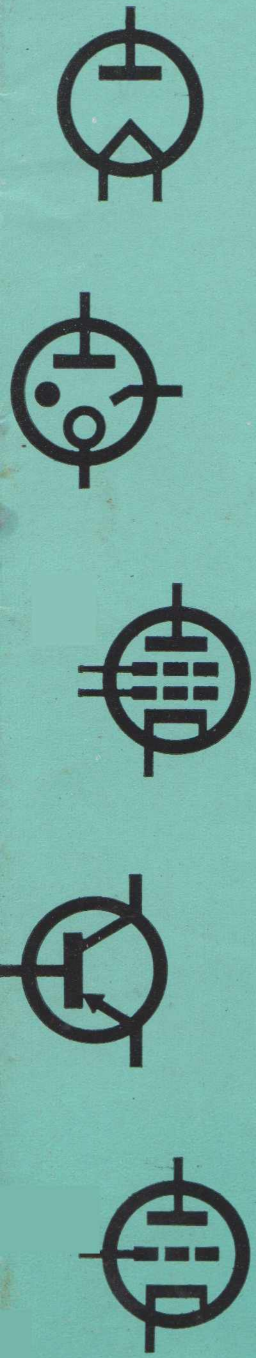

RADIOTRONICS

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IN THIS ISSUE

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A NUVISTOR CONVERTER FOR 432 MEGACYCLES

By J. M. Filipczak, K2BTM

RCA Electron Tube Division, Harrison, N.J.

New performance possibilities in the field of amateur receiver equipment resulting from the introduction of RCA nuvistors have led increasing numbers of hams to explore the various frequencies which might fully utilize the wide capabilities of these unique tubes. After achieving notable successes in one area, the author—like many of his fellow hams—was encouraged to proceed with experimentation in another. Excellent results with nuvistor converters for 144 and 220 megacycles in the VHF band soon prompted him to investigate designs for the UHF band. In the following article, he reports on a nuvistor converter for 432 megacycles—a highly dependable unit which ". . . has produced many hours of enjoyable QSO's."

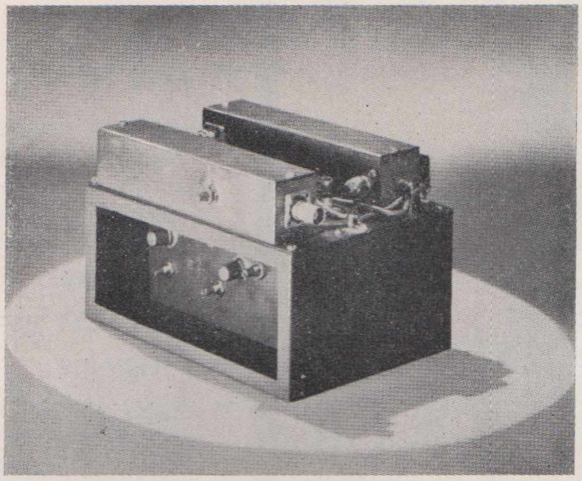
Description

This article describes a nuvistor converter for the 432-megacycle uhf band. As shown in the schematic diagram (Figure 1), the converter has two rf amplifier stages. Both stages employ the 8058, a double-ended high-mu nuvistor triode which was announced commercially early in 1962.

This nuvistor type has been used successfully in cathode-drive amplifier service at frequencies up to 1200 Mc. Although its cost is somewhat higher than other nuvistor types, it is inexpensive when compared with other industrial valves capable of operating up to 1200 Mc.

Demonstrating excellent stability over a wide range of frequencies, the 8058 is designed to provide high gain with low noise in cathode-drive amplifier service. It is particularly suited to such service because the peripheral lugs used for indexing are also used as the connections to the grid. Furthermore, three base-pin connections for the cathode reduce lead inductance and provide flexibility in circuit layout.

The 8058 is especially useful in equipment which requires valves having low drain and exceptionally high uniformity of characteristics. The double-ended construction of this nuvistor provides a high degree of isolation between the input and output circuits.



Front view of K2BTM's 432-Mc nuvistor converter. (Note how portion of chassis has been removed to facilitate final adjustments and additional cooling of oscillator-multiplier section.)

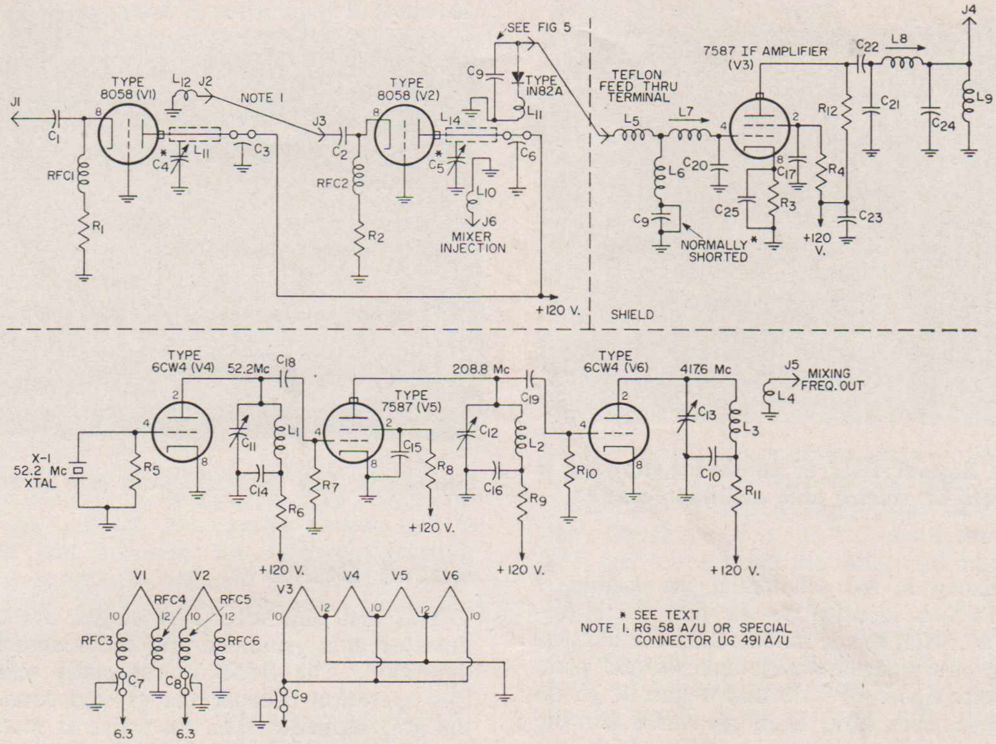


Figure 1: Schematic diagram and parts list of K2BTM's 432-Mc converter.

PARTS LIST

C_1, C_2—100 pf, ceramic tubular
C_3, C_6, C_7, C_8, C_9—1,000 pf, feed-thru
C_4, C_5—See Figure 3
C_{10}—500 pf, silver button
C_{11}—20 pf, miniature
C_{12}—15 pf, miniature
C_{13}—5 pf, miniature
C_{14}, C_{15}, C_{16}, C_{17}—500 pf, disc ceramic
C_{18}, C_{19}—5 pf, ceramic tubular
C_{20}—5 pf, N.P.O. ceramic
C_{21}—15 pf, N.P.O. ceramic
C_{22}, C_{23}—1,000 pf, disc ceramic
C_{24}—100 pf, silver mica
C_{25}—.003 disc ceramic

J_1, J_2, J_3, J_4—BNC-type connector
J_5, J_6—Phono connector

L_1—6 turns of No. 20 on $\frac{1}{2}$-inch diameter
L_2—1 turn of No. 18 enamelled wire on $\frac{1}{2}$-inch diameter
L_3—See Figure 3
L_4—Hairpin loop, No. 16 enamelled wire cut to $\frac{1}{2}$-inch length
L_5, L_9—9 turns of No. 26 enamelled wire, close wound on $\frac{1}{4}$-inch diameter poly form
L_6—18 turns of No. 26 enamelled wire, close wound on $\frac{1}{4}$-inch diameter poly form
L_7—28 turns of No. 26 enamelled wire, close wound on $\frac{3}{8}$-inch diameter slug-tuned form
L_8—20 turns of No. 26 enamelled wire, close wound on $\frac{3}{8}$-inch diameter slug-tuned form
L_{10}—Hairpin loop, No. 18 enamelled wire cut to $\frac{1}{2}$-inch length
L_{11}—No. 18 insulated wire, $\frac{3}{4}$-inch length, bent into loop and coupled approximately $\frac{1}{8}$-inch from L_{14}
L_{12}—Same as L_{11}, except for coupling of loop to L_{13}
L_{13}, L_{14}—See Figure 3

R_1, R_2—56 ohm, $\frac{1}{2}$ watt
R_3—68 ohm, $\frac{1}{2}$ watt
R_4—47,000 ohm, $\frac{1}{2}$ watt
R_5—47,000-to-100,000 ohm, $\frac{1}{2}$ watt (See text)
R_6—4,700 ohm, $\frac{1}{2}$ watt
R_7, R_{10}—100,000 ohm, $\frac{1}{2}$ watt
R_8—120,000 ohm, $\frac{1}{2}$ watt
R_9—1,000 ohm, $\frac{1}{2}$ watt
R_{11}—22,000 ohm, $\frac{1}{2}$ watt

RFC_1, RFC_2, RFC_3, RFC_4, RFC_5, RFC_6—RF choke

Miscellaneous—One feed-thru Teflon insulator; crystal socket; one crystal 52.2-Mc overtone; six nuvistor sockets; one chassis, aluminum, 5-by-7-by-3 inches

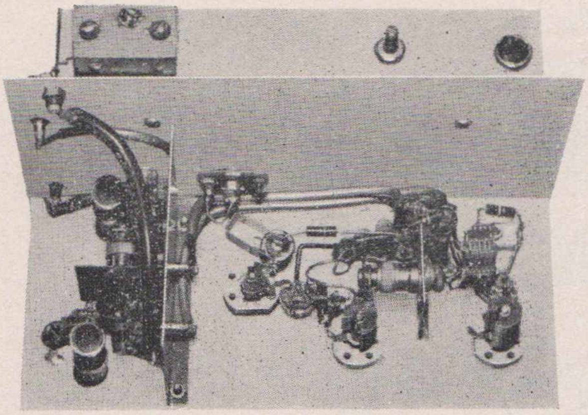


Figure 2a: Bottom view of converter showing if stage (left of shield) and oscillator circuits.

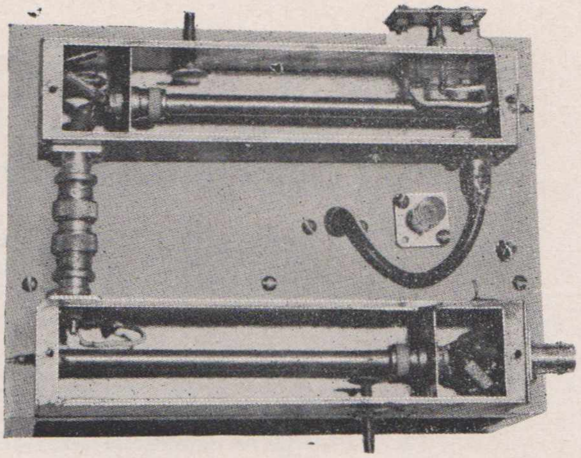


Figure 2b: Top view showing two rf amplifiers.

As indicated in the schematic, the second rf amplifier (V2) is identical to the first but is followed by a crystal mixer mounted on the chassis. Both stages use quarter-wavelength shorted plate lines. A noise figure of 7 db and a gain of 15 db at 450 megacycles have been measured for the first rf stage. In operation, signals which are generally hidden in the noise level of other converters are easily detected with this converter.

The output of the crystal mixer is link-coupled to a low-noise bandpass if amplifier which uses the 7587, a general-purpose sharp-cutoff nuvistor tetrode. This nuvistor type is designed for use in a wide variety of small-signal applications requiring compactness, low current drain, relatively low-voltage operation, exceptional uniformity of characteristics from valve to valve, and ability to withstand severe mechanical shock and vibration.

Performance and stability of this tetrode stage have been most satisfactory. The gain of the if amplifier is about 20, and its output is fed to a receiver which tunes from 14 to 18 megacycles. A 52.2-megacycle overtone crystal in the oscillator-multiplier circuit multiplies the signal frequency up to the final injection frequency of 417.6 megacycles.

This frequency multiplication is accomplished with two 6CW4 high-mu nuvistor triodes and a 7587 tetrode. The 6CW4 features high-gain capabilities which are achieved by very high transconductance and excellent transconductance-to-plate-current ratio (12500 micromhos at a plate current of 8 milliamperes and a plate voltage of 70 volts). The design of the oscillator-multiplier insures an adequate amount of injection frequency free of unwanted frequencies.

Power requirements for the converter are 120 volts at about 40 milliamperes and 6.3 volts ac at 950 milliamperes for the heaters.

Circuit Design

The first and second rf stages use the 8058 nuvistor in a grounded-grid (cathode-drive) configuration. The 8058 is especially suitable for this operation because the ground connection to the grid is made when the valve is inserted into the socket. Optimum performance of both rf stages occurs at about 430 megacycles; only a slight drop in gain occurs at 420 and 450 megacycles. Coupling from the antenna is through C_1 to the cathode of V1. The heaters are isolated above ground by rf chokes to provide stable operation. Oscillation has not been experienced in either stage.

As previously mentioned, the plate lines are quarter-wavelength shorted lines tuned by a small copper disc capacitor at the plate end. Plate voltage is fed to the line at the rf ground end through a 1000-picofarad capacitor. The two amplifiers are connected with a double BNC connector. Instead of this double connector, coaxial cable with conventional BNC fittings can be used.

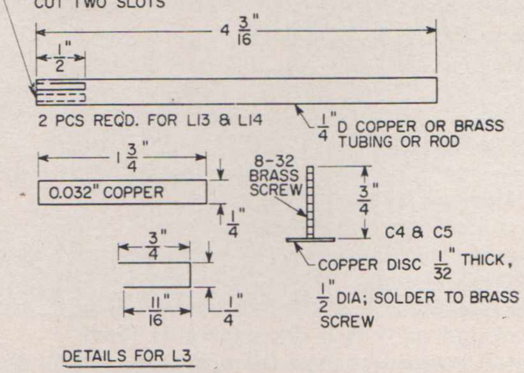
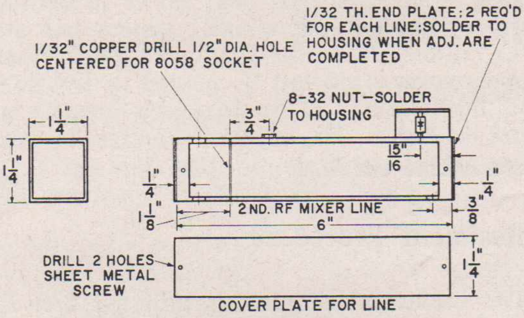


Figure 3: Detailed view of variable capacitors and inductors in rf stages.

The 1N82A crystal mixer is easy to construct, and was selected in preference to other types because it can take a considerable amount of rf voltage from the transmitter before burning out. Nevertheless, precautions should be taken for cutting off B+ during transmission to prevent damage to the rf circuits and the crystal mixer.

The output impedance of the crystal is matched to the input of the 7587 nuvistor (V3) by the coupling network (L_5, L_6, and L_7). Although this bandpass-coupling network is designed to operate at a frequency of 14 to 18 megacycles, slight retuning of coils (L_7, L_8) is required when tuning 16 to 18 megacycles. During normal operation, the capacitor C_7 is shorted to ground. During initial operating adjustments of the converter, the short across C_7 is removed, and a milliampere meter is placed in series with this point and ground. As a result, the crystal current can be measured and adjusted for normal operation. Noise measurements indicate that overall noise figure of the 7587 is less than other equivalent valves.



1ST RF STAGE IDENTICAL TO ABOVE EXCEPT FOR CRYSTAL MIXER

Figure 4: Construction details for two rf amplifiers.

Because the oscillator-multiplier circuit is of conventional design, no trouble should be encountered if good high-frequency wiring techniques are used. The 6CW4 (V4) oscillator stage is a harmonic overtone crystal circuit. Although slightly higher in cost than other crystals, overtone crystals are more accurate. Slight shifts in crystal frequency can be troublesome when multiplying to 417 megacycles. Because a number of receivers can tune below 14 megacycles and above 18 megacycles, a slight shift in the injection frequency can be compensated for.

When the 52.2-megacycle crystal in the grid circuit of the 6CW4 (V4) is oscillating, the plate circuit should be tuned to 52.2 megacycles. The high-value grid resistance (around 100,000 ohms) prevents excessive crystal current flow. Most active harmonic crystals oscillate readily with 100,000-ohm grid resistance. If this resistance is too high, however, it can be reduced to 47,000 ohms without causing excessive crystal current flow.

The next stage (V5)—a 7587 nuvistor tetrode—operates as a quadrupler and multiplies the frequency to 208.8 megacycles. The plate circuit is a single turn of No. 18 wire ($\frac{1}{2}$-inch diameter). The Q of this coil is sufficiently high to reject unwanted frequencies. This stage and the next doubler stage require extreme care in layout so that short direct connections can be made. Figures 2a and 2b show the positions of the components in these two stages.

The next nuvistor triode stage doubles the frequency to 417.6 megacycles. The plate-circuit inductance (L_3) is a short piece of copper bent into the shape of a "U." Construction details of this tank circuit and the other coil assemblies are shown in Figure 3.

The 417.6-megacycle injection frequency is linked-coupled to the mixer stage through a short piece of 50-ohm coaxial cable. The coupling loop L_{10} is about $\frac{1}{16}$ to $\frac{1}{8}$ of an inch from L_{14}.

Mechanical Description

A chassis measuring 5-by-7-by-3 inches is used as the enclosure for the converter. The circuit is constructed on a flat piece of flashing copper with a shield separating the oscillator-multiplier from the if amplifier. The top plate is also 5-by-7-by-3 inches and is fastened to the aluminum chassis which forms the base for the two rf lines. One side of the aluminum chassis is cut out to facilitate tuning of the oscillator-multiplier circuits as well as the coils in the if amplifier. Figure 2 shows the position of the shields.

Construction of Quarter-Wavelength Lines

The chassis is made of $1\frac{1}{4}$-inch-square extruded brass. One side is cut out, except for two end ribs which are required for mounting the cover. The plate on which the socket is mounted is made of flashing copper and soldered into position inside the brass extrusion. Position of components and dimensions for the lines are shown in Figures 2 and 4.

The crystal mixer is coupled to the line by means of coupling loop L_{11}, which is spaced $\frac{1}{8}$ to $\frac{3}{16}$ inch from the plate line. The ungrounded end of this loop is connected to a valve pin removed from an old octal valve. This pin is force-fitted into an insulating block mounted on the chassis. Details for this construction are shown in Figure

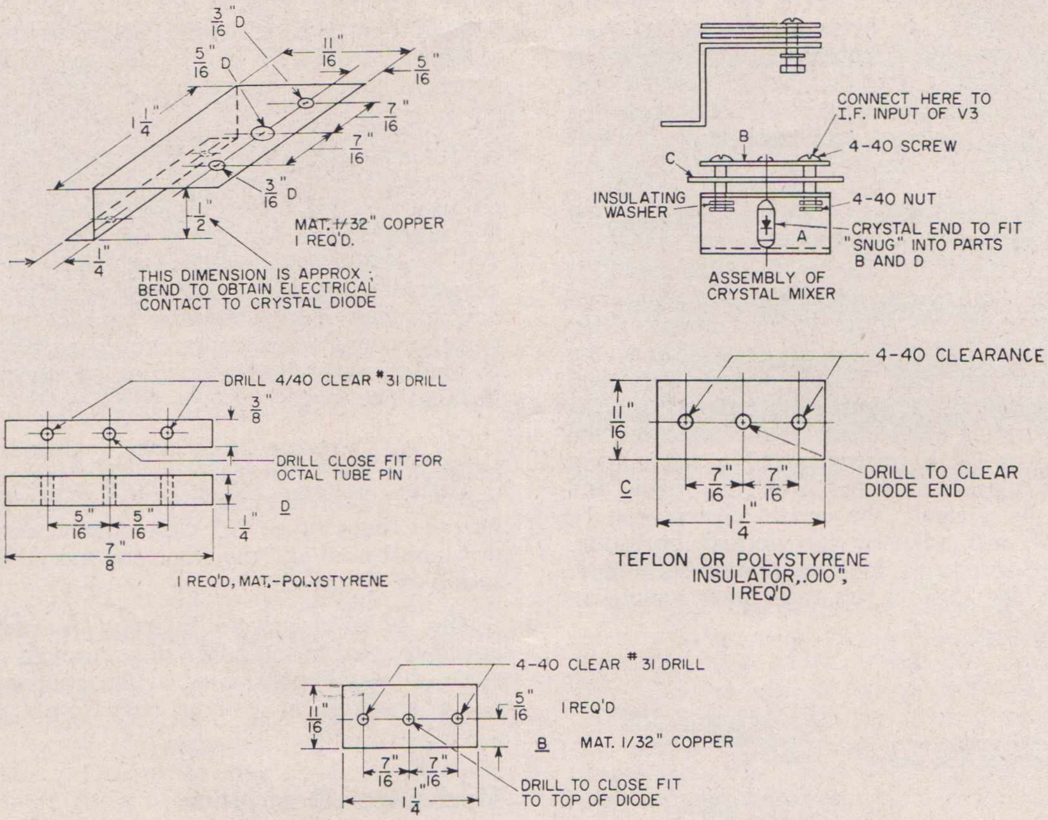


Figure 5: Construction for crystal mixer circuit.

5. This arrangement does not require any soldering at either end of the crystal diode. The L-shaped bracket is made to a close tolerance, and permits electrical contacts to be made at either end of the crystal without soldering.

By the addition of another piece of copper and one layer of Teflon sheet 0.010-inch thick, the L-shaped bracket also becomes capacitor C_9, having a capacitance of 45 picofarads. The mixing frequency is injected to the plate line of the second rf amplifier by the coaxial cable, both ends of which use a "phono-type" jack.

The size of the mixer-coupling loop (L_{10}) determines the amount of crystal current. A piece of wire, approximately ½-inch in length, should be formed into a small loop. One end of this loop is connected to the phono socket and the other end is soldered to the chassis. Adjustment of the distance of the loop to the plate line determines the amount of injection voltage to the mixer and also the mixer crystal current flow. Precaution should be taken because excessive injection voltage may result in reception of signals outside the band. Optimum adjustment of the mixer is required to eliminate unwanted frequencies.

Adjustment Procedure

The oscillator-multiplier is adjusted first for normal operation. A grid-dip meter is a very useful instrument and is considered a necessity when building converters such as the one discussed here. Insert V4 (the 6CW4 oscillator) into its socket. Temporarily connect a milliammeter (10 milliamperes full scale) in series with the 4700-ohm resistor in the oscillator plate circuit. Apply 120 volts B+ and tune C_3 until a sharp "kick" in current on the milliammeter indicates that the circuit is oscillating. Couple the grid-dip meter near L_1 and read the frequency (which should be the frequency marked on the crystal, i.e., 52.2 megacycles). The stage should oscillate readily with an active crystal; if it does not, reduce the value of the grid resistor until oscillation is obtained. It is not advisable to go lower than 47,000 ohms because too much crystal current flow may cause the crystal to heat and, as a result, drift in frequency.

Remove the milliammeter and solder the 4700-ohm resistor back into the circuit. Insert V5 (7587 quadrupler) into its socket. Apply B+ and

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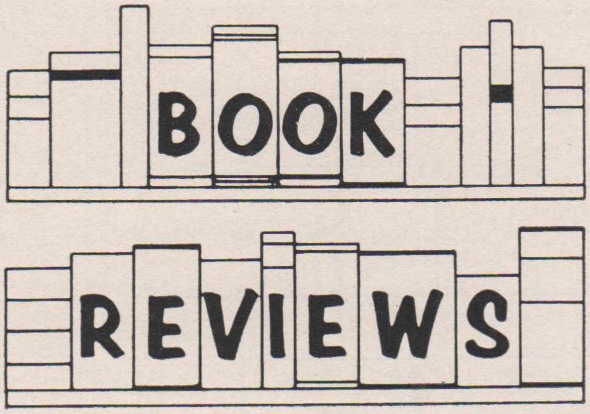


BOOK REVIEWS

"Permanent Magnets and Magnetism", Editor D. Hadfield, Iliffe Books Ltd., Size 10″ x 6″, 556 pages, 243 diagrams, 28 pages of art plates.

Because of their versatility, permanent magnets have many and diverse uses, ranging from the small compact magnets of specialized and expensive material, used in the control systems of rockets, to the field systems of large generators and motors. This is the first fully comprehensive and definitive book on the subject to be published in Britain. It has been written, under the General Editorship of Dr. D. Hadfield, by a team of authors, each an acknowledged expert in his own field, and with the assistance of a panel of consultants.

This book should prove invaluable to students of electrical engineering and electronics, to potential designers of permanent magnet systems, to users of permanent magnets, and to manufacturers and metallurgists in the industry.

"Junction Transistor Circuit Analysis", S. S. Hakim, Iliffe Books Limited, 521 pages, 443 diagrams in the text. Size 8¾″ x 5½″.

This book deals with the mathematical treatment of a wide range of problems associated with the design of transistor circuits. Although the approach is largely theoretical, many examples are included to illustrate the application of theory to practice.

The volume contains much that has not reached textbooks before, including original work by the author, who has not hesitated to deal with subjects which have daunted others. Unlike some authors on this subject he uses conventional active circuit analytical methods, employing modern mathematical techniques. Although the book deals with an advanced subject, the introductory remarks at the beginning of each chapter will give the newcomer a sense of connection with things which he already knows, and will enable him to follow the contents of each chapter.

This book will prove invaluable to established designers, analysers and research workers on transistor circuitry. Typical questions and a bibliography are included at the end of each chapter for further study.

* * *

2N1632S

GERMANIUM P-N-P DRIFT FIELD TRANSISTOR

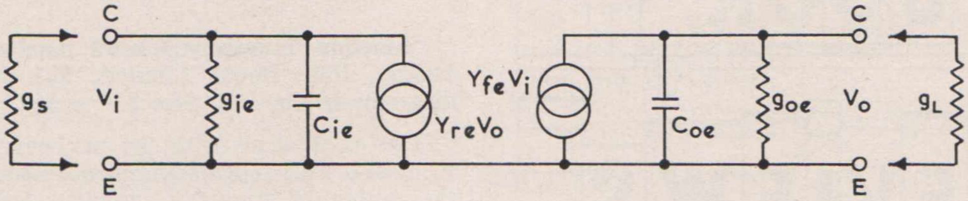
For Radio-frequency Amplifier Applications
in Battery-operated Radio Receivers
Dimensional Outline TO-1

MAXIMUM RATINGS, ABSOLUTE

Collector-to-base voltage, peak	—34 volts
Collector-to-emitter voltage, emitter reverse biased, peak	—34 volts
Emitter-to-base voltage, peak	—0.5 volt
Collector current, peak	—10 ma
Emitter current, peak	10 ma
Transistor dissipation in free air:	
At $T_a = 25°C$	120 mw
At $T_a = 55°C$	60 mw
Junction temperature	85°C
Storage temperature:	
Maximum	85°C
Minimum	—65°C

TYPICAL OPERATION

Radio frequency amplifier, common emitter circuit, base input. Ambient temperature = 25°C.



DC V_{CE}	−8	−8	−8	−8	volts
DC I_E	−1	−1	−1	−1	ma
FREQUENCY	0.5	1.5	10	20	Mc
g_{ie}	0.27	0.5	2.3	5	ma/v
C_{ie}	85	76	70	60	pf
g_{oe}	0.002	0.005	0.036	0.1	ma/v
C_{oe}	4	4	4	4	pf
$\lvert Y_{fe}\rvert$	34	32	30	29	ma/v
θ_{fe}	359	358	337	320	degrees
$\lvert Y_{re}\rvert$	0.009	0.023	0.15	0.3	ma/v
θ_{re}	270	269	267	265	degrees
G*	57	50	35	26	db
g_s †	2.5	5	3.2	8	ma/v
g_L †	0.33	0.4	2.7	1.5	ma/v
S†	3	3	3	3	
G_m †	41	37	21	17	db

*The maximum available unilateralized power gain, with matched and tuned input and output, is given by:

$$G = \frac{|Y_{fe}|^2}{4 g_{ie} g_{oe}} \quad \ldots\ldots\ldots\ldots 1$$

†The maximum useful power gain is given by:

$$G_m = \frac{|Y_{fe}|^2}{(g_L + g_{oe})^2} \, \frac{g_L}{g_{in}} \quad \ldots\ldots\ldots\ldots 2$$

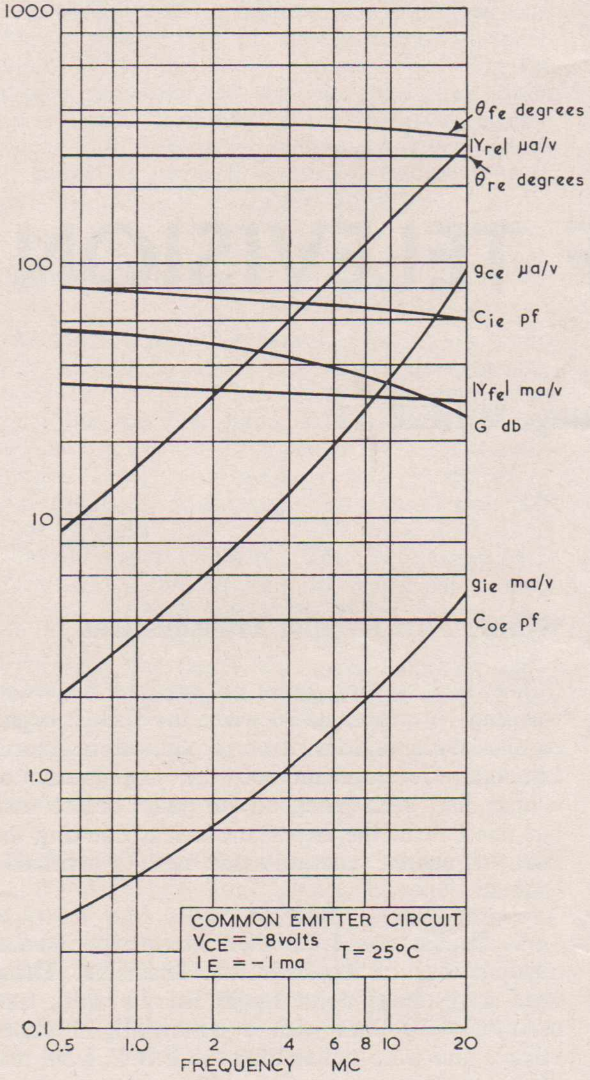
g_L and g_S have been selected to produce an optimum compromise in gain, noise and stability at the frequencies indicated. A stability factor of 3 has been used at all frequencies, as defined by the expression:

$$S = \frac{(g_s + g_{ie})(g_L + g_{oe})}{|Y_{fe}|\,|Y_{re}|}$$
$$= 3$$

ELECTRICAL CHARACTERISTICS

Voltage values are given with respect to base, and at an ambient temperature of 25°C unless otherwise stated.

	Min.	*Typical*	*Max.*
Collector leakage current:			
With dc collector volts = −34, emitter current zero	—	—	−50 μa
With dc collector volts = −12, emitter current zero	—	—	−16 μa
Emitter leakage current:			
With dc emitter volts = −0.5, collector current zero	—	—	−16 μa
Small-signal current gain at 1 Kc:			
With dc collector volts = −6, dc collector current = −2 ma	20	100	—
Frequency for unity current gain:			
With dc collector volts = −6, dc collector current = −2 ma	40	60	— Mc



NUVISTOR CONVERTER

Continued from Page 94

couple the grid-dip meter near L_2 and adjust C_4 for maximum output at 208.8 megacycles. Place V6 (6CW4 doubler) into its socket. (This stage may present an adjustment problem because most grid-dip meters used by ham operators do not cover frequencies above 220 megacycles.) If a grid meter is not available to measure 418 megacycles, adjust C_5 for maximum mixer crystal current (1.0 to 1.5 milliamperes maximum).

After a signal generator or antenna system with a characteristic impedance of 50 ohms is connected to the first rf stage and the receiver is tuned to 15 megacycles, tune C_4 and C_5 for maximum noise and crystal current. If the crystal current is more than 1.0 milliampere, bend the injection loop (L_{10}) toward the chassis until the crystal current measures between 0.6 and 0.8 milliampere. At this time, trim the oscillator-multiplier circuits for maximum noise signal.

The if amplifier can now be checked for operation and performance. Remove the connection to the crystal and connect a signal generator to the grid of the 7587 mixer. Response should be fairly flat over the 14-to-16-megacycle range. Tuning of the generator over the 14-to-18 megacycle range requires some peaking of the coils (L_7, L_8). If no generator is available, noise from the rf amplifier and the mixer can be used to peak the coils.

No oscillation should be observed when a properly matched antenna is connected to the first rf stage and C_1 and C_2 are tuned for maximum noise. If oscillation does occur, the coupling loops (L_{12}, L_{11}) in the rf amplifier probably are coupled too loosely.

(With acknowledgements to RCA)

NEW RELEASES

8032

The 8032, with its 13.5-volt heater is the latest member of the famous 6146 family with the same big power output: 70 watts of ICAS CW power at 60 Mc, 35 watts ICAS CW power at 175 Mc for mobile communications. The 8032 is fitted with the latest "dark heater."

4449

The 4449 is a new special-purpose image-converter tube designed for ultra-high-speed photographic shutter service and is offered as a new scientific tool in the photography of a single or a series of time-sequential events of extremely short duration. This new tube utilizes a highly-sensitive photocathode having S-11 spectral response and an aluminized P11 phosphor which emits high-intensity actinic blue fluorescence to facilitate its use in photographic applications. Among the outstanding features of this new tube shutter speeds as short as 10 nanoseconds with little loss in resolution, and a minimum resolution capability of 17 line-pairs per millimetre.

25 YEARS OF TELEVISION

by W. T. Cocking, M.I.E.E.

At the present time, the British television services comprise two independent networks of transmitters, each covering over 95 per cent. of the population of the country. One is owned and operated by the British Broadcasting Corporation (B.B.C.), which also provides the programmes; the other is owned by the Independent Television Authority (I.T.A.), and the programmes for this are provided by a number of programme companies. A licence is required to operate a television receiver and a proportion of the licence fee is paid to the B.B.C. and it is this which forms its revenue. The I.T.A., on the other hand, gets its income indirectly from advertising; the companies which supply the programmes pay the I.T.A. for the provision of the technical services of the transmitters and they obtain their income from advertisers.

Nationwide Link Up

In each network the transmitting stations are all linked by coaxial cables and/or cm-wave radio links so that a single programme can be, and often is, radiated from them all. Nearly everywhere the viewer has the choice of two alternative programmes one from the B.B.C. and the other from I.T.A. The B.B.C. transmissions are all on frequencies between 41 Mc and 68 Mc (Band 1) while the I.T.A. lie between 184 Mc and 216 Mc (Band 111).

It has taken many years of development to reach this present position and it has taken longer in Britain to achieve nationwide coverage than in some other countries because Britain was the first country to start regular television broadcasting and had to learn how to do it the hard way. Other countries have had the benefit of Britain's experience.

World's First Regular Transmissions

The real starting point of modern television was 2nd November 1936 when the B.B.C. began regular transmissions from a station in North London. Development of the apparatus, of course, had been going on for years before this, but this date is the important one as marking the start of regular transmissions with a workable system.

As far back as 1929 there were experimental transmissions of low-definition television. These were a result of John Logie Baird's work and used only 30 lines with a bandwidth of about 10kc/s and were radiated by the B.B.C. from one of its medium wave transmitters. An ordinary sound broadcast receiver was used and its output fed into the picture-producing apparatus. This comprised a neon tube, the light output from which varied according to the signal, mounted behind a Nipkow disc. This was a light metal disc with 30 holes in it driven by an electric motor at 750 revolutions per minute. There were 12½ fields a second only. The resulting picture was only about an inch (2.5 cm) across and was viewed through a magnifying glass.

These transmissions were purely experimental and aroused little general interest, the picture was much too small and its quality much too poor for that. They served, however, to demonstrate the impracticability of television on the medium waveband and the serious shortcomings of mechanical methods. They were a precursor of modern television but formed no direct link in the chain of development. In a sense they were a digression from the direct path.

As early as 1911 Campbell-Swinton had outlined a scheme for an all-electronic television system which included a camera tube using the storage principle! It was at that time quite impracticable for none of the necessary electronic devices had then been adequately developed; it was really an inspired prophecy, for his scheme was surprisingly like modern television.

Alternate Systems

As already stated, however, modern television really started in 1936 and in its development during the early 1930's there were two great rivals. On the one hand E.M.I. (Electric and Musical Industries) associated with Marconi's Wireless Telegraph Company and on the other hand the Baird Company. They developed different systems and by 1936 they had both achieved similar results. The Marconi-E.M.I. system had 405-lines and 50 fields per second with 2:1 interlace while the Baird System had 240 lines 25 fields with sequential scanning. Apart from this the E.M.I. system had an Emitron (iconoscope-type) camera tube utilising the image-storing principle, whereas the Baird used an image-dissector and, for some purposes, a mechanical mirror-drum scanner. Cathoderay tube receivers were used for both.

Both Systems produced pictures of about equal quality. Each had some points in which it was the better and others in which it was inferior. Because of this there was great difficulty in deciding which should be adopted. Accordingly, when regular transmissions started on 2nd November, 1936 they were both used, alternately, each for a week at a time.

When experience had been gained with both under operating conditions the decision was made to adopt the 405-line Marconi-E.M.I. system exclusively and ever since this has remained the British television system. This was on 6th February 1937. The reason for the choice was no outstanding advantage of the system over its rival at that time, but the fact that it showed itself to have much more potentiality for future development.

Basic System Adopted

That it was the right decision is shown by the fact that all other countries have subsequently adopted the same basic system. There are differences in the number of scanning lines used, of course, and in the form of modulation, but the basic principles of an all-electronic system with image storage in the camera tube and 2:1 interlacing are universal.

Television transmissions continued regularly until 1st September 1939 when the imminence of World War II made it necessary to stop the service. In this three and a half year period of pre-war operation considerable development took place, especially in the televising of film and in outside broadcast equipment. This was of major importance in popularising television because it permitted the televising of sporting events.

Receivers in this pre-war period usually had cathode-ray tubes with 12-inch (30.5 cm) screens. Good quality stable pictures were obtained, but the brightness was low by modern standards and no more than subdued room lighting was permissible. As time went on smaller tubes were used to reduce the cost of receivers and the 9 inch (23 cm) screen became fairly common and some sets had even smaller tubes.

The Pioneers' Problems

In looking back it must be remembered that everything necessary for television was in an early stage of development. It was then a real achievement to radiate kilowatts of power at 45 Mc with a bandwidth of some 5 Mc (Double-sideband operation was then employed). It was also an achievement to build high-gain r.f. amplifiers for this frequency and bandwidth. It was not merely that few people then knew how to do it; it was much more difficult then than now for the only valves available were ones which we should now consider unsuitable for the job.

Television thus stimulated valve development and by the start of the war valves with satisfactory characteristics were in large-scale production.

Rapid Post-war Development

When television restarted after the war on 6th June 1946, using the same 405-line standard, its further development was rapid. On the transmitting side the B.B.C. started on the erection of a network of stations to cover the country. The first new station to be opened (December 1949) was at Sutton Coldfield, near Birmingham, and three more were completed by August 1952, making a total of five high-power stations, with effective radiated powers between 100 Kw and 200 Kw. In March 1956 the original London station at Alexandra Palace in North London was replaced by a new station of higher power at Crystal Palace in South London. Five medium power (about 12-30 Kw e.r.p.) stations were erected between 1953 and 1956 and a number of low-power (1-1.5Kw) stations have since been brought into use.

The five high-power stations occupy separate channels in Band 1 (41-68 Mc). The other stations use the same channels, stations sharing a channel being geographically remote and also using different polarization of the radiated signals. Further to reduce any interference the vision carrier frequencies are offset by two-thirds of the line scanning frequency. By 1959 the B.B.C. television service was available to about 98.6 per cent of the population of Great Britain. Further expansion, which is still in progress, is for a further 25 satellite stations to increase the coverage to 99.4 per cent.

Alternative Programmes

It was in 1955 that an alternative programme became available to London viewers with the opening of the first of the Independent Television Authority's stations near Croydon in South London. Since then an I.T.A. network has been erected giving a second programme to most of the country.

In producing this second chain of transmitters fresh technical problems arose because the transmissions are all on frequencies around 200 Mc instead of around 50 Mc. Problems arose in obtaining sufficient power, but now the main stations are of 200-475 Kw e.r.p. with smaller ones of 25-100 Kw.

Further problems arose on the receiving side in aerials, tuning systems and methods of station selection. These have long been solved and the turret tuner with a cascode r.f. amplifier and triode-pentode frequency changer has become virtually the standard "front-end" of all television receivers.

Progressive Increase of Screen Size

The first post-war receivers usually had a 9-inch (23cm) tube, but tube sizes have greatly increased. The 17-inch (43cm) is now the most popular size but 19-inch (48cm) and larger are quite common. As the size of the screen has increased the length of the tube has decreased with the result that modern sets are much shallower back-to-front than the older ones despite the larger pictures.

This has meant that the electron beam in the tube must be deflected through a much larger angle and a great deal of circuit and component development has been necessary to enable this to be done satisfactorily and economically.

As is usual in any engineering work spectacular inventions are rare and progress mainly consists in the accumulation over the years of a host of minor improvements, some of which are individually almost trivial. As far as receivers are concerned, the result has been not merely greatly improved performance and reliability but also a great reduction of price in real money terms. The nominal prices of television sets today are the same as or cheaper than pre-war in spite of the fact that there is now a heavy purchase tax on them and the pound is only worth about a third of its pre-war value.

The Zoom Lens

Some of the most important post-war developments have lain in a branch of television that is often forgotten. This is in the cameras and their control equipment and other associated apparatus. The orthicon, image-orthicon and vidicon type tubes have had great benefits. Some permit pictures to be secured with but little lighting, others are noteworthy for their small size and so have particular application in portable equipment. Each has its own particular sphere of proper operation. The zoom lens is another development of particular value in outside broadcasts where rapid changes from long shots to close-ups are needed.

Camera control equipment is designed especially to facilitate the production of a television programme by mixing, fading or cutting the pictures from several different cameras. It is even possible to cut a hole into the picture from one camera and insert into it a picture from another camera (inlay). Thus odd effects can easily be secured, such as of a group of midgets dancing in a man's hand!

In addition to all these things for live programmes, there is apparatus for televising pictures recorded on film. This is a particularly difficult electro-mechanical operation, but the problems have long been solved. More recently, apparatus for recording live television programmes has been developed, both photographic and magnetic recording are used.

Space does not permit discussion of standards converters, whereby pictures produced on one set of television standards can be converted into signals on a different standard, nor of methods whereby a picture can be transmitted slowly over a narrow bandwidth, recorded and then transmitted at normal bandwidth. By this means a moving picture of an event in the U.S.A., say, can be transmitted over the transatlantic cable and broadcast in this country, perhaps an hour later.

This brief account of the development of British television gives an idea of the events of the last 25 years. It has taken this time because

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GRID CURRENTS AND GRID BIAS

by B. J. Simpson

This item started off as a note on the various types of bias arrangements used with electron valves, because our correspondence files show that there are a few points that could be profitably cleared up. During the preparation of the text, it seemed a good idea to include also a few words on grid currents, as in some cases they are directly related to the problem of grid bias.

When we visualise a valve operating, it is very easy to ignore or forget grid currents, although we know quite well that they are a factor. In many cases, the forgetfulness is excusable because grid currents pose no problem. Others seem to think that grid currents are of interest only in relation to large transmitting valves and the like, but this is certainly far from the truth. Grid currents can be encountered in small receiving type valves as well, and in fact in any type of valve. Sometimes these currents are detrimental in some way, at other times we can make good use of them.

In order to define our area of interest, we will restrict ourselves to consideration of currents in the control grid of a valve. There are four sources of control grid current, and they are:

Contact Potential. This is largely determined by the initial velocity of electrons leaving the cathode.

Gas Currents. These are the result of positive ions striking the grid; the positive ions are themselves created by collisions between electrons and stray gas molecules inside the valve, hence the name.

Inter-electrode Leakage. Low insulation between electrodes at different potentials will allow a relatively significant current to flow between them and through the external circuit connecting them.

Spurious Emission. Emission from the control grid itself will produce a grid current.

A typical comparison of the four sources of control grid current is shown in Fig. 1. The actual conditions will depend on the valve type under consideration and its operating conditions, and in some cases may vary appreciably from one valve to another of the same type. The pattern of behaviour, however, may be expected to follow the typical case within broad limits. Thus, a study of Fig. 1 can immediately tell us quite a lot about this problem, and ways of reducing it.

We will note for example, that the contact potential current varies with both heater or filament temperature and with bias voltage. For a given value of heater/filament voltage (temperature), contact potential current can be virtually cut off. It will also be seen that the leakage current is roughly linear with respect to applied voltage; being a resistive component, this is what would be expected. In a good valve, the actual value of the leakage current would be negligible.

The gas current and spurious emission current follow a very similar law, and this also would be expected. They are decreased with increasing bias voltage; gas current is increased because the increased negative bias voltage attracts more strongly the positive ions, whilst spurious emission currents are likely to be increased as the grid is made more negative with respect to the other electrodes.

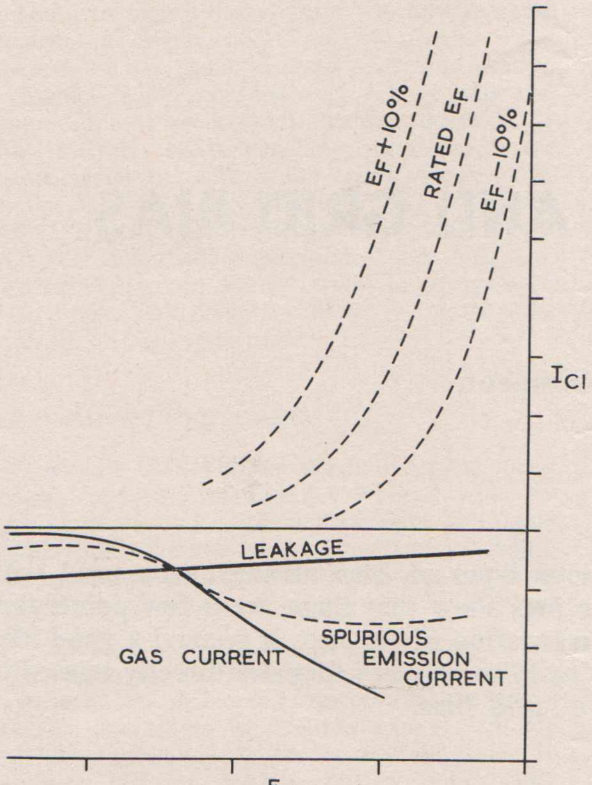

Fig. 1

Contact Potential

The contact potential of an electron valve is arbitrarily fixed by valve manufacturers as the negative grid potential required to produce a current of 0.1 microampere. This value of current is regarded as the cutoff point. Contact potential may therefore be described as the value of electric retarding field necessary to restrain those electrons that have sufficient kinetic energy to travel from the cathode to the grid.

Contact potential also includes thermally-generated voltages arising from thermal differences between dissimilar metals forming the cathode and grid assemblies. Because contact potential is a function of the initial electron velocity, it is dependent on the temperature of the heater or filament, that is, upon the heater or filament voltage. This is shown in Fig. 1, where the variation is typically shown for the median or "bogey" value of heater voltage, and for values of +10% and −10%.

It will be seen from Fig. 1 that even with a +10% heater voltage applied, the contact potential current is virtually cutoff for grid bias voltages greater than about 1 volt. The exact value of cutoff bias will depend on the specific valve type, but will usually be of this order. In the region below cutoff, that is, with say less than −1 volt grid bias, contact potential current has two effects.

Firstly, the current represents a finite dynamic grid impedance, and secondly, it is a direct-current source of high internal resistance. These effects in turn can be detrimental to performance in many ways, such as the production of low-frequency distortion in audio amplifiers, loading of preceding tuned circuits, variation of agc voltage values, and so on. Where the grid resistance has a high value, the actual bias applied to the valve may vary considerably from one valve to another, that is, the circuit is not tolerant of valve changes, even if the replacement valve is of the same type and make.

It is usual to avoid these troubles by applying a sufficient bias voltage between the grid and the cathode to take the operating point outside the regions of contact potential current. If a valve must be operated in the contact potential current region, then the grid resistance value should be kept as low as possible to minimise these effects.

Because of the importance of contact potential currents, and the fact that they are sometimes used for biasing purposes, it may be as well to look further into this question. In Fig. 2 we see three curves of contact potential current resulting from three values of heater voltage, the nominal voltage and +10% and −10% values. Two resistive load lines are drawn on the diagram, one representing a high value of grid resistance and the other a low value of grid resistance.

An examination of Fig. 2 yields some interesting data. We can see that the actual value of bias resulting from the contact potential current flow through the external grid resistor will vary

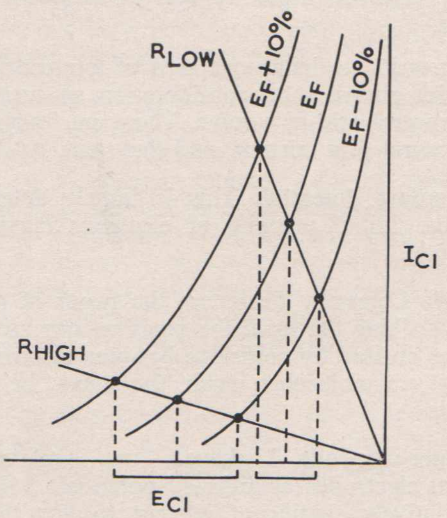

Fig. 2

not only with the value of the grid resistor, as it obviously will, but also with the heater voltage. Remember that the heater voltage is not an immutable value, but will vary with variations in supply line voltage. Moreover, the position of the contact potential current lines in the diagram will vary within limits for different valves of the same type number.

It will also be seen from Fig. 2 that the variations just mentioned occur over a smaller range when the value of the grid resistor is lower. A lower value of grid resistor also allows a lower value of bias to be obtained if this is a consideration. The low values of bias available with this method of biasing will also mean that the stage is incapable of handling large signal levels without serious distortion.

So far we have mentioned contact potential current as a rather variable characteristic of a valve, and it is certainly one for which a controlled specification is not usually issued. There is, however, an exception, and that is the "hybrid" valve specially produced for use in automobile radio receivers. The low plate potential available for these valves means that the valves must be operated very close to zero bias to achieve satisfactory performance, that is, they must be operated in the contact potential current region.

This means that this class of valve must be tested and controlled within the contact potential region, and this is in fact done. More will be said on this point later, when the various biasing methods are discussed.

Gas Currents

Every effort is made by the valve manufacturer to exclude gas from high-vacuum valves. During manufacture, the valve assemblies are heated to high temperatures to drive out occluded gases in the glass, metal and mica parts. This happens whilst the valve is being pumped, so that any gas released is immediately removed from the assembly. Finally, after the valve has been pumped to a very low pressure, it is sealed off and the getter is fired electronically. The getter is usually of magnesium or a similar material. Its purpose is to absorb any molecules of gas remaining in the valve after sealing, and any gas released in the valve, or which enters the valve, during its life.

Gas is released from the valve parts, particularly the cathode, during normal operation of the valve. Whilst the getter will clean up this gas, the gas is free within the envelope for a finite time. When electrons collide with gas molecules, positive ions are produced, which are attracted towards the grid, normally the most-negative electrode in the assembly. The greater the cathode current, the greater the risk of collision and the larger the number of positive ions produced.

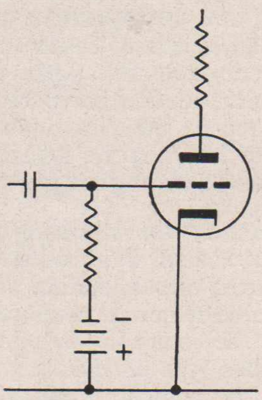

Fig. 3

Occluded gas released within the valve during life is largely a function of the operating temperature. Operation of a valve in a hot location, or beyond the maximum rated dissipation is therefore detrimental to operation and long life.

A factor which is often questioned is the different rated maximum grid circuit resistances for self-bias and fixed-bias operation. This is directly related to the gas current, which is the limiting factor which determines the quoted figures. If the grid circuit resistance is too high, the gas current flowing through it will produce a positive bias, which in turn will allow a higher plate current to flow. Increasing the plate current increases the valve dissipation, accelerating the release of occluded gas and so causing more gas current to flow. It will be seen that this is a form of positive feedback, which, if allowed to become established, will lead to a run-away condition and will eventually destroy the valve.

In the case of self-bias, an increase in cathode current will also increase the bias voltage, so that to some extent the condition is self-correcting with self-bias. This is why the maximum value of grid circuit resistance quoted for self-bias operation is always higher than that for fixed-bias operation.

Inter-electrode Leakage

In those places where mechanical support is necessary for the electrodes of a valve, insulation is provided by glass, mica, ceramic or other material. Whilst it is a fact that infinite insulation resistance can never be achieved, at the same time, suitable precautions will allow the insulation resistance to be raised to the point where leakage is of no consequence.

Mica is the most common insulating material used in valves, and the deposition of material on the surface can seriously lower the insulation resistance. Precautions are taken to select the best quality mica; the surface is then roughened or coated to reduce the deposition of material, slots are cut to lengthen the leakage paths, and great care is taken in preparation and assembly.

During operation, the insulating material may become lightly coated with conductive material through a process of sublimation or the condensation of metallic materials evaporated from the cathode on to the cooler insulating surfaces. The formation of this type of leakage path is largely a function of the cathode temperature at which the valve is operated, and is another good reason why the manufacturers' recommendations should be followed in relation to heater voltage and current. Dirt and moisture on the valve envelope can also give rise to appreciable leakage currents.

Leakage resistances can form potential dividers with circuit resistances, and if the values of the circuit resistances are high enough to approach the values of leakage resistances, the bias may be shifted. In severe cases, this can lead to rising distortion, complete malfunction of the circuit, or a damaging "run-away" condition.

Spurious Emission

It is customary to regard the cathode of a valve as the one and only emitting electrode, but this is not strictly true. In principle, any metal is capable of emitting electrons if heated to a sufficient temperature, the only difference being the work function and the number of electrons emitted. The work function is a measure of the energy that must be added to the energy already possessed by electrons in the metal in order to allow the electrons to leave the surface of the metal and become free electrons. The added energy in this context is provided by heating the metal.

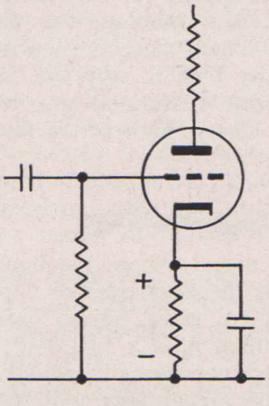

Fig. 4

As far as the grid is concerned, we are interested in currents originating at that electrode as a result of either primary or secondary emission to some more positive electrode. This current, with the grid acting as a cathode, will cause a positive shift in bias, the amount of the shift being dependent on the value of the grid circuit resistance. The effect is similar to that produced by gas current, in that it gives rise to a condition that is capable of producing a cumulative effect leading to damage to or destruction of the valve.

It is also possible, where the grid is not the most negatively-maintained electrode in the valve, for the grid to act as an anode and to receive currents emitted from other electrodes. This current will cause a negative shift in the bias, which, whilst not potentially destructive, could certainly prove detrimental to satisfactory operation.

As a step to avoiding emission from electrodes other than the cathode, the valve manufacturer will use materials for the other electrodes which have a high work function, that is, materials which emit electrons only reluctantly. The maintenance of low operating temperatures, adherence to the makers' recommendations regarding valve dissipation, and the use of low values of grid circuit resistance will assist in avoiding the effects of spurious emission currents.

Grid Bias

Having got this far, it will already be obvious why grid currents were included in a discussion of the various methods of applying bias to a valve. Whatever means are adopted to bias a valve, precautions must also be taken to ensure that the bias is not subsequently shifted by poor circuit design or incorrect operation of the valve.

It is proposed to discuss here six of the more popular methods of applying bias to a valve, and their respective merits. Considerations involved in assessing the merit of any method include its effect on the initial spread of electrical characteristics of the valve type to be used, the effect of supply variations on valve performance, the effects of falling valve performance during life on the operation of the circuit, hum and heater-cathode leakage, maximum permissible grid circuit resistance, circuit protection afforded by the chosen method, performance available from the valve, the amount of grid current drawn, and cost.

The six biasing methods to be discussed are:

Fixed-bias, in which the bias voltage is supplied by a voltage source provided for the purpose.

Self-bias, where the bias is derived from the voltage drop across a resistor in the cathode lead of the valve. This is also known as cathode bias.

Partial fixed and self bias, which is a combination of the two methods previously mentioned.

Grid-leak bias, sometimes called contact-potential bias, in which the bias voltage is derived from the contact potential current.

Signal-bias, which is derived from the current through a grid circuit resistance by driving the valve into grid current at the positive peaks of the input signal.

Combined signal and self bias, the description of which is self-explanatory.

Not all of these methods will be familiar to all readers, particularly to those who are mainly interested in receivers and audio amplifiers. The first two mentioned are by far the most common, and are met with every day.

Fixed Bias

The general arrangement for fixed bias is shown in Fig. 3. Here a pre-determined and unvarying bias voltage is applied from a battery or special bias circuit. Because of the constant voltages applied, the only degeneration present in the circuit will be that due to the plate load resistance and the screen dropping resistance. Although degeneration from these two sources will narrow initial spreads in such valve characteristics as plate and screen current, and transconductance, the effect is less than with cathode or self bias.

The initial characteristics spreads are the broadest with this method, and the effects of supply voltage variations are also at a maximum. Any change in a characteristic during the life of the valve will immediately be seen in a change of performance.

Since no cathode resistor is normally used with fixed bias circuits, hum due to heater-cathode leakage should be eliminated. No grid current is drawn, and as explained earlier, the grid circuit resistance should preferably be as low as possible; there is no circuit protection inherent in the method itself.

It must be recognised that with this method, there is a danger of damage to the valve should the bias supply be lost. This is important because in practice, the bias voltage is invariably derived either from a suitable voltage that already happens to be available in the circuit, or from a special circuit designed to develop the bias voltage. In large equipments, elaborate precautions are taken to "lock-out" the high tension voltages until the bias voltage is present, but in smaller equipments this is not an economic idea. Some degree of protection can be afforded by the use of large values of plate and screen resistors, and operation at low B supply voltages.

Other things being equal, fixed bias is capable of realising the full performance potential of a valve. From a cost point of view, it depends on whether a bias voltage is already available in the equipment, and if not, on the extra cost involved in providing it.

Self Bias

This method is probably the most common used today. It is shown in Fig. 4, and it will be seen that the cathode is taken positive with respect to ground by inserting a resistor in the cathode lead. The voltage developed across this resistor will depend on its size and the cathode current flowing. Because the grid circuit is returned to ground, the grid is negative with respect to cathode.

The presence of the cathode resistor introduces dc negative feedback, and to some extent makes the circuit self-compensating for variations in valve characteristics. The dc degeneration is a disadvantage in some dc amplifier circuits, but as far as audio and higher frequencies are concerned, full performance is available. Degeneration at signal frequencies is avoided by by-passing the cathode resistor with a capacitor offering a low impedance at the frequencies of interest.

The self-bias method reduces dramatically the initial spread of valve characteristics and reduces the effect of power supply voltage variations to a minimum, by virtue of its inherent dc feedback. For the same reason, the effect of valve changes during life upon the performance of the equipment is also reduced to a minimum, and the circuit is largely self-protecting.

A comparison of the cathode current spread in a typical valve at the high and low plate current limits under conditions of fixed and self bias is shown in Fig. 5. The diagram shows the range of cathode current with a fixed bias equal to the mean value of bias derived from a cathode resistor. It will immediately be seen that the spread of cathode current is quite high particularly when compared with the spread using self bias.

If self bias is used, the spread of cathode current, as indicated by the intersections of the line representing the cathode resistor and the two transfer curves, is seen to be much lower. Even when a 20% tolerance is allowed for the cathode resistor, the spread of cathode current is still seen to be only about half that for the fixed bias arrangement.

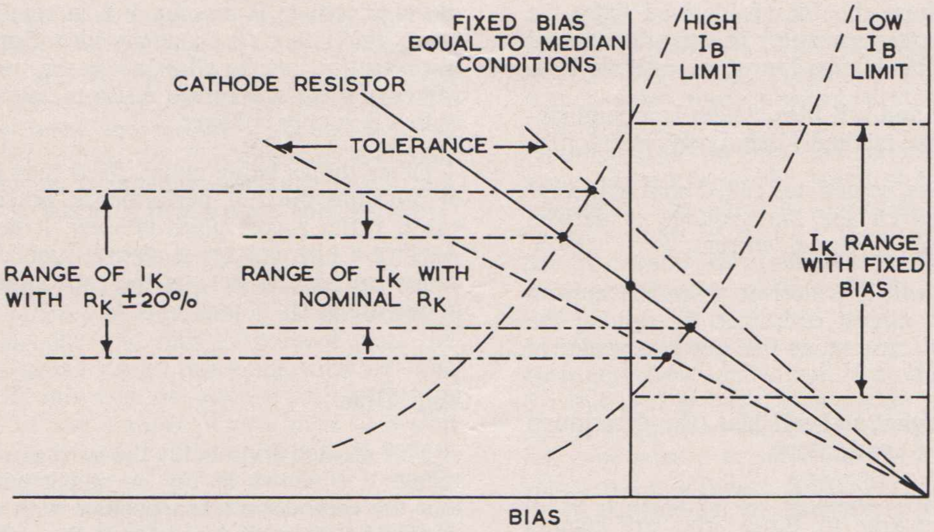

Fig. 5

Higher values of grid circuit resistance are possible with self bias, whilst the cost of the provision is in general quite low. It must however, be realised that this method increases the possible effect of heater-cathode leakage. This is of some significance in audio amplifier and similar applications, where hum may result. With suitable precautions, this should present no unusual problem as long as the designer is aware of the possibility.

Combination Fixed and Self Bias

The arrangement here is shown in Fig. 6, and is rather unusual except in certain types of application. Usually this method is chosen where the application requires high peak current levels at the cathode, which in turn requires a minimum resistance in the cathode lead. The arrangement, as will be obvious, is a compromise between the two methods; features of both methods will be present in proportions determined by the ratio of bias supplied in fixed form to the bias supplied by the cathode resistor.

Because some self bias is present, the circuit will have some degree of self-protection, but the lower cathode resistor will make it less potentially susceptible to the effects of heater-cathode leakage, such as hum. Because this circuit is generally used under high drive conditions and the designer wishes to get the best efficiency, there is a strong temptation to place too much reliance on the (usually) small amount of self bias provided, and allow the grid circuit resistance and the drive voltage to rise beyond what may be considered safe values. Caution is therefore necessary when using this configuration in high drive circuits, to ensure that the operating conditions are acceptable.

Grid Leak Bias

Grid leak bias is derived from the voltage developed across the grid circuit resistance due to the passage of the contact potential current. Several words have already been said about this current. High values of resistor are generally used to develop sufficient bias, and a reference back to Fig. 2, with the high value of grid resistor, shows the basis of operation. The basic circuit arrangement is shown in Fig. 7.

The contact potential current varies appreciably with variations in supply line voltage and with the life of the valve. The bias obtained from the current, however, provides compensation for these factors, and the circuit therefore reduces the effect of spread in characteristics, variations of line voltage, and the effect of life on performance. The absence of the cathode resistor provides low hum levels, and the full performance of the valve can be obtained, provided the input signal is not too large.

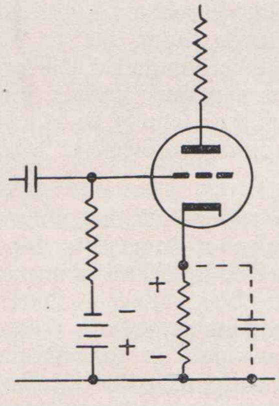

Fig. 6

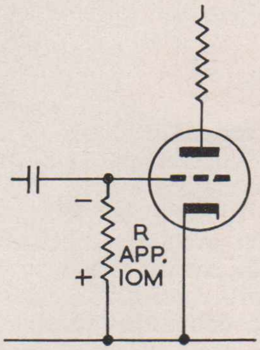

Fig. 7

Beyond 10 megohms, little further increase in bias can be obtained, so that the circuit is limited as far as input signal levels are concerned. It is in general suitable only for very low level stages, where there is not a risk of overload. The circuit is a low-cost one, as there are no extra components to buy to produce the bias. The circuit cannot be recommended except where large values of plate and screen resistors are used. As previously mentioned, certain valves intended for hybrid automotive service are specially designed for this type of operation, and the contact potential current characteristic is controlled; in conventional valves it is not controlled, and suitable precautions should be taken in using the circuit.

Signal Bias

The arrangement for signal bias is shown in Fig. 8, and will be seen at first glance to be identical with that of Fig. 7 showing grid leak bias. The difference resides in the value of the grid circuit resistance and the input signal level.

Signal bias is obtained by supplying sufficient signal voltage to the grid to drive the grid momentarily positive into the grid current region on the positive peaks of the input signal. Small pulses of grid current are drawn through the grid circuit resistance, charging the input capacitor to a mean voltage which is dependent on the input frequency, and the amplitude and duration of the grid current pulses. That is, the dc bias on the valve is proportional to the drive amplitude. This is in effect the leaky grid detector in slightly different guise.

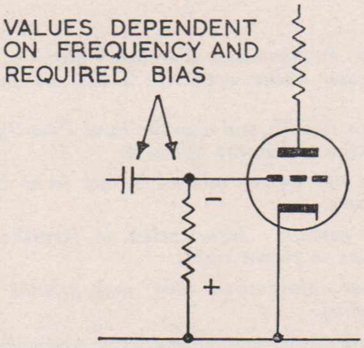

Fig. 8

Where the circuit is used with a high-value plate load resistance, the advantages are very largely those enumerated for grid leak bias. The circuit must obviously be safe when no signal is applied, this being achieved by the use of high plate and the screen resistors. High resistance to valve and power supply line variations is obtained. High values of grid resistor can be used, and the circuit is not susceptible to hum.

Where signal bias is to be used with low values of plate circuit resistance, the limiting feature of a high plate resistance is not available. Care must be taken in these cases to ensure circuit reliability, as the circuit will be very dependent on plate current, screen current and transconductance. Signal bias here has little dc degeneration to compensate for spreads in characteristics, falling valve performance or power supply line variations. There is no protection against "run-away" due to gas current.

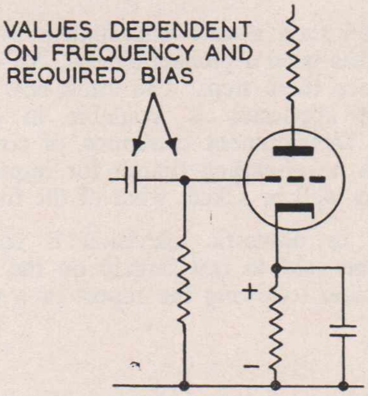

Fig. 9

Grid dissipation is increased as more grid current is drawn, and this may lead to heating of the grid to the point where it becomes an emitter in its own right. In addition, if the driving signal is lost, the valve will operate at or close to zero bias, increasing further the possibility of "run-away".

Unless a low value of grid circuit resistance is used to preclude "run-away" and the plate supply potential is kept low enough to prevent electrode dissipations being exceeded in the event of failure of the signal bias, this circuit could not be regarded as satisfactory.

Combined Signal and Self Bias

This arrangement, shown in Fig. 9, is only one of a number of circuits which utilize parts of two or more of the basic methods already discussed. Each application is a compromise aimed at obtaining the best features of the methods incorporated, and to meet the particular requirements of the application.

As in all combinations, the proportions of the bias obtained by one method against the bias obtained from the other can be infinitely varied. A typical application of this particular configuration will be familiar to all amateur transmitting station operators. It is a common method used with low and medium-power final stages to ensure that a minimum cathode resistance is present, to reduce degeneration, whilst at the same time, sufficient self bias is present under no-drive conditions to keep the valve in a safe condition.

Summary

To many, the ratings applied to valves, the recommended operating conditions, and the methods of biasing them appear to be very arbitrary. It can be seen that this is far from the truth, and that even the selection of a biasing method and the correct setting up of the method chosen involves a considerable amount of thought. There is little doubt that much of the trouble experienced in using valves is due to an insufficient appreciation of their characteristics, ratings, and modes of operation; this has been shown statistically in independent surveys made of the subject of valve failure.

* * *

25 YEARS OF TELEVISION

Continued from Page 100

it has been such a vast achievement every step of which has been a pioneering one. No one now need retrace these steps. The know-how is there and most apparatus is available in standard packages. Development continues, of course, for there is a never-ending search for improvement and it may well be asked, what of the future?

So far as domestic television is concerned, this can be said to rest largely on the Government's action following the report of a Committee on Broadcasting, set up two years ago, which has just published its findings. Among the 120 recommendations put forward in the report is one to change from the present 405-line system to 625 lines, the internationally agreed standard in general use throughout Europe. This would lead the way to the introduction of a colour service on 625 lines, which the Committee recommends should be started as soon as possible.

It is also suggested that a third television programme should be authorised, for operation by the British Broadcasting Corporation.

(Courtesy, British Information Services)

Editor .... **Bernard J. Simpson**

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