RADIOTRONICS

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6X4

Full Wave Vacuum Rectifier

REVISED RATINGS

Radiotron 6X4 is a full-wave vacuum rectifier of the heater-cathode type intended for use in vibrator-type power supplies of automobile radio receivers operating from a 6-volt storage battery, and in ac-operated radio receivers.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:

Voltage (AC or DC)	6.3 volts
Current	0.6 ampere

Mechanical:

Mounting Position	Any
Maximum Overall Length	$2\frac{5}{8}$"
Maximum Seated Length	$2\frac{3}{8}$"
Length from Base Seat to Bulb Top (Excluding Tip)	2" ± 3/32"
Maximum Diameter	$\frac{3}{4}$"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No. E7-1)

RECTIFIER SERVICE

Maximum Ratings, Design-Centre Values:

PEAK INVERSE PLATE VOLTAGE	1250 max.	volts
PEAK PLATE CURRENT PER PLATE	210 max.	mA
AC PLATE SUPPLY VOLTAGE (RMS) PER PLATE	See Rating Chart 1	
DC OUTPUT CURRENT PER PLATE	See Rating Chart 1	

HOT-SWITCHING CURRENT:

If hot-switching is regularly required in operation, the use of choke-input circuits is recommended. Such circuits limit the hot-switching current to a value no higher than that of the peak plate current. When capacitor-input circuits are used, a maximum peak current value per plate of 1 ampere during the initial cycles of the hot-switching transient should not be exceeded.

PEAK HEATER-CATHODE VOLTAGE:

Heater negative with respect to cathode	450 max.	volts
Heater positive with respect to cathode	450 max.	volts

Typical Operation as Full-Wave Rectifier with Capacitor-Input to Filter:

AC Plate-to-Plate Supply Voltage (RMS)	650	volts
Filter Input Capacitor	10	μf
Effective Plate-Supply Impedance per plate*	520	ohms
DC Output Voltage at Input to Filter (Approx.):		
At half-load current of 35 mA	360	volts
At full-load current of 70 mA	300	volts
Voltage Regulation (Approx.):		
Half-load to full-load current	60	volts

* Higher values of capacitance than indicated may be used but the effective-plate supply impedance should be increased to prevent exceeding the maximum rating for peak plate current.

Typical Operation as Full-Wave Rectifier with Choke-Input to Filter:

AC Plate-to-Plate Supply Voltage (RMS)	900	volts
Minimum Filter Input Choke	10	henries
DC Output Voltage at Input to Filter (approx):		
At half-load current of 35 mA	385	volts
At full-load current of 70 mA	370	volts
Voltage Regulation (Approx.):		
Half-load to full-load current	15	volts

OPERATING CONSIDERATIONS

The maximum ratings in the tabulated data for the 6X4 are working design-centre maximums established according to the standard design-centre system of rating electron tubes.

RATING CHARTS AND OPERATION CHARACTERISTICS

Rating Chart I given in Fig. 1 represents graphically the relationships between maximum ac voltage input and maximum dc output current derived from the fundamental ratings for conditions of capacitor-input and choke-input filters. This graphical presentation gives the equipment designer considerable latitude in choice of operating conditions.

Rating Chart II given in Fig. 2 represents graphically the relationship between maximum rectification efficiency and maximum dc output current per plate for conditions of capacitor input to filter.

A choice of operating values of dc output current per plate and rectification efficiency should be made

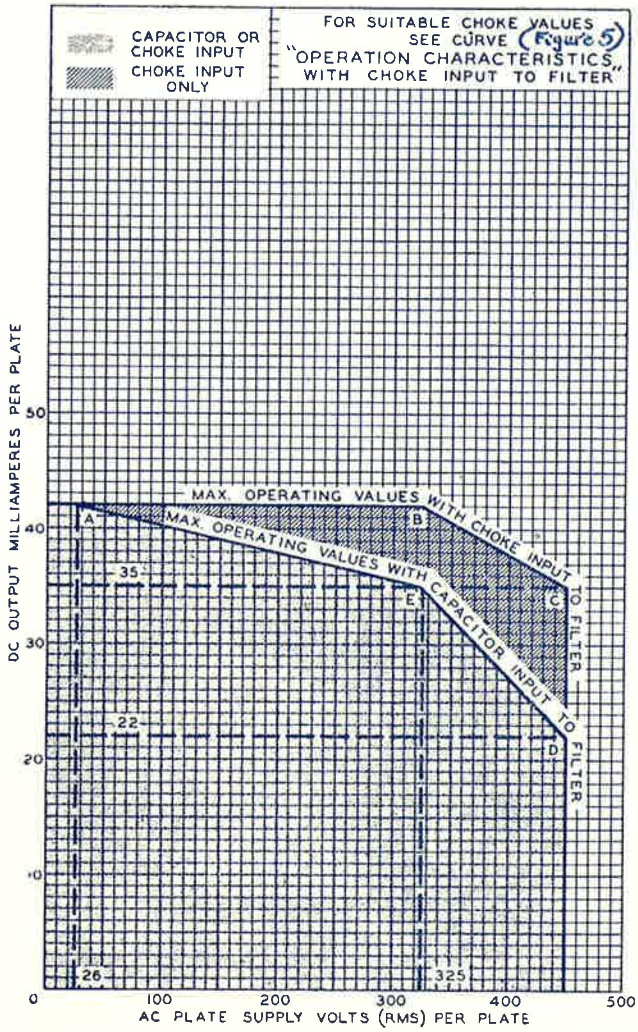

Fig. 1. Rating Chart I for Type 6X4 with Choke and/or Capacitor Input to Filter as Indicated in Legend.

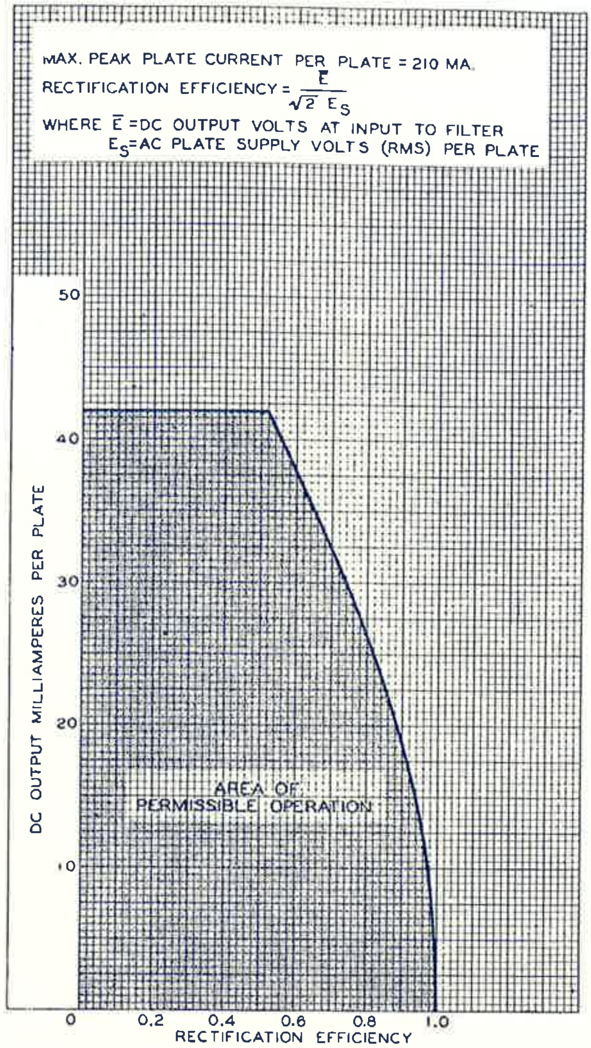

Fig. 2. Rating Chart II for Type 6X4 with Capacitor Input to Filter.

such that they fall within the area of permissible operation to insure that the maximum peak plate current will not be exceeded. If the operating values chosen fall outside the permissible operating area, a different choice of parameters should be made. For a given value of ac voltage input and dc output current, it is possible to reduce the rectification efficiency by either increasing the plate-supply resistance per plate or by using a smaller value of input filter capacitor.

Rating Chart III given in Fig. 3 represents graphically the relationships between minimum plate-supply resistance per plate and maximum ac plate-supply voltage per plate under no-load conditions for conditions of capacitor input to filter when occasional hot-switching is employed.

If occasional hot-switching is required with capacitor input circuits, it is important to protect the tube and the circuits against the flow of plate currents having magnitude in excess of the maximum permissible hot-switching current of 1 ampere as indicated under *Maximum Ratings*. To limit the hot-switching current, adequate series plate-supply resistance per plate is necessary. The may be determined with the formula shown in legend of *Rating Chart* III. To insure that the maximum hot-switching current is not exceeded, a value of series plate-supply resistance per plate should be chosen such that it is equal to or greater than the minimum value indicated by the curve.

If appreciable series inductance is present in the plate supply, a value of series plate-supply resistance smaller than that indicated by the curve may be employed provided it is experimentally determined that the combined effect of inductance and plate-supply resistance used are adequate to limit the hot-switching current to the indicated maximum value.

The *Operating Characteristics* given in Fig. 4. show the usual typical operating curves for a full-wave rectifier with capacitor-input filter. In addition, they show by means of boundary line "DEA" the limiting current and voltage relationships presented in Fig. 1.

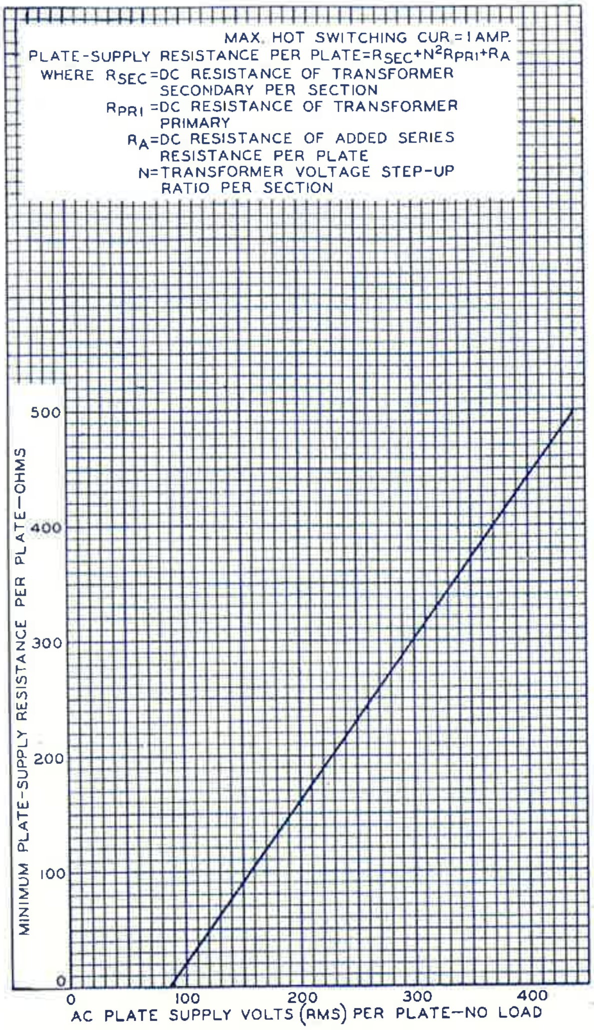

Fig. 3. Rating Chart III for Type 6X4 with Capacitor Input to Filter.

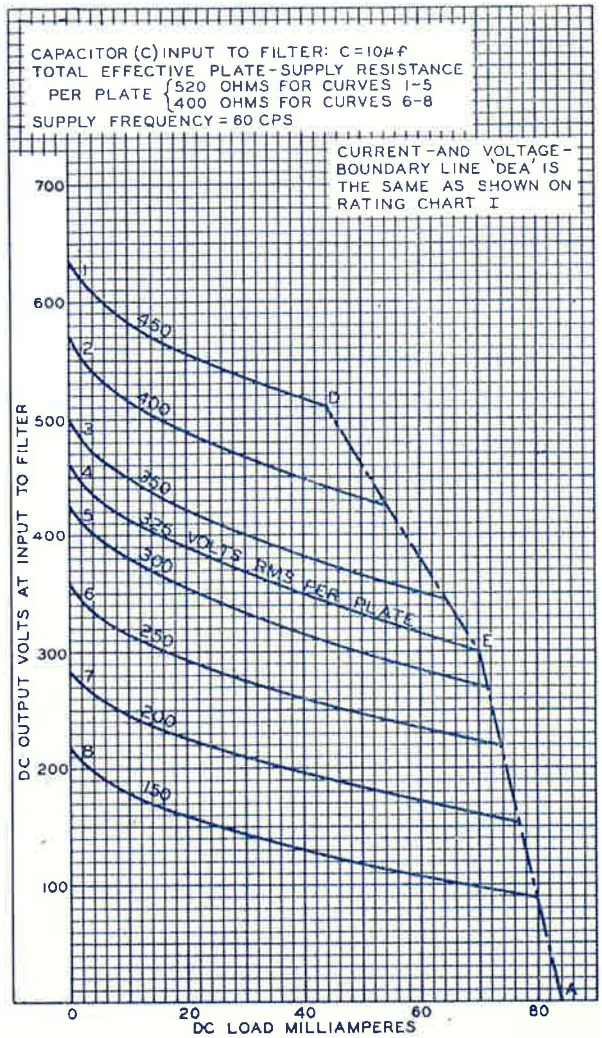

Fig. 4. Operation Characteristics for Type 6X4 in Full-Wave circuit with 10 µf-Capacitor Input to Filter.

A choice of operating values to the left of the boundary line should be made such that operation of the tube at these values will ensure that the maximum ratings will not be exceeded.

The *Operation Characteristics* given in Fig. 5 show the usual typical operating curves for a full-wave rectifier with choke input filter. They not only show by means of boundary line "ABC" the limiting current and voltage relationships presented in Fig. 1, but also give information as to the effect of various size chokes on regulation. The solid-line curves show the dc voltage outputs which would be obtained if the filter chokes had infinite inductance. The long-dash lines radiating from the zero position are boundary lines for various sizes of chokes as indicated. The intersection of one of these lines with a solid-line curve indicates the point on the curve at which the choke no longer behaves as though it had infinite inductance. To the left of the choke boundary line, the regulation curves depart from the solid-line curves as shown by the representative short-dash regulation curves. It will be noted that regulation improves with an increase in the value of choke inductance, but for cost reasons, the value of inductance is usually held to the smallest value which will give the desired regulation over the operating current range. It is also to be noted that at the lower load currents, higher values of inductance are required to maintain good regulation. A choice of operating values to the left of the boundary line "ABC" should be made such that operation of the tube at these values will ensure that the maximum ratings are not exceeded.

SEE FOLLOWING PAGE FOR FIG. 5.

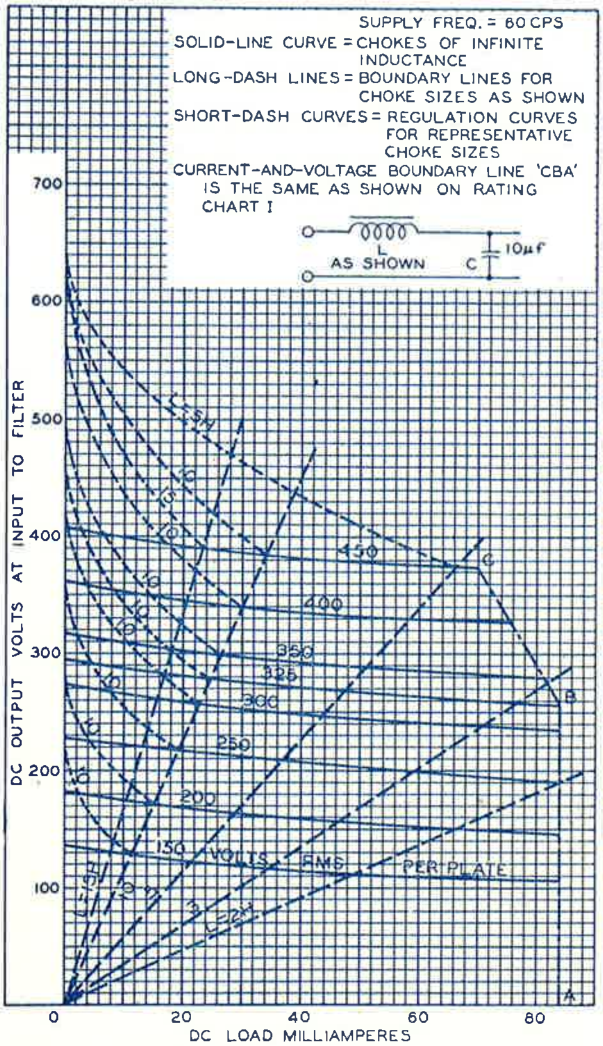

Fig. 5. Operation Characteristics for Type 6X4 in Full-Wave Circuit with Choke Input to Filter.

New RCA Releases

RADIOTRON 4-1000A is a forced-air-cooled power tetrode intended for use as an oscillator, amplifier, and modulator. It has a maximum plate-dissipation rating of 1000 watts, and is rated for operation at frequencies as high as 110 megacycles per second.

RADIOTRON 6W6-GT is a beam power amplifier of the glass-octal type designed for use in the audio output stage of radio and television receivers. When connected as a triode, it is especially useful as a vertical deflection amplifier in television receivers. The 6W6-GT has high sensitivity and high efficiency and is capable of providing high power output at relatively low plate-supply voltages.

RADIOTRON 6CF6 is a sharp-cutoff pentode of the miniature type especially designed for use in gain-controlled video IF stages operating at frequencies in the order of 40 megacycles. It is also well suited for use as an RF amplifier in VHF television tuners.

The 6CF6 features controlled plate-current cutoff and very high transconductance (6200 micromhos) combined with low capacitance values. It is provided with separate base pins for grid No. 3 and the cathode. This arrangement permits the use of an unbypassed cathode resistor to minimize changes in input loading and input capacitances with bias without causing oscillation which would otherwise result if grid No. 3 were internally connected to the cathode.

RADIOTRON 12X4 is a full-wave vacuum rectifier of the heater-cathode type intended especially for use in vibrator-type power supplies of automobile radio receivers operating from a 12-volt storage battery. It may also be used in a.c.-operated radio receivers.

RADIOTRON 5690 is a new "Special Red" vacuum rectifier tube especially designed for industrial and aircraft applications where rigid requirements for dependability, stability, and long tube life are of prime importance.

The 5690 has two separate diode units of the indirectly heated cathode type. It is conservatively rated to withstand a maximum peak inverse plate voltage of 1120 volts, a maximum peak plate current per plate of 375 milliamperes, and a maximum dc output current per plate of 150 milliamperes.

Careful and conservative design, exact processing control, and detailed inspection of each assembly provide the 5690 with a minimum life of 10,000 hours when it is operated within maximum ratings. The extreme uniformity and exceptional stability featured in the 5690 have been achieved both initially and during life by precision design, extreme care in the selection and inspection of materials, and close gauging of parts.

The unique structural design of the 5690 makes it capable of withstanding continuous vibration of 2.5 g at a frequency of approximately 25 cycles per second for hundreds of hours at maximum rated voltage. It is also capable of withstanding impact shocks of 500 g for short periods at maximum rated voltage.

RADIOTRON 6101 is a "premium" medium-mu twin triode of the 7-pin miniature type specifically for use as a class A amplifier and control tube in mobile and aircraft equipment where dependable performance under shock and vibration is a fundamental consideration. It is constructed and processed to meet military requirements.

Developed from the type 6J6, the 6101 offers important advantages in dependability and ability to resist shock and vibration — advantages achieved by structural refinements, stringent production controls, rigorous tests for shorts and leakage, and quality control of critical characteristics both initially and during life. These factors all contribute to long and dependable performance from the 6101.

NOISE PERFORMANCE OF V.H.F. RECEIVERS

By E. G. HAMER, B.Sc., A.M.I.E.E.

The sensitivity of V.H.F. receivers has been specified in the past by the signal input required, at a given depth of modulation, to produce a specified audio power output. This figure, together with information as to the bandwidh, maximum audio output and distortion have given a measure of the overall performance of the receiver. More recently additional information has been supplied such as the level of spurious responses, and the unwanted signal required to cause blocking or cross modulation. It was found that as the sensitivity of receivers increased noise was introducing a limit to the maximum usable sensitivity obtainable. In recent years a considerable effort has been expended investigating the effects of noise in limiting the absolute sensitivity of receivers[1], and various circuits have been analysed theoretically and tried experimentally to see which would give the best performance with respect to noise.

Most modern V.H.F. receivers, particularly those used for mobile communications systems, have sufficient gain for their performance to be limited by noise, and it is important that the noise effects should be reduced to a minimum. The resultant audio noise output is due to several causes, the major sources of noise being:—

(a) atmospheric noise due to lightning discharges,
(b) cosmic noise due to solar bodies,
(c) man-made noise from electrical equipment,
(d) thermal noise in the aerial and receiver input circuits.

and of these sources the circuit designer has no control over (a) and (b), while the audible effects of (c) can sometimes be mitigated by special circuits, and the noise contribution due to the receiver input circuits can be reduced to a minimum by the use of special valves and circuits. Dealing in turn with the various forms of radio noise, we have atmospheric noise which is mainly due to lightning discharges and other natural effects and will, of course, vary greatly with the time of day, year, weather, and the geographical location. Above frequencies of the 40 Mc/s the level of atmospheric noise is usually less than the receiver and aerial thermal noise except in the case of local thunderstorms, and it can therefore be neglected in the design of V.H.F. receivers and systems. It is usually assumed that the peak amplitude of atmospheric noise is proportional to the square root of the receiver bandwidth.

Cosmic noise is normally a small component and can be neglected at V.H.F. unless man-made noise is absent or a highly directive aerial array is being used, and happens to be pointing at a solar body. Cosmic noise decreases approximately as the inverse cube of the frequency, and can generally be completely neglected at frequencies above 200 Mc/s. In special cases it can be taken into account by assuming an increase or decrease in the amount of thermal noise from the aerial.

Man-made noise may take many forms, and will be greatest in densely populated and industrial areas. Certain types such as that due to diathermy and industrial radio frequency heating machines will be the same irrespective of the receiver bandwidth, while that due to automobile ignition will increase with an increased receiver bandwidth.

Ignition interference is usually of a very peaky nature, and its audible effects can often be reduced by the use of suitable audio limiter circuits, but in some cases in certain areas the man-made noise may originate from so many sources as to have the same form of random distribution as thermal noise, and the mean man-made noise level will be high. In such cases audio limiter circuits will be ineffective and no improvement in man-made noise performance can be obtained. This, of course, refers to any particular system or type of modulation, as certain systems may have a superior performance with respect to a given amount of random and man-made noise than other systems using different types of modulation. It is usually assumed that the receiver output due to man-made noise increases uniformly with receiver bandwidth, although from recent investigations it does not appear to increase quite as rapidly as the receiver bandwidth. Man-made noise in general decreases with frequency in a complex manner, the variation depending on the type of man-made noise and other local factors. Typical measured figures in England evaluated on a statistical basis for the noise level exceeded for a total of one minute in every hour with respect to a power of one watt, are:—

Town	77 Mc/s	—165db per cycle of bandwidth.
Town	172 Mc/s	—175db per cycle of bandwidth.
Country	77 Mc/s	—180db per cycle of bandwidth.
Country	172 Mc/s	—180db per cycle of bandwidth.

These compare favourably with typical median values for the U.S.A., where half the sites have lower values of peak noise power, which are:

Town	100 Mc/s	—160db per cycle of bandwidth.
Town	200 Mc/s	—166db per cycle of bandwidth.
Country	100 Mc/s	—166db per cycle of bandwidth.
Country	200 Mc/s	—172db per cycle of bandwidth.

The figures quoted above are averaged on a statistical basis for a large number of sites and may be considerably increased in the immediate vicinity of large industrial areas, or town centres where there are a large number of vehicles in close proximity to the receiver.

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Thermal noise is due to the thermal agitation of electrons in resistances, and the R.M.S. value of the equivalent thermal noise voltage in series with the resistance is given by:—

$$e^2 = 4kTR\Delta f$$

where k = Boltzman's constant = 1.38×10^{-23} joules/degree Kelvin.
T = Absolute temperature in degrees Kelvin.
Δf = Bandwidth in cycles per second.
R = Resistance in ohms.

At normal temperature this is usually taken as –204db with respect to a power of one watt per cycle of bandwidth, and this type of noise has a uniform distribution of power throughout the radio frequency spectrum. The figure quoted is an average value as the instantaneous peak value of thermal noise will be greater than the average value.

The sources of thermal noise are the aerial itself, the receiver input circuits and the input valves. It can be shown that the thermal noise contribution due to the aerial itself is the same as that due to resistance equal to the radiation resistance of the aerial. If in special cases it is desired to take account of cosmic noise the aerial is assumed to have a higher temperature than its physical temperature.

The input circuits of the receiver also generate thermal noise, and in this case the noise power is the same as that which would be generated by a resistance equal to the effective resistance of the tuned circuit allowing also for the losses in the valve. A careful choice of input circuit and a valve with a high input resistance of the frequency concerned will reduce this noise to a minimum. If the gain of the first stage is low the second stage may also contribute an appreciable amount of thermal noise to the total thermal noise output of the receiver.

Valves contribute, however, another source of noise, and this is due to the random motion of electrons which leave the cathode. In the case of multi-electrode valves an additional amount of noise is caused by the "partition effect", that is, the random division of the cathode current among the various electrodes.

For the purpose of circuit analysis these effects may be simulated by means of a hypothetical noise generator in series with the grid of a perfect valve, and a convenient way to simulate random noise is to use a resistance of a suitable value as the noise generator. This resistance does not exist as a physical ohmic resistance in the usual way, and when analysing the circuit it must only be treated as a generator of a noise voltage. It is also a convenient figure to quote to indicate the merit of a valve for low noise applications. The "noise resistance" of a valve is intimately related to the mutual conductance and the following formulae give the approximate "noise resistance" of various valve types:—

Triode amplifiers

$$R_n = 2.5/g_m$$

Pentode amplifiers

$$R_n = \frac{I_a}{I_a + I_{g2}}\left(2.5/g_m + \frac{20I_{g2}}{(g_m)^2}\right)$$

Triode mixers

$$R_n = 4/g_c$$

Pentode mixers

$$R_n = \frac{I_a}{I_a + I_{g2}}\left(4/g_c + \frac{20I_{g2}}{(g_c)^2}\right)$$

Multi-grid mixers and Convertors

$$R_n = \frac{20I_a\,(I_K - I_a)}{(g_c)^2 I_K}$$

where R_n = equivalent "noise resistance" in ohms
g_m = mutual conductance in mhos
g_c = conversion conductance in mhos
I_a = anode current in amperes
I_{g2} = screen grid current in amperes
I_K = cathode current in amperes

and typical values are:

Triode amplifiers	200-400 ohms
Pentode amplifiers	700-2000 „
Pentode mixers	3000-5000 „

As would be expected, due to the additional partition noise of the multi-electrode valves, pentodes have a much larger noise resistance than triodes, and with the object of reducing receiver thermal noise to a minimum triode valves are to be preferred for the input stages. Triode valves have the disadvantage of large input to output capacitances, and special circuits must be used to overcome this difficulty. Among the more common triode valve input circuits are those using neutralizing and grounded grid connexions. The advantage of the neutralized circuit for narrow band applications is the higher voltage gain per circuit. Several previous authors have analysed various types of circuit with respect to their thermal noise performance and have derived formulae for the combined thermal noise due to the circuit and valve to be a minimum[2].

When the input circuit consists of a silicon crystal mixer a similar technique may be employed to allow for the thermal noise generated by the crystal. Usually where the crystal mixer is used in a V.H.F. receiver it is desirable to use a low noise I.F. amplifier following it, and often a cascode circuit is used for the input stages of the I.F. amplifier. The cascode circuit consists of a neutralized triode input stage followed by a grounded grid triode second stage, giving the advantage of a large power gain with a stable circuit arrangement.

One important factor has up to now been neglected and is the transit time effects, which are due to the finite time taken for the electrons to travel from the cathode of the valve to the various electrodes. These effects assume greater importance at the higher frequencies; but the consideration of transit time effects at the higher frequencies is somewhat empirical, and at the lower frequencies the noise contributions are small. It has been found possible to improve the noise performance of V.H.F. receivers by detuning the input circuits, although the mechanism of this is as yet not fully understood, and it creates additional problems with the gain and the stability of the circuits[2].

The performance of a receiver with respect to thermal noise is usually specified as the ratio of the actual noise power output of the receiver when connected to its aerial, to the noise power output which would be obtained if the aerial were the only source of thermal noise in the system. This assumes that over-loading of the receiver and detector is not taking place; that is, the whole receiver from input to output is a linear device under the conditions of test. This ratio is usually expressed in decibels and is termed the noise factor of the receiver. For a given input circuit this figure does not depend on the bandwidth of the receiver as determined by the following I.F. stages. When the amount of thermal noise from the aerial has been predicted the total effective thermal noise, including that due to the receiver, is obtained by multiplying by the noise factor. This only applies to thermal noise, and must not be used directly when evaluating any other form of noise component. An improvement in receiver noise factor will only decrease the thermal noise; output due to the other sources will not be effected.

The noise factor is primarily determined by the design of the input stage, although further stages may make a small contribution to the total noise power output. In such cases the overall noise factor is:

$$N = N_1 + \frac{N_2 - 1}{G_1} + \frac{N_3 - 1}{G_2} \ldots \text{etc.}$$

where N_1, N_2, N_3, etc., are the noise factors of the individual stages defined in a similar way to that for the complete receiver, and G_1 is the power gain from 1 to 2, G_2 from 2 to 3, etc.; and with normal receiver designs using R.F. valve amplifiers the contribution of all the other stages apart from the input stage is less than 15 per cent.

Where a silicon crystal mixer is used we have:

$$N = 1/G_c\,[N_1 G_c + (N_{I.F.} - 1)]$$

where G_c is the conversion power gain of the crystal mixer, N_1 is the noise factor of the crystal mixer, and $N_{I.F.}$ is the overall noise factor of the I.F. amplifier. N_1G_1 is usually called the noise temperature t_r of the crystal mixer; at V.H.F. for silicon crystals has a value approximately equal to 1 when the local oscillator injection power is 1 milliwatt.

$$\text{Hence } N \approx N_{I.F.}/G_c$$

and from this equation can be seen the importance of having a low noise factor I.F. amplifier when a direct silicon crystal mixer is used.

Fig. 1 shows the variation of the levels of the various types of noise with frequency; in the case of thermal noise a resultant thermal noise level has been drawn allowing for the noise factor likely to be obtained with carefully designed receivers at the appropriate frequencies. Fig. 1 must only be taken as a general guide to the noise levels because, as previously stated, the noise is not exactly proportional to bandwidth in all cases; and slightly different forms of statistical analysis have been applied to the various types of noise; this especially refers to man-made noise where allowance is normally made for short duration peaks of high noise level.

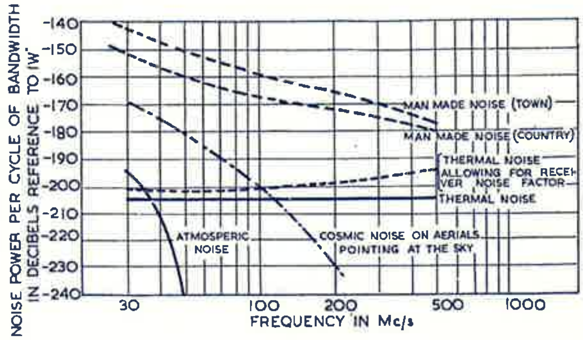

Fig. 1. Radio noise levels.

The noise factor of a receiver may be measured in several ways, but the basis of nearly all the methods is that if a known signal, or additional known amount of random noise is added to the existing noise input, and the actual increase of noise power output noted, the total input noise may be evaluated. The noise contribution from the aerial, or equivalent aerial load can be calculated, and that due to the receiver itself evaluated. A convenient method is to vary the extra input until the total noise output power from the receiver has been doubled.

In one method a signal generator is used whose output impedance is equal to the appropriate aerial impedance, a known c.w. signal at the receiver centre frequency is injected and varied until the total R.F. power at the receiver detector has been doubled. For this test the usual detector must be replaced by a calibrated R.F. power measuring device such as a thermocouple or bolometer bridge, and if the output power level has been doubled the receiver noise factor is given by:—

$$N = \frac{P}{kT\Delta f}$$

where P = C.W. input power to double the detector power

f = Receiver bandwidth (usually taken at the 3 or 5db points, depending on the shape of the receiver frequency response curve)

kT can be taken as –204db per cycle of bandwidth.

This method is not often used, as it means modifying the detector circuits of the receiver being tested.

A more convenient method is the use of the calibrated source of random noise, and the one most commonly used at V.H.F. is the diode noise generator.

In this case the difficulties of making an accurate determination of the effective bandwidth of the receiver and the characteristic of the detector vanish. The noise current I_n of a diode valve when working in the temperature saturated region is

$$I_n^2 = 2eI_o\Delta f$$

where e = electron charge

I_o = D.C. current through the diode valve

and hence the mean square noise voltage across an external resistor R in parallel with the diode is:

$$E_n^2 = 2eI_0R^2\Delta f$$

this is in addition to the thermal noise power available from the resistor itself. The impedance of the diode is also shunted across the resistance, but the value of the diode impedance is usually large compared to that of the resistor. If now R has the same resistance as the appropriate aerial of the receiver and is connected to the receiver input, the noise output power of the receiver in the absence of any diode current will be proportional to $4kTR\Delta fN$. With the diode switched on and the filament current adjusted so as to double the noise output power we have:

$$2eI_0R^2\Delta f = 4kTR\Delta fN$$
$$\therefore N = (e/2kT)I_0R$$

and if $T = 300^0K$

$$N = 20I_0R$$

or in decibels, $N = 10\log_{10}20I_0R$

this formula enables the noise factor of the receiver to be measured directly, assuming the existence of a suitable noise diode and circuit. The type CV172* noise diode valve has been used successfully up to frequencies of 250 Mc/s before effects due to the resonance of the leads, and transit time effects have invalidated the results. Improved noise diode valves have been developed capable of being used up to 500 Mc/s. It has been found that the high frequency resistance value of the disc type resistance is the same as the D.C. value to frequencies much higher than 500 Mc/s, and Fig. 2 shows a circuit diagram of a noise generator suitable for frequencies up to 500 Mc/s. The diode and spray capacitances are resonated at the receiver centre frequency by means of a shunt coil. Recently further methods have been developed for increasing the useful range of diode noise generators, and these include the use of symmetrical diode arrangements, and peaking inductances in series with the terminating resistor[4].

Measurements made in the past indicate that the following noise factors may be obtained by careful design:—

40 Mc/s	3db
100 Mc/s	4db
200 Mc/s	6db
500 Mc/s	10db

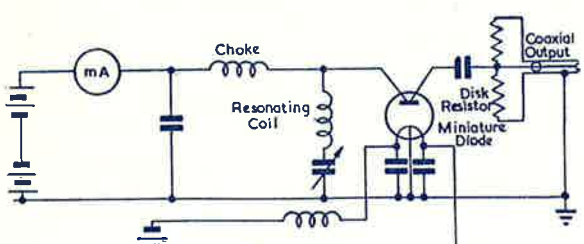

Fig. 2. Thermal noise generator.

Above 500 Mc/s simple based valves are not yet commercially available, and either more elaborate types such as disc seal valves, or direct crystal mixers must be used.

It is important when designing radio receivers to assess beforehand if the additional complexity and cost of a low noise factor design is justified. The improvement due to a low noise factor design only applies to thermal noise, and not general radio noise such as that due to atmospheric and man-made sources.

The deciding factor will be the frequency at which the system is to operate, and also the type of service, as the greater the frequency the greater will be the contribution made by the thermal noise components. To some extent the type of service will influence the choice as the characteristics of noise depend on its origin. Thermal noise is evenly distributed over the frequency spectrum, and it is not possible to reduce the audible effects of this type of noise by special post detector circuits on any given system. Man-made noise may, however, have peaks of short duration very much larger than the mean level, and in certain cases, such as mobile communication systems, special post detector circuits may be used to reduce the audible effects of this type of noise.

Even if these noise effects cannot be reduced, but are only of short duration, they may be acceptable for a simple radio link, provided they do not degrade the intelligibility of the receiver signal too greatly. In the case of a more elaborate system such as one carrying a large number of telephone circuits, a short interruption of service may have serious operational effects, and the peak level of man-made noise should be the criterion of design. At frequencies in the region of 100 Mc/s the man-made noise is dominant, and as long as the receiver noise factor is reasonable there would seem little point in special low noise factor designs. Above 200 Mc/s, particularly for mobile services, thermal noise is the dominating factor, and an improvement in the receiver noise factor would give a direct improvement to the range of a system. For nearly all multi-channel systems, except at frequencies above 500 Mc/s, a reasonable low noise factor receiver design is required, but the system as a whole must be designed to override the peak noise bursts due to man-made causes.

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* ≡ E1468
≈ A1468

Revised Germanium Diode Data

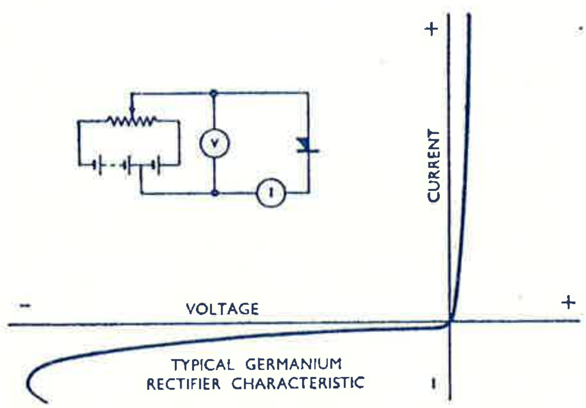
Issued by Amalgamated Wireless Valve Co. Pty. Ltd.

Germanium diodes consist of a small piece of germanium and a point contact or catwhisker, the whole being sealed into a glass capsule.

The advantages of this type of rectifier include very small size, robustness, low capacitance and ability to be soldered directly into the circuit. In addition, since a heater is not required, no hum is introduced.

Compared with other non-thermionic rectifiers, germanium is outstanding in its H-F performance and its ability to handle high voltages.

A typical characteristic curve is given below from which it will be noticed that when the reverse voltage exceeds a certain figure the reverse resistance suddenly decreases and then becomes negative. The potential at which this occurs is known as the "turnover" voltage.



Other curves show variations between different types and variation with temperature.

Germanium rectifiers are divided into two categories, the first being the high back voltage types made from germanium of great purity and the other being the special low resistance types using germanium containing deliberately introduced impurities. The high back voltage types are differentiated mainly by their turnover voltage and back resistance figures which are the most important factors when considering their applications.

Capacitance

0.2 $\mu\mu$F min.
0.7 $\mu\mu$F average.
1.0 $\mu\mu$F max.

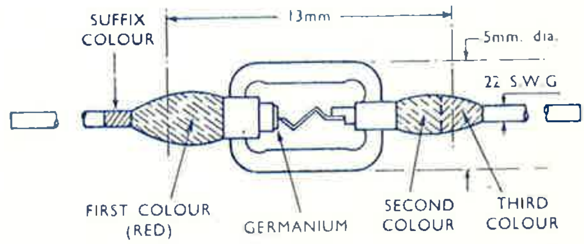
GENERAL

Temperature range

The rectifiers will function satisfactorily in the range —100°C to +120°C.

Humidity

The rectifiers are hermetically sealed and it is impossible for moisture to penetrate to the working surfaces. They may be immersed in boiling water or exposed to low temperature steam without detriment to their characteristics.



Vibration

All rectifiers are subjected to severe vibration test after manufacture.

Connection

Soldered joints may be made directly to the wire leads. No special precautions are necessary when carrying out this operation since they will withstand the 10 second test required by R.I.C. component specifications.

Expectation of life

Shelf life is expected to be greater than 10 years. Operating life is greater than 10,000 hours.

HIGH BACK VOLTAGE TYPES

Common Ratings (at 20°C.)

Forward current (continuous)	50 mA max.
Repetitive peak (sinusoidal)	100 mA max.
Repetitive peak (brief, recurrent)*	200 mA max.
Occasional one-second overload ...	0.5A max.
Dissipation with reverse voltage ..	120 mW max.

* On-off ratio 1/1000.

The above ratings are for operation at an ambient temperature of 20°C. and for higher ambient temperature must be reduced in the proportion $\frac{120-t}{100}$ where t is the new ambient temperature in degrees centigrade.

Colour code

In the colour coding system, when compared with a thermionic diode, the red end of the rectifier corresponds to the cathode.

The second and third colours give the type number according to the R.T.M.A. standard code used for resistors. Where a suffix is used, e.g. GEX45/1, this is indicated by a colouring of the wire at the red end.

LIST OF TYPES

GEX00

Colour code: Red/Black/Black.

Superseded by GEX35.

GEX03

Colour code: Red/Black/Orange.

Superseded by GEX45/1.

GEX33

Colour code: Red/Orange/Orange.

Superseded by GEX35.

***GEX34**

Colour code: Red/Orange/Yellow.

T.V. sound detector, sound noise limiter and high level video detector. Turnover voltage is greater than 60V. Current at +1V greater than 1 mA. Current at —10V less than 100μA. Current at —50V less than 2000μA.

***GEX35**

Colour code: Red/Orange/Green.

Low level video detector. Turnover voltage greater than 30V. Functionally tested at 35 Mc/s to give 400μA rectified current in 6800 ohm load.

GEX35/0

Colour code: Red/Orange/Green with Black wire.

Superseded by GEX35.

GEX36

Colour code: Red/Orange/Blue.

Mixer diode. For use as telephony modulator at higher voltage levels than GEX64. Available in groups matched for forward voltage at 5 mA in the range +0.625 to +0.875V.

GEX44

Colour code: Red/Yellow/Yellow.

Superseded by GEX34.

GEX44/1

Colour code: Red/Yellow/Yellow with Brown wire.

Superseded by GEX34.

GEX45

Colour code: Red/Yellow/Green.

Superseded by GEX45/1.

***GEX45/1**

Colour code: Red/Yellow/Green with Brown wire.

Medium back-resistance diode for all purposes. Turnover voltage greater than 75V. Current at +1V greater than 4 mA. Current at —50V less than 1000μA.

***GEX54**

Colour code: Red/Green/Yellow.

High back voltage rectifier. Turnover voltage greater than 100. Current at +1 volt greater than 4 mA. Current at —50 volts less than 100 μA.

GEX54/3

Colour code: Red/Green/Yellow with Orange wire.

High back voltage rectifier. Turnover voltage greater than 120V. Current at +1 volt greater than 3 mA. Current at —100 volts less than 625μA. U.S. equivalent: 1N38-A.

GEX54/4

Colour code: Red/Green/Yellow with Yellow wire.

High back voltage rectifier. Turnover voltage greater than 170V. Current at +1 volt greater than 3 mA. Current at —150V less than 800 μA. U.S. equivalent: 1N55-A.

***GEX54/5**

Colour code: Red/Green/Yellow with Green wire.

High back voltage rectifier. Turnover voltage greater than 220V. Current at +1 volt greater than 1.5 mA. Current at —200V less than 600 μA. U.S. equivalent: 1N39-A.

GEX55

Colour code: Red/Green/Green.

Superseded by GEX55/1.

*GEX55/1

Colour code: Red/Green/Green with Brown wire.

High impedance rectifier for all purposes. Turnover voltage greater than 75V. Current at +1V greater than 1 mA. Current at —50V less than 200 μA.

GEX56

Colour code: Red/Green/Blue.

Very high back resistance diode for computer use. Current at +1V greater than 1 mA. Current at —10V less than 2μA.

GEX64

Colour code: Red/Blue/Yellow.

Mixer diode with very low forward resistance. Typical applications are telephony modulator in multi-channel systems and meter rectifier. Available in groups for forward voltage at 5 mA in the range +0.2 to +0.3V. The comparatively high capacitance of 30μμF limits the effective operating frequency in high impedance circuits.

*GEX66

Colour code: Red/Blue/Blue.

UHF mixer for use up to 1,000 Mc/s. In the TV range up to 100 Mc/s the noise as a mixer is not greater than that from the cartridge type silicon mixer. Efficiency is good and noise fairly low up to 1,000 Mc/s and there is considerable response at 10,000 Mc/s. Current at +0.5V greater than 6 mA. Reverse current at —1V less than 50μA.

GEX69

Colour code: Red/Blue/White.

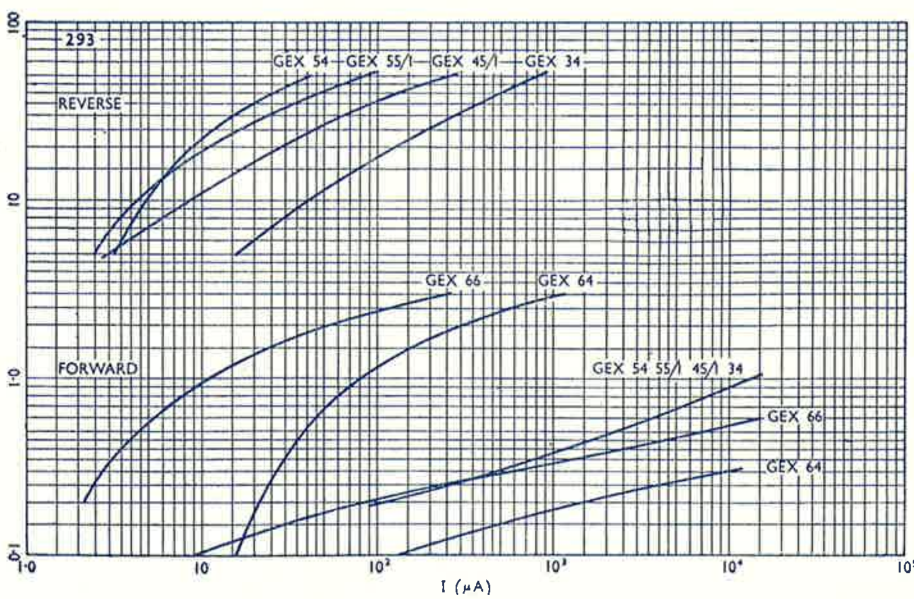
Superseded by GEX66.

GEX99

Colour code: Red/White/White.

Superseded by GEX35.

* Preferred types normally carried in stock.



Typical characteristics at 20° C

New Publications

"INTRODUCTION TO VALVES", by R. W. Hallows and H. K. Milward. 152 pages. 107 line illustrations and a frontispiece.

"INTRODUCTION TO VALVES" describes the principles of operation of the radio valve and its uses in circuits of various types. Following an explanation of the fundamental thermionic valve, the book deals with diodes, as rectifiers and detectors; triodes and their various applications; tetrodes and pentodes; multiple-grid valves for frequency-changing; power-output valves; and valves for U.H.F. and E.H.F. operation. Other chapters discuss special-purpose types and the construcion of modern miniature and sub-miniature valves.

The system of letter symbols for valves, introduced by the British Standards Institution in 1947, is used throughout, and a full explanation of this valuable system is given. The text is supplemented by over 100 diagrams and graphs, including many typical circuits.

While — as the title indicates — this book does not attempt to provide more than a general introduction to this large and complex subject, the reader is given an excellent grounding in a clear and concise form, and the technical level is sufficiently advanced to make the work useful to the more knowledgeable radio student as well as to the novice.

Our copy was received with the compliments of the publishers, Iliffe & Sons Ltd., Dorset House, Stamford Street, London, S.E.1.

"TELEVISION ENGINEERING" Principles and Practice, Volume 1: Fundamentals, Camera Tubes, Television Optics, Electron Optics, by S. W. Amos and D. C. Birkinshaw, in collaboration with J. L. Bliss. Over 300 pages. 188 illustrations.

This is the first volume of a textbook on television engineering, written by members of the B.B.C. Engineering Training Department, primarily for the instructions of the Corporation's own operating and maintenance staff. The work is intended to provide a comprehensive survey of modern television principles and practice, on both the transmitting and receiving sides.

The first volume discusses in detail the vision waveform derived from synchronizing and picture signals. Types of camera tubes in use by the B.B.C. and lenses are then described, and the final chapters are devoted to electron optics, involving a study of electric and magnetic lenses. The second volume, now in course of preparation, will cover vision-frequency amplifiers and waveform generation, and later volumes will deal with the remaining aspects of the subject.

The technical level of the work has been devised to satisfy the student grade; mathematical argument has been excluded from the text, but appendices are included where special treatment of particular subjects has seemed desirable.

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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 $1.50, and in all other countries 12/6. Price of a single copy is 1/-.

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