometer, or thermocouple type) must be used to set the heater current to the correct value.

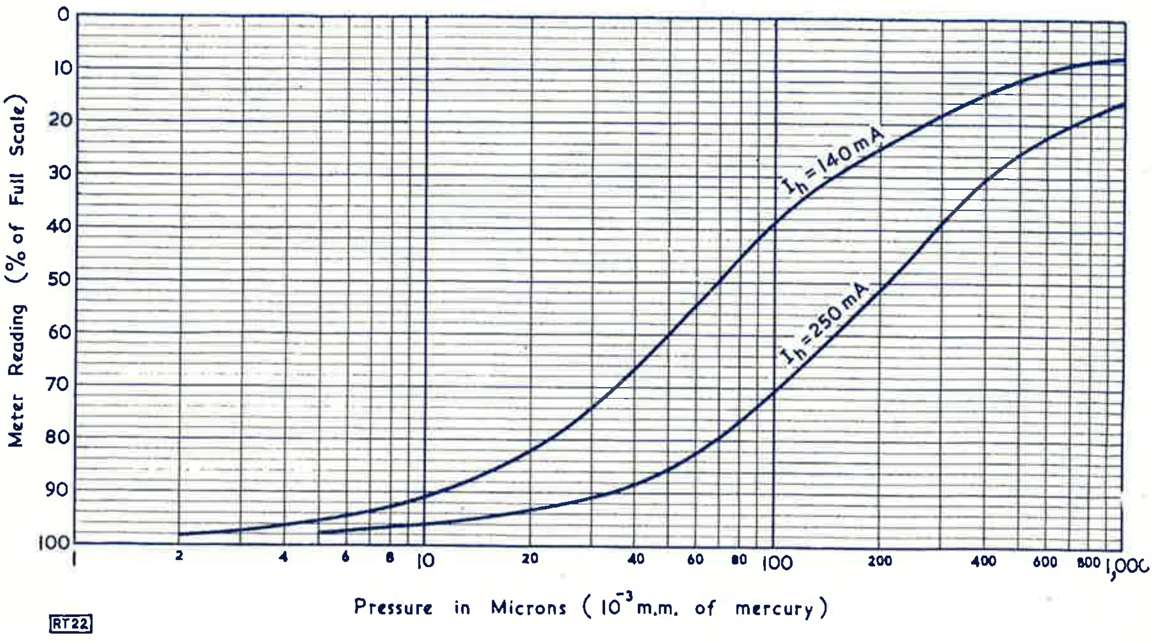


Fig. 2. AV34 Calibration Curves.

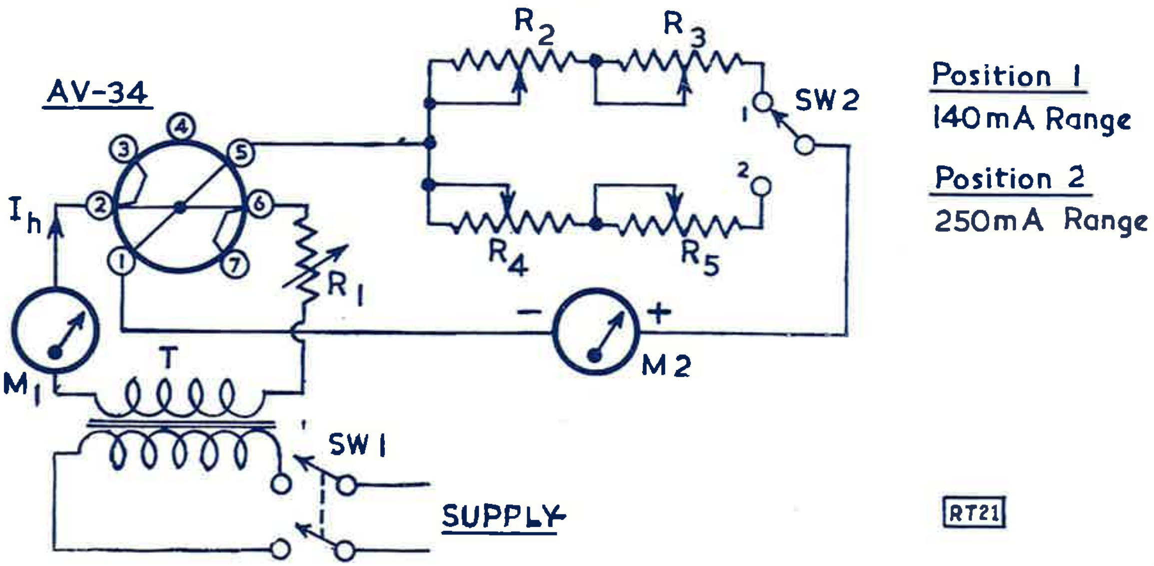


Fig. 3. Typical gauge circuit.

COMPONENTS LIST

SW 1	240V, 1A, double pole, single throw toggle switch.
SW 2	240V, 1A, single pole, double throw toggle switch.
T	Transformer, 240V/8V at 1A.
M2	Meter, 0-8 mV, D.C., 50 Ω resistance.
M1	Meter, 0-0.5 Amperes AC.
R1	Potentiometer 100 Ω 50W.
R2	Adjustable resistor 5 Ω 20W.
R3	„ „ 25 Ω 20W.
R4	„ „ 10 Ω 20W.
R5	„ „ 100 Ω 20W.

N.B.—Power resistors are used because they are capable of fine adjustment.

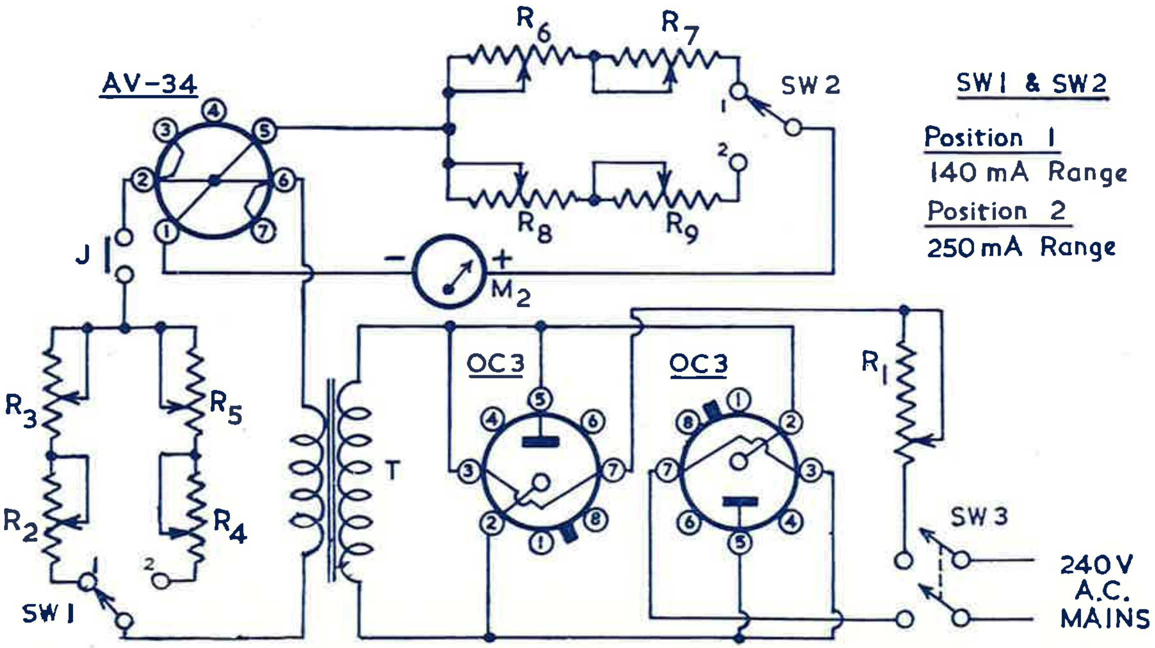


Fig. 4. Regulated gauge circuit.

COMPONENTS LIST

SW 1 & SW 2	240V/1A, double pole, single throw toggle switch.
SW 3	240V/1A, double pole, double throw switch.
M2	Meter, 0-8 mV, D.C., 50 Ω movement
J.	Normally closed meter jack.
T.	240V/8V at 1A transformer.
R1	Typical value 6000 Ω 10W. Absolute value is dependent on magnetising current of T (see text).
R2	Adjustable resistor 5 Ω 20W.
R3	„ „ 25 Ω 20W.
R4	„ „ 1 Ω 20W.
R5	„ „ 15 Ω 30W.
R6	„ „ 10 Ω 20W.
R7	„ „ 100 Ω 20W.
R8	„ „ 5 Ω 20W.
R9	„ „ 25 Ω 20W.

N.B.—Power resistors are used because they are capable of fine adjustment. The meter jack (J) allows the resistors R_2, R_3, R_4 and R_5 to be set to give the required heater current.

A Note on Noise in Audio Amplifiers

H. J. Woll and F. L. Putzrath,

RCA Victor Division, Camden, New Jersey

There are a number of noise sources in audio amplifiers such as:

a. Thermal noise in the input coupling circuit
b. Shot noise
c. Partition noise in pentodes
d. Flicker noise
e. Ballistics and microphonics
f. Pops
g. Hum.

Hum will not be considered here although it is a serious problem and much can be said concerning its elimination. Ballistics, microphonics, and pops are matters of tube design and selection rather than circuit design and will not be considered either.

This paper will be primarily concerned with flicker, shot, and partition noise and the effects of the input coupling network. An attempt will be made to outline the requirements of the input circuit and to discuss the magnitude of second stage noise in conventional configurations.

Noise is generated in the resistive component of any impedance by the thermal agitation of the electrons. The magnitude of the thermal noise voltage of a resistance in temperature equilibrium is:

$$e = \sqrt{4kTBR} \text{ volts rms}$$

where

k = Boltzmann's constant
T = temperature in degrees Kelvin
R = resistance in ohms
B = bandwidth in cycles per second.

A certain signal-to-noise ratio is available from the source and is determined by the signal strength and the magnitude of thermal noise. Using an amplifier, it can be approached but never exceeded. Noise figure is a convenient way of expressing the amount by which an amplifier deteriorates the signal-to-noise ratio available from the source. Noise figure may be defined as the available signal-to-noise ratio at the source divided by the available signal-to-noise ratio at the amplifier output. An equivalent definition is that noise figure is the ratio of the total noise power at the output of the amplifier to component of the noise output power which is due to thermal noise in the source impedance. Noise figure is customarily expressed in db.

Shot noise is generated because the plate current of a tube is not continuous, but consists of discreet charges which are numerous enough to very closely approximate a continuous current. Partition noise in pentodes is similar to shot noise but is caused by the division of current between the plate and the screen. Flicker noise is caused by local fluctuation of emissivity of the cathode. These sources of noise may be lumped and their effect duplicated by an equivalent voltage generator. This generator is commonly represented by a resistor, R_{eq}, in series with the grid of the tube and is chosen to be of such a value that the thermal noise voltage generated by it is equal to the sum of the shot, partition, and flicker noise voltages referred to the grid circuit. Thus:

$$R_{eq} = R_{shot} + R_{part} + R_{flicker}$$

Shot noise and partition noise are independent of frequency and their equivalent noise resistances are generally considered to be:

$$R_{shot} = \frac{2.5}{g_m}$$

$$R_{part} = \frac{20\ I_{screen}}{g_m\ I_{cathode}}$$

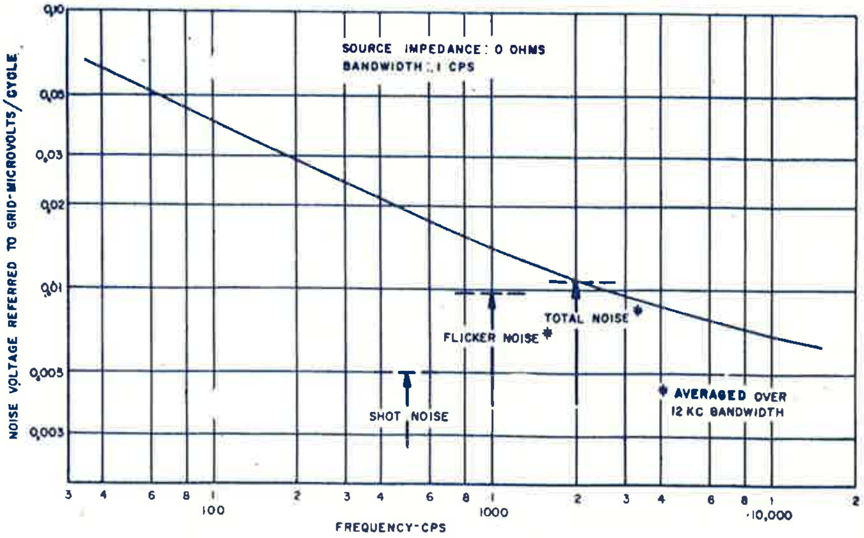


Fig. 1. Triode tube noise vs. frequency.

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In the audio frequency band, flicker noise is much greater than either of the above two noise sources. It is a function of frequency and thus its equivalent noise resistance, $R_{flicker}$, is also. For any particular frequency characteristic an integrated $R_{flicker}$ can be found that is a constant.

The noise spectrum of a typical low noise triode with a coated cathode is shown in Fig. 1. In this tube, R_{shot} is 1500 ohms and $R_{flicker}$ integrated over a 12 kc flat bandwidth is 6000 ohms.

Consider the problem of determining the noise figure of an audio amplifier stage. Identical grounded-grid and grounded-cathode triodes with the same source resistance, R, are shown in Figs. 2 and 3.

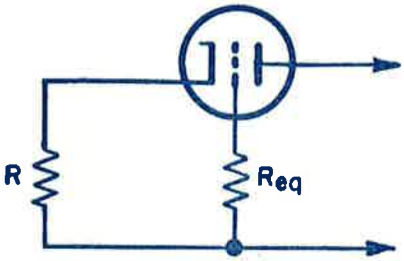

Fig. 2. *Grounded-grid equivalent circuit.*

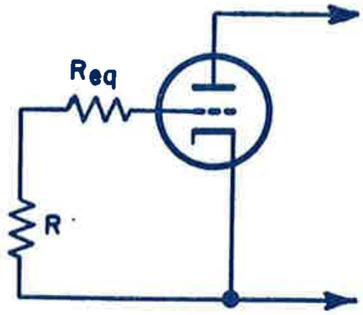

Fig. 3. *Grounded-cathode equivalent circuit.*

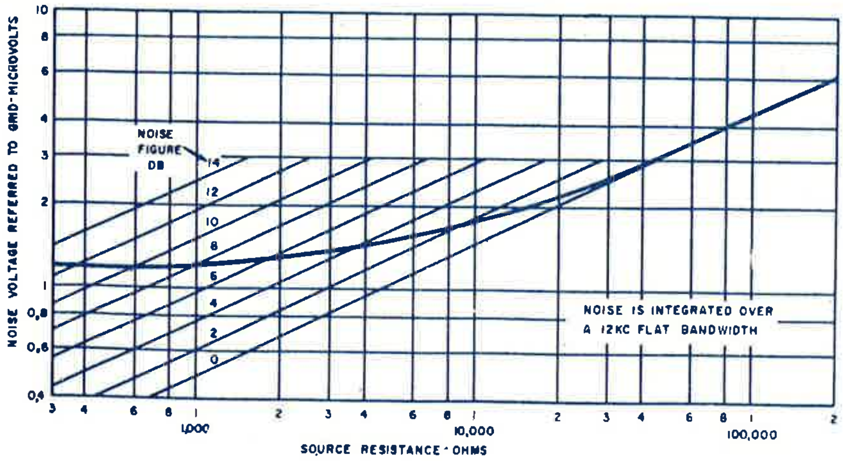

Fig. 4. *Noise vs. source resistance.*

The tube noise is referred to the grid circuit and is represented by R_{eq}, which is a fictitious generator of voltage $e = \sqrt{4kTBR_{eq}}$. The tubes are then considered to be ideal amplifying devices. Since noise figure is:

$$F = \frac{\text{total noise power at the output}}{\text{that component of output noise due to thermal noise in the source}}$$

$$= \frac{4kTBR_s + 4kTBR_{eq}}{4kTBR_s} = 1 + \frac{R_{eq}}{R_s}$$

The interesting fact is that the noise figures of the grounded-cathode and grounded-grid stages are identical. Thus, although the input resistance of a grounded-grid stage might be under 500 ohms, a high source resistance of perhaps 30,000 ohms is required to obtain a good noise figure just as in the case of the grounded-cathode connection.

It is to be noted that the above expressions represent *first* stage noise figures. The noise figure of an amplifier represents the deterioration of signal to noise ratio by *all* the stages in the amplifier. If the first stage gain is high, the succeeding stages do not contribute appreciable noise, and the noise figure of the amplifier is about the same as that of the first stage. This is generally the case in audio amplifiers.

On the other hand, an amplifier with a grounded-grid input tube must be operated from a low source resistance to obtain appreciable first stage gain. Hence this amplifier is either operated from a high resistance source and suffers from noise contributed by the second stage, or is operated from a low resistance source and has a poor first stage noise figure, or some combination of the two.

Excepting ballistics, microphonics, hum, and pops, the following general conclusions can be drawn:

Noise figure improves as the source impedance increases and zero db noise figure can be approached in practice. (A low-noise triode with 22,000 ohm source resistance has a 1.0 db noise figure. See Fig. 4.) As a result, efficient input transformers greatly improve the noise figure of a system with a low impedance source such as magnetic pickups and microphones.

If the source impedance is low and bandwidth requirements or other conditions permit, the noise figure can be improved by paralleling input tubes increasing the g_m and thereby lowering R_{eq}.

It is to be noted that noise figure, per se, is meaningless. To express the performance of an amplifier, one must specify the noise figure with a given source resistance.

The noise figure of a stage is independent of the configuration, i.e., whether the stage is grounded-cathode or grounded-grid. Generally the gain of the first stage is high enough so that second and later stage noise make only a small contribution to the total.

Thus it can be generalized that cascaded grounded cathode stages at audio frequencies will give as good or better noise performance than other possible circuit configurations. In addition this configuration is most advantageous from a practical point of view—such as heater and B + supplies.

APPENDIX

A typical amplifier employing two cascaded grounded cathode stages is shown in Fig. 5. R_s and L_s are respectively the series resistance and inductance of the source. T is an input transformer with a turns ration of *n*, a primary resistance of R_1, and a secondary resistance of R_2.

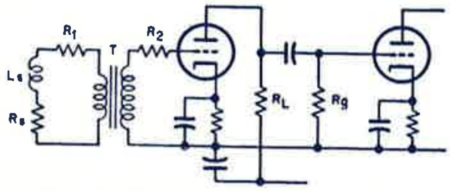

Fig. 5. Typical two-stage amplifier.

The noise voltage due to the interstage coupling circuitry and the second tube is:

$$E_i = \sqrt{4kTB}\sqrt{\left(\sqrt{R_i}\frac{R_p}{R_p + R_i}\right)^2 + \left(\sqrt{R_{eq2}}\right)^2}$$

$$= \sqrt{4kTB}\sqrt{\frac{R_i}{\left(1 + \dfrac{R_i}{R_p}\right)^2} + R_{eq2}}$$

where R_p is the plate resistance of the first tube. Dividing the above expression by the first stage voltage gain, G, this noise voltage is referred to the amplifier input so that the ratio of the ideal to actual noise powers due to the source and due to the interstage circuitry is:

$$F_2 = \frac{\dfrac{R_i}{\left(1 + \dfrac{R_i}{R_i}\right)^2} + R_{eq2}}{G^2R_s}$$

The over-all noise figure of the two stages up to point A is then:

$$F = F_1 + F_2 = 1 + \frac{R_t}{R} + \frac{R_{eq1}}{R} + \frac{1}{G^2}\frac{\dfrac{R_i}{\left(1 + \dfrac{R_i}{R_p}\right)^2} + R_{eq2}}{R}$$

The equivalent circuit is shown in Fig. 6 where

$$L = n^2L_s$$
$$R = n^2R_s$$
$$R_t = n^2R_1 + R_2$$
$$R_i = \frac{R_g + R_L}{R_gR_L}$$

The equivalent noise resistors of the two stages are represented by R_{eq1} and R_{eq2} respectively.

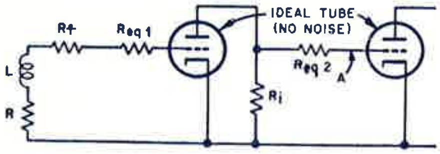

Fig. 6. Equivalent circuit of two-stage amplifier.

Examination of the noise figure of this amplifier will be made at point A. The noise figure at the input of the first ideal tube is:

$$F_1 = \frac{4kTB\,(R + R_t + R_{eq1})}{4kTBR} = 1 + \frac{R_t}{R} + \frac{R_{eq1}}{R}$$

The above formula might be construed to mean that it would be desirable to let the source impedance have as high a resistive component as possible. However, an increase in source resistance must be accompanied by a corresponding increase in signal voltage, as is realized with an input transformer or with a "high impedance" magnetic playback head.

A typical amplifier using a 12AY7 twin triode might have the following constants:

$n = 28.3$
$L_s = 2$ mh
$R_s = 1$ ohm
$R_1 = 8$ ohms
$R_2 = 6000$ ohms

$$R_{shot1} = R_{shot2} = \frac{2.5}{1660 \times 10^{-6}} = 1500 \text{ ohms}$$

$$R_{flicker1} = R_{flicker2} = 6000 \text{ ohms}$$

$$\left.\begin{aligned} R_L &= 100{,}000 \\ R_g &= 1{,}000{,}000 \end{aligned}\right\} R_i = 100{,}000 \text{ ohms.}$$

$R_p = 25{,}000$ ohms.
$G = 30$

then:

$$R_{eq1} = R_{eq2} = 7500 \text{ ohms}$$
$$n^2 = 800$$
$$L = 1.6 \text{ hy}$$
$$R = 800 \text{ ohms}$$
$$R_t = 12{,}400 \text{ ohms}$$

and

$$F = 1 + 15.5 + 9.4 + 0.02 = 25.9$$

or an equivalent ratio of 14.1 db.

From the above example it can be seen that the noise in this system is over 14 db worse than that which could have been obtained with an ideal amplifying device. A substantial noise contribution is made by the resistance in the input transformer, yet a negligible amount is contributed by the interstage coupling network and the second tube.

A preferred arrangement that would eliminate the noise contribution of the input transformer could be obtained by the use of a "high impedance" head. Thus:

$$n = 1$$
$$L_s = L = 1.6 \text{ hy}$$
$$R_s = R = 800 \text{ ohms}$$
$$R_1 = R_2 = R_t = 0 \text{ ohms}$$

other values as above.

Under these conditions

$$F = 1 + 9.4 + 0.02 = 10.4$$

or an equivalent ratio of 10.2 db.

Even here, the second stage noise contribution is negligibly small.

New Publications

"The Oscilloscope at Work", by A. Hass and R. W. Hallows, M.A. (Cantab.), M.I.E.E. Published by Iliffe & Sons Ltd. 172 pages. 102 diagrams and 217 oscillograms.

The cathode-ray oscilloscope is an instrument of remarkable versatility and diverse uses in many branches of electronics, but the user may not always be aware of all its possible applications. This book, originally published in France, is a practical guide to these applications, though having especial reference to radio and television receivers. It has been adapted for English-speaking readers and considerably enlarged by R. W. Hallows, the well-known author of technical books on electronics, and will prove invaluable to anyone desiring to get the best out of his oscilloscope.

An important feature is the wealth of oscillograms which help to make the book of such practical value. Over 200 of these, representing more than two years' work, were specially prepared by Alfred Haas, while many new ones have been added for the English adaptation. Numerous circuit drawings and other diagrams have also been provided to clarify the text.

Although, as its title implies, "The Oscilloscope at Work" deals mainly with the uses of the instrument and correct interpretation of the oscillograms produced, it also contains much valuable information on oscilloscope circuits, construction and adjustment, while one chapter is devoted to explaining how it can be made to diagnose its own troubles when faults develop.

"Wireless and Electrical Trader Year Book: Radio, Television and Electrical Appliances", 1954. 25th edition.

For more than a quarter of a century the Wireless and Electrical Trader Year Book has been firmly established as *the* reference book to the radio and electrical industries. The Trader Year Book is a valuable guide for everyone connected with sales and service, and a recognised authority for overseas buyers anxious to contact British sources of supply.

In the 1954 edition, data of practical use to dealers and general references and technical information have been carefully selected. Features include condensed specifications of more than 250 current commercial television receivers (with such valuable facts as valves used, I.F. Values, etc.), and information on valve and cathode ray tube base connections, with over 300 valve base diagrams. These alone are invaluable to radio and TV service engineers.

The comprehensive list of the I.F. values of commercial radio receivers which have been marketed during the past six years has been revised and extended. Other data includes specifications of current radio receivers (over 300 models are given), and a directory of trade associations.

One of the principal aims of the Year Book is to assist traders to keep abreast of the constant changes in the names, addresses, telephone numbers and products of the firms engaged in the radio and electrical industries. These revisions have been incorporated in the directory sections, and the lists of names and addresses of firms therefore make the Trader Year Book an invaluable and time-saving desk companion for every retailer and business man in the industry.

Directory sections are printed on distinctly tinted papers for ease of reference.

Copies of both books have been received with the compliments of Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1.

F.M. Service Problems

by Kenneth Fowler

Introduction

Many of the troubles encountered in F.M. receivers will be very similar to those found in A.M. receivers and, therefore, will not be discussed here. However, there are a number of troubles which might occur in an F.M. receiver that would require special attention and, therefore, will be considered in some detail.

Troubles in F.M. receivers

Some of the troubles encountered in F.M. receivers which have the same symptoms as in A.M. receivers but may be due to quite a different cause, are listed below.

Weak reception.—This trouble could be due to any or all of the possible causes as found in A.M. receivers, plus the following:

(a) F.M. antenna not properly oriented with respect to transmitting antenna.
(b) Improper matching of transmission line between antenna and receiver.
(c) Improper operating conditions of the limiter circuit.
(d) Insufficient gain ahead of limiter.
(e) Misalignment of discriminator or other faults in discriminator circuit.
(f) Defects in the corrector network used for de-emphasis.

Distortion.—In addition to the usual causes of distortion, we have the following:

(a) Improper operation of the limiter due to defective components in the limiter circuit.
(b) Improper operation of the limiter due to insufficient gain ahead of the limiter, resulting in distortion of the dynamic range of the signal as transmitted.
(c) Improper response to the full deviation range due to oscillator drift.
(d) Improper response to the full deviation range due to regeneration which narrows the response of the i-f amplifier.
(e) Misalignment of i-f transformers.
(f) Improper operation of the discriminator due either to misalignment or defective components.

Noise.—There are two sources of noise which affect a receiver—that which is due to static (man-made or otherwise), and that which is generated in the receiver itself. The first source of noise can be eliminated by action of the limiter provided there is sufficient signal picked up by the antenna and also provided that there is sufficient gain ahead of the limiter.

The second source is due to faulty components such as noisy resistors, loose connections, noisy tubes, etc. In connection with tube noise, there is liable to be a certain amount of noise in the form of a hiss which originates in the plate circuit of the mixer tube when the receiver is tuned to a weak F.M. signal. Some of the possible causes of noise are as follows:

(a) Insufficient gain ahead of the limiter for proper limiting action.
(b) Defective antenna system.
(c) Defective converter tube.
(d) Improper operation of limiter due to faulty components in limiter circuit.
(e) Sustained oscillations due to regeneration.

Regeneration.—Since the R-F and I-F stages of an F.M. receiver operate at a higher frequency than A.M. receivers, they are more susceptible to regeneration and special attention should be given to the following possible causes.

(a) Critical leads not properly dressed.
(b) Loose shields and ground connection.
(c) Open or defective by-pass condensers.
(d) Improper screen or plate voltages.
(e) Misalignment of tuned circuits.

Interference.—There are several forms of interference which might be encountered such as interference from a station operating on the same channel, adjacent channel interference, and interference from a signal at or near the i-f frequency.

The first form of interference, a station operating on the same channel, is not nearly so serious as is the case with A.M. receivers, since the desired signal need not be more than twice as strong as the undesired signal for the undesired signal not to be heard. This condition is due to the action of the discriminator and is very helpful in eliminating this type of interference.

The second form of interference, adjacent channel interference, should be eliminated by the i-f-amplifier system but may exist due to improper alignment of the i-f transformers so that the i-f response curve is much broader than need be, or may also exist due to some defect in the i-f transformer itself which broadens the response curve.

The third form of interference, i-f signal interference, due to some signal at or near the i-f centre frequency, can only be eliminated by the use of a wave trap at the i-f frequency or in the realignment of the i-f system to a different centre frequency.

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Alignment procedure — general

Under normal operating conditions, it should not be necessary to realign the tuned circuits of an F.M. receiver due to the good stability of the components and the wide-band characteristics of the tuned circuits. However, if alignment should be necessary, it is possible to align an F.M. receiver in the conventional manner by using a fixed frequency A.M. oscillator and an output indicator, but it is recommended that the visual method of alignment be used which employs an oscilloscope as the indicating device and a signal generator which is frequency modulated.

In order to satisfactorily perform the necessary alignment operations on an F.M. receiver, the following equipment is needed:

(1) A good signal generator capable of covering all the frequencies to which the receiver will tune.
(2) A wide band signal generator capable of covering the i-f of the receiver with a sweep circuit of ± 200 kc.
(3) A cathode ray oscilloscope.
(4) A sensitive d-c voltmeter vacuum tube type or otherwise.

I-F alignment.—The alignment should be started by connecting the vertical amplifier of the scope across the grid resistor in the limiter circuit. The low side of the vertical amplifier should connect to ground and the high side should connect to the grid load resistor through a ½ megohm resistor to isolate the connecting lead. Adjust the sweep generator so that the middle or centre of the sweep is exactly at the i-f frequency of the receiver to be aligned. The sweep width should be ± 200 kc. Connect the high side of the signal generator through a .05 mfd. condenser to the grid of the i-f tube preceding the limiter. The low side of the signal generator should be connected to the same ground used for the oscilloscope, otherwise if different grounds are used oscillations in the i-f circuits are likely to develop. The signal input from the oscillator should be sufficiently high so that the limiter is functioning. This point is indicated when an increase in signal input no longer changes the amplitude of the curve. Align the limiter input transformer by adjusting the primary and secondary trimmers so that the curves on the oscilloscope screen on the forward and reverse sweep coincide and are as nearly flat-topped as possible without materially reducing the amplitude of the curve. During these adjustments the horizontal sweep of the oscilloscope should be adjusted to synchronize with the synchronizing pulses developed in the signal generator so as to keep the pattern on the scope stationary.

After the limiter input transformer has been adjusted, the input of the signal generator should be connected to the grid of the next preceding i-f tube (if there are two i-f tubes, which is the usual case). Adjust the trimmers on the i-f transformer connected to the plate of this tube for coincidence of the forward and reverse sweeps and make the curve as nearly flat-topped as possible without loss of amplitude. The next step is to connect the signal generator to the grid of the converter tube through a 22 mmf. capacitor and adjust the trimmers on the 1st i-f transformer as before so that the resultant curve will appear as shown in Figure 38. This completes the alignment of the i-f transformers and the next step is to align the discriminator transformer. The i-f transformers have been aligned stage-by-stage and no over-all adjustments should be made after completing the stage-by-stage adjustments.

Fig. 38. I-F alignment curve.

Discriminator alignment.—The signal generator is left connected to the grid of the converter tube and its frequency setting remains the same as before but the scope is removed from across the limiter grid resistor and is now connected across the diode load of the discriminator, which simply means that it is connected across the audio output of the discriminator. When this is done, the trimmer on the primary of the discriminator transformer should be adjusted for maximum vertical deflection on the oscilloscope. The secondary trimmer is then adjusted for centre crossover of the two curves. This crossover point should be approximately midway between the two sets of peaks as shown by Figure 39. If necessary, readjust crossover lines. This completes the alignment of the discriminator transformer.

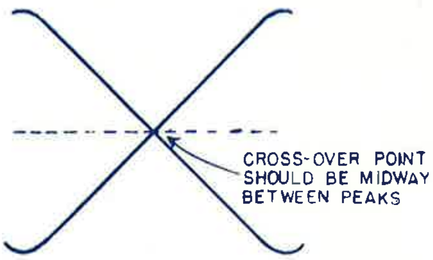

Fig. 39. Discriminator alignment curve.

R-F alignment.—Remove the signal generator from the grid of the converter tube and connect it directly to the antenna input terminals of the receiver. The scope should be removed from across the diode load and a sensitive d-c voltmeter should be connected across the limiter grid resistor with a ¼ meg. resistor in series with it to isolate the lead. Make sure that the dial pointer coincides with the proper mark on the low frequency end of the scale when the gang condenser is completely closed.

Adjust the signal generator to some frequency near the high end of the receiver dial and set the dial pointer to this frequency. The output of the signal generator should be unmodulated. Adjust the oscillator trimmer for maximum output as indicated on the voltmeter across the limiter grid load. Adjust the high frequency trimmers in the antenna and r-f tuned circuits for maximum output. This takes care of the alignment on the high end of the dial.

Next, adjust the signal generator to some point on the low end of the dial and set the dial pointer to this frequency and adjust the oscillator padder (if one is provided) for maximum output. Adjust the low frequency trimmers in the antenna and r-f circuits (if provided) for maximum output. This completes the alignment procedure for an F.M. receiver.

The r-f alignment on the low end of the dial may not be necessary on some receivers since the only alignment required is either at the high end of the dial or near the centre of the dial.

During the alignment of the r-f stages, the output of the signal generator should be kept as low as possible for satisfactory meter reading.

During the alignment of the i-f stages, the output of the signal generator should be high enough so that the limiter is functioning. The above alignment procedure is only a general outline and, when aligning any particular F.M. receiver, the specific instructions given in the service notes for that receiver should be followed.

ANGSTROM UNITS

A note on pronunciation

A Swedish reader of the Radiotron Designer's Handbook has drawn our attention to the fact that the name Angstrom is Swedish, and is pronounced "ong-strem" with the first syllable accented. We are happy to pass on this information to those interested.

$1\,A^\circ = 10^{-10}$ metre.

$= 10^{-7}$ mm. $= 10^{-4}$ micron.

RADIOTRON DESIGNER'S HANDBOOK

World sales of the 4th edition of the Radiotron Designer's Handbook have now exceeded 50,000 copies — a phenomenal figure considering the size and price, and the comparatively short time since its publication in U.S.A. and England.

The third Australian impression which is now available includes a large number of revisions of the text which were not included in the second impression. Libraries, in particular, are recommended to purchase a copy of the new impression in addition to any copies of earlier impressions which they may hold. Radio manufacturers and engineers would benefit if at least one copy of the new impression is available for reference.

1 Micron $= 10^{-6}$ metre $= 10^{-3}$ mm. $= 10^{4}\,A^\circ$.

Editor .. .. Ian C. Hansen

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