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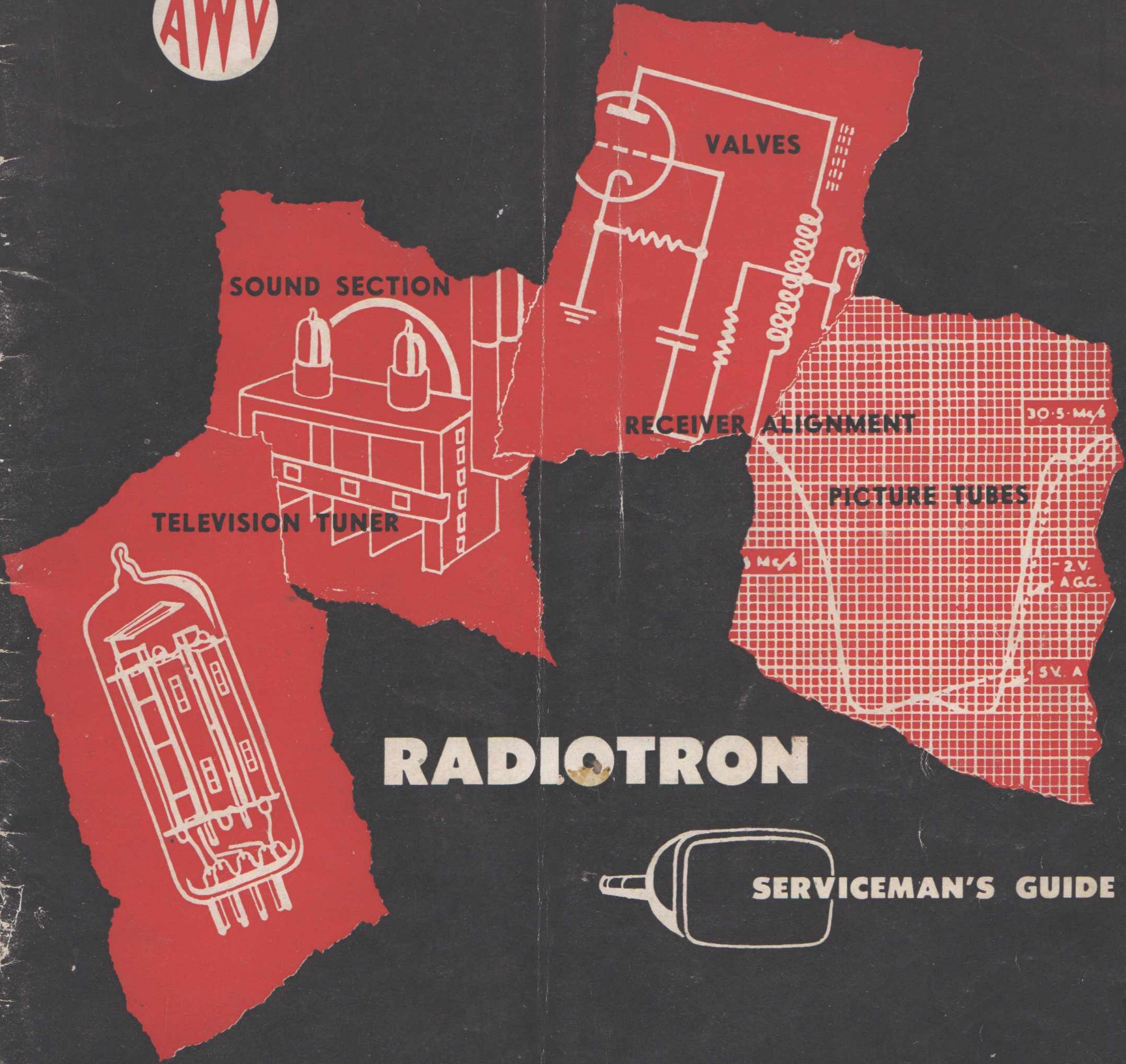



# RADIOTRON

## SERVICEMAN'S GUIDE

# TV

of television receivers
nplifier circuit. Use
tion in noise with

2/-

AMALGAMATED WIRELESS VALVE CO. PTY. LTD.

Cat. No. RSG-1

# INTRODUCTION

The Radiotron Serviceman's Guide to TV has been prepared to collate the wide variety of information previously published in Radiotronics and other magazines by the Amalgamated Wireless Valve Company.

As A.W.V. is preparing many more articles on TV for future publication, this guide is but the first of a series.

The articles herein give data on two of the Radiotron picture tubes, discuss the operation of a number of circuits developed in the Applications Laboratory of A.W.V.'s Rydalmere factory, and describe the function of a number of Radiotron valves in those circuits.

E J Baker

# CONTENTS

# TELEVISION I-F AMPLIFIERS

**The valves used in a video i-f amplifier provide the main part of the high gain necessary in a sensitive television receiver. They do so using circuits which require to be of low Q and hence low impedance in order to amplify uniformly the wide band of frequences represented by the T.V. signal. A useful figure of merit for a valve for use in a T.V. video i-f amplifier is the wide band factor. This factor which is an indication of the valve's ability to amplify a wide band of frequencies, is proportional to the valve's transconductance and inversely proportional to its input plus output capacitances.**

$$\left( \text{Figure-of-merit} = \frac{gm}{C\ in + C\ out} \right)$$

**Listing then the main properties desirable in such a valve, we have: —**

(1) High figure of merit, i.e. high transconductance and low input and output capacitances. The latter is important since, in most video i-f amplifiers, gain is approximately inversely proportional to the capacitance placed by the valve across the tuned circuits.

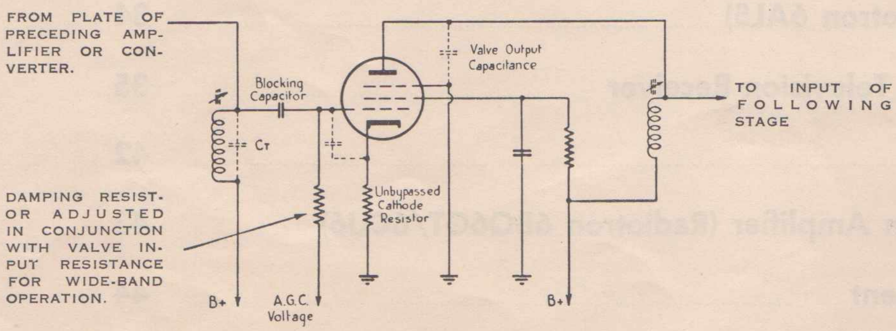
(2) Low grid-to-plate capacitance for low feedback between output and input circuits and small change in input resistance and capacitance.

(3) Separate connection to the suppressor grid to enable use of an unbypassed cathode resistor.

(4) High input resistance to prevent the valve's input circuit placing too much damping across the tuned circuit.

(5) Grid and plate connections on opposite sides of the socket for simple layout and wiring and low external feedback.

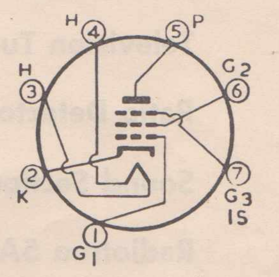
Since the overall gain of video i-f amplifier stages must be automatically varied to maintain the output to the video detector as constant as possible with changes in the signal input, one, two or more of the valves used must be capable of having their gain changed over very wide limits by the automatic gain control voltage. When the gain of a valve, operating on the frequencies of the order of those in the desirable intermediate frequency range for Australian television receivers, is changed by varying the grid bias, feedback leading to instability can occur unless the valve (which is nearly always a pentode) has the suppressor brought out to a separate base pin. It is normal to use a carefully selected value of cathode impedance for all the controlled valves of video i-f amplifiers to reduce the large variation in input characteristics which normally occurs as the automatic gain control bias is varied. Unfortunately the presence of this impedance can cause a great increase in the effective grid No. 1-to-plate capacitance and therefore in the coupling between input and output circuits. The earthing of the suppressor largely prevents this by reducing greatly the plate to cathode capacitance. See simplified circuit diagram.




**The Radiotron 6CB6 is a pentode designed specifically as an amplifier for the frequencies used in T.V. video i-f stages. It has a high transconductance and low input and output capacitances for high gain, low grid No. 1-to-plate capacitance for low coupling between input and output circuits and separate connection to the suppressor grid simplify automatic gain control problems.**


## 6CB6

**SOCKET CONNECTIONS**




**(bottom view)**

Pin 1—Grid No. 1
Pin 2—Cathode
Pin 3—Heater
Pin 4—Heater
Pin 5—Plate
Pin 6—Grid No. 2
Pin 7—Grid No. 3, Internal Shield

# VIDEO I-F AMPLIFIER

By R. DARNELL, A.S.T.C., A.M.I.R.E. (Aust.), Grad. I.E. (Aust.).

**The requirements of a video i-f amplifier for a television receiver are discussed and some design details of an amplifier using the Radiotron 6CB6 to fulfil these requirements are given. The alignment procedure with some relevant problems is also detailed.**

### Requirements of the I-F Amplifier

Much has been written about the requirements of the i-f amplifier in a television receiver. The Australian Broadcasting Control Board has allotted a frequency spectrum for use by television receiver manufacturers for the i-f channel which will be kept as free from interfering signals as is possible. The recommendation is to use 36 Mc/s as the i-f vision carrier frequency and 30.5 Mc/s as the i-f sound carrier frequency.

Where the r-f channels are directly adjacent it is possible to get interference from the adjacent channel vision or sound carriers which can heterodyne with the oscillator frequency in the tuner to produce 29 Mc/s and 37.5 Mc/s interference signals. To minimise the possibility of this interference showing on the picture, trap circuits are provided in the i-f amplifier to attenuate these signals. A trap circuit is also used to attenuate the accompanying sound i-f carrier relative to the vision i-f carrier for two reasons:—

1. To allow the vision carrier to be predominant at the second detector (video detector) to ensure satisfactory demodulation of the sound i-f carrier.
2. To prevent frequency modulation patterns from reaching the picture tube. Further attenuation is usually provided in the video amplifier circuit.

Vestigial side-band transmission has been standardized for television broadcasting in Australia. This means that one sideband and a "vestige" or "remnant" of the other are transmitted. This is used because of the smaller transmitter bandwidth required. A further advantage is that the possibility of ghosts appearing due to phase differences between the two sidebands is eliminated. The transmitter amplitude characteristic is then as shown in Fig. 1 (a). The detected output amplitude characteristic obtained from such a transmission is shown in Fig. 1 (b). Here twice the output is obtained for the low frequencies where energy is obtained from both sidebands. To overcome this and obtain a flat overall response. the receiver response curve must be suitably shaped as shown in Fig. 1 (c).

The actual bandwidth of the video i-f channel is left entirely to the manufacturer. A 6db bandwidth of 4.25 Mc/s will give very good resolution. Any increase over this will be increasing the noise spectrum for additional resolution which would be practically impossible to see, particularly on a moving picture.

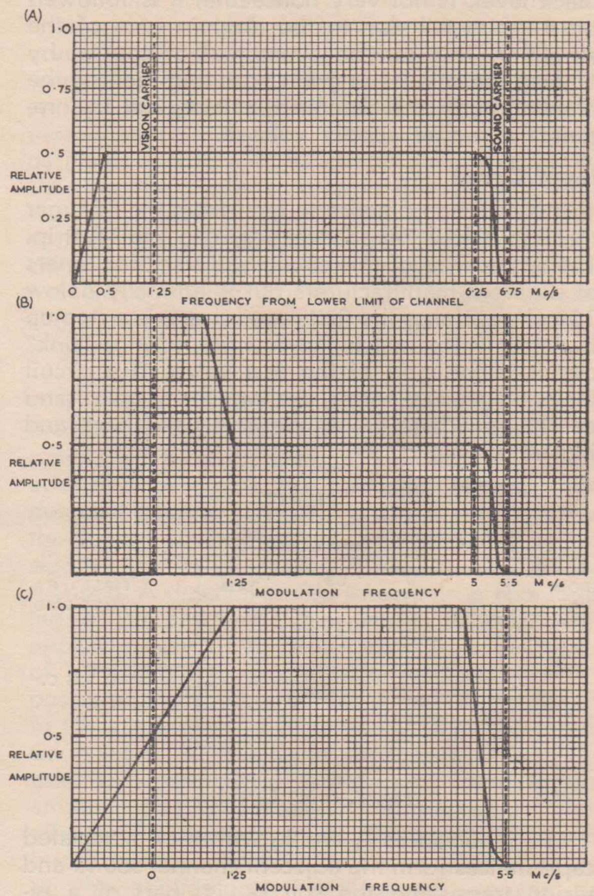



*Fig. 1. (A) Transmitted Amplitude Characteristic.*
*(B) Detected Amplitude Characteristic.*
*(C) Ideal Receiver I-F Response Curve.*

Bifilar wound transformers are commonly used for interstage coupling in stagger-tuned i-f amplifiers. The additional winding cost is considered to be quite negligible when compared with the saving of a coupling capacitor. Adequate insulation between the two windings must be provided because the plate winding will be at the plate supply voltage.

The use of bifilar transformers also ensures better noise immunity. Where a coupling capacitor and grid leak are used, with the coupling coil in the plate circuit, high noise peaks can cause the following valve to draw grid current, causing a charge to be built up on the coupling capacitor and the valve to be biased off. If the time constant of the coupling capacitor and grid leak resistor are high enough this bias can be maintained long enough to effect the picture. A noise impulse causes the gain of the stage to drop and although the noise impulse itself, which pushes the modulation into the black level, is not very noticeable, it is followed by a white tail due to the drop in gain of the amplifier. This can be overcome, of course, by placing the coil in the grid circuit and feeding the plate through the damping resistor, but this requires a higher supply voltage.

**Input Circuit**

It is common practice to feed from the r-f tuner through a low impedance circuit to the i-f strip. The impedance of this circuit will vary for tuners of different manufacturers but is normally below 100 ohms. Hence the first requirement is a step-up transformer to match the low impedance "link" circuit to the grid of the first valve. This circuit may take several forms, perhaps the simplest and easiest to adjust being the one used here and illustrated in Fig. 2.

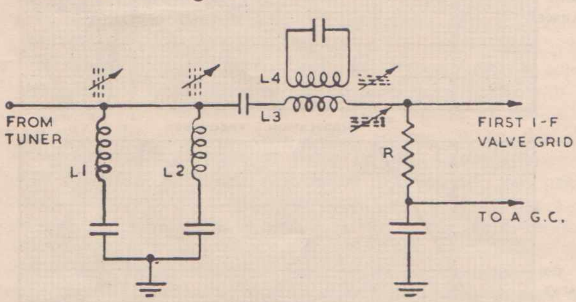



*Fig. 2. Input Circuit.*

The inductances $L_1$ and $L_2$ with their associated capacitances form the adjacent channel sound and vision traps, and the coil $L_3$ is part of a pi-matching network. The coil $L_4$ is coupled to $L_3$ and is tuned to the intermediate sound carrier frequency. The coupling may be adjusted to give the desired attenuation. Overseas experience has been that for equivalent effect on the picture, the interfering signal from the adjacent channel on the lower side (adjacent channel vision carrier) must be 11 db stronger than the interfering signal from the adjacent channel on the higher side (adjacent channel sound carrier). Hence, the attenuation of the adjacent channel sound carrier (37.5 Mc/s) should be greater than that for the adjacent channel vision carrier (29 Mc/s). For this reason the 37.5 Mc/s coil is usually a high Q coil wound on a large former from about 16 gauge copper wire whereas the 29 Mc/s trap coil $L_2$ can be wound on a smaller diameter former with a small gauge wire.

**Valves**

Four valves have been used, the first three (a Radiotron 6AU6 and two Radiotron 6CB6's) forming a staggered triple and the fourth (a 6CB6) feeding the video detector via a wideband transformer. A.G.C. has been applied to the first two stages. From the curves given in the previous article, a value of unbypassed cathode resistor can be chosen for which the input impedance changes in the 6CB6 for different a.g.c. voltages are a minimum.[1] In this circuit the cathode resistor of the first valve (6AU6) is left unbypassed but the cathode resistor of the controlled 6CB6 is bypassed. The values of cathode resistance have been chosen to give the desired change in overall response with a.g.c. voltage changes. The effect is to broaden the response when weak signals are being received and thus reduce the difference in level between the vision and sound carriers. This effect can be seen in Fig. 3.

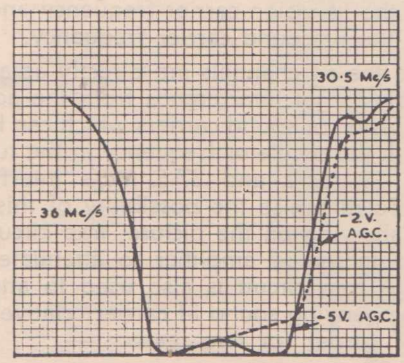



*Fig. 3. Effect of a.g.c. on overall response.*

**Staggered Triple**

The staggered triple has been designed to have a 4.25 Mc/s bandwidth with a centre frequency of 33.88 Mc/s. The following information can be obtained by calculation[2]:—

| | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|
| Centre Frequency .... | 32 Mc/s | 35.7 Mc/s | 33.9 Mc/s |
| Bandwidth .... .... | 2.13 Mc/s | 2.13 Mc/s | 4.25Mc/s |
| Q .... .... .... .... | 15.1 | 16.8 | 8 |
| Damping Required .... | 3040 ohms | 3810 ohms | 1705 ohms |
| Added Resistor .. .... | 5.6K ohms | 8.2K ohms | 2.2K ohms |

The damping resistance is the parallel combination of the equivalent parallel resistance of the coil, the resistance of added resistor and the grid input resistance of the following valve (the plate resistance of the preceding valve is large enough to be neglected).

The input resistance of the following valve can be obtained from information given on page 55 of Radiotron Designer's Handbook. An extrapolation of the frequency-input conductance curve is shown in Fig 4. From this curve at 34 Mc/s the input resistance is appoximately 17,000 ohms.

These values provide a starting point, but adjustment must be made on a properly wired pilot model.

Normally a slight change in the damping resistors is necessary to get the response exactly as required. The resistors in stages 1 and 3 have been changed to to 6.8 KΩ and 4.7 KΩ respectively.

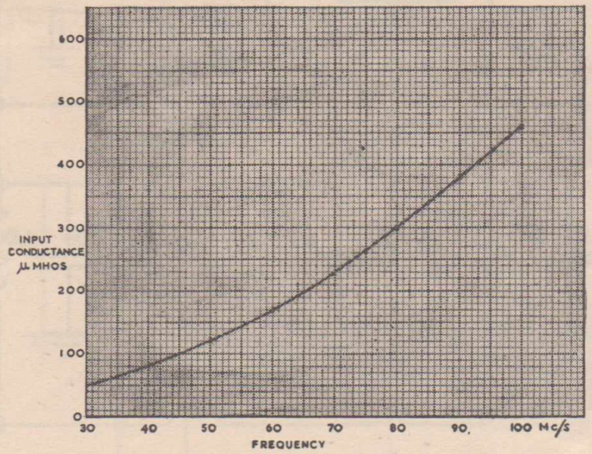



*Fig. 4. Input conductance versus frequency.*

## ALIGNMENT

The circuit for the i-f amplifier is shown in Fig. 5. Complete alignment can only be achieved when the amplifier is used with the associated tuner and it is done with 5 volts a.g.c. applied. This is considered to be a typical a.g.c. voltage. As the a.g.c. voltage falls below this value the response shape of the amplifier changes in the manner already described. A 7.5 volt battery and 10,000 ohm potentiometer can be used to provide this bias as shown in the circuit. This bias must be measured with a high impedance meter.

### Spot Frequencies

Connect a signal generator, suitably terminated to the grid of the mixer valve in the tuner through a 1000 µµF capacitor with no more than one inch of lead unshielded. With a d.c. meter of impedance at least 50,000 ohms at the detector output align the bifilar coils as below for maximum output, keeping the detector output level at about 2 to 3 volts:—

| | |
|---|---|
| T1 .................... | 32 Mc/s |
| T2 .................... | 35.7 Mc/s |
| T3 .................... | 33.9 Mc/s |

The three traps should then be adjusted to give minimum output at their respective frequencies, as below:—

| | |
|---|---|
| $L_1$ (Adjacent channel sound carrier trap) .................... | 37.5 Mc/s |
| $L_2$ (Adjacent channel vision carrier trap) .................... | 29 Mc/s |
| $L_4$ (Accompanying sound trap) ........ | 30.5 Mc/s |

Then disconnect the signal generator and connect a sweep generator, again suitably terminated, through a 1000 µµF capacitor to the mixer valve grid with no more than one inch of lead unshielded. A sweep of from 27 Mc/s to 38 Mc/s is required for proper alignment. Care must be taken not to overload the amplifier when using the sweep generator. Overloading in the amplifier shows as a very distorted and peaky pattern on the oscilloscope. The first step is to align the input, or link circuit. This must be done in conjunction with the output transformer in the tuner. It may be necessary to disable the oscillator by shorting the grid to earth. Sometimes, one channel is selected in which the oscillator does not have a very great effect on the pattern on the oscilloscope. The important thing is to select a method and use the same method for all adjustments and measurements. In a tuner with "stacked" oscillator and mixed sections in the mixer valve, shorting the oscillator grid to ground will alter the d.c. operating conditions of the pentode section, and hence the output impedance will change. This will affect the alignment of the link circuit slightly but can be tolerated as any slight misadjustment will be set right when aligning from the antenna terminals.

It is then necessary to detect the output of the link circuit. To do this properly, no tuned circuit other than those between the mixer valve plate and first i-f valve grid should influence the detected pattern. The plate of the first i-f valve is the logical take-off point, but, to eliminate the selectivity, the plate circuit has to be heavily damped. A detector probe to do this is shown in Fig. 6. The first valve then acts as a buffer with approximately unity gain. Now short the grids of V3 and V4 to ground with leads as short as possible, and loosely couple a marker generator to the mixer grid, or to the detector probe input. Coupling through a 5 µµF capacitor to the mixer grid will normally give sufficient input to the amplifier to provide reasonable markers without affecting the sweep generator output. If there is insufficient gain to provide a reasonable pattern on the oscilloscope the a.g.c. voltage can be reduced to as low as 3.5 volts for this step.

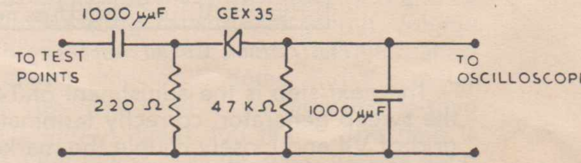



*Fig. 6. Detector probe (negative output).*

Adjust the slug in the tuner output transformer to give maximum output at 36 Mc/s. Now adjust

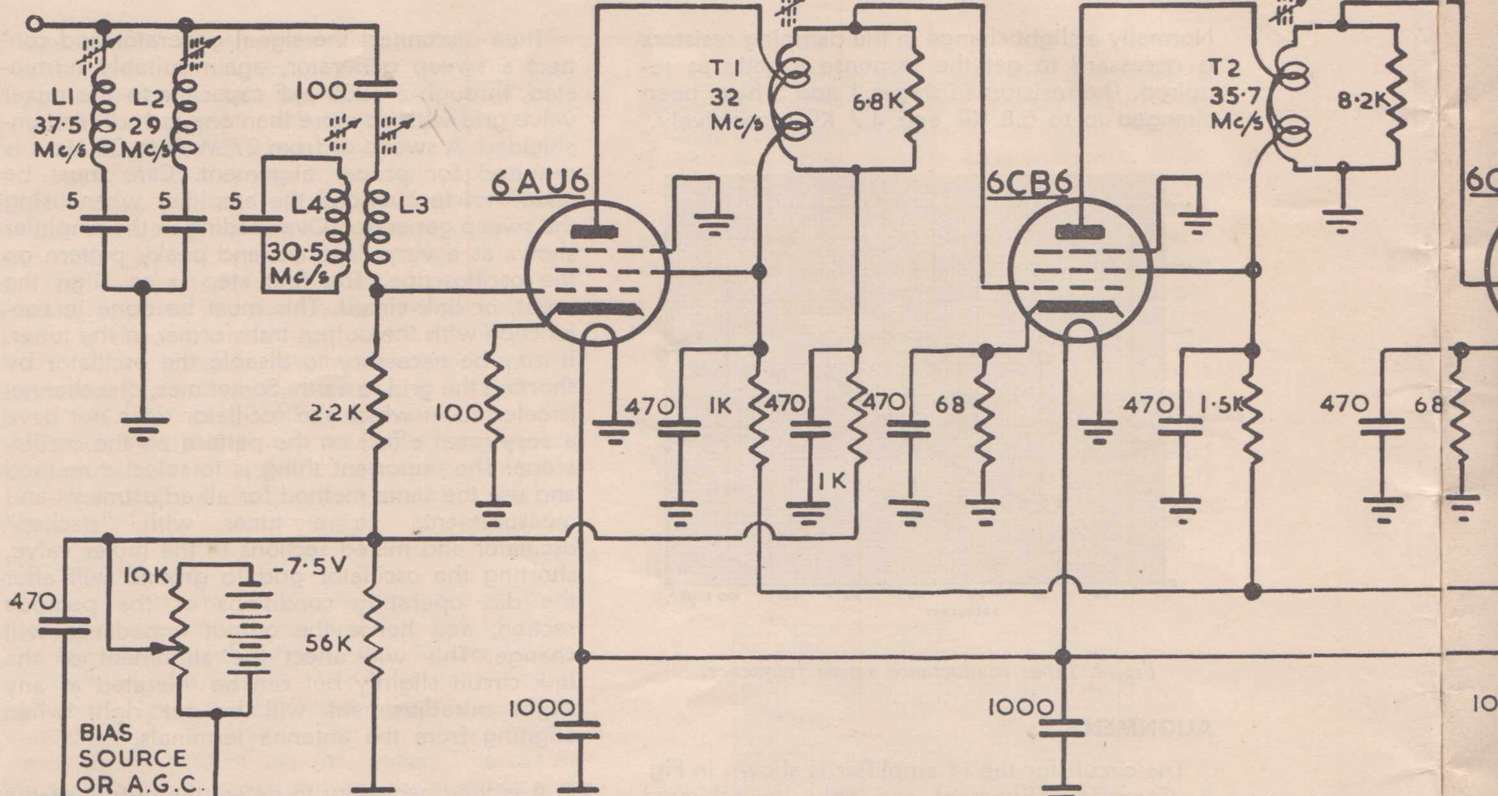



*Fig. 5. Video i-f amplifier circuit.*

CAPACITOR VALUES IN $\mu\mu$F

RESISTOR VALUES IN OHMS

the series coil $L_3$ to bring the 31.75 Mc/s marker to 75% of maximum amplitude. Readjust each control in turn if necessary to give a response as illustrated in Fig. 7. A slight dip between the two shoulders can be tolerated but should be kept below 10% of maximum amplitude.

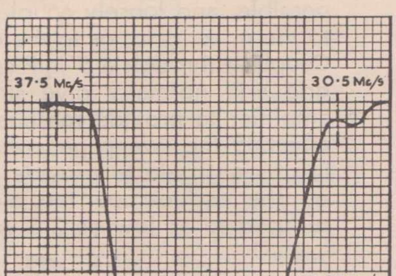



*Fig. 7. Link Circuit response.*

The next step is the adjustment of T4. Connect the sweep generator, correctly terminated, to the grid of V4 and loosely couple the marker generator. (It may be sufficient to leave the lead from the marker generator lying on the bench near the grid terminal.) Now connect the oscilloscope directly to the detector output and adjust the top and bottom cores in T4 to get maximum gain and the response shown in Fig. 8.

The sweep generator is now connected to the mixer valve grid through a 1000 $\mu\mu$F capacitor with the marker generator loosely coupled, and the shorting leads removed from the grids of V3 and V4. Retouch various adjustments as necessary to obtain the response shown in Fig. 9.

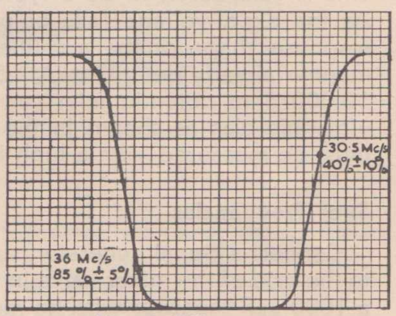



*Fig. 8. T4 response.*

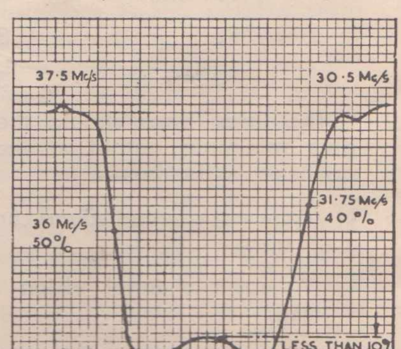
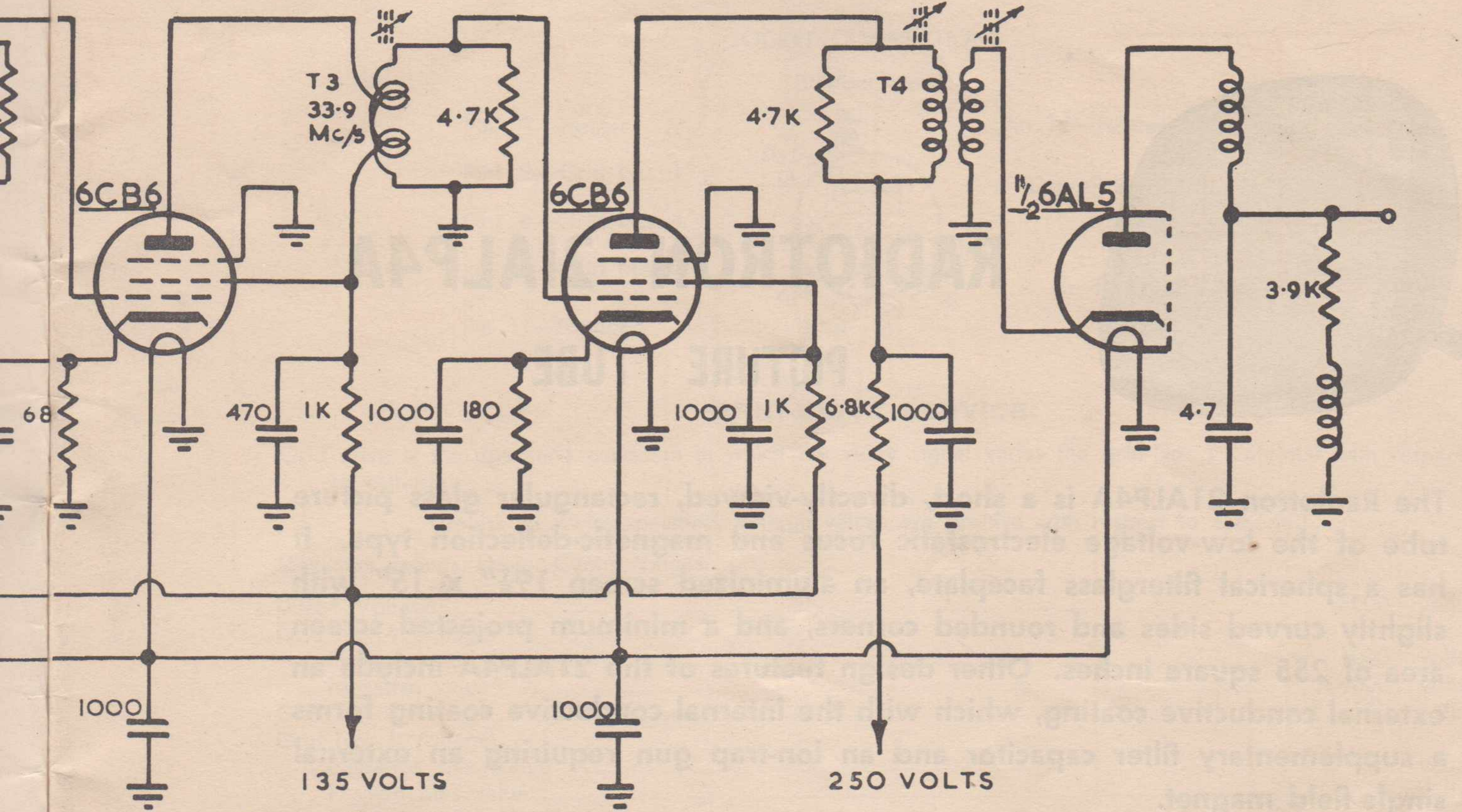



*Fig. 9. Overall response.*




MUST NOT EXCEED 150 VOLTS

FOR ANY A.G.C. VOLTAGE

The associated sound carrier level should be about 26 db below the picture carrier level. As mentioned previously, this difference will be reduced on low values of a.g.c. voltage. The adjacent channel carrier traps should give attenuations at their respective frequencies of 50 db with respect to the picture carrier level. Although, as previously explained, the attenuation of the adjacent channel sound carrier is most important, the desired attenuation is much more difficult to achieve because it is so close to the high frequency end of the desired "pass band" of the video i-f amplifier. Hence, although a high Q coil is used here it is quite normal to find the attenuation at this frequency the same or less than that at the adjacent channel picture carrier frequency which is already very much attenuated by the various tuned circuits and the associated sound carrier trap.

Having correctly aligned the i-f amplifier, the next thing is to check the response shape at different a.g.c. bias levels. This should be done with bias voltages down to zero to ensure that the amplifier is quite stable when the gain is at a maximum.

The power supplies both to the i-f amplifier and the other sections of the receiver should be so designed that maximum ratings of valves are not exceeded for any a.g.c. voltage. It must be remembered that for high values of a.g.c. voltage when some valves are operating near plate-current cut-off, the high tension voltage will rise and voltage or dissipation limits of valves in other sections of the receiver may be exceeded.

**Measurement of Gain.**

The method of gain measurement depends on the way in which it is desired to express the performance of the amplifier. One method is to measure the input to the mixer valve grid required to give a nominal d.c. voltage at the detector output, e.g., three volts, or three volts above noise level. This must be done at the picture carrier frequency using the mixer valve as an amplifier, disabling the oscillator if required.

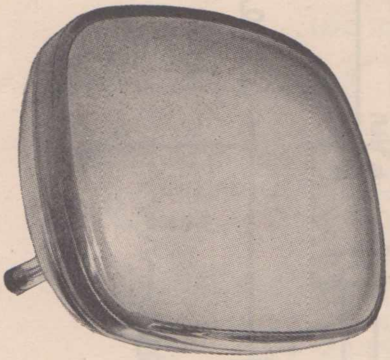
To measure the gain up to the detector input, the method is as follows:—

Connect a vacuum tube voltmeter from the cathode of the detector to ground, using a diode probe to measure alternating volts, and a high impedance meter across the diode load to measure direct volts. An input signal of frequency 36 Mc/s is applied to the mixer valve grid and its level adjusted to give a direct output voltage of say three at the diode load. The alternating voltage at the detector is noted and the meter removed. The input level is now adjusted to give three volts output again and noted. The gain is then the alternating voltage measured divided by the latter input level.

The method chosen is not very important, but should be specified so as to avoid confusion.

**REFERENCES:**

1. Radiotron Designer's Handbook by F. Langford-Smith, page 56.
2. Vacuum Tube Amplifiers, by G. E. Valley Jr. and H. Wallman.



# RADIOTRON 21ALP4A

## PICTURE TUBE

**The Radiotron 21ALP4A is a short, directly-viewed, rectangular glass picture tube of the low-voltage electrostatic focus and magnetic-deflection type. It has a spherical filterglass faceplate, an aluminized screen 19⅛″ x 15″ with slightly curved sides and rounded corners, and a minimum projected screen area of 255 square inches. Other design features of the 21ALP4A include an external conductive coating, which with the internal conductive coating forms a supplementary filter capacitor and an ion-trap gun requiring an external single-field magnet.**

**The principle of operation of the 21ALP4A is identical to that of the 17HP4B, and the article on page 11 entitled "Radiotron 17HP4B Picture Tube, Operation and Application" should be read in conjunction with this data.**

### GENERAL DATA

Heater Voltage ........ 6.3 volts
Heater Current ........ 0.6 amp.
Direct Interelectrode Capacitances:
- Grid No. 1 to all other electrodes ........ 6 μμF
- Cathode to all other electrodes ........ 5 μμF

External conductive coating to ultor { 750 max. μμF / 500 min. μμF }
- Faceplate, Spherical ........ Filterglass
- Light transmission (approx.) ........ 75%

Phosphor, metal-backed ........ P4-Sulphide Type
- Fluorescence ........ White
- Phosphorescence ........ White
- Persistence ........ Short

Focusing Method ........ Electrostatic
Deflection Method ........ Magnetic
Deflection Angles (approx.):
- Diagonal ........ 90°
- Horizontal ........ 85°
- Vertical ........ 68°

Ion-Trap Gun:
Requires External, Single-Field Magnet

Tube Dimensions:
- Overall Length ........ 20″ ± ⅜″
- Greatest Width ........ 20¼″ ± ⅛″
- Greatest Height ........ 16⅜″ ± ⅛″
- Diagonal ........ 21⅜″ ± ⅛″

Screen Dimensions (minimum):
- Greatest Width ........ 19⅛″
- Greatest Height ........ 15″
- Diagonal ........ 20¼″
- Projected area ........ 255 sq. in.

Cap ........ Recessed small cavity (JETEC No. J1-21)
Bulb ........ J171
Base ... Small-Shell Duodecal 6-pin (JETEC No. B6-63)
Weight (approx.) ........ 24 lbs.
Mounting Position ........ Any

## SOCKET CONNECTIONS

(bottom view)

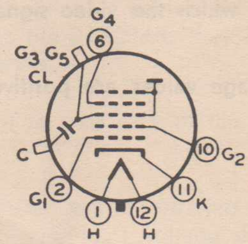
Pin 1—Heater

Pin 2—Grid No. 1

Pin 6—Grid No. 4

Pin 10—Grid No. 2

Pin 11—Cathode




Pin 12—Heater

Cap—Ultor (Grid No. 3
Grid No. 5 Collector)

C—External Conductive
Coating.

## GRID-DRIVE SERVICE

**Grid drive is the operating condition in which the video signal varies the grid-No. 1 potential with respect to cathode.**

**(Unless otherwise specified, voltage values are positive with respect to cathode.)**

**Maximum Ratings,** Design-Centre Values:

| | | |
|---|---|---|
| Ultor● Voltage | 18000 | volts |
| Grid No. 4 Voltage: | | |
| Positive value | 1000 | volts |
| Negative value* | 500 | volts |
| Grid No. 2 Voltage | 500 | volts |
| Grid No. 1 Voltage: | | |
| Negative bias value | 125 | volts |
| Positive bias value | 0 | volts |
| Positive peak value | 2 | volts |
| Peak Heater-Cathode Voltage: | | |
| Heater negative with respect to cathode: | | |
| During equipment warm-up period not exceeding 15 seconds | 410 | volts |
| After equipment warm-up period | 180 | volts |
| Heater positive with respect to cathode | 180 | volts |

**Equipment Design Ranges:**

(With any Ultor Voltage ($E_{c5k}$) between 14000# and 18000 volts and Grid No. 2 Voltage ($E_{c2k}$) between 200 and 500 volts)

| | | |
|---|---|---|
| Grid No. 4 Voltage for Focus with Ultor Current of 100 μamp | —0.45% to +2.2% of $E_{c5k}$ | volts |
| Grid No. 1 Voltage for Visual Extinction of Focused Raster | —9.3% to —24% of $E_{c2k}$ | volts |
| Grid No. 1 Video Drive from Raster Cutoff (Black Level): White Level Drive (Peak Positive) | 9.3% to 24% of $E_{c2k}$ | volts |
| Grid No. 4 Current | —25 to +25 | μamp |
| Grid No. 2 Current | —15 to +15 | μamp |
| Minimum Field Strength of PM Ion-Trap Magnet § | $\sqrt{\frac{E_{c5k}}{16000}} \times 33$ | oersteds |
| Ion-Trap Magnet Current** (average) | $\sqrt{\frac{E_{c5k}}{16000}} \times 30$ | mA |
| Field Strength of Adjustable Centring Magnet | 0 to 8 | oersteds |

**Examples of Use of Design Ranges:**

| | | | |
|---|---|---|---|
| With Ultor Voltage of | 16000 | 18000 | volts |
| And Grid No. 2 Voltage of | 300 | 400 | volts |
| Grid No. 4 Voltage for Focus with Ultor Current of 100 μamp | —65 to +350 | —75 to +400 | volts |
| Grid No. 1 Voltage for Visual Extinction of Focused Raster | —28 to — 72 | —37 to — 96 | volts |
| Grid No. 1 Video Drive from Raster Cutoff (Black Level): White-Level Drive (Peak Positive) | 28 to 72 | 37 to 96 | volts |
| Minimum Field Strength of PM Ion-Trap Magnet | 33 | 35 | oersteds |

**Maximum Circuit Values:**

| | | |
|---|---|---|
| Grid No. 1 Circuit Resistance | 1.5 | megohms |

## CATHODE-DRIVE SERVICE

**Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to Grid No. 1 and the other electrodes..**

**(Unless otherwise specified, voltage values are positive with respect to Grid No. 1.)**

**Maximum Ratings,** Design-Centre Values:

| | | |
|---|---|---|
| Ultor to Grid No. 1 Voltage | 18000 | volts |
| Grid No. 4 to Grid No. 1 Voltage: | | |
| Positive value | 1000 | volts |
| Negative value* | 500 | volts |
| Grid No. 2 to Grid No. 1 Voltage | 625 | volts |
| Grid No. 2 to Cathode Voltage | 500 | volts |
| Cathode to Grid No. 1 Voltage: | | |
| Positive bias value | 125 | volts |
| Negative bias value | 0 | volts |
| Negative peak value | 2 | volts |
| Peak Heater-Cathode Voltage: | | |
| Heater negative with respect to cathode: | | |
| During equipment warm-up period not exceeding 15 seconds | 410 | volts |
| After equipment warm-up period | 180 | volts |
| Heater positive with respect to cathode | 180 | volts |

**Equipment Design Ranges:**

(With any Ultor to Grid No. 1 Voltage ($E_{c5g1}$) between 14000# and 18000 volts and Grid No. 2 to Grid No. 1 Voltage ($E_{c2g1}$) between 220 and 620 volts)

| | | |
|---|---|---|
| Grid No. 4 to Grid No. 1 Voltage for Focus with Ultor Current of 100 μamp | 0% to 2.6% of $E_{c5g1}$ | volts |
| Cathode to Grid No. 1 Voltage for Visual Extinction of Focused Raster | 8.5% to 19.4% of $E_{c2g1}$ | volts |
| Cathode to Grid No. 1 Video Drive from Raster Cutoff (Black Level): White-Level Value (Peak negative) | 8.5% to 19.4% of $E_{c2g1}$ | volts |
| Grid No. 4 Current | — 25 to + 25 | μamp |
| Grid No. 2 Current | — 15 to + 15 | μamp |
| Minimum Field Strength of PM Ion-Trap Magnet (approx.) | $\sqrt{\frac{E_{c5g1}}{16000}} \times 33$ | oersteds |
| Ion-Trap Magnet Current** (average) | $\sqrt{\frac{E_{c5g1}}{16000}} \times 30$ | mA |
| Field Strength of Adjustable Centring Magnet | 0 to 8 | oersteds |

**Examples of Use of Design Ranges:**

| | | | |
|---|---|---|---|
| With Ultor to Grid No. 1 Voltage of | 16000 | 18000 | volts |
| And Grid No. 2 to Grid No. 1 Voltage of | 300 | 400 | volts |
| Grid No. 4 to Grid No. 1 Voltage for Focus with Ultor Current of 100 μamp | 0 to 415 | 0 to 470 | volts |
| Cathode to Grid No. 1 Voltage for Visual Extinction of Focused Raster | 25 to 58 | 34 to 78 | volts |
| Cathode to Grid No. 1 Video Drive from Raster Cutoff (Black Level): White-Level Value (Peak negative) | 25 to 58 | 34 to 78 | volts |
| Minimum Field Strength of PM Ion-Trap Magnet | 33 | 35 | oersteds |

**Maximum Circuit Value:**

| | | |
|---|---|---|
| Grid No. 1 Circuit Resistance | 1.5 | megohm |

• The "ultor" in a cathode-ray tube is the electrode to which is applied the highest d.c. voltage for accelerating the electrons in the beam prior to its deflection.

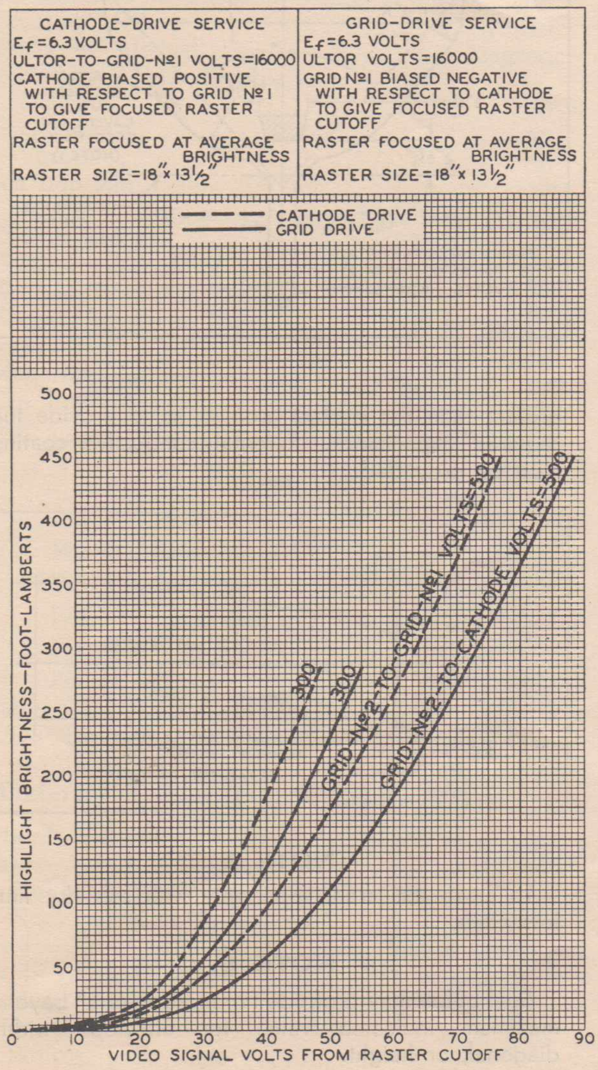
In the 21ALP4A, the ultor function is performed by grid No. 5. Since grid No. 5, No. 3, and collector are connected together within the 21ALP4A, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

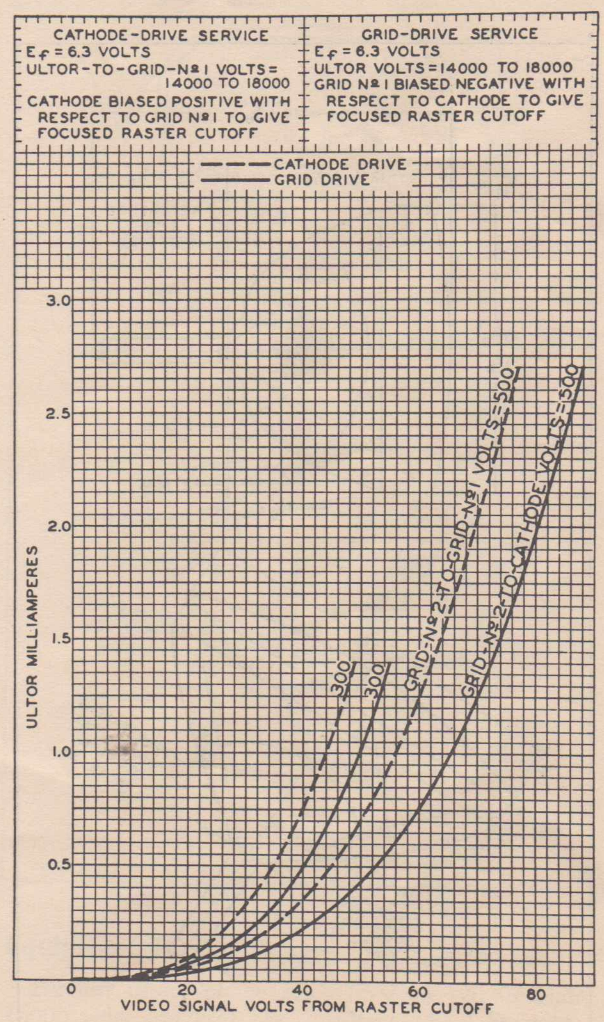
* This value has been specified to take care of the condition where an a.c. voltage is provided for dynamic focusing.

♯ Brilliance and definition decrease with decreasing ultor voltage or ultor-to-grid-No. 1 voltage. In general, the ultor voltage or the ultor-to-grid-No. 1 voltage should not be less than 14000 volts.

** For specimen ion-trap magnet similar to JETEC Ion-Trap Magnet No. 117 located in optimum position and rotated to give maximum brightness.

§ For specimen PM ion-trap magnet located in optimum position and rotated to give maximum brightness. For a given equipment application, the tolerance range for the strength of the PM ion-trap magnet should be added to the minimum value. The maximum strength of this magnet should not exceed the specified minimum value by more than 6 oersteds. This procedure will ensure use of a PM ion-trap magnet allowing adequate adjustment to permit satisfactory performance without loss of highlight brightness.



## NOTE 1.

The plane through the tube axis and pin No. 6 may vary from the plane through the tube axis and bulb terminal by angular tolerance (measured about the tube axis) of 30°. Bulb terminal is on the same side as Pin No. 6.

## NOTE 2.

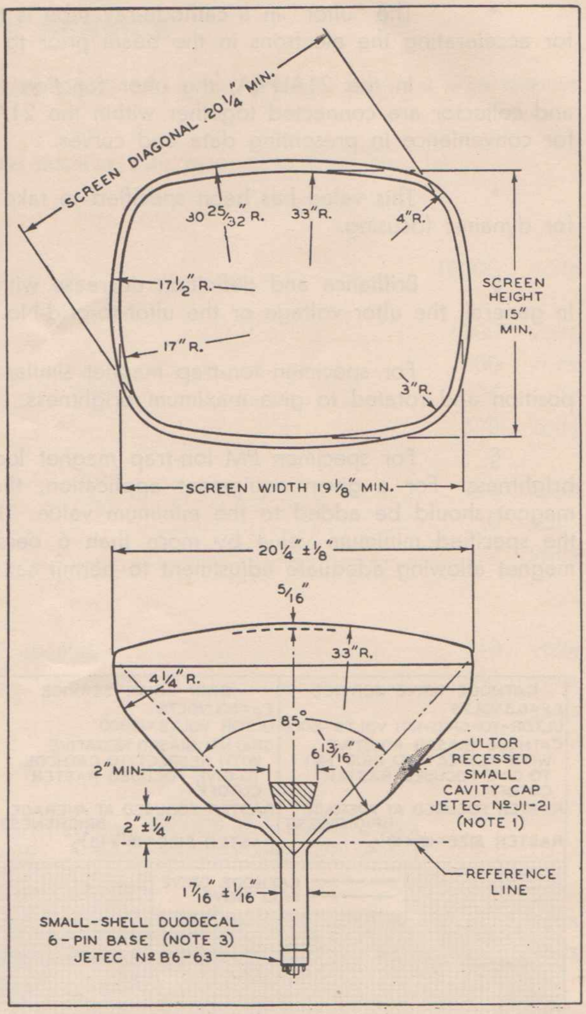
With tube neck inserted through flared end of reference-line gauge (JETEC No. 116) and with tube seated in gauge, the reference line is determined by the intersection of the plane CC′ of the gauge with the glass funnel.

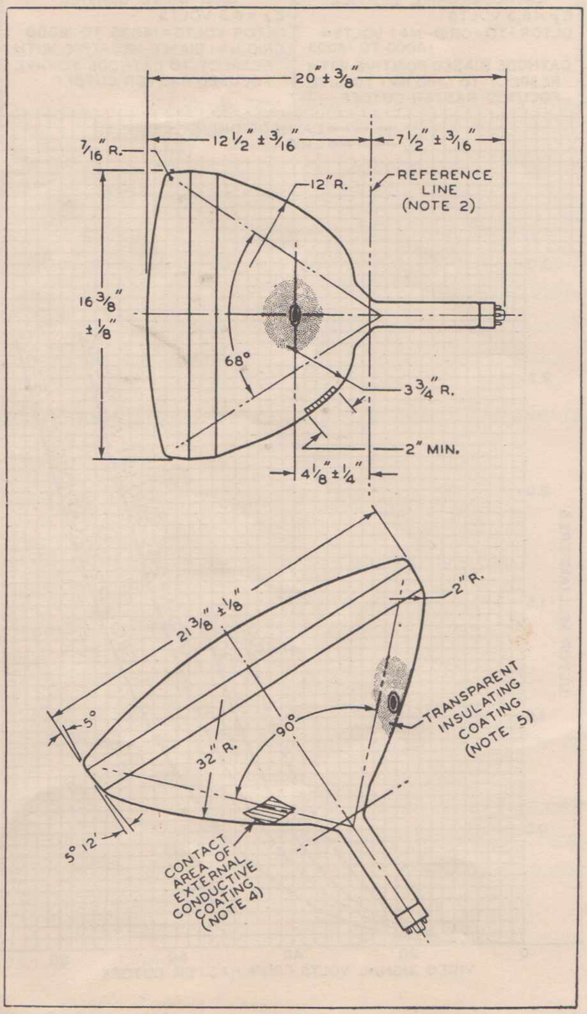
## NOTE 3.

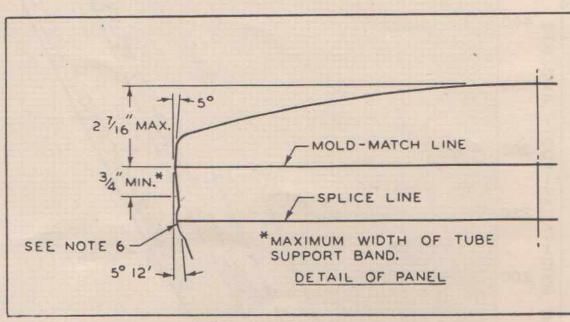
Socket for this base should not be rigidly mounted; it should have flexible leads and be allowed to move freely. Bottom circumference of base shell will fall within a circle concentric with bulb axis and having a diameter of 3″.

## NOTE 4.

The drawing shows minimum size and location of the contact area of the external conductive coating. The actual area of this coating will be greater than the contact area so as to provide the required capacitance. External conductive coating must be grounded.




## NOTE 5.

To clean this area, wipe only with soft dry lintless cloth.

## NOTE 6.

Seal bulge may protrude not more than ⅛″ beyond maximum indicated value for envelope width, diagonal, or height.

# RADIOTRON 17HP4B PICTURE TUBE

## Rectangular Glass Type

### Low-voltage Focus Magnetic Deflection

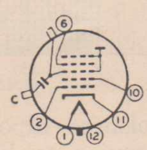
### DATA

**General:**

| | |
|---|---|
| Heater, for Unipotential Cathode: | |
| Voltage | 6.3 ac or dc volts |
| Current | 0.6 amp |
| Direct Interelectrode Capacitances: | |
| Grid No. 1 to All Other Electrodes | 6 μμF |
| Cathode to All Other Electrodes | 5 μμF |
| External Conductive Coating to Ultor* | 1500 max. μμF / 750 min. μμF |
| Faceplate, Spherical | Filterglass |
| Light Transmission (approx.) | 66% |
| Phosphor | P4 — Sulfide Type |
| Fluorescence and Phosphoresence | White |
| Persistence of Phosphorescence | Short |
| Focusing Method | Electrostatic |
| Deflection Method | Magnetic |
| Deflection Angles (approx.): | |
| Diagonal | 70° |
| Horizontal | 65° |
| Vertical | 50° |
| Ion trap gun: | Requires External, Single-Field Magnet |
| Overall Length | $19\frac{3}{16}'' \pm \frac{3}{8}''$ |
| Greatest Diagonal of Tube | $16\frac{5}{8}'' \pm \frac{1}{8}''$ |
| Greatest Width of Tube | $15\frac{3}{8}'' \pm \frac{1}{8}''$ |
| Greatest Height of Tube | $12\frac{9}{32}'' \pm \frac{1}{8}''$ |
| Screen Size | $14\frac{3}{8}'' \times 11\frac{1}{16}''$ |
| Mounting Position | Any |
| Cap | Recessed Small Cavity |
| Base | Small Shell Duodecal 6-Pin |

**Bottom View**

Pin 1 — Heater
Pin 2 — Grid No. 1
Pin 6 — Grid No. 4
Pin 10 — Grid No. 2
Pin 11 — Cathode
Pin 12 — Heater



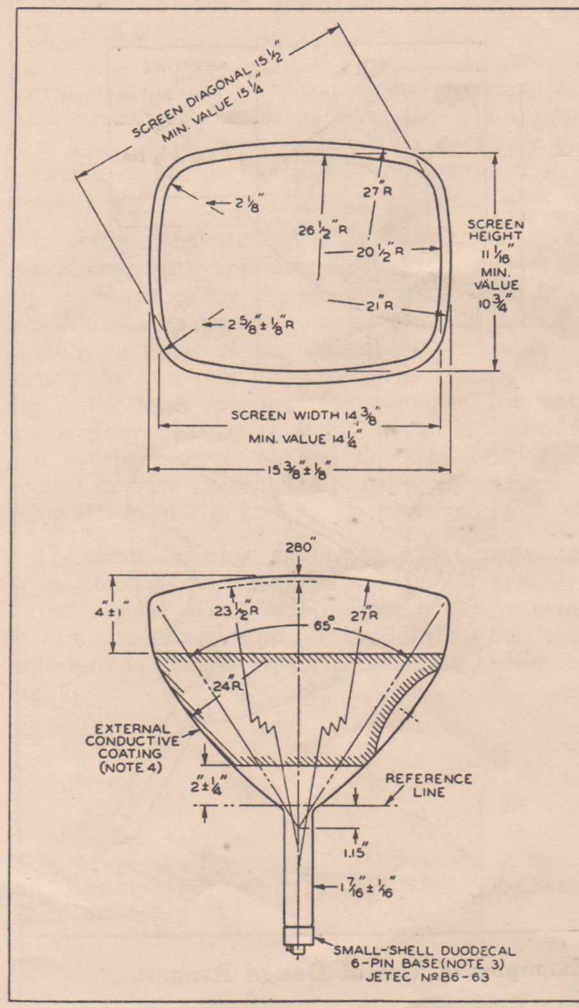

Cap — Grid No. 3, Grid No. 5, Collector
C — External Conductive Coating.

**Maximum Ratings, Design Centre Values:**

| | |
|---|---|
| Ultor* Voltage | 16000 max. volts |
| Grid — No. 4 Voltage: | |
| Positive Value | 1000 max. volts |
| Negative Value** | 500 max. volts |
| Grid — No. 2 Voltage | 500 max. volts |
| Grid — No. 1 Voltage: | |
| Negative bias value | 125 max. volts |
| Positive bias value | 0 max. volts |
| Positive peak value | 2 max. volts |

**Peak Heater — Cathode Voltage:**

| | |
|---|---|
| Heater negative with respect to cathode: | |
| During equipment warm-up period not exceeding 15 seconds | 410 max. volts |
| After equipment warm-up period | 180 max. volts |
| Heater positive with respect to cathode | 180 max. volts |




**Equipment Design Ranges:**

For any ultor voltage ($E_u$) between 12000† and 16000 volts and grid No. 2 voltage ($E_{c2}$) between 150 and 500 volts.

Grid — No. 4 Voltage for Ultor Current of 100 $\mu$amp ....... —0.4% to 2.2% of $E_u$ volts

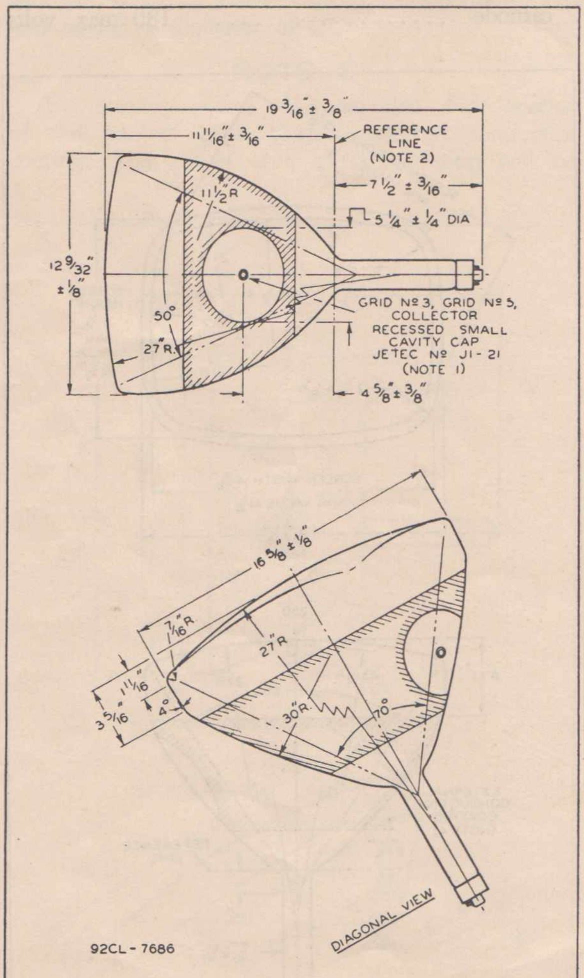
Grid — No. 1 Voltage for Visual Extinction of Undeflected Focussed Spot .... 11% to 25.7% of $E_{c2}$ volts

Grid — No. 4 Current —25 to +25 $\mu$amp

Grid — No. 2 Current —15 to +15 $\mu$amp

Field Strength of Single-field Ion-Trap Magnet (approx.)♯ ........... $\sqrt{\left(\frac{E_u}{12000}\right)} \times 42$ oersteds

Field Strength of Adjustable centring Magnet .. 0 to 8 oersteds

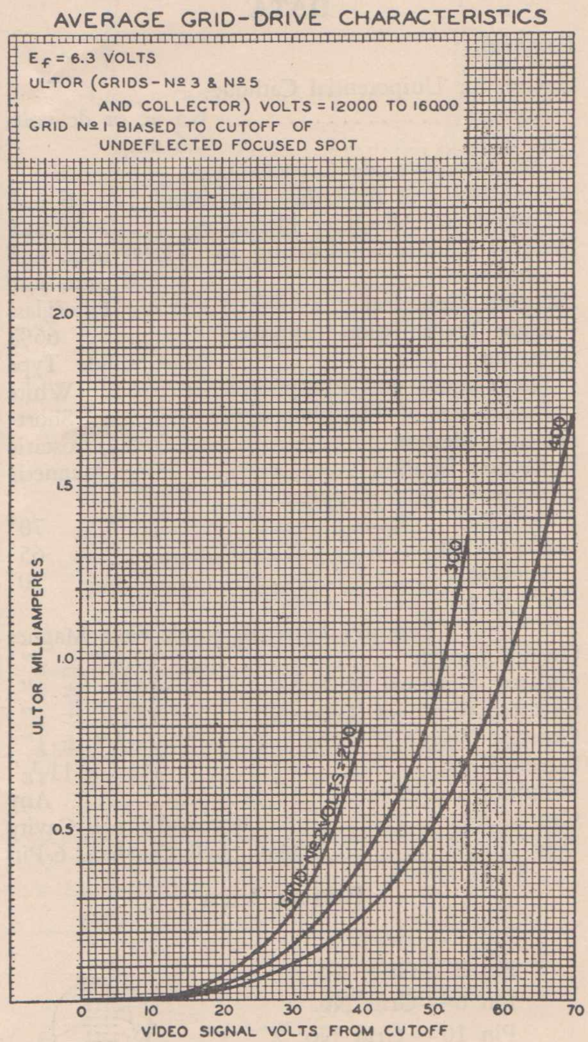



**Examples of Use of Design Ranges:**

| | | | |
|---|---|---|---|
| For ultor voltage of | 14000 | 16000 | volts |
| and grid No. 2 voltage of | 300 | 300 | volts |
| Grid — No. 4 Voltage for Ultor current of 100 $\mu$amp: | —55 to +300 | —65 to +350 | volts |
| Grid — No. 1 Voltage‡: | —33 to —77 | —33 to —77 | volts |

## OPERATING NOTES

**X-Ray Warning** — When operated at ultor voltages up to 16 kilovolts, the 17HP4B does not produce any harmful X-ray radiation. However, because the rating of the tube permits operation at voltages as high as 17.6 kilovolts (absolute value), shielding of the 17HP4B for X-ray radiation may be needed to protect against possible injury from




prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

The following notes refer to the tube outline drawings:

**Note 1:**

The plane through the tube axis and pin No. 6 may vary from the plane through the tube axis and bulb terminal by an angular tolerance (measured about the tube axis) of ±30°. The bulb terminal is on the same side as pin No. 6.

**Note 2:**

With the tube neck inserted through the flared end of the reference-line gauge and with the tube seated in the gauge, the reference line is determined by the intersection of the plane CC′ of the gauge with the glass funnel.

**Note 3:**

The socket for this base should not be rigidly mounted; it should have flexible leads and be allowed to move freely. The bottom circumference of the base shell will fall within a circle concentric with the bulb axis and having a diameter of $2\frac{3}{4}''$.

**Note 4:**

The external conductive coating must be grounded.

**Maximum Circuit Values,**

Grid — No. 1 Circuit Resistance:

1.5 max. megohms

* In the 17HP4B, grid No. 5 which has the ultor function, grid No. 3, and collector are connected together within the tube and are conveniently referred to collectively as "Ultor". The "Ultor" in a cathode-ray tube is the electrode, or the electrode in combination with one or more additional electrodes connected within the tube to it, to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection.

** This value has been specified to take care of the condition where an ac voltage is provided for dynamic focusing.

† Brilliance and definition decrease with decreasing ultor voltage. In general, the ultor voltage should not be less than 12,000 volts.

‡ For visual extinction of undeflected focused spot.

♯ Direction of the field of the ion-trap magnet should be such that the north pole is approximately adjacent to pin location No. 8 and the south pole to pin No. 2.

# RADIOTRON 17HP4B PICTURE TUBE

## OPERATION AND APPLICATION

*By F. J. ROBERTS, A.S.T.C.**

This article gives helpful information on the operation and application of Radiotron 17HP4B picture tube, and it is hoped that the prospective user will thus be assisted to obtain the best pictures possible.

Radiotron 17HP4B is a 70° rectangular glass aluminized picture tube using magnetic deflection and low voltage electrostatic focusing. An ion trap is provided in conjunction with the aluminium backing to protect the screen from negative ion bombardment. The trap also serves to protect the cathode from positive ion bombardment. The bulb incorporates a neutral density filter glass face plate, light transmission through the face plate being approximately 66%, to improve contrast and to minimise halation effects. An external conductive coating on the bulb acts both as a shield to minimise beam radiation and as a filter capacitor for the usual type of "flyback" high tension power supply.

The electrostatically-focused tetrode gun is of the low voltage symmetrical lens type. The electron optical system in a picture tube, commonly referred to as the electron gun, has as its function the focusing of a beam of electrons emitted by the cathode to a small spot on the screen, and the control of the intensity of that electron beam.

* Picture Tube Section, Valve Works, Ashfield.

In conventional picture tubes there are at least two electron lens systems employed (as shown in Fig. 1) for focusing the electron beam. The first lens forms a cross-over point of electrons a short distance in front of the cathode. A second lens focuses the cross-over point on to the screen, resulting in the small spot used for scanning. The first lens is always electrostatic and is formed in a tetrode gun by the cathode, $G_1$ and $G_2$, typical voltages applied to these elements (referred to the cathode) being shown in Fig. 2.

The second lens may be magnetic or electrostatic or a combination of the two. In magnetically focused tubes an external magnetic field is used to form the second lens. In the 17HP4B the lens is formed by the $G_3$ $G_5$ $G_4$ combination shown in Fig. 2.

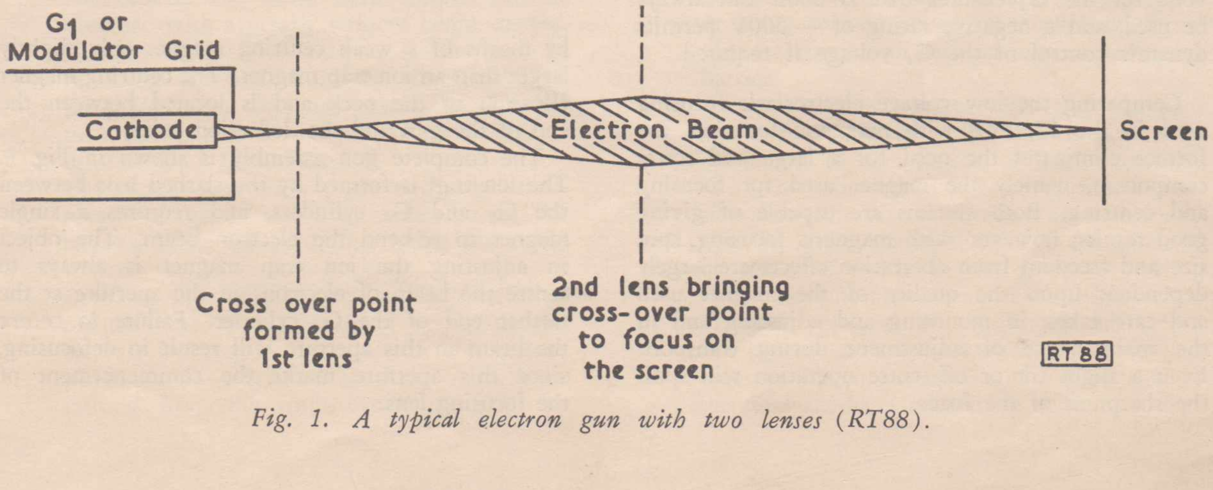



*Fig. 1. A typical electron gun with two lenses (RT88).*

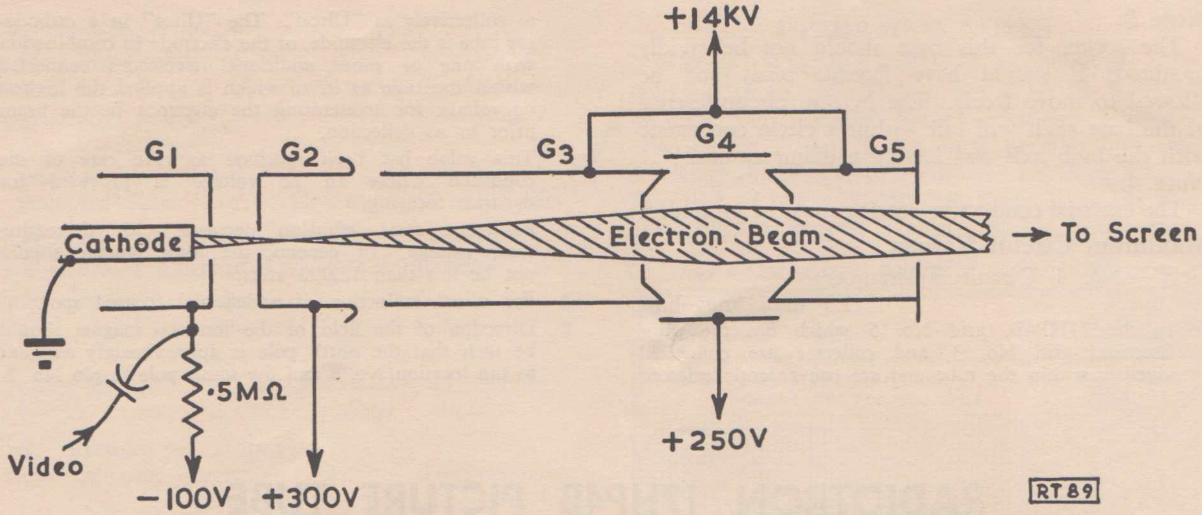



*Fig. 2. The tetrode electron gun with electrostatic second lens as used in Radiotron 17HP4B. The ion trap has been omitted from this diagram for simplicity (RT89).*

The element designated $G_4$ is the focusing electrode. The elements $G_3$ and $G_5$ are electrically connected internally and through bulb spacers make contact, via the internal graphite and aluminium coatings, with the high tension contact on the side of the bulb. These elements form the ultor of the tube.

As indicated in the design range for the 17HP4B, $G_4$ voltage for focusing a 100 $\mu$a beam will lie between —0.2% and + 2.2% of E ultor.

The focus characteristic of this type of gun is very soft, that is, it will hold focus over a wide range of beam currents and the value of $G_4$ voltage can be carried in most cases by 50 volts or 100 volts without visible defocusing occurring. By connecting the $G_4$ electrode to a fixed voltage relative to the cathode some degree of automatic focus compensation for changing ultor voltage is achieved. Typical overseas practice is to operate the picture tube in a T.V. receiver with the $G_4$ connected to the chassis, B+ or B boost, whichever provides the best focus for the electrical conditions used. The high voltage rating of + 1000 volts for the $G_4$ ensures that B boost can always be used, and a negative rating of —500V permits dynamic control of the $G_4$ voltage if required.

Comparing the low voltage electrostatic focusing used in the 17HP4B with magnetic focusing, the former eliminates the need for a large and costly component, namely the magnet used for focusing and centring. Both systems are capable of giving good results; however with magnetic focusing, spot size and freedom from aberration effects are largely dependent upon the quality of the magnet used and care taken in mounting and adjusting and in the maintenance of adjustment during transport. Even a slight tilt or off-centre operation will spoil the sharpness of the focus.

In order to centre the picture on the screen of an electrostatically focused tube it is necessary to provide a centring adjustment. Slightly off-centre operation will otherwise occur because of any small asymmetry in bulbs and gun location within the neck. With the 17HP4B the centring is adjusted

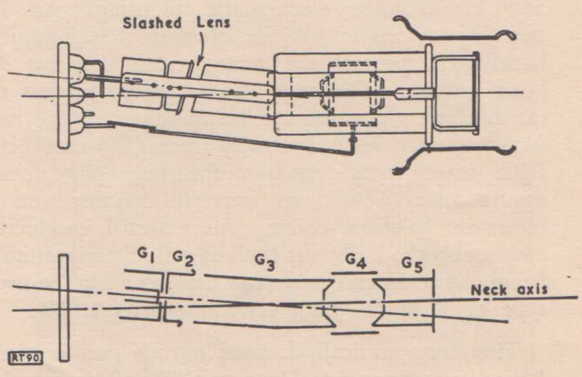



*Fig. 3. Complete gun assembly of type 17HP4B (RT90).*

by means of a weak centring magnet only slightly larger than an ion trap magnet. The centring magnet clips on to the neck and is located between the end of the gun and the deflection yoke.

The complete gun assembly is shown in Fig. 3. The ion trap is formed by the slashed lens between the $G_2$ and $G_3$ cylinders, and requires a single magnet to re-bend the electron beam. The object in adjusting the ion trap magnet is always to centre the beam of electrons in the aperture at the farther end of the $G_3$ cylinder. Failure to centre the beam in this aperture will result in defocusing, since this aperture marks the commencement of the focusing lens.

If the beam is allowed to strike the sides of the aperture light output will suffer, and there is also a great risk of local heating of the aperture taking place with consequent evolution of gas. The positioning of the ion trap magnet, centring magnet and yoke on the neck of a 17HP4B can be seen in Fig. 4.

reflection from the curved surface of the picture tube face plate. It is therefore advantageous to be able to attenuate this light. Having increased light output from an aluminized tube it is possible to use a light-absorbing safety glass in front of the picture tube whilst still maintaining the same high-

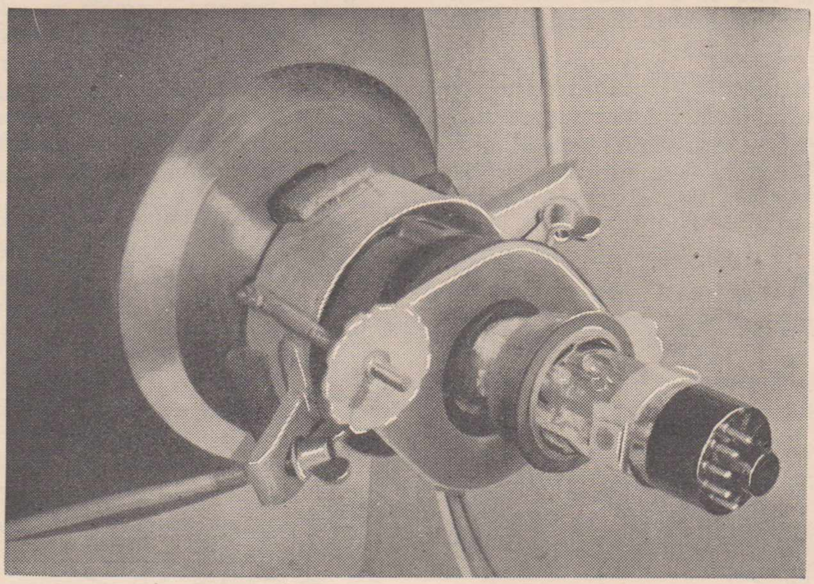


*Fig. 4. Photograph showing the position of the ion trap magnet, centring magnet and yoke on the neck of type 17HP4B (RT91).*

The yoke should always be placed as far forward on the neck as possible, with the formed winding lightly pressing against the picture tube bulb. Failure to position the yoke far enough forward will result in neck shadows as the deflected beam fails to clear the neck of the tube.

The 17HP4B uses a metal backed (aluminized) screen. There are several advantages resulting directly from the use of an aluminized screen, these being:—

1. At normally used values of high-tension voltage the light output is almost doubled or alternatively the same light output can be obtained with a greatly reduced beam current. The increased light output is obtained by reflecting forward the light which, without the aluminium backing, would be directed towards the rear of the picture tube. This is illustrated in Figs. 5 and 6.
2. The picture contrast is improved by the elimination of glare caused by reflection of the backward-directed light, this being inevitable without the aluminium backing.
3. Ambient light shining on to the face of a picture tube from the front spoils picture contrast by illuminating areas of the picture which would otherwise be dark. Also, light shining from the front can cause glare by

light brightness as that obtainable from a non-aluminized tube.

The unwanted light from the front is thus attenuated twice, since it passes through the light absorbing glass twice, and a contrast improvement of 2:1 can easily be obtained in this manner. Alternatively, use can be made of higher ambient lighting whilst still maintaining good picture contrast.

4. The phosphor is protected from the effects of bombardment by negative ions. It is true that modern ion traps are very efficient, but in the event of stray ions not being trapped or being formed outside the influence of the trap the aluminium backing forms a protecting barrier.
5. The aluminium ensures that the phosphor screen is electrically rather than electronically connected to the source of high potential. With non-aluminized tubes, secondary emission from the screen is relied upon to maintain the screen potential close to the potential of the final anode in the gun. Depending upon the phosphor used, when high values of final potential are employed the screen can become charged negatively, which means that the screen potential lags behind that of the final anode. Under these conditions, ions

formed as a result of gas liberation during the life of the tube can, in conjunction with the negatively charged screen, cause the phenomenon known as X or cross burn. By maintaining the phosphor screen at essentially the same potential as the final anode, the aluminizing process eliminates this trouble.

6. Aluminizing results in an improvement in pattern stability as regards surface leakage effects on the face of a picture tube. The effect can be demonstrated by touching the face of an operating tube.

The aluminium backing is evaporated on to the back of the screen and the bulb inside surface after the phosphor screen has been settled and the neck area has been internally graphite-coated. The aluminium backing must be smooth in order to obtain good light-reflecting properties. The phosphor surface is rough, and for this reason the aluminium cannot be evaporated directly on to the phosphor screen. A thin plastic film is first applied to the back of the screen. This film fills in irregularities and presents a smooth, even surface. The aluminium coating is then evaporated directly on to the plastic film to a thickness of about $4 \times 10^{-6}$ inch.

Before the gun assembly is sealed into the neck of the tube, the aluminized bulb is baked at a temperature high enough to decompose the plastic film. The vapour escapes through pores in the aluminium coating and when the process is complete the aluminium backing remains, resting on the high spots of the phosphor screen.

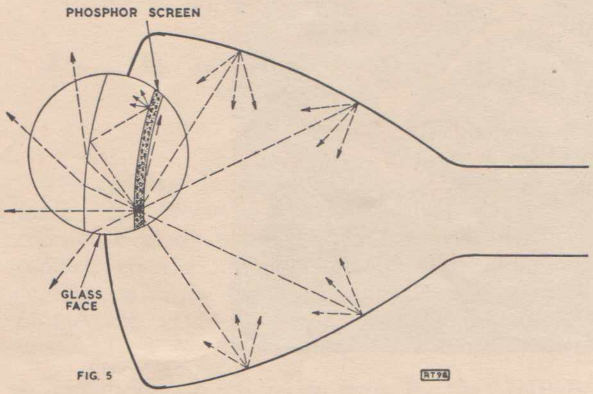



*Fig. 5* *Conventional non-aluminized picture tube showing typical distribution of light from a spot (RT92).*

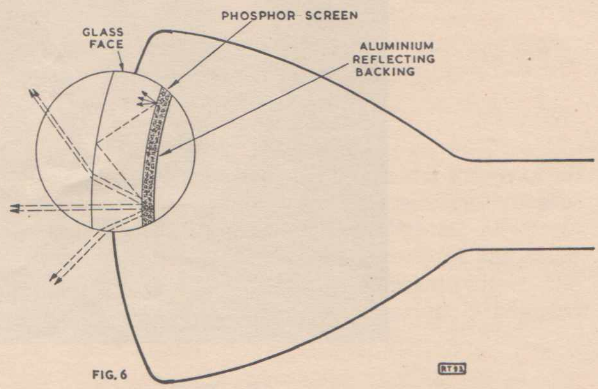



*Fig. 6* *Picture tube with aluminium backing film showing gain due to improved distribution of light (RT93).*

NOTE: Figs. 5 and 6 were based on D. W. Epstein and L. Pensak, "Improved cathode ray tubes with metal-backed luminescent screens", published in R.C.A. Review, March 1946, modified.

# ADJUSTMENT PROCEDURE FOR PICTURE TUBE ION-TRAP MAGNETS*

**This note describes a recommended procedure for adjusting ion-trap magnets to obtain maximum picture brightness and to minimise the possibility of damage to picture tubes. Misadjustments of the ion-trap magnet may cause imperfect centring of the picture tube electron beam and result in excessive bombardment of the masking aperture within the electron gun. As a result of such bombardment, ions may be formed beyond the control of the ion trap and produce an ion spot on the fluorescent screen.**

1. Centre the deflecting yoke on the tube neck and press the mounting- bracket cushion firmly against the glass funnel. For a tube using electrostatic focus, a small adjustable centring magnet is usually required. It should be placed on the tube in the normal position.
2. Place the ion-trap magnet on the tube neck. The initial position of the magnet should be in accordance with the instructions given in the data for the specific tube type. For such tubes as the Radiotron 17HP4B and 21ALP4A, the proper initial position of the ion-trap magnet is shown in Fig. 4, page 19.
3. Adjust the brightness or background control of the television receiver midway between its minimum and maximum positions and set the picture or contrast control to its minimum position. The brightness-control adjustment will provide the picture tube with grid-No. 1 voltage approximately midway between zero

(Continued on page 55)

* Printed with acknowledgment to RCA.

# A SYNC CLIPPER-AMPLIFIER
## *using the* RADIOTRON 12AU7

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

**Summary.**

*Circuit description and performance details of a simple sync clipper-amplifier, functioning with positive going video inputs from 8V p-p upwards, are given*

### INTRODUCTION.

In all modern TV systems the picture intelligence is transmitted by specifying (a) the brightness, and (b) the position of a number of picture elements of the image. **Brightness** is conveyed by amplitude modulation of the transmitted carrier wave; in the Australian system increased carrier amplitude corresponds to a darker picture element. The **position** of the picture element is conveyed basically by sync pulses which ensure that the scanning process at the received picture tube end is in synchronism with that at the camera end.

In other words, the vertical sync pulses transmitted just before the camera "looks" at the top left-hand picture element, and the horizontal sync pulses transmitted just before the camera commences to scan a new line — in conjunction with suitable circuitry in the receiver — ensure that the brightness information transmitted will be assigned to spots on the picture tube screen in a relative position, which will always correspond to that in the original image.

The suitable circuitry referred to is basically the sync clipper — amplifier, which separates the video (or brightness information) from the sync information, the wave shaping circuits, which separate the horizontal and vertical sync pulses, and the deflection oscillators, which — in synchronism with these pulses — produce the sawtooth currents required for magnetic deflection of the electron beam in the picture tube.

Whilst a description of the exact nature of these sync pulses is outside the scope of this article, it should be noted that they are superimposed on "blanking pulses"; i.e., for the duration of sync pulses the picture information transmitted is always "black". This permits separation of the sync pulses from the picture information (video) by clippers with a clipping threshold at (or above) black level. This method is universally used in receiver circuitry and also in the circuit described below.

*Regarding the position of the sync clipper in the TV receiver*, it is obvious from the above that it will be followed by the horizontal-to-vertical separating circuits, the outputs of which synchronise their respective deflection oscillators.

The input to the sync clipper could be derived from basically 2 points: the video detector or the video amplifier output. The "composite video" (i.e., video, blanking and sync pulses) is present at both points. As the level at the video detector is only 3 to 5 V p-p, it is decidely advantageous to derive the input from the video amplifier output. The level there will be — for a normal picture — 30 to 80 V p-p, depending on the viewing conditions and picture tube characteristics. Under adverse receiving conditions, however, the video amplitude may be as low as 15 V p-p.

### GENERAL REQUIREMENTS.

The technical requirements of a sync clipper-amplifier may be summarised as follows:—

a. Its output should consist of sync pulses only — video, blanking pulses and noise should be effectively suppressed to avoid spurious triggering of the deflection oscillators.

b. The output should be sufficient to synchronise positively the deflection oscillators, taking into account the attenuation occurring in the wave shaping networks.

c. The output should be independent of the input provided the latter exceeds 15 V p-p.

d. Whilst the amount of tolerable waveform distortion will depend on the nature of the deflection oscillator, a fast rise time — to ensure accurate synchronisation — is generally important.

---

* Applications Laboratory, A.W.V. Co.

The circuit described below will effectively separate the sync content from the input video signal and will yield an output of 45 V p-p independent — regarding both amplitude and waveform of the amplitude of the video input, provided this exceeds 8 V p-p. This feature permits taking the input from the video amplifier plate, even when contrast control is effected by varying the gain of same. Tests indicate that the circuit provides a degree of discrimination against ignition type interference adequate for good quality commercial television receivers.

The other function normally associated with synchronizing circuits, namely that of separating and shaping vertical and horizontal sync pulses, will be dealt with only briefly as the nature of these pulses (amplitude, waveform and source impedance) is determined by the succeeding deflection oscillators which are to be synchronised. The 45 V p-p output of the circuit, at a source impedance less than 10,000 ohms, will cater for all currently used deflection oscillators and the wave shaping networks required thereby.

## CIRCUIT DESCRIPTION.

Figure 1 shows the circuit of a sync clipper-amplifier using the Radiotron 12AU7 twin triode.

The positive going video signal is applied to the grid of the first triode via a network consisting of $R_1$, $R_2$, $R_3$, $C_1$ and $C_2$. $R_1$ isolates the stray capacities of the circuit from the plate of the video amplifier; $R_3$ and $C_1$ — in conjunction with grid current — clamp the positive peaks of the video signal ("sync tips") at earth potential; while $R_2$ and $C_2$ form a short time-constant noise filter network.

From Thevenin's theorem the voltage divider type plate load formed by $R_4$ and $R_5$ is equivalent to a plate supply voltage of 25 V in series with a resistance of approximately 30,000 ohms (plate load). Under these conditions the cut-off control grid voltage is only −2 V. Therefore, in case of a composite video input of 8 V p-p, the video content will not appear at the plate. The plate voltage swing will be approximately 20 V p-p, from +25 V to +5 V. (See $W_1$ and $W_2$, Fig. 2.)

The second stage is cathode biased to 15 V when driven. Thus clipping due to grid current will occur whenever the plate voltage of the first stage exceeds + 15V. This clipping is effective in removing most of the video content appearing at the plate of the first stage due to grid-plate capacity. (See $W_3$, Fig. 2.)

The plate supply dividing network of the second stage is equivalent to a plate supply voltage of approximately 90 V in series with a 10,000 ohm plate load resistance. Under these conditions the plate current will be cut off at approximately −7 V control grid-to-cathode voltage. As the cathode potential is held at +15 V, further clipping will take place. The plate voltage swing of the second stage is 45 V p-p. (See $W_9$, Fig. 2.)

Figure 3 shows an 8 V p-p horizontal blanking and sync pulse and the three levels of clipping effected by the circuit. For simplicity's sake, the pulse has been shown as having equal amplitude whilst passing through the various stages. The actual amplitudes, of course, are those shown in Fig. 2.

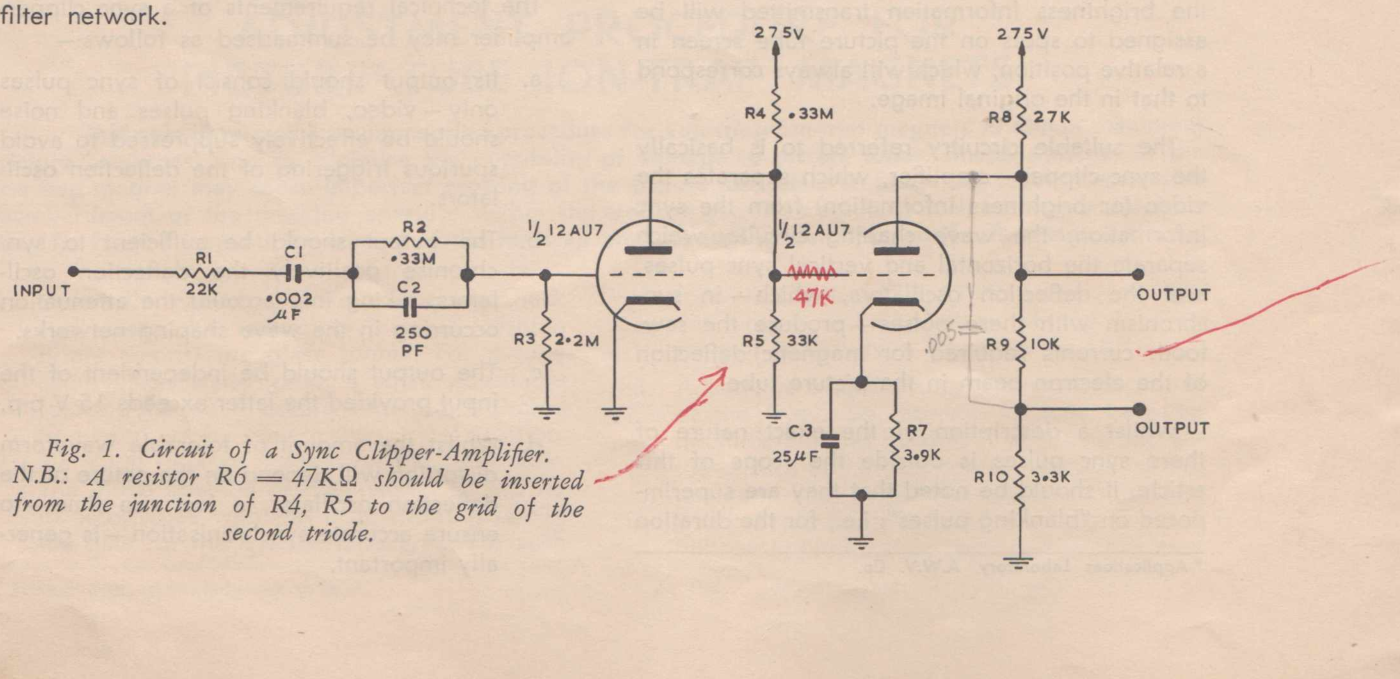



*Fig. 1. Circuit of a Sync Clipper-Amplifier. N.B.: A resistor R6 = 47KΩ should be inserted from the junction of R4, R5 to the grid of the second triode.*

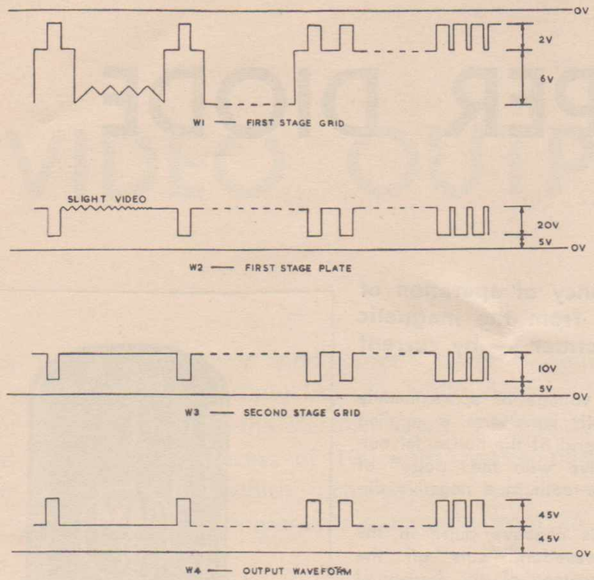



*FIG. 2 .. .. .. Waveforms.*

## PERFORMANCE SPECIFICATION.

**Input:** 8 V p-p positive going (minimum).

**Output:** 45 V p-p, positive going, sync tips clipped at +90 V.

**Video Content of Output** (measured with Marconi Test Pattern Signal).

| Input | Video in output relative to 45 V p-p |
|---|---|
| 10 V p-p | 0.6% |
| 100 V p-p | 6% |

**Rise Time:****

| Input | Rise time |
|---|---|
| 10 V p-p | 0.8 micro seconds. |
| 100 V p-p | 0.7 micro seconds. |

** Time required by the leading edge of the output pulses to rise from 10% to 90% of their final amplitude.

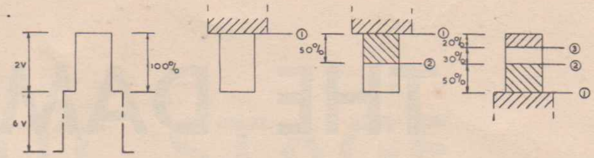



*FIG. 3 .. .. ..*

*Relative Clipping Levels at 8 V p-p (min.) input.*
*(a) due to cut-off in first stage.*
*(b) due to grid current in second stage.*
*(c) due to cut-off in second stage.*

## PULSE SHAPING CIRCUITS.

As mentioned in the introductory section, the amplitude, waveform, and source impedance of the actual synchronising pulses are largely determined by the deflection oscillators controlled by them.

Figure 4 shows a network which will yield satisfactory performance when used in conjunction with the A.W.V. 70° or 90° deflection circuits using either of the Radiotrons 12BH7 or 6CM7 twin triodes as vertical blocking oscillator and output amplifier, and the Radiotron 6SN7GTA twin triode as horizontal frequency control and oscillator in a "synchroguide" circuit.

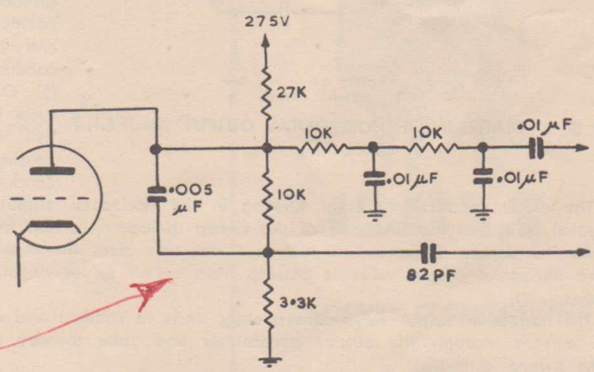
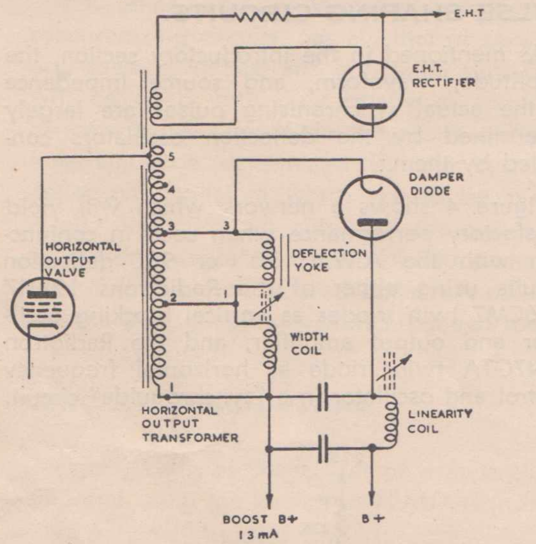



*Fig. 4. Wave shaping network suitable for A.W.V. 70° and 90° deflection circuits.*
*(a) from 0.01 μF — to vertical oscillator valve.*
*(b) from 82 pF — to horizontal oscillator valve.*

**Mr. P. Gonda was born in Budapest, Hungary, in 1926. He received the Radio Engineering Diploma (Credit) in 1950. In 1956 he joined Amalgamated Wireless Valve Company. He is at present engaged in developing television circuitry around the Radiotron range of TV receiving valves. Mr. Gonda is a Member of the Institute of Radio Engineers (Australia).**

# THE DAMPER DIODE

**The damper diode in a TV receiver increases the efficiency of operation of the horizontal deflection circuit by recovering energy from the magnetic field which is set up — in the yoke and output transformer — by current from the output valve. Briefly the operation is:—**




SIMPLIFIED DIAGRAM OF HORIZONTAL OUTPUT AND E.H.T. CIRCUITS.

(1) A voltage of approximately saw-tooth wave-form is applied to the grid of the horizontal output valve with the "pulse" of the saw-tooth in a negative direction.

(2) This negative pulse in the grid wave-form cuts off the plate current of the horizontal output valve so that a large positive pulse is developed across the inductance of the horizontal output transformer.

(3) This positive pulse sets up, and becomes the first quarter-cycle of, a damped high-frequency oscillation in the plate circuit.

(4) During the first half-cycle of the damped oscillation the cathode of the damper diode is positive with respect to the plate and the damper diode cannot conduct.

(5) During the second half-cycle the cathode becomes negative with respect to the plate causing the damper diode to conduct.

(6) The diode conduction current flowing in the horizontal output transformer (and thus in the yoke) is in fact the first part of the sweep deflection current in the yoke.

(7) As the damper-diode current decreases towards zero, the saw-tooth voltage on the grid of the horizontal output valve is passing from cut-off to less-negative and then positive grid voltages.

(8) The horizontal output valve consequently starts to conduct and draws a steadily increasing plate current through the output transformer and yoke thereby providing the second half of the sweep current.

(9) During the period of damper-diode conduction the horizontal output valve is cut off and current flows into the capacitor across the linearity coils, charging them to a voltage some hundreds of volts higher than the normal B+ supply voltage.

(10) The plate of the horizontal output valve is supplied from this boost supply, thereby making use of the power recovered by the damper diode from the magnetic field of the deflection yoke and output transformer.

**The damper diode thus provides the first half of each cycle of deflection current in the yoke by rectifying the damped oscillation in the output transformer and then allows the power recovered to be used in the plate circuit of the horizontal output valve.**

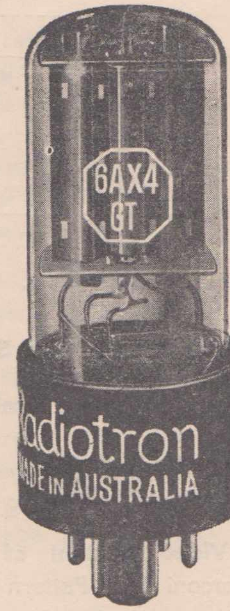
**CHARACTERISTICS:**

| | |
|---|---|
| HEATER VOLTAGE | 6.3 volts |
| HEATER CURRENT | 1.2 amps. |
| CAPACITANCE (Heater to cathode) | 7.5 $\mu\mu$F |

**MAXIMUM RATINGS (damper service)**

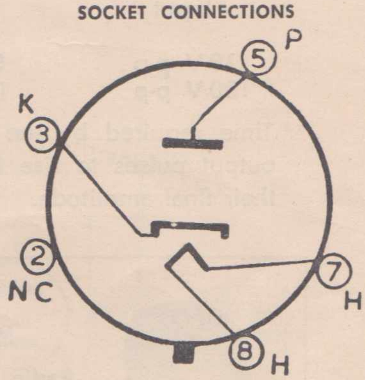
| | |
|---|---|
| PEAK INVERSE PLATE VOLTAGE* (absolute max.) | 4400 volts |
| PEAK PLATE CURRENT | 750 mA |
| AVERAGE PLATE CURRENT | 125 mA |
| PLATE DISSIPATION | 4.8 watts |
| PEAK HEATER-CATHODE VOLTAGE (absolute max.) (heater negative with respect to cathode). | 4400 volts |

* The duration of the voltage pulse must not exceed 15% of one horizontal scanning cycle




## 6AX4GT

**SOCKET CONNECTIONS**




(bottom view)

Pin 2 — No Connection (Do not use.)
Pin 3 — Cathode
Pin 5 — Plate
Pin 7 — Heater
Pin 8 — Heater

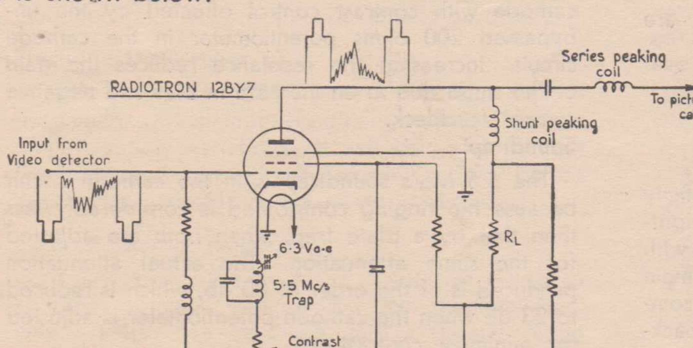
# VIDEO OUTPUT STAGE

The television receiver video-output stage is required to amplify, without compression, the output from the video detector to a level which is sufficient to modulate fully the electron beam in the picture tube. The level required is normally in excess of 100 volts peak-to-peak. The frequency spectrum of this signal, which includes both picture and synchronising information, can include components extending from 25 c/s to as high as 5 Mc/s.

To maintain the desired pass-band shape a low plate-load resistance is used in association with peaking coils. The higher the circuit capacitance (which consists of the output capacitance of the video amplifier valve, the input capacitance of the picture tube and stray capacitance) the lower must be the load resistance and the more difficult is the practical achievement of the desired gain bandwidth product.

To achieve the necessary gain and output with the low plate-load resistance, a high transconductance valve capable of a relatively high plate current swing is necessary.

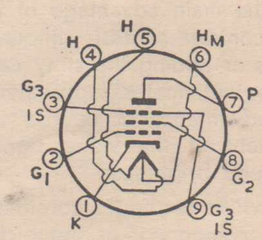
A typical video amplifier circuit is discussed on page 26. A simplified circuit is shown below.




**The Radiotron 12BY7 is a 9 pin miniature valve designed specifically to meet the requirements of the video output stage. Its transconductance of 12,000 μmhos enables adequate gain to be realised with low plate-load resistances, and its large signal handling capacity ensures compression-free amplification. The low output capacitance of this valve assists in keeping the circuit capacitance to a minimum, thus facilitating the stage design. The centre-tapped filament enables it to be used with both 6.3 and 12.6 volt supplies.**


**12BY7**

**SOCKET CONNECTIONS**




(bottom view)

Pin 1 — Cathode
Pin 2 — Grid No. 1
Pin 3 — Grid No. 3, Internal Shield
Pin 4 — Heater
Pin 5 — Heater
Pin 6 — Heater Centre-Tap
Pin 7 — Plate
Pin 8 — Grid No. 2
Pin 9 — Grid No. 3, Internal Shield

# VIDEO-AMPLIFIER

## USING RADIOTRON 12BY7

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

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

### DESIGN CONSIDERATIONS.

**General.**

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

**Load Capacitance.**

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

**Coupling to Picture Tube.**

The three basic alternatives currently used are as follows:

(a) d.c. coupling;

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

(c) a.c. coupling.

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

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

* *For the purpose of this article, sync compression is defined*

$$\text{as } 20 \log \frac{\text{sync to peak-to-peak ratio at input.}}{\text{sync to peak-to-peak ratio at output.}}$$

### BRIEF SPECIFICATIONS.

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

### CIRCUIT DESCRIPTION.

**General.**

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

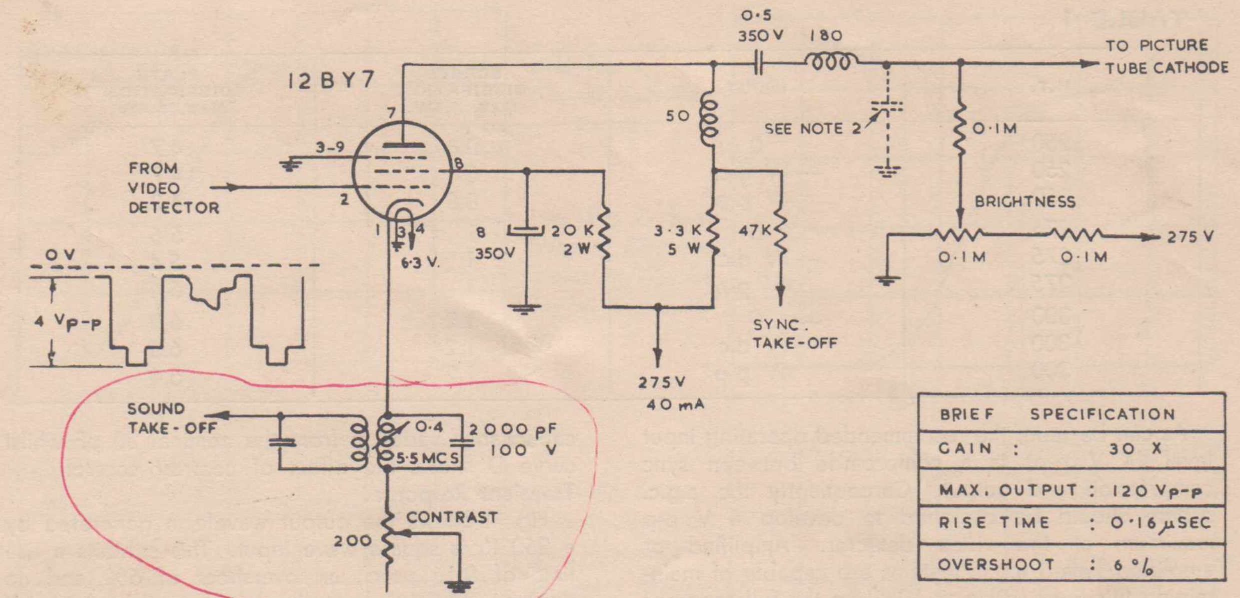
**Soundtrap.**

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

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

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

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




**NOTE 1**

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

**NOTE 2**

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

**NOTE 3**

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

*Fig. 1. Video Amplifier Circuit.*

## CIRCUIT PERFORMANCE.

### General.

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

### Electrode Dissipations.

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

### Contrast Control Range.

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

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

### Linearity and Overload Characteristics.

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

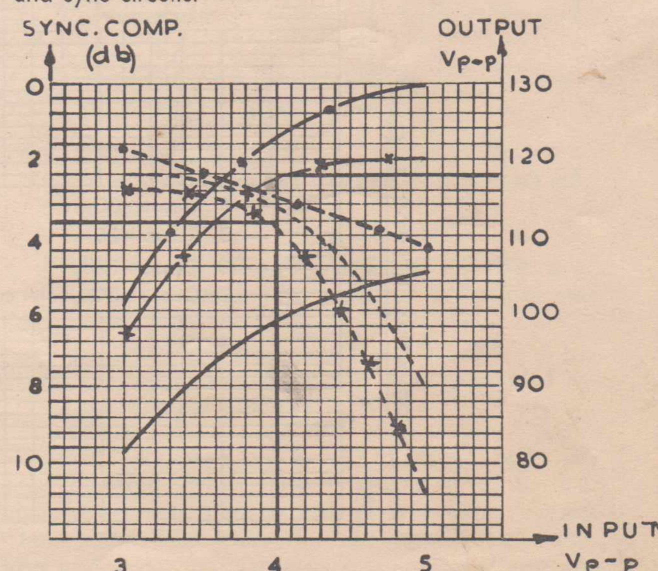



*Fig. 2. Family of curves showing Sync Compression and Maximum Output v. Input to Grid.*

**TABLE 1**

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

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

**Frequency Response.**

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

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

**Transient Response.**

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

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

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

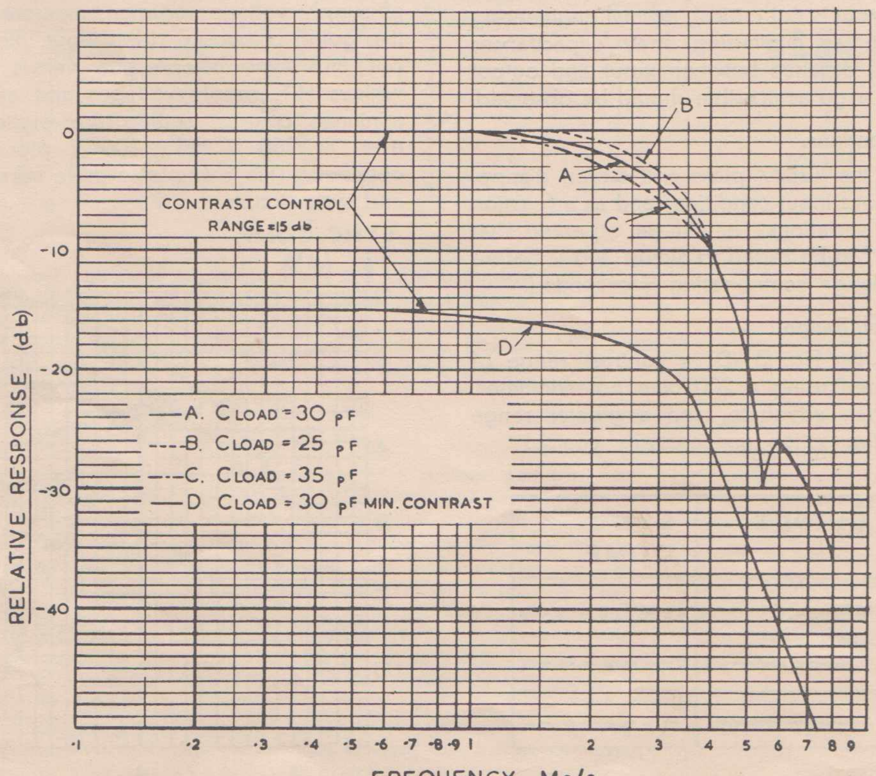



*Fig. 3. Frequency Response.*

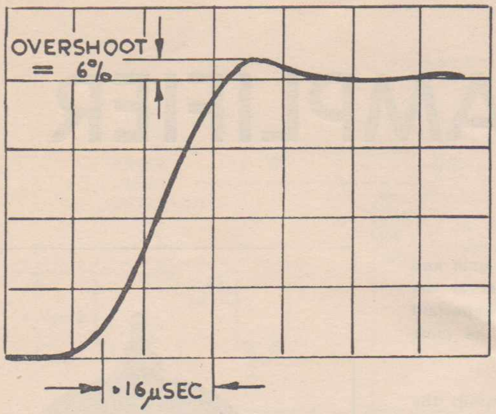
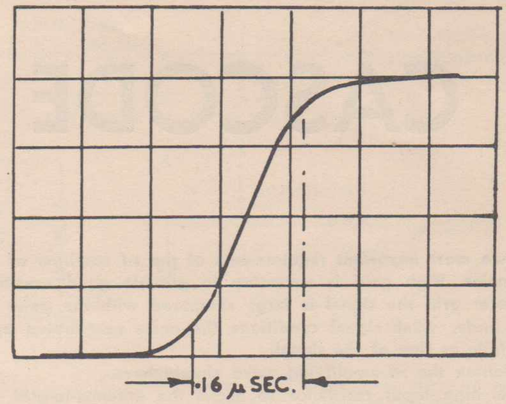



*Fig. 4. Normal Transient Response.*

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



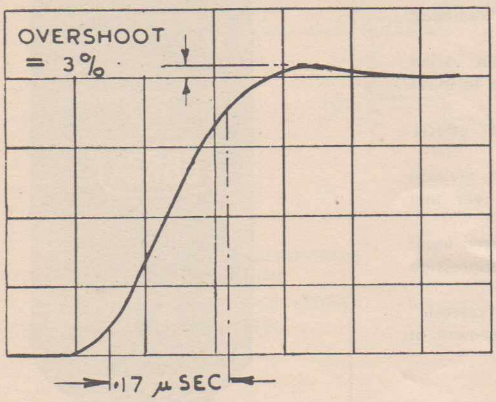
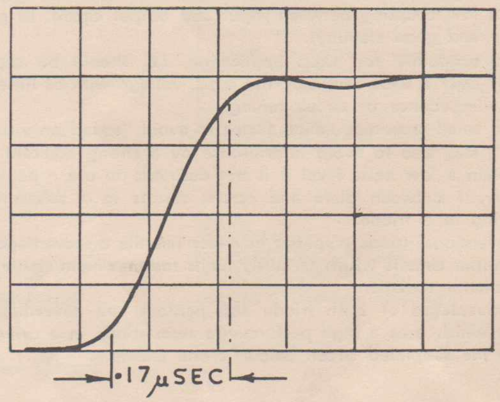




*Fig. 6. Transient Response: load capacitance 5 pF above normal.*

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



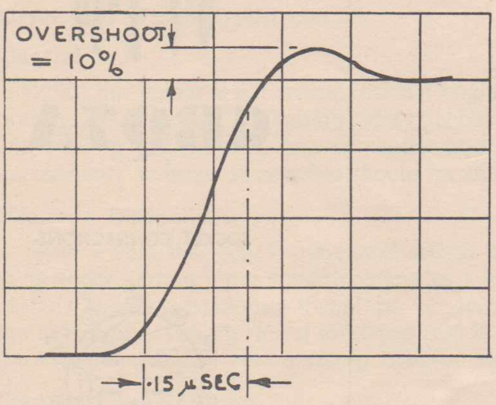
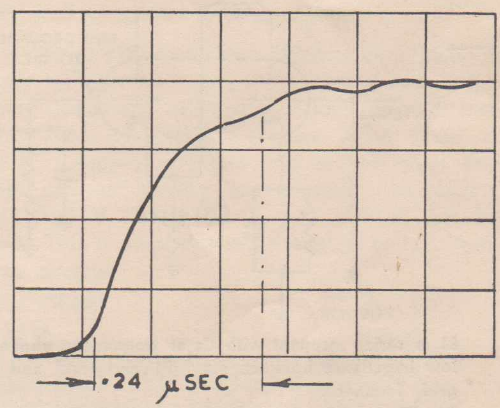




*Fig. 8. Transient Response: series peaking coil removed.*

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




**Test Pattern Performance.**

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

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

## CONCLUSIONS — APPLICATIONS.

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

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

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

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

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

# CASCODE RF AMPLIFIER

**The two most important requirements of the r-f amplifier of a TV receiver are high gain and low noise. High gain is necessary to provide good sensitivity and to ensure that at the converter grid the signal is large compared with the noise voltage. Low noise is important since under weak signal conditions the noise contributed by the stage may have the same amplitude as that of the signal.**

**In addition the r-f amplifying valve should have:**

(a) high input resistance to allow the antenna-to-grid matching circuit to step-up the impedance, and thus the voltage, from antenna to grid;

(b) low coupling between input and output circuit, to give both low oscillator radiation and good stability;

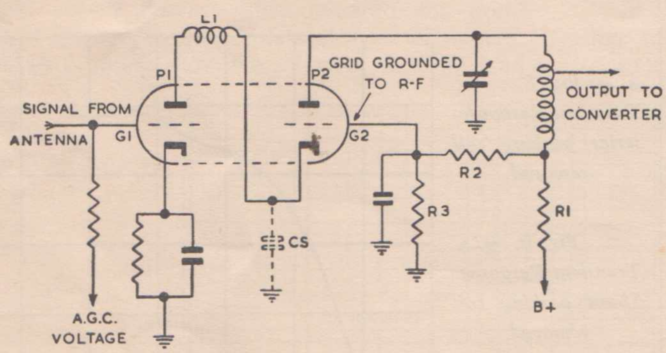
(c) suitability for a.g.c. application, i.e. should be capable of having its gain varied over a wide range by the a.g.c. voltage with as little disturbance as possible to input impedance or circuit tuning;

(d) small cross-modulation factor to avoid "sound on vision" or "vision on sound" effects and also to avoid interference by a strong adjacent carrier.

To obtain a low noise level it is not desirable to use a pentode because the random division of current between plate and screen results in a substantial increase of noise over that occurring in a triode.

A conventional triode amplifier however has the disadvantage of high coupling between input and output circuits which seriously limits the maximum stable gain and gives poor suppression of oscillator radiation.

The advantages of both triode and pentode are nevertheless obtainable in the "cascode" circuit which uses a high performance twin triode in a driven grounded-grid arrangement of which the simplified circuit below is one example.




**L1 is series resonant with Cs at frequencies above 220 Mc/s to produce low impedance between plate P1 and earth and hence reduce plate-to-grid feedback.**

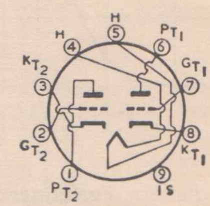
**R1, R2 and R3 are adjusted to provide appropriate variation in bias on G2 as signal input and a.g.c. to G1 vary. Cs is the stray capacity between cathode and earth.**

The overall gain obtained in such a circuit is higher than that of a pentode, particularly at the 200 Mc/s end of the TV band because amplification is obtained from the two series-connected triodes and it is accompanied by the characteristically low noise of the triode. Good a.g.c. and cross-modulation are obtained with the circuit because as the a.g.c. voltage is applied to the grid of the first triode its plate voltage rises, thus increasing the bias necessary to cut-off its plate current, and at the same time, depending on the point to which the second grid is connected, increases the bias on the second triode. The overall effect of the a.g.c. voltage therefore is to make the cut-off characteristic of the 1st triode more remote and to obtain some control from the 2nd triode thus giving a smooth and effective a.g.c. action and freedom from cross-modulation effects. The circuit also allows very little oscillator radiation back through the r-f amplifier.

The Radiotron 6BQ7A has been designed for use in cascode circuits such as that described and has special shielding to produce low capacitive coupling between each half of the valve which this circuit requires. The valve also has a high ratio of gm to input-plus-output capacitance and to plate current, both of which are required for high gain and low noise.


## 6BQ7A

SOCKET CONNECTIONS




**(bottom view)**

- Pin 1 — Plate of Unit No. 2.
- Pin 2 — Grid of Unit No. 2.
- Pin 3 — Cathode of Unit No. 2.
- Pin 4 — Heater.
- Pin 5 — Heater.
- Pin 6 — Plate of Unit No. 1.
- Pin 7 — Grid of Unit No. 1.
- Pin 8 — Cathode of Unit No. 1.
- Pin 9 — Internal Shield.

# FREQUENCY CONVERTER

**The desirable requirements for a TV frequency converter can be summarised as follows:—**

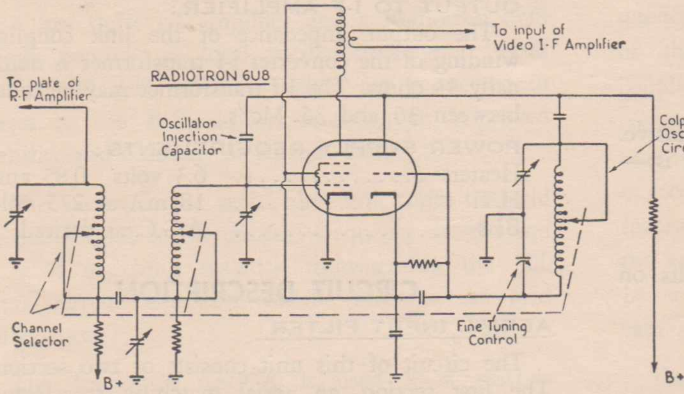
(a) conversion transconductance should be high to provide as much gain as possible in the low-impedance, wide-band circuits used in a TV receiver.

(b) the equivalent noise resistance should be low for good signal to noise ratio.

(c) there should be little feed-through from the oscillator to the r-f stage, to keep the oscillator radiation to a minimum.

(d) the oscillator section of the converter should have good frequency stability and possess characteristics which make oscillation of the right amplitude easy to obtain by using various types of circuits and applied operating voltages.

### SIMPLIFIED CIRCUIT OF TV FREQUENCY CONVERTER




Theory predicts that the higher transconductance ($g_m$) and the sharper the cut-off characteristic of the pentode, the higher will be the conversion transconductance ($g_C$). The lower the bias required for plate current cut-off, the smaller the oscillator injection voltage needs to be for maximum $g_C$ and hence the lower is the oscillator radiation. Multi-grid types of converter, i.e. those in which the signal and oscillator voltages are applied to separate grids in the mixer section of the valve, can be shown to be noisier and to have lower $g_C$ at high frequencies than the types in which both voltages are applied to the one grid.

For the oscillator the most satisfactory operation is obtained by using a triode of high $g_m$ and medium amplification factor ($\mu$) in a circuit which will provide good frequency stability. The Colpitts type is often used for this purpose.

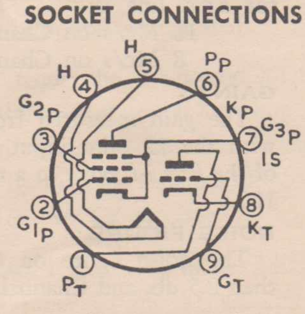
These and other considerations suggest that best frequency conversion will be obtained using a valve of the triode-pentode type comprising a high $g_m$ medium $\mu$ triode and a high $g_m$, sharp cut-off pentode in a circuit similar to the one shown.

The series connection of the triode and pentode sections of the converter across the B. supply offers the advantage of a slight reduction in current drain and more constant oscillator injection over the frequency range, due to the current-stabilising effect of this type of connection.

**The Radiotron 6U8, which has been designed to meet these requirements and which will give high performance in the frequency converter stage of TV tuners, has characteristics which make it useful for other functions in the TV receiver. For example, the pentode may be used as a sound or video i-f amplifier, a.g.c. amplifier etc. and the triode as 1st a-f amplifier or a-f output where moderate output is required, sync. separator or as a cathode follower driven from the pentode in a video amplifier-output stage.**


## 6U8

### SOCKET CONNECTIONS

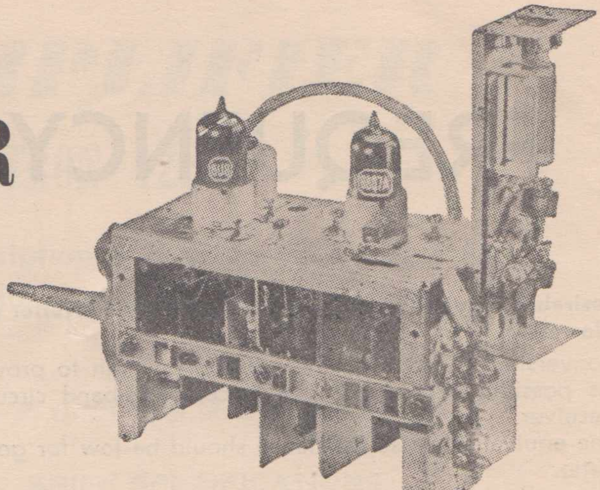



(bottom view)

Pin 1—Triode Plate
Pin 2—Pentode Grid No. 1
Pin 3—Pentode Grid No. 2
Pin 4—Heater
Pin 5—Heater
Pin 6—Pentode Plate
Pin 7—Pentode Cathode, Pentode Grid No. 3, Internal Shield.
Pin 8—Triode Cathode
Pin 9—Triode Grid

# TELEVISION TUNER

## Type STT1



Tuner STT-1 has been designed to fulfil the requirements of a high performance front end for Australian television receivers. It is a high quality tuner, using the wafer switch type of construction, which is proving to be the most reliable and economical method of channel selection for T.V. receivers.

## PERFORMANCE DATA:

### FREQUENCY COVERAGE:

Australian television channels 1 to 10 inclusive. The fine tuning range of the local oscillator is:—

± 2 Mc/s on Channels 3-10
± 1 Mc/s on Channels 1 and 2.

### BANDWIDTH:

The bandwidth measured with —3 volts on the a.g.c. line is:—

10 Mc/s on Channels 4-10
8 Mc/s on Channels 1-3.

### GAIN:

The gain measured from the Aerial Terminal with the 72 ohm input termination to the grid of the first i-f valve in a receiver is approximately 100.

### NOISE FIGURE:

The noise figure on Channels 4-10 is better than 8.5 db, and Channels 1-3 better than 6.5 db.

### I-F REJECTION:

The i-f rejection on Channel 1 is better than 80 db. Other channels have better figures.

### IMAGE REJECTION:

The Image Rejection on Channel 10 is better than 50 db. Other channels have better figures.

### INPUT IMPEDANCE:

The input impedance may be selected to be either 300 ohm balanced or 72 ohm unbalanced by suitable connection to input connector.

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The standing wave ratio for the nominal impedance is less than 2 : 1 on all channels.

### OSCILLATOR RADIATION -

Field intensity measurements have shown that the oscillator radiation is less than the Australian Broadcasting Control Boards recommendations by the factor of two.

### OUTPUT TO I-F AMPLIFIER:

The output impedance of the link coupling winding of the converter i-f transformer is nominally 33 ohms. The i-f transformer may be tuned between 30 and 35 Mc/s.

### POWER SUPPLY REQUIREMENTS:

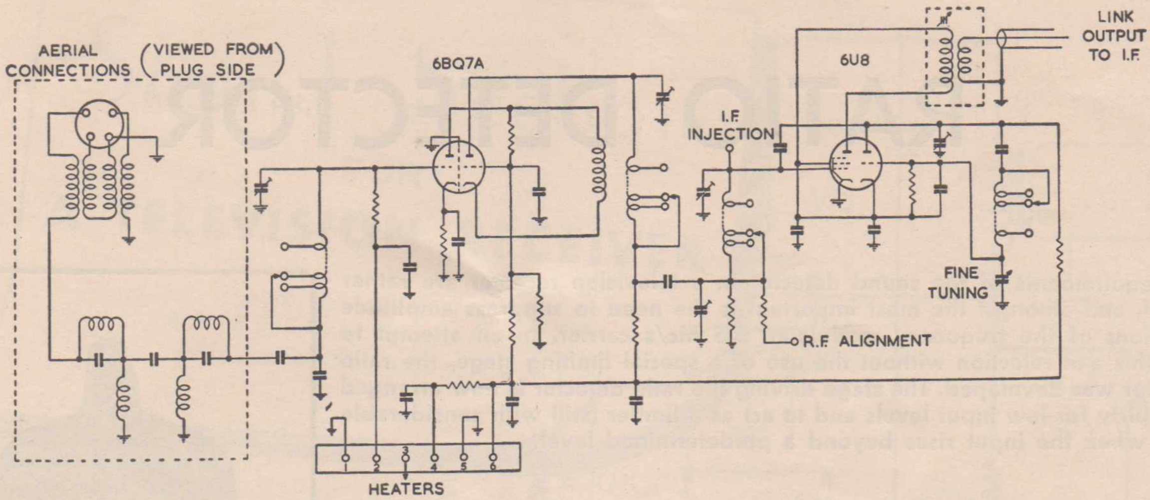
| | |
|---|---|
| Heaters ............... | 6.3 volts 0.85 amp |
| H.T. ................. | 18 mA at 275 volts |
| Bias ................. | A.G.C. as desired. |

## CIRCUIT DESCRIPTION

### AERIAL INPUT FILTER:

The circuit of this unit consists of two sections. The first section, an aerial matching transformer or balun, matches the impedance from either a 300 ohm balanced feeder or a 72 ohm coaxial line to a 300 ohm single-ended (or side-grounded) circuit. This is accomplished by using the equivalent of two 150 ohm transmission lines coiled up on separate coil forms. Because they are coiled, these transmission lines have high impedance for unbalanced currents. Furthermore, the use of this arrangement allows either a series or series-parallel connection to provide a match for a balanced 300 ohm input or an unbalanced input as shown on page 4, since each end of the coils may be grounded independently of the other.

The second section is a composite high-pass filter, having a constant K mid-section and terminating half sections with rejection frequencies of 36.0 Mc/s. The filter is adjusted to provide attenuation for signals below 49 Mc/s., and high attenuation to 36.0 Mc/s., the vision carrier frequency of Australian receivers.




SIMPLIFIED CIRCUIT DIAGRAM

**TUNER:**

Tuner STT-1 uses a Radiotron 6BQ7A twin triode as a low noise r-f amplifier and a Radiotron 6U8 triode pentode as local oscillator-converter. Both sections of each of these valves are connected in series to the B+ supply, resulting in improved stability and economy of current drain.

The output of the aerial filter unit tunes the grid of the 6BQ7A to the channel frequency desired and is a π matching network transforming the 300 ohm output impedance of the filter to the grid impedance.

The Radiotron 6BQ7A is used in a cascode circuit. The signal is injected on the grid of the first triode, amplified and direct coupled through a series inductor to the cathode of the following grounded grid amplifier. The inductor is used to give greater gain on the higher frequency channels. A.G.C. is applied to the first triode, and a resistor network to the grid of the second section is designed to give better a.g.c. characteristics to the valve as a whole. The plate of the second triode is connected to a band pass network tuned to each channel. Coupling in this circuit is obtained by the present variable capacitor on the high channels, and by this and on additional capacitors on Channels 1, 2 and 3. This circuit, together with the tuned signal grid circuit provides the necessary bandwidth and selectivity of the tuner.

The triode section of the Radiotron 6U8 is used as the local oscillator in a Colpitt's type circuit, and is operated on the high side of signal frequency. Injection from the oscillator to the grid of the pentode section is by fixed capacitive coupling. Consistent injection is achieved by the compensating effect of the series operation of the two sections of the 6U8. Tuning of the oscillator is accomplished, as in other r-f circuits by switching incremental inductance which is adjustable from the knob end of the tuner. Fine-tuning is achieved by a variable capacitor, which is driven by a cam spindle, concentric with the switch shaft.

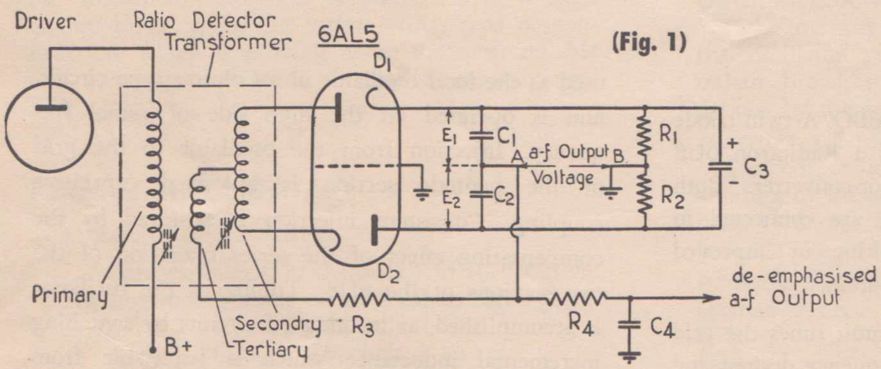
The output voltage from the Radiotron 6U8 converter plate is transformed across a low impedance link winding in the tuner. Connection to the receiver i-f strip is made by a coaxial lead to a suitable link input transformer in the TV receiver.

This arrangement allows a great deal of flexibility in the location of the tuner to the i-f amplifier and results in low radiation of oscillator voltage present in the converter plate circuit. A suitable coupling arrangement incorporating adjacent sound and vision frequency trap circuits is shown above. A sweep voltage may be injected on the test point on top of the chassis for alignment of the i-f line circuit.

An additional test point for use during the switch alignment of the tuner is located on the side strap.

# RATIO DETECTOR

**The requirements of the sound detector in a television receiver are rather varied, and amongst the most important is the need to suppress amplitude variations of the frequency modulated 5.5 Mc/s carrier. In an attempt to gain this a-m rejection without the use of a special limiting stage, the ratio detector was developed. The stage driving the ratio detector is now arranged to amplify for low input levels and to act as a limiter (still with considerable gain) when the input rises beyond a predetermined level.**




**(Fig. 1)**

The voltages applied to the two diode circuits (referring to Fig. 1) are each the vector sum of the tertiary winding voltage and the appropriate half secondary voltage. The normal phase relationships existing in coupled circuits result in a phase difference of 90° between the latter two voltages when the incoming signal is at the centre frequency, i.e., in the condition of zero modulation. This phase difference varies as the instantaneous frequency is affected by the degree of modulation and causes a variation in amplitude of the voltage applied to the diode circuits. One increases and the other decreases as the instantaneous frequency increases and vice versa. Thus the frequency deviation of the incoming signal is converted to an amplitude variation of the voltages applied to the diode circuits.

C3 is a large capacitor which becomes charged in the presence of a carrier and plays a major part in the suppression of amplitude modulation of the input signal. The discharging time constant of C3 through R1 and R2, the diode load resistance, is long compared to the period of the lowest audio frequency to be detected (usually about 0.2 seconds). The voltage across C3 is hence maintained constant over short intervals of time.

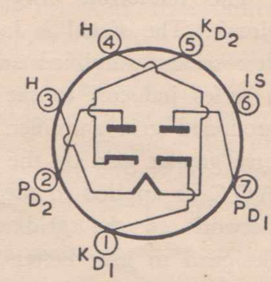
Consider the operation of the circuit at a time when the frequency of the incoming signal differs from the centre frequency by a deviation, $\Delta f$, such that the voltage applied to D1 is greater than that applied to the diode D2. The current flowing in C1 must be greater than that flowing in C2. Hence the voltage developed across C1 (E1) is greater than that developed across C2 (E2). The sum E1 + E2 is held constant by C3 and hence point A must be negative relative to point B (earth). So it can be seen that the instantaneous voltage at point A will vary in proportion to the difference between E1 and E2, and hence to the instantaneous value of $\Delta f$, and at a rate equal to the rate of change of $\Delta f$. Thus the audio output voltage follows the audio modulation of the sound carrier.

R3 is a small resistance which limits the peak diode currents, thus tending to reduce the effects of unbalance in the two halves of the circuit. R4 and C4 form the de-emphasis network which is necessary to correct for the pre-emphasis used at the transmitter to gain an improved signal to noise ratio.

**A twin diode ideally suited for use in such a circuit is the Radiotron 6AL5. The performance of a circuit using the 6AL5 is described on page 35. The 6AL5 is also suitable for use as a video detector, a.g.c. clamp and in other applications.**


# 6AL5

## SOCKET CONNECTIONS

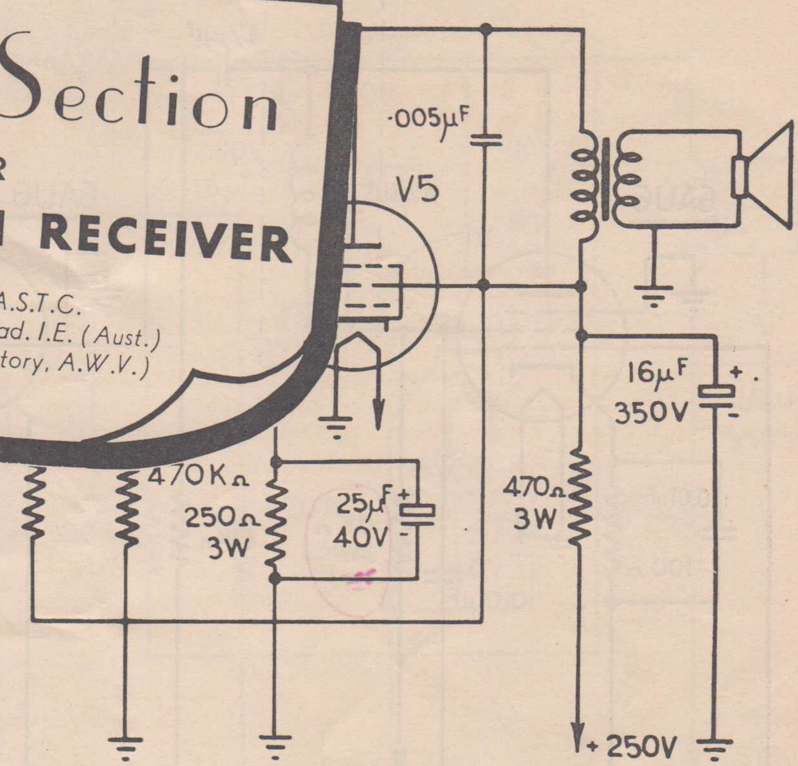



bottom view

Pin 1 — Cathode of Diode No. 1.
Pin 2 — Plate of Diode No. 2.
Pin 3 — Heater.
Pin 4 — Heater.
Pin 5 — Cathode of Diode No. 2
Pin 6 — Internal Shield.
Pin 7 — Plate of Diode No. 1.

# Sound Section
## FOR
# A TELEVISION RECEIVER

*by R. Darnell, A.S.T.C.*
*A.M.I.R.E. (Aust.), Grad. I.E. (Aust.)*
*(Applications Laboratory, A.W.V.)*




**A typical sound i-f and audio amplifier circuit is presented with a discussion of its performance. Coil and circuit details are given as well as the alignment procedure and test specifications.**

## INTRODUCTION.

The use of frequency modulation for television sound was originally adopted in 1941 because it allows a higher signal to noise ratio in the very high frequency transmitting band. However, the advent of the intercarrier system has made F-M sound even more desirable because it simplifies the separation of the video signal and the sound signal at the video detector. The United States and continental European standards specify F-M sound but Great Britain and France use A-M sound. Australia has followed the former lead combining the improved signal to noise ratio with the advantages to receiver manufacturers of intercarrier receivers. These advantages are that fewer valves are required and that since the intercarrier frequency is dependent on the spacing between the transmitted sound and video carriers alone, the need for highly stable and non-microphonic local oscillator operation is removed.

The ratio detector has been most commonly used as an F-M detector for television receivers in the past although other methods of detection are now rapidly gaining favour overseas. Much has been written about ratio detector transformers and their operation.[1,2,3] The main reason for their popularity has been their ability to suppress amplitude modulation of the sound carrier without the use of a limiter. However, as this suppression is not normally considered sufficient the valve driving the ratio detector transformer is usually arranged to act as an amplifier at low levels but as a limiter for larger input signals.

## INTERCARRIER BUZZ.

If, during any portion of a field, the ratio of the video carrier level to the sound carrier level falls below a value of about 2, excessive amplitude modulation of the sound carrier will occur. This is evident in the audio system as a buzz at the field frequency rate. The sound carrier is normally attenuated about 26 db relative to the video carrier in the i-f amplifier. It is already down 7 db because of the 5 to 1 video to sound power ratio of the transmitter. This gives a total of 33 db difference which means that the sound carrier level is normally 2.2% of the video carrier level. Now the minimum white level has been fixed at 10% in the Australian system and provided this level is adhered to by the transmitting stations at all times, the attenuation of the sound carrier in the i-f amplifier has to be decreased by 7 db before the level of the sound carrier is 5%, giving a ratio as defined above of 2:1. Hence, if the attenuation of the sound carrier in the i-f amplifier is less than 19 db, intercarrier buzz may become evident when the picture contains a white portion. Another form of intercarrier buzz is described in the next section.

## SOUND TAKE-OFF TRANSFORMER.

The 5.5 Mc/s frequency modulated beat note which becomes the sound carrier is present in the

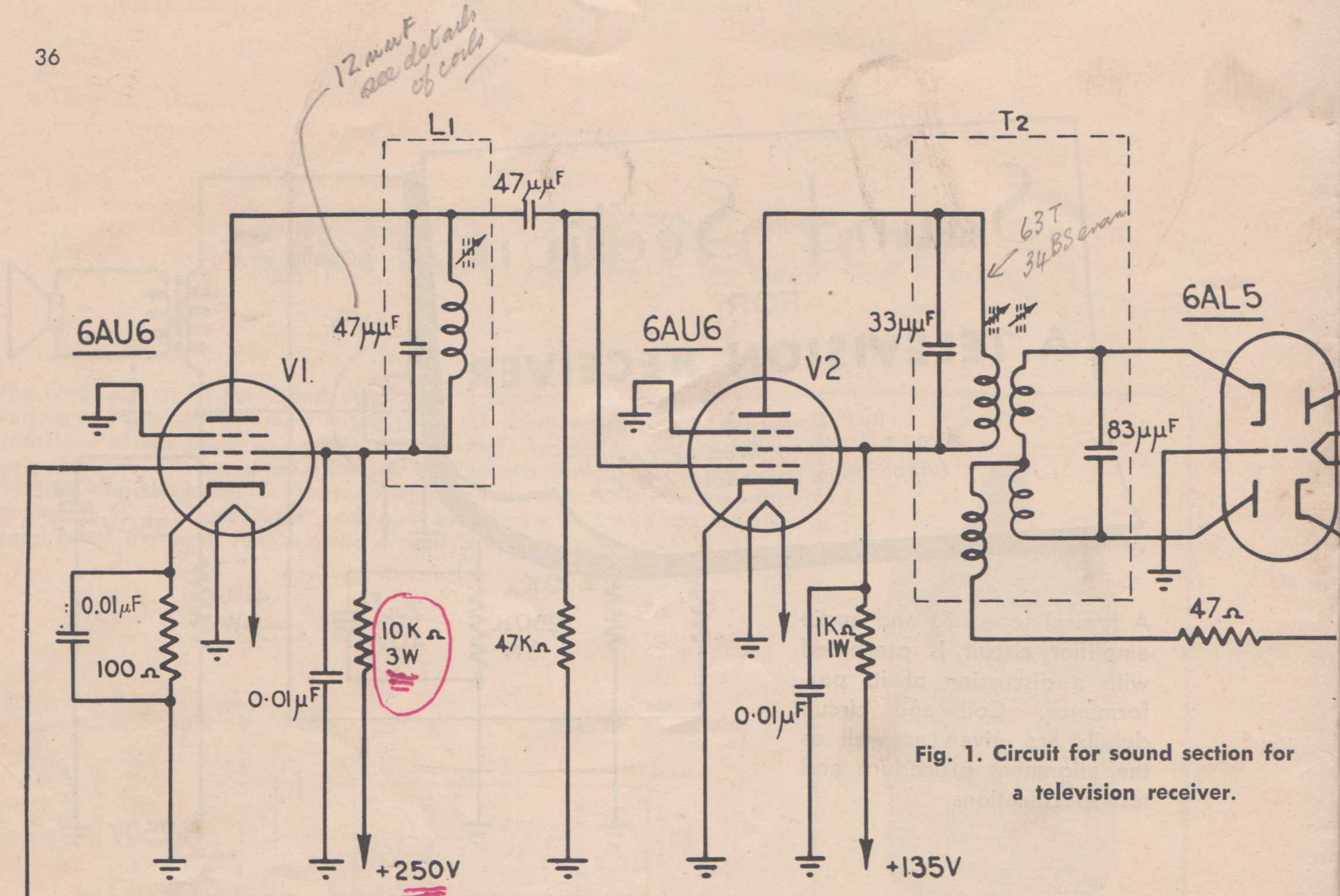
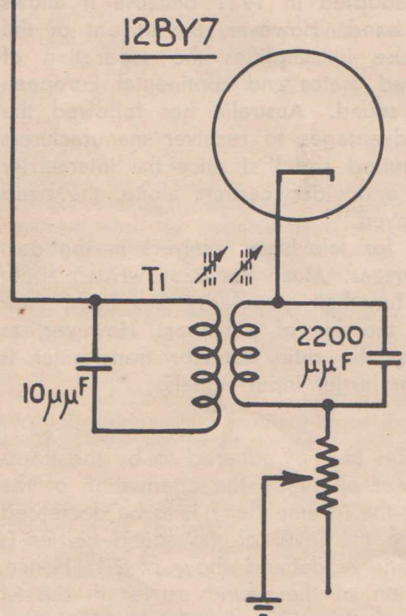



Fig. 1. Circuit for sound section for a television receiver.




output of the video detector and can be separated from the video information by a tuned circuit either in the detector output circuit or in the video amplifier plate or cathode. Taking the sound carrier from the video amplifier can cause the following trouble. If the a.g.c. system of the receiver is not good enough, the synchronising information could cause the video amplifier to become cut off both at the line frequency and at the field frequency. If only the tips of the synchronising pulses cause this cutting off, the picture will remain synchronised but the sound carrier will be interrupted and will present intercarrier buzz and possibly a line frequency whistle if the audio system is good enough. This trouble is more likely to be apparent where simple a.g.c. systems are used. The circuit described here is designed to work in a receiver which has an adequate a.g.c. system.

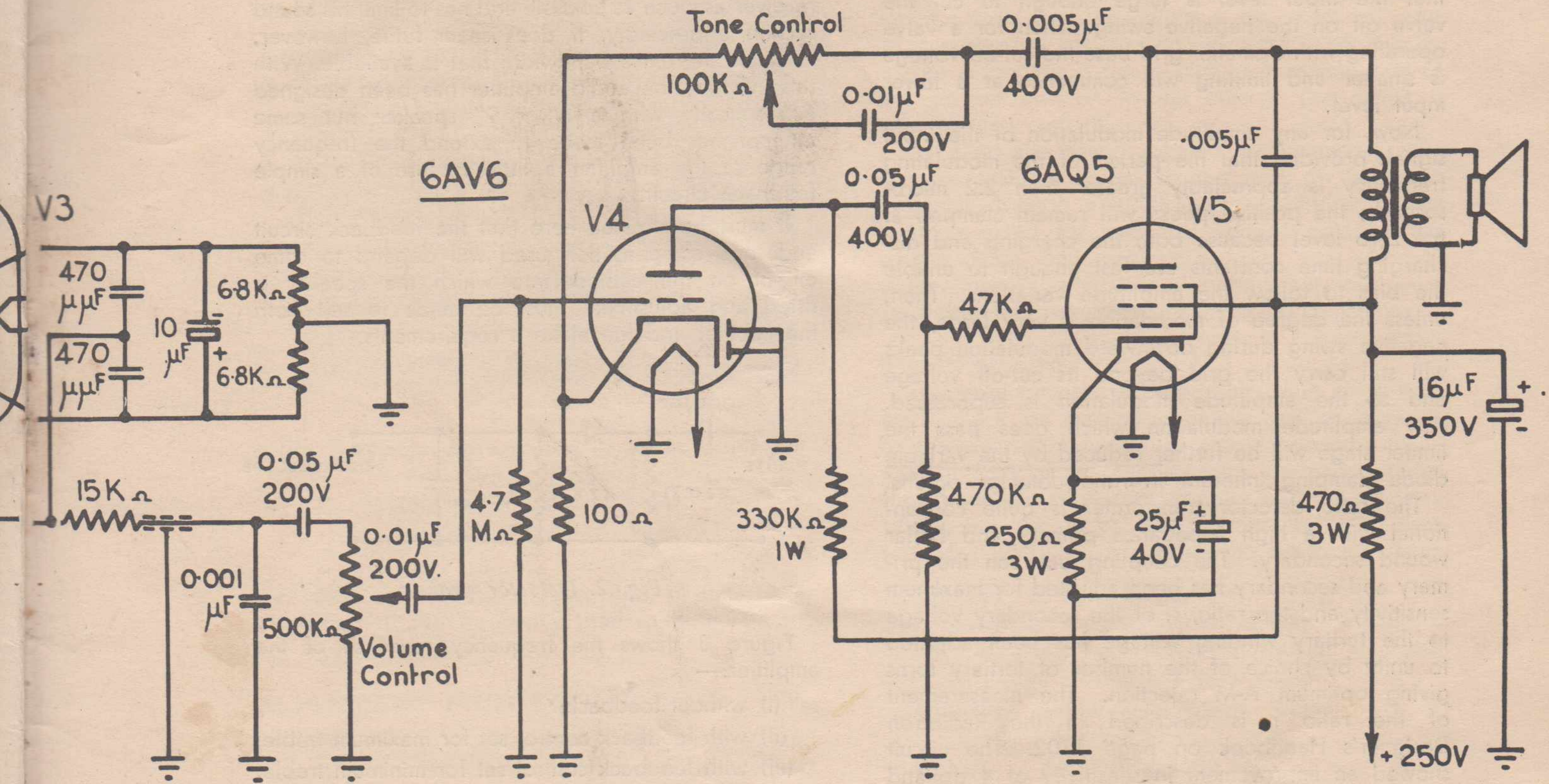
The take-off point for the circuit described here is a high impedance winding tuned to 5.5 Mc/s and coupled to the trap in the video amplifier cathode.[4] This system does not utilise the gain of the video amplifier but provides a step up of two times from the video amplifier grid. This step up could be obtained from a tapped transformer in the video detector output circuit, but it is more convenient to use the cathode trap and save complicating the detector circuit.

## DESCRIPTION OF CIRCUIT.

The circuit is shown in Fig. 1.

**Sound I-F Amplifier Stage.**

This stage is a single tuned 6AU6 amplifier fed from the secondary of the sound take-off transformer and has a gain of 40. By using a higher inductance and smaller tuning capacitor the gain of this stage could be almost doubled but considerable detuning is then experienced when the input level changes. This detuning is caused by input impedance changes in the following (limiter) stage as the level changes and can be quite high. As the gain requirement of this stage is not extremely high, as will be seen later, it is desirable to reduce this detuning effect at the expense of some stage gain as has been done in this circuit. The detuning for a change in input from 3·1 mV to 100 mV was found to be 80 Kc/s whereas for a higher impedance circuit tuning with 12 μμF it was 200 Kc/s.




When measurements are made without the take-off transformer connected a d.c. grid return must be provided for this stage — say a 100,000 ohm resistor. The total bandwidth must be about four times the maximum deviation frequency which for the Australian system is 50 Kc/s thus giving a requirement of 200 Kc/s. If a vacuum tube milli-voltmeter with a diode probe suitable for working at a frequency of 5.5 Mc/s is available, the band-width of this stage can be measured directly by noting the change in input frequency between the points where the output measured at the plate (with the V.T.V.M.) is 3 db down. If such a meter is not available a diode detector as shown in Fig. 2 can be connected to the plate of the following stage. (The 220 ohm resistor which damps out the effect of the ratio detector primary could be larger, say 1000 ohm. The lower value was chosen because such a detector is used in the video i-f amplifier alignment.)[5] The input frequency can be varied as before to find the bandwidth between 3 db points measured with a direct voltmeter at the detector output or a sweep generator input can be used, the detector output being observed on an oscillo-scope and the bandwidth determined by use of a marker generator. These measurements should be done at a low input level, say 1 mV, to eliminate limiting at the grid of the following stage. The stage in the amplifier described here has a band-width of 200 Kc/s.

**Limiter Stage and Ratio Detector.**

As mentioned previously the limiter stage acts as an amplifier at low input levels. The level at which limiting commences depends on the grid base of the valve. The more remote the cut-off, the higher will be the input level at which limiting com-mences. The limiting level can be reduced by shortening the grid base. This is achieved by re-ducing the screen voltage of the valve. To enable the valve to act as an amplifier for low levels the screen voltage in this case is kept fairly high at 120 volts. The valve then begins to limit at an input level of from 0.6 to 1 volt at its grid. The high gain of the preceding stage should ensure that the input is always maintained well above this level except in very extreme conditions.

Limiting is achieved by using a coupling time constant in the grid circuit which is long compared with the carrier frequency but very short compared with any amplitude modulation likely to be super-imposed on the carrier. The 47 μμF and 47,000 ohm combination used has a time constant of 2.2 micro-seconds. A bias is developed by grid current which flows on positive peaks of the input signal and causes the coupling capacitor to charge. The charging time constant is the capacitance times the input impedance of the valve during this grid current flow and is hence smaller than the dis-charge time constant of 2.2 microseconds. The bias developed is just large enough to clamp the positive peaks at the zero bias level. The plate current of the valve then varies from that for zero bias to cut-off current during each cycle provided that the input level is large enough to cut the valve off on the negative swing. Then for a valve operating with a smaller grid base the cut-off voltage is smaller and limiting will commence at a lower input level.

Now, for any amplitude modulation of the input signal, provided that the period of the modulating frequency is appreciably greater than 2.2 microseconds, the positive peaks will remain clamped at the zero level because both the charging and discharging time constants are fast enough to enable the bias to follow the amplitude variations. Then, unless the degree of modulation is very large, the negative swing during downward modulation peaks will still carry the grid beyond its cut-off voltage and so the amplitude modulation is suppressed. Any amplitude modulation which does pass the limiter stage will be further reduced by the variable diode damping inherent in ratio detector circuits.

The ratio detector transformer is quite conventional with a high impedance primary and bifilar wound secondary. The coupling between the primary and secondary has been adjusted for maximum sensitivity and the ratio, r, of the secondary voltage to the tertiary winding voltage has been adjusted to unity by choice of the number of tertiary turns giving optimum A-M rejection. The measurement of the ratio r is described in the Radiotron Designer's Handbook on page 1102. The circuit showed an improvement in sensitivity of 4 db and in A-M rejection of 20 db when the spacing between windings was changed from 0 to $\frac{1}{8}$" and r altered from 1.4 to 1.

The measurement of A-M rejection was done in a manner different from that normally used,[6] but one which is very simple if there is available a signal generator which can be set to produce either frequency or amplitude modulated output. The results, of course, are relative and cannot be compared with those obtained using other methods. With the circuit correctly aligned (the alignment procedure will be described later) feed a 5.5 Mc/s signal, frequency modulated to a deviation of 15 Kc/s (which is approximately 30% of the maximum deviation), to the grid of $V_1$ and adjust the input level to some point well below the limiting level and note the audio power (50 mW is a convenient level). Now switch from F-M to A-M and modulate to a depth of 30% and note the drop in audio output power. This will give the A-M rejection figure as mentioned above. A figure of 27 db was obtained for this circuit at an input level of 450 microvolts. As the input will normally be well above the limiting level the figure will be much greater than this in practice.

**Audio Amplifier.**

Television transmissions do not have the 5 Kc/s bandwidth restriction as in radio broadcasting and can utilise the full audio bandwidth. This means that a good audio section in a television receiver can produce some good quality sound on normal programmes. However, the receiver manufacturer is concerned with keeping down the cost of his receiver as much as possible and has to limit his sound section appreciably. It does seem futile, however, to waste the extra bandwidth that is available. With this in view, the audio amplifier has been designed economically with a 6" x 9" speaker but some attempt has been made to extend the frequency range of the amplifier a little by use of a simple feedback circuit.

It must be stressed here that the feedback circuit and tone compensation used will depend to some extent on the cabinet into which the speaker is fitted and adjustment must be made to suit both the cabinet and the maker's requirements.

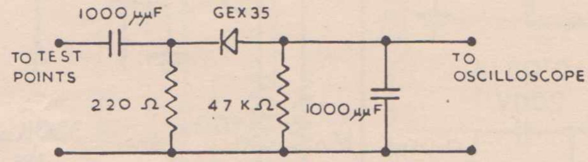



*Fig. 2. Detector probe.*

Figure 3 shows the frequency response of the amplifier:—

(i) without feedback;

(ii) with feedback control set for maximum treble;

(iii) with feedback control set for minimum treble.

Curve (ii) is the interesting curve. It will be seen that at 10 Kc/s the response is down 11 db relative to 500 c/s. This is too far down for good quality reproduction but can be effectively lifted by altering the de-emphasis network which precedes the audio amplifier. The use of pre-emphasis and de-emphasis is briefly explained here but is generally well known. Since the noise introduced in the early stages of the television receiver is mainly concentrated in the higher audio frequency region and the normal high frequency components in a typical programme are of much lower magnitude than the lower frequency components, the higher frequencies can be boosted relative to the low frequencies in the transmitter (pre-emphasised) and attenuated again in the receiver (de-emphasised) with the subsequent advantage that the noise introduced in the receiver is attenuated in the de-emphasis network with the wanted high frequency components resulting in a much improved signal to noise ratio. The time constant of both the pre-emphasis and de-emphasis networks in the Australian system is 50 microseconds.

Due to the shortcomings of the audio amplifier there is already some attenuation of the high frequencies which provides part of the de-emphasis required and which can be allowed for by using less de-emphasis in the R-C filter. A 15 microsecond time-constant has been used giving a lift of 5 db at 10 Kc/s over that which would be present using a 50 microsecond de-emphasis network. This effect can be seen in Figure 4 which shows three curves each obtained by measuring the current in

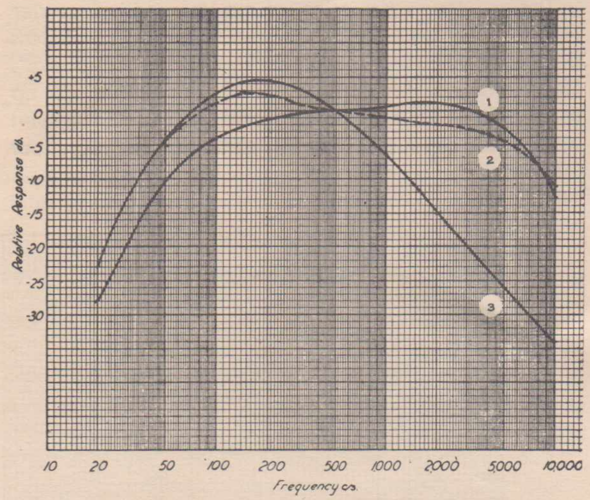



*Fig. 3. Frequency response of audio amplifier*
(i) *without feedback*
(ii) *for maximum treble*
(iii) *for minimum treble.*

the voice coil of the speaker and plotting it as a function of the frequency used to modulate the 5.5 Mc/s input signal.

## ALIGNMENT PROCEDURE:-

Connect a signal generator to the grid of $V_1$ and feed in a 5.5 Mc/s unmodulated carrier. Connect a meter of impedance at least 10,000 ohms per volt to read the direct voltage developed across either of the two 6,800 ohm load resistances. An input voltage of about 5 millivolts should produce a direct voltage of 3 to 4 volts across each of the resistors. Tune the coil $L_1$ for maximum d.c. output. Then tune first the primary and then the secondary of $T_2$ for maximum d.c. output. Now connect the meter across the de-emphasis capacitor and, using the most sensitive range of the meter, tune the secondary carefully for zero direct voltage on the meter. (Note that the output at this point will pass from positive to negative or vice-versa rather quickly as the secondary is tuned slightly from one side of the correct position to the other.) The circuit is now aligned correctly.

To align the sound take-off transformer $T_1$ the 5.5 Mc/s signal is fed to the grid of the video amplifier through a 1000 $\mu\mu$F capacitor and each winding tuned for maximum voltage across either of the diode load resistors.

In aligning both $L_1$ and $T_1$ the input level must be below that required for limiting to commence.

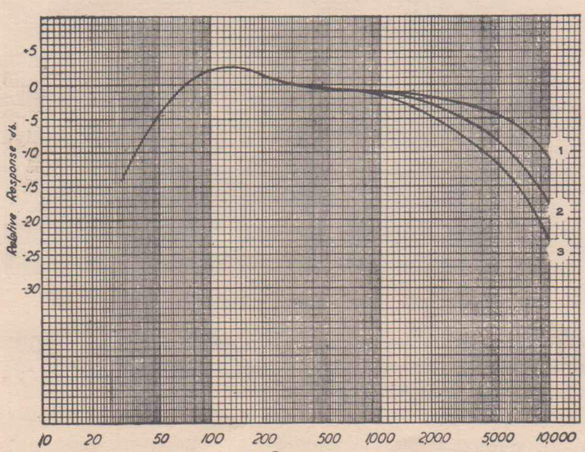



*Fig. 4. Overall response showing effect of de-emphasis*
(i) *no de-emphasis*
(ii) *15 µsecs de-emphasis*
(iii) *47 µsecs de-emphasis*

## MEASUREMENTS.

The measurements recorded here were made both as a check on the performance and as a guide to readers who may wish to check the circuit themselves. Many of the measurements are made without the feedback connected mainly because of simplicity, but also to provide a means of comparison for those who wish to modify the feedback circuit.

### Sensitivities For Each Stage.

Measurements of the input to each stage for 50 mW audio output were taken without the feedback connected. These are listed below:—

| Sensitivity | Input to Grid of | Signal |
|---|---|---|
| 900 mV | 6AQ5 ($V_5$) | 1000 c/s |
| 14 mV | 6AV6 ($V_4$) | 1000 c/s |
| 18 mV | 6AU6 ($V_2$) | 5.5 Mc/s; $\Delta f = 15$ Kc/s |
| 450 $\mu$V | 6AU6 ($V_1$) | 5.5 Mc/s; $\Delta f = 15$ Kc/s |

Feedback at 1000 c/s is 7 db with feedback control in maximum treble position and 12 db for minimum treble.

### Input Versus Output Curve.

The limiting action of $V_2$ can be seen in Figure 5 which shows the ratio detector output plotted as a function of the input to the grid of $V_1$. The output was actually measured at the 6AQ5 plate on a power output meter but the audio signal was attenuated in 10 db steps at the volume control each time the output reached 50 mW and the 10 db added to all subsequent readings. The limiting level can be obtained readily from this curve. Also, if a high impedance a.c. voltmeter is not available the curve can be used to determine the maximum audio output voltage from the ratio detector.

This is done as follows:—

Input to $V_4$ grid for 50 mW output
$= 14$ mV

Increase in ratio detector output over this level
$= 36$ db from curve

Hence maximum audio output from ratio detector
$= 14 \text{ mV} + 36 \text{ db}$
$= 880$ mV

The actual voltage at which the second stage begins to limit cannot be measured accurately by feeding a signal into the grid because the different source impedance will effect the result. As well as this, not many signal generators have sufficient output for this purpose. However, the level can be obtained from the curve as follows:—

Gain of $V_1$ from previous measurements

$$= \frac{18 \times 10^{-3}}{450 \times 10^{-6}}$$

$$= 40$$

Input to $V_1$ at which limiting is fully effective

$$= 45 \text{ mV from curve}$$

Therefore, the input to $V_2$ at which limiting is fully effective

$$= 45 \times 40 \text{ mV}$$

$$= 1.8 \text{ volts}$$

This level could be reduced by working $V_2$ at a lower screen voltage, as mentioned previously, but this would result in reduced sensitivity.

The maximum voltage output from the sound take-off transformer will normally be less than 100 millivolts and hence the need for the first stage is apparent where good sound reception is required particularly in weak signal areas.

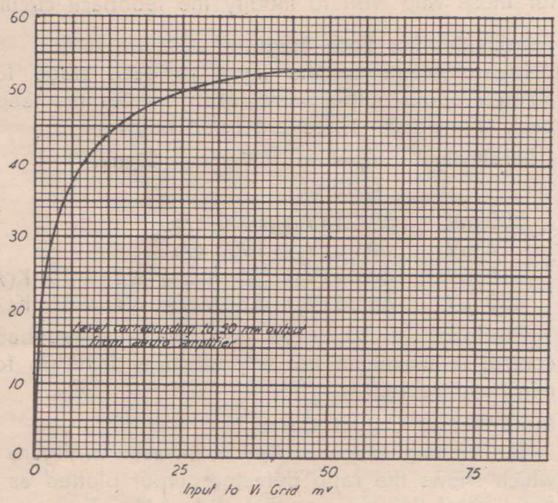



*Fig. 5. I-F input versus A-F output (deviation 15 Kc/s; feedback disconnected).*

**Distortion Measurements.**

For all distortion measurements the signal generator used was externally modulated by a low distortion oscillator. The distortion introduced in the modulation process was found to be reasonably small. Each measurement was done with the feed-back control set for maximum treble to produce the worst conditions. The input was 100 mV in each case but the distortion was found to be independent of input level. The distortion was measured on a distortion meter connected across the voice coil.

Figure 6 shows the distortion as a function of deviation. The output power of the audio amplifier was limited to 50 mW by the volume control during the test to ensure that the increase in distortion measured was due to the ratio detector circuit alone.

The maximum deviation of the transmitted carrier is 50 Kc/s. At this deviation the distortion is less than 2% ensuring good reproduction of "peaks". The distortion is still below 10% for deviations up to 125 Kc/s thus ensuring good reproduction even when the ratio detector is detuned up to about 100 Kc/s.

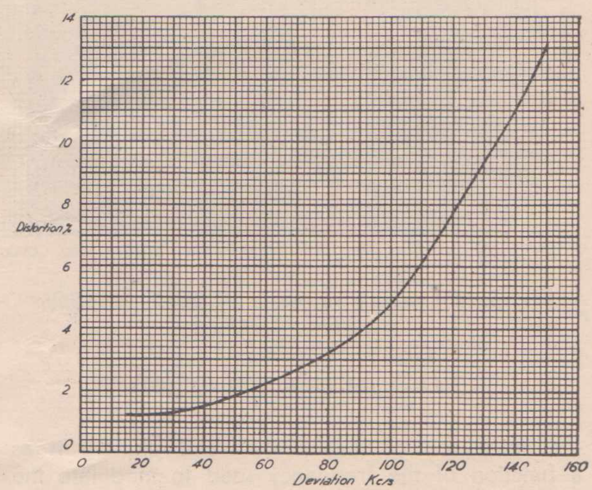



*Fig. 6. Distortion versus deviation (input 100 mV, output 50 mW, modulating frequency 1 Kc/s).*

Figure 7 shows the distortion as a function of output power measured at the plate of the 6AQ5. The deviation was maintained at 15 Kc/s during these measurements and the output power controlled by the volume control. At a level of 2 watts the distortion was only 2.5% which, combined with the distortion at large deviations still ensures quite good reproduction.

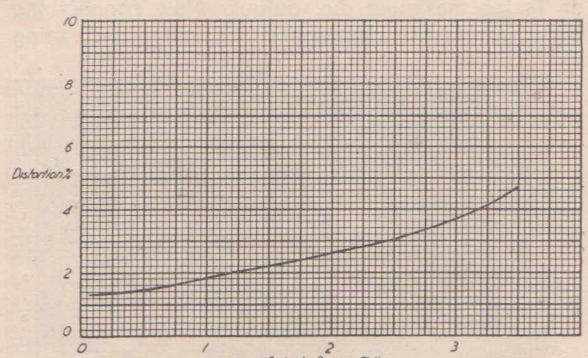



*Fig. 7. Distortion versus output power (input 100 mW, deviation 15 Kc/s, modulating frequency 1 Kc/s).*

**Peak Separation.**

The peak separation can be measured by one of three different methods. The first and simplest is to observe the audio output from the ratio detector on an oscilloscope while increasing the deviation of the 5.5 Mc/s input signal. When the audio output waveform becomes flattened on both peaks the deviation is equal to half the peak separation. Using this method, the peak separation measured was 200 Kc/s.

If this method cannot be used due to lack of a suitable signal generator, the response of the ratio detector can be plotted in the following manner:—

Feed a 5.5 Mc/s carrier into the grid of $V_1$ at a level above the limiting level — say 100 mV. This high level is used to eliminate the effect of the first stage. Measure the direct voltage across the two diode load resistors in series. Connect a battery equal to this voltage across these two resistors of such a polarity that the voltage will be maintained constant. Now vary the input in 20 Kc/s steps from 5.3 Mc/s to 5.7 Mc/s and note the direct voltage across the de-emphasis capacitor each time. By plotting the output obtained in this manner against the input frequency the response curve of the ratio detector will be obtained and the peak separation can be measured. The response obtained is illustrated in Figure 8. It will be noted that the peak separation is 225 Kc/s.

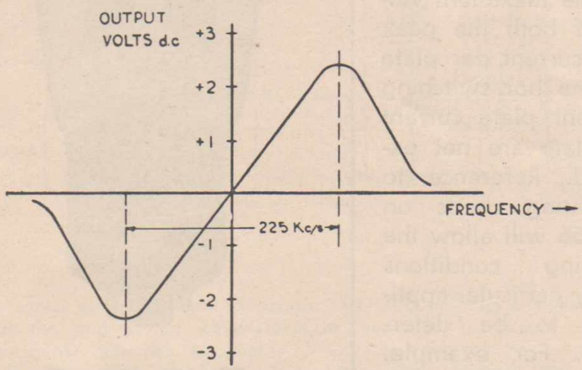



*Fig. 8. Ratio detector response showing peak separation (10 mV input to grid $V_1$).*

The third method is to feed a sweep generator into the grid of the first stage with a frequency deviation of at least ± 200 Kc/s at a centre frequency of 5.5 Mc/s. By observing the voltage across the de-emphasis capacitor on an oscilloscope and feeding in separate markers to the amplifier, the peak to peak separation can be measured.

It is interesting to note that as the signal input level is increased up to the limiting level, the diode damping of the secondary will be heavier and the peak separation will increase. However, above this level the damping, and hence the bandwidth, of the ratio detector will remain almost constant.

## DETAILS OF COILS.

All formers $\frac{17}{64}$″ outside diameter.
All cores Vitriflex.
Cans $\frac{3}{4}$″ square.

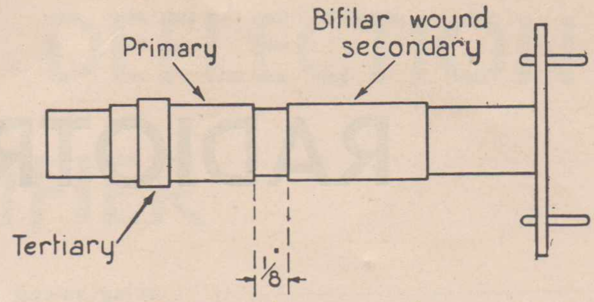



*Fig. 9. Ratio detector transformer.*

**Sound Take-Off Transformer—T1.**

| | | |
|---|---|---|
| Primary | 6 turns | 18 S.W.G. Tinned copper wire. Length of winding $\frac{3}{8}$″. Tune with 2,200 $\mu\mu$F. |
| Secondary | 60 turns | 30 S.W.G. Cotton covered enamelled copper wire. $\frac{1}{8}$″ Pie winding. Tune with 10 $\mu\mu$F. |
| Spacing $\frac{1}{4}$″ | | Both windings tunable. |
| $L_1$ | 65 turns | 34 B & S enamelled copper wire — close wound — tunable. Tune with 12 $\mu\mu$F capacitor. |

**Ratio Detector Transformer—T2.**

(See Figure 9.)

| | | |
|---|---|---|
| Primary | 63 turns | 34 B & S enamelled copper wire — close wound. Tune with 33 $\mu\mu$F capacitor. |
| Secondary | 20 turns | Bifilar wound. One winding using 33 B & S nylon covered copper wire and the other using 34 B & S bare copper wire. Tune with 82 $\mu\mu$F. Spacing $\frac{1}{8}$″. |
| Tertiary | 8 turns | 33 B & S nylon covered wire wound $\frac{1}{8}$″ from outside end and directly on primary. |

## ACKNOWLEDGMENTS.

In conclusion I wish to acknowledge the work done by Mr. E. Pietor who assisted in the development of this circuit and carried out the various measurements and to thank him and other members of the Applications Laboratory staff who have assisted in the preparation of this material. I also wish to thank Mr. J. Patterson, of Bondi, who supplied the coils used in this circuit.

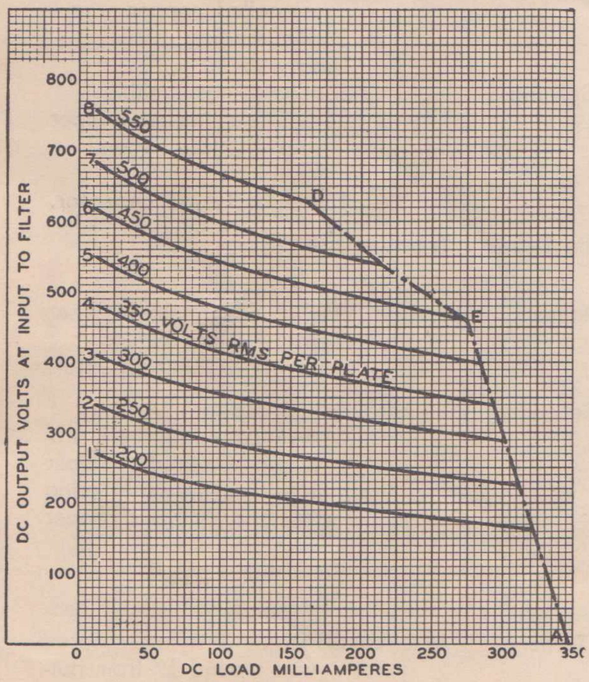
### REFERENCES.

1. R.C.A. Review, June, 1947.
2. Radiotron Designer's Handbook, p. 1095.
3. K. R. Sturley, Wireless World, November, 1955.
4. Radiotronics, April, 1957.
5. Radiotronics, December, 1956.
6. Radiotron Designer's Handbook, p. 1103.

# RADIOTRON 5AS4

**The Radiotron 5AS4 is a full-wave vacuum rectifier of the filamentary cathode type intended for use in the power supplies of television receivers and in electronic equipment having high direct current requirements.**

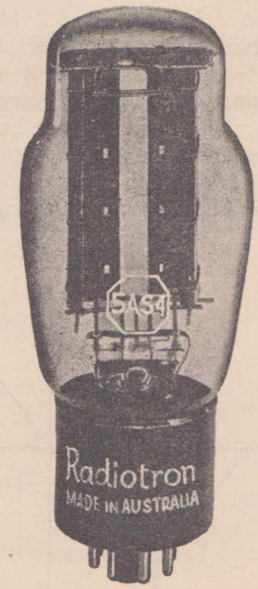
**The maximum ratings of the 5AS4 allow it to supply, using a capacitor input filter, a direct current load of 300 mA at an output of 290 volts d.c. (input to filter).**




Operation Characteristics—Full-wave circuit, capacitor input to filter = 40μF

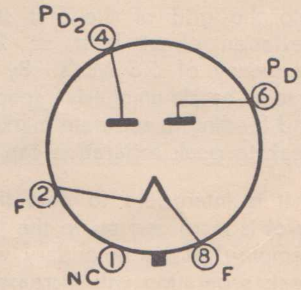
When a capacitor input filter is used, care should be taken to see that the maximum values of both the peak plate current per plate and the hot switching transient plate current per plate are not exceeded. Reference to the rating charts on page 56 will allow the operating conditions for any particular application to be determined. For example, suppose a 5AS4 is to be used in a T.V. receiver with the following low voltage power supply requirements: Filter input capacitance = 40 μF, voltage at input to filter = 300 volts, current drain = 275 mA. The curves show that using a full-wave arrangement for a direct load current of 275 mA, and a direct output voltage of 300 volts, an alternating voltage of about 310 volts r.m.s. per plate will be required.

A check should be made to make sure that the two peak current maxima are not exceeded, using the Rating Charts on page 56.




**5AS4**

**PIN CONNECTIONS**




**(bottom view)**

Pin 1—No connection.
Pin 2—Filament.
Pin 4—Plate No. 2.
Pin 6—Plate No. 1.
Pin 8—Filament.

## GENERAL DATA

**ELECTRICAL:**

| | |
|---|---|
| FILAMENT VOLTAGE | 5 volts a.c. or d.c. |
| FILAMENT CURRENT | 3 amps. |

**MAXIMUM RATINGS:**

| | |
|---|---|
| PEAK INVERSE PLATE VOLTAGE | 1550 max. volts |
| STEADY STATE PEAK CURRENT PER PLATE | 1.0 max. amp |
| A.C. PLATE VOLTAGE (R.M.S.) PER PLATE | 550 max. volts |
| TRANSIENT PEAK PLATE CURRENT PER PLATE | 4.6 max. amp. |

(Continued on page 56)

# HORIZONTAL DEFLECTION AMPLIFIER

**The Radiotron 6BQ6GTB/6CU6 is a high perveance beam power valve designed especially for use in horizontal deflection amplifier service of television receivers. Design features include a mount structure which permits cool operation of both grids to guard against grid emission. The plate structure is such that heat is distributed evenly and not localised to form hot spots.**

**These factors, in conjunction with high design ratings enable this valve to deflect picture tubes having deflection angles up to 90 degrees.**

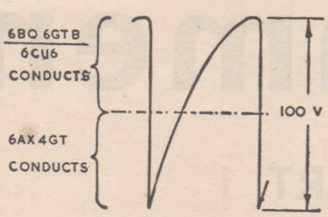



Figure 1

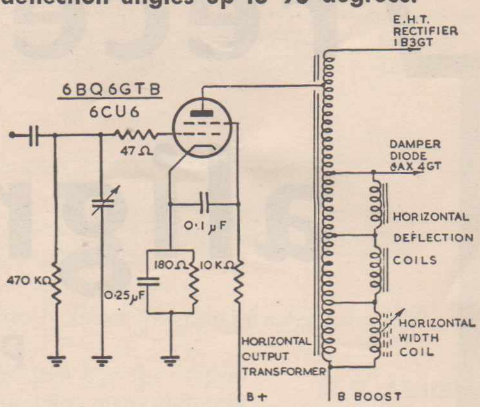



Figure 2

The horizontal sweep oscillator (Radiotron 6SN7GTA) provides a signal of roughly sawtooth form to the grid of the 6BQ6GTB/6CU6 (see Fig. 1). (Figure 2 is a typical circuit of a horizontal deflection amplifier.)

During the first half of the negative but positive going sawtooth, the valve is biased beyond cut-off (for this period, the 6AX4GT damper diode provides current to the deflection coils — see earlier article). As the input signal becomes less negative, the 6BQ6GTB/6CU6 commences to conduct. The output current is transformed through the horizontal output transformer into the deflection coils of the yoke to provide the second half of the sweep.

Due to the sawtooth form of the input signal, the peak current that is drawn by the plate may be 3.5 times the average current.

At the peak of the signal, which corresponds to the end of the horizontal sweep, the sudden negative pulse cuts the output valve off. This change in current through the output transformer, taking place during a few microseconds, results in a high peak voltage on the plate of the 6BQ6GTB/6CU6. This valve is designed to withstand a peak positive pulse plate voltage of 6000 volts.

**CHARACTERISTICS:**

| | |
|---|---|
| **Heater Voltage** | **6.3 volts** |
| **Heater Current** | **1.2 amps.** |

**MAXIMUM RATINGS (Horizontal Deflection Amplifier):**

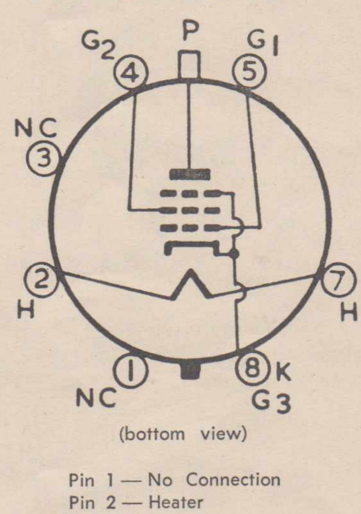
| | |
|---|---|
| **Direct Plate Voltage** | **600 volts** |
| **Peak Positive-Pulse Plate Voltage *(abs. max)** | **6000 volts** |
| **Peak Negative-Pulse Plate Voltage** | **1250 volts** |
| **Direct Grid No. 2 Voltage** | **200 volts** |
| **Peak Negative-Pulse Grid No. 1 Voltage** | **300 volts** |
| **Peak Cathode Current** | **400 mA** |
| **Average Cathode Current** | **112.5 mA** |
| **Plate Dissipation** | **11 watts** |
| **Grid No. 2 Input** | **2.5 watts** |

IN R+H Set 160ma

*** The duration of the voltage must not exceed 15 per cent. of one horizontal scanning cycle. In a 625 line, 25 frame system, 15 per cent. of one horizontal scanning cycle is 10$\mu$ sec.**

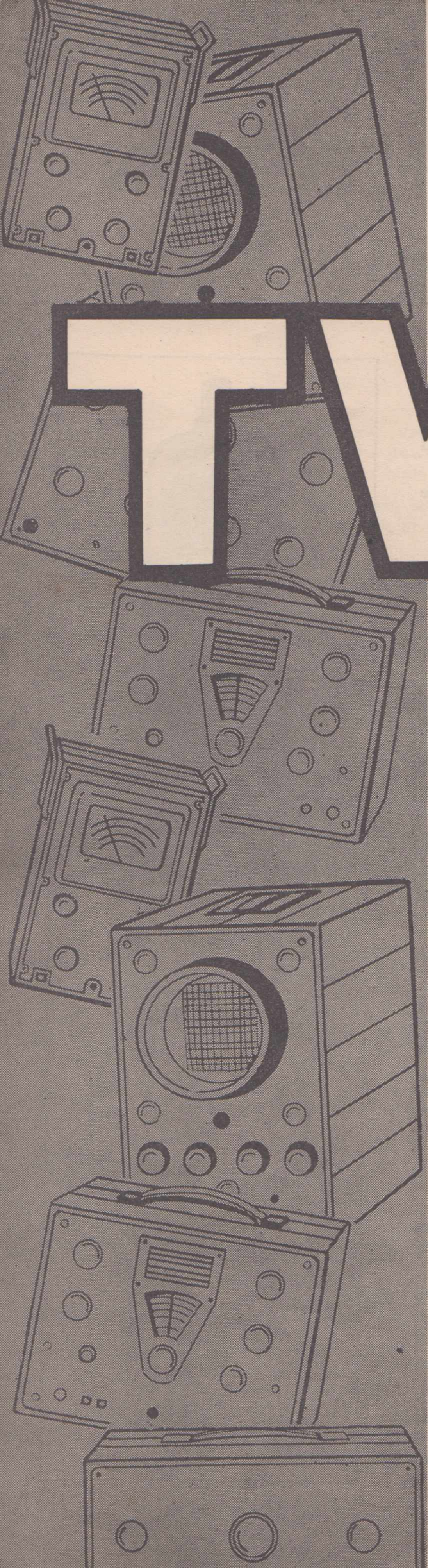

**6BQ6GTB/6CU6**

SOCKET CONNECTIONS




(bottom view)

Pin 1 — No Connection
Pin 2 — Heater
Pin 3 — No Connection
Pin 4 — Grid No. 2
Pin 5 — Grid No. 1
Pin 7 — Heater
Pin 8 — Cathode, Grid No. 3
Cap — Plate



# TV receiver alignment


A two-part article by
C. HAMMER
(Test Instrument Section, A.W.A.)


## PART 1

### GENERAL.

This article has been prepared for all those concerned with the adjustment of television receivers, whether they be professional service men, whose main task is the correction of faults in their customers' euipment, or home constructors faced with the task of setting up their receivers to give the best possible picture.

The alignment and general servicing of television receivers requires the use of techniques which differ from those used in general radio servicing. Although the television receiver is more complex than the conventional radio the servicing of these receivers is greatly simplified by the use of special television test equipment.

To properly service the television receiver the following test instruments are listed as being outstanding facilities for the television service test bench.

(1) Television Sweep Generator

(2) Cathode Ray Oscilloscope

(3) Television Crystal Calibrated Marker Generator

(4) Voltohmyst with High Voltage Probe

(5) Universal Measuring Bridge.

## USE AND APPLICATION OF SWEEP GENERATOR.

In conjunction with a suitable cathode ray oscilloscope, the sweep generator is used for the visual checking and alignment of television or f-m receivers, aerials and feeders. The main radio frequency output embraces the television bands in the approximate range 50 Mc/s to 250 Mc/s with fundamental signals on all TV channels.

A block diagram of a typical television receiver omitting sync circuitry is shown in Fig. 1.

The initial alignment of stagger tuned i-f systems is generally achieved with an unmodulated Rf source, each circuit being peaked at the frequency recommended by the manufacturer; final alignment can be achieved with the sweep generator, marker generator and an oscilloscope, and working back from the picture second detector.

The alignment of the sound channel in the television receiver is accomplished in the same manner as in conventional f-m practice, a procedure described below under "Sound I-F and Discriminator Stages".

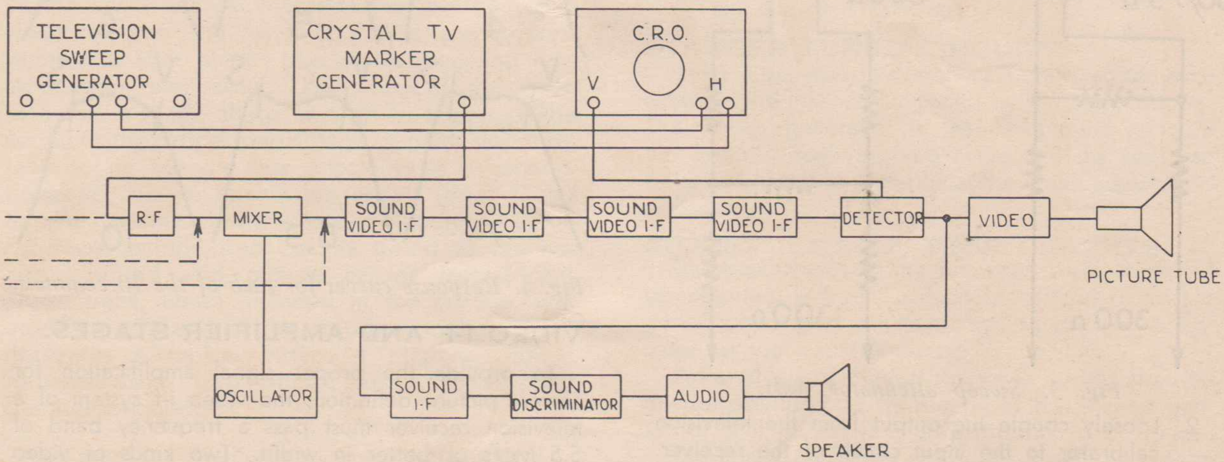



*Fig. 1. Block diagram of a typical television receiver.*

Although most receivers in use can be represented by such a diagram, in practice many different variations will be found. This is particularly true in intercarrier (video i-f) amplifier circuits where the stages may have been coupled, stagger tuned, or combinations of these arrangements. Therefore, when aligning a television receiver, it is necessary to follow closely the manufacturer's service notes. The information below will enable the serviceman to adapt his television sweep generator to the receiver under test. The reader is cautioned that the aligning of any portion of a television receiver should not be attempted unless previous analysis of the difficulty shows alignment to be necessary.

Distortion of the response curve will occur if too large a signal is applied to the receiver from the sweep generator. This is due to overload in the last video i-f amplifier. To check overload, reduce the input from the sweep generator to the receiver until the output seen on the C.R.O. is halved. Increase the C.R.O. vertical amplifier gain to restore the pattern to its original size. If the shape of the response curve alters, then overload is occuring. In most receivers, overload occurs when the output from the video detector exceeds 10-15 volts p/p; most service manuals specify alignment with an output voltage of 2-5 volts p/p.

Alignment should also be carried out at the bias specified in the service manual. This will be 2-5 volts which corresponds to the bias the receiver would develop with an average signal, 10-30mV.

## R-F ALIGNMENT.

By comparing the r-f response curve of the television receiver under test with the response curve illustrated in the manufacturer's service notes, the serviceman can readily determine the circuit adjustments necessary for proper r-f alignment. The procedure outlined below is a typical method of utilizing the television sweep generator to the receiver under test to produce an r-f response curve.

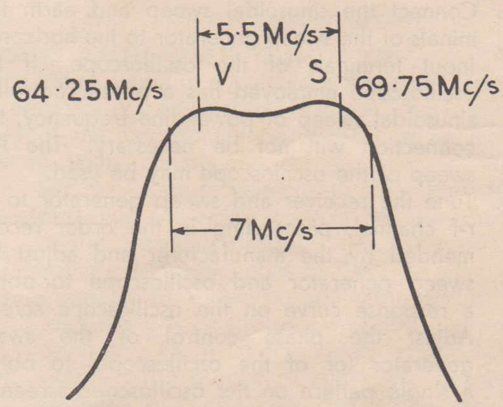



*Fig. 2. Response curve of r-f stage (tuned to channel 2).*

Fig. 2 shows a response curve for the r-f stage of a typical television receiver which for purposes of illustration is tuned to channel 2. Note the 5.5 Mc/s separation between the sound and video carriers. Since the r-f portion of the receiver must pass both sound and picture signals a channel width of approximately 7 Mc/s is required.

1. Connect the r-f output cable of the sweep generator to the antenna terminals of the receiver via a suitable matching pad where necessary. See Fig. 3.

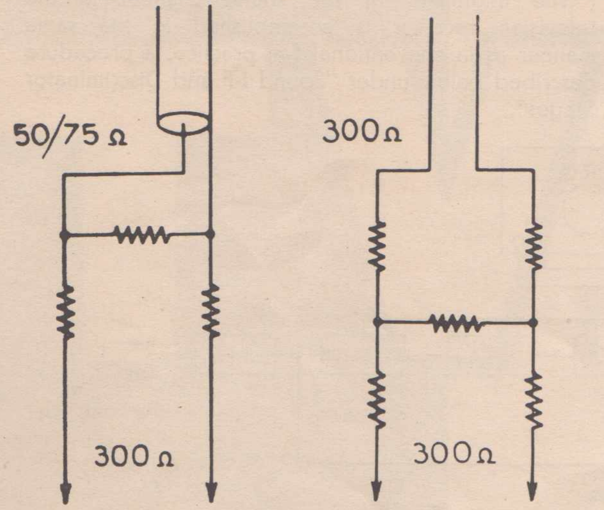



*Fig. 3. Sweep attenuator pads.*

2. Loosely couple the output from the television calibrator to the input circuit of the receiver. This can usually be done by connecting the ground clip of the calibrator to the receiver chassis and placing the active lead near the antenna circuit of the receiver.
3. Connect the vertical input circuit of the oscilloscope to an appropriate point in the receiver for viewing the r-f response. This connection will vary with different receivers, reference should be made to the manufacturer's service notes. In some sets it may be possible to pick up the signal directly from the converter (or mixer) grid circuit, while in others it may be necessary to modify the converter circuit temporarily in order to obtain the signal.
4. Connect the sinusoidal sweep and earth terminals of the sweep generator to the horizontal input terminals of the oscilloscope. If the oscilloscope employed has a phase controlled sinusoidal sweep of power line frequency, this connection will not be necessary. The line sweep of the oscilloscope may be used.
5. Tune the receiver and sweep generator to an r-f channel, proceeding in the order recommended by the manufacturer and adjust the sweep generator and oscilloscope to obtain a response curve on the oscilloscope screen. Adjust the phase control of the sweep generator (or of the oscilloscope) to obtain a single pattern on the oscilloscope screen.
6. The picture carrier and sound carrier pips from the television calibrator should appear within the flat-topped portion of the response curve of each channel, at points indicated in Fig. 4. (These will vary with every receiver.)

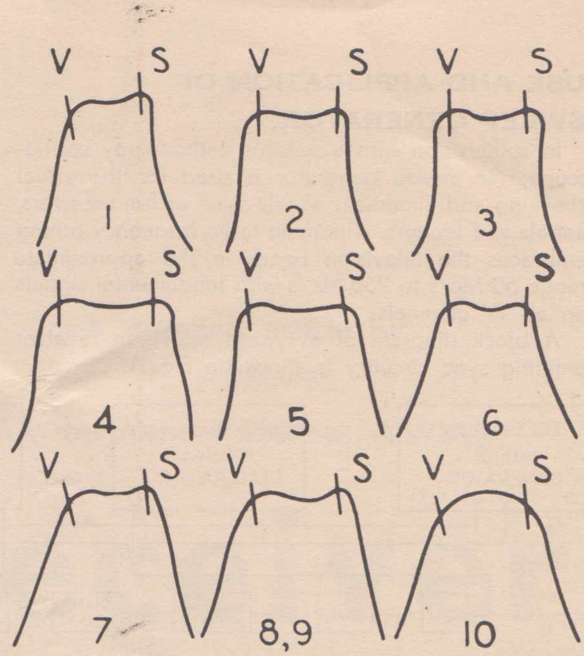



*Fig. 4. Response curves for each of the 10 channels.*

## VIDEO I-F AND AMPLIFIER STAGES.

To provide the proper signal amplification for correct picture definition, the video i-f system of a television receiver must pass a frequency band of 5.5 Mc/s or better in width. Two kinds of video i-f systems are generally used to give the necessary bandwidth. In the over coupled system, both the primary and secondary of the coupling transformers are tuned to the same frequency and the transformers are over coupled to pass the 5.5 Mc/s band. In the stagger tuned system, successive i-f stages are tuned to different frequencies producing a final overall i-f response of the proper bandwidth. Reference to the manufacturer's notes will indicate which system is used in the particular receiver under test.

A hypothetical response curve for the video i-f channel of a typical television receiver is shown in Fig. 5. In this case the receiver employs a video intermediate frequency of 36 Mc/s and is tuned to channel 2.

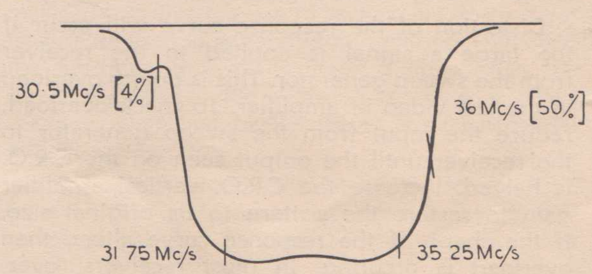



*Fig. 5. Video i-f response curve.*

## VIDEO I-F RESPONSE CURVE.

The frequency relation of sound carrier to picture carrier is reversed in the i-f amplifier since the local oscillator operates at a higher frequency than the carrier.

The following two characteristics of the video i-f response curve should be noted:

(a) The video carrier frequency is set at 50% response because vestigial sideband transmission is used.

(b) The sound carrier frequency is usually less than 5% of maximum response.

If the circuit is adjusted to put the video carrier too high on the response curve, the effect will be a general decrease in picture quality. The low frequency response is increased relative to the high frequency response resulting in an overall reduction in bandwidth. Placing the picture carrier too low on the curve will cause loss in the low frequency video response and result in trailing and reversal with white after black. Loss of blanking and synchronisation may occur. The slope of the video i-f curve is made sharp enough to attenuate the sound to the proper percentage of peak response. In order to achieve this selectivity it is conventional to use an absorption circuit (trap) tuned to the sound intermediate frequency. Some receivers include trap circuits tuned to the adjacent sound and picture carrier frequencies. These traps, when included in the circuits, will modify the shape of the response curve. Fig. 6 illustrates a typical video i-f response for a receiver using trap circuits tuned to adjacent channel frequencies.

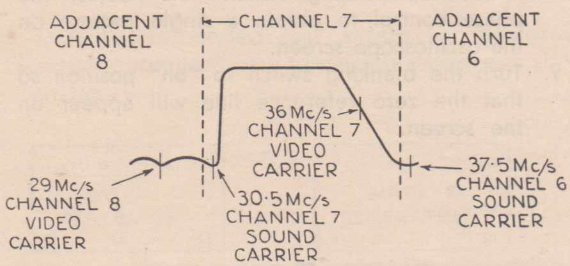



*Fig. 6. Video i-f response curve for a receiver using a trap circuit tuned to the adjacent channel frequencies.*

## OVER-COUPLED VIDEO I-F CIRCUITS.

The following procedure is suggested:

1. Adjust the sweep generator to cover the intermediate frequency range of the receiver under test.
2. Connect the i-f video output Cable to the input of the i-f system. Reference to the manufacturer's notes will indicate the exact point of signal injection for i-f alignment. The signal may be fed to the converter or mixer grid; the recommended feed-point may be shifted progressively from the in put of the last stage back to the converter. The design of some receivers is such that visual alignment of the i-f system is achieved only by feeding into the antenna circuit a signal at the channel frequency, which has been frequency modulated.
3. Loosely couple the output of the television calibrator to the input circuit of the receiver.
4. Connect the output of the video second detector to the vertical input terminals of the oscilloscope.
5. Connect the sinusoidal sweep and ground terminals of the sweep generator to the horizontal input terminals of the oscilloscope.
6. Adjust the test equipment to give the i-f response curve on the oscilloscope screen. With the blanking switch of the sweep generator at "OFF" position, adjust the phase control to produce a single pattern on the screen.
7. Adjust the i-f tuned circuits in order to obtain the response characteristics discussed above, checking the band width response, the trap positions, and the i-f carrier frequencies with the television calibrator.

## STAGGER TUNED CIRCUITS.

Using a suitable television calibrator, adjust each circuit in the manner suggested by the manufacturer. The sweep generator is then employed to give the overall visual response curve and the response curve analysed to determine the final adjustments necessary.

## ADJUSTMENT OF TRAP CIRCUITS.

The trap circuits in the television receiver should be adjusted with an accurately calibrated marker generator to give minimum reading on the oscilloscope at the trap frequency.

An analysis of overall response curve obtained on the oscilloscope by means of the sweep generator will reveal final adjustments to be made.

The final adjustments should be made to conform to an accepted response curve. If, for instance, the response is peaked in the middle of the picture carrier and the picture carrier is low on the response curve, the circuit tuned nearest the picture frequency should be adjusted to bring the carrier up on the curve.

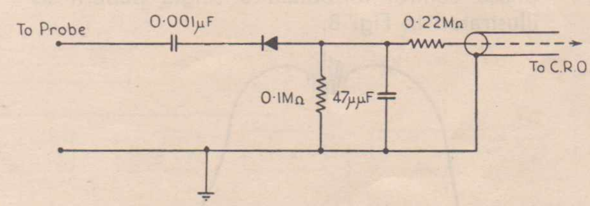



*Fig. 7. Crystal rectifier circuit.*

## VIDEO AMPLIFIER CIRCUITS.

The video amplifier circuits in a television receiver are normally not adjustable. However, the response curve of this circuit may be studied as an aid in locating faulty components.

1. Set the channel selector to the i-f position and the i-f video control to the proper centre frequency (about 3 Mc/s).
2. Set the blanking control ON.
3. Connect the video output cable across the load resistor of the video second detector: or to the input of the video amplifier.
4. Connect the output of the video amplifier through a crystal rectifier circuit to the vertical input terminals of an oscilloscope: a suggested crystal rectifier circuit is illustrated in Fig. 7.
5. The response curve of the sweep generator voltage frequency output requires retrace blanking in order to develop a usable display.

## SOUND I-F STAGES.

The alignment of the sound i-f and F-M detector is similar to the procedure adhered to for the conventional F-M receiver.

1. Set the Channel Selector of the television sweep generator to i-f position and the i-f video control to the proper intermediate frequency.
2. Connect the i-f video output cable to the input of the i-f stage which feeds the limiter, or to the input of the second last sound i-f stage. (Note: there may be no limiter.)
3. Connect the sinusoidal sweep and ground terminals to the horizontal input terminals of an oscilloscope and adjust the oscilloscope for external horizontal input.
4. Connect the vertical input terminals of the oscilloscope across the resistor in the grid circuit of the limiter tube. In some receivers, the time constant of the grid RC circuit of the limiter may be large enough to distort the pattern obtained when the output is taken from the i-f system at this point. If the pattern is distorted, temporarily remove the capacitor of the RC circuit or shunt the resistor with another resistor of suitable value to produce an undistorted output.
5. Adjust the sweep width for a total deviation of approximately 1 Mc/s.
6. Loosely couple the output from the marker generator to the same point at which the sweep generator is connected and tune the marker generator to the sound i-f.
7. With the blanking set to "off" adjust the phase control to obtain a single pattern as illustrated in Fig. 8.

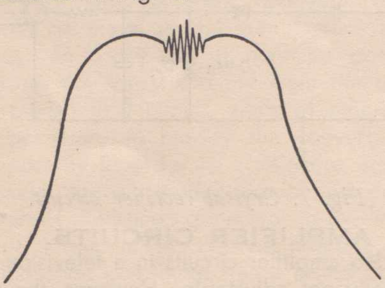


*Fig. 8. Marker pattern.*

8. Adjust cores for maximum amplitude and symmetry of pattern about the marker.
9. Connect the output from the sweep generator to the input of the i-f stage preceding the one just turned and align this circuit according to the above procedure.
10. Continue the alignment working through the i-f system toward the detector valve.

## DISCRIMINATOR ALIGNMENT.

After the i-f stages have been properly aligned, the discriminator circuit can be rapidly and efficiently adjusted by the visual method outlined below:—

1. Set the channel selector of the sweep generator to the i-f video control to the sound intermediate frequency.
2. Connect the i-f video output cable to the input of the limiter stage feeding the discriminator.
3. Connect the sinusoidal sweep and ground terminals to the horizontal input terminals of an oscilloscope, and adjust the oscilloscope for external horizontal input.
4. Loosely couple the output cable from a marker generator to the point at which the sweep generator is connected.
5. Connect the vertical input terminals of the oscilloscope to the discriminator circuit at points A and B. Fig. 9.

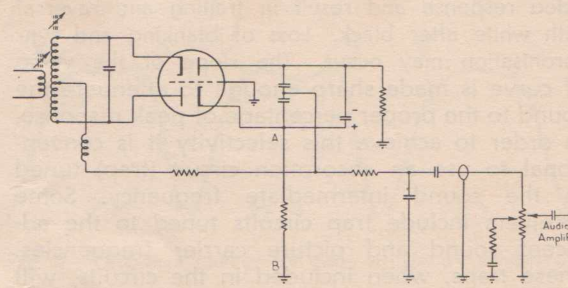



*Fig. 9. Typical TV discriminator circuit.*

6. Adjust the sweep width control for a total deviation of approximately 1 Mc/s.
7. With the blanking switch "off" adjust the phase control to obtain a single pattern on the oscilloscope screen.
9. Turn the blanking switch to "on" position so that the zero reference line will appear on the screen.

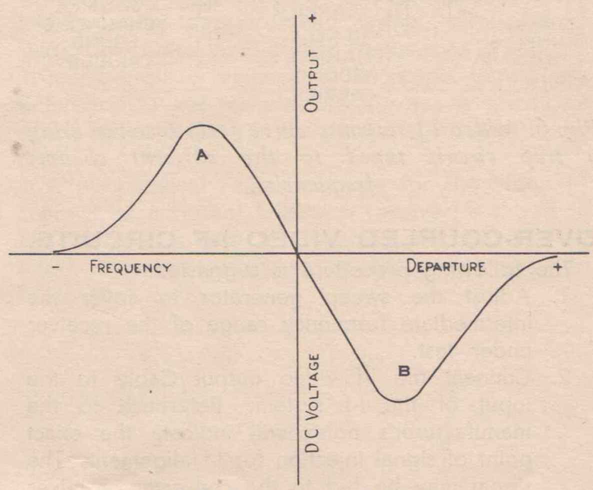



*Fig. 10. Ideal response of discriminator.*

9. The ideal response of a discriminator which has been properly aligned is illustrated in Fig. 10. The calibrator is used to check the points on the curve at which the various sweep frequencies appear. The sound i-f point should appear at the intersection of the response curve and the zero reference line. Tune primary and secondary of the Discriminator Transformer for maximum linearity between points A and B, Fig. 10, and symmetry about the zero reference line.

# TV receiver alignment

## PART 2

### GENERAL

The alignment of a television receiver or other equipment employing wide-band circuits necessitates a visual indication of the circuit band-pass characteristic. The visual alignment method can be used quickly and effectively and when a television calibrator is used with the sweep generator, alignment can be precise.

A recommended test set-up for performing visual alignment of a television receiver is shown in fig. 1.

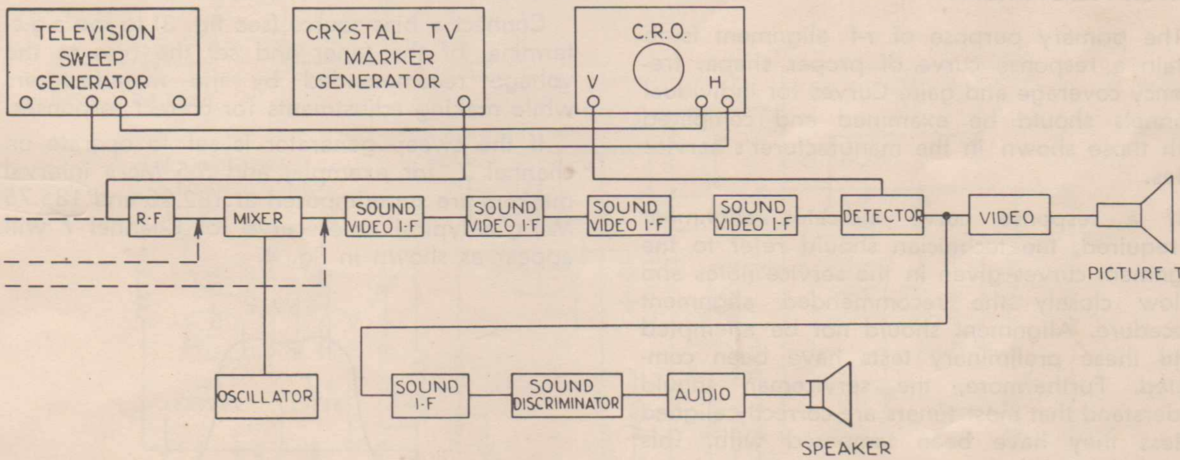



Fig. 1. Recommended Test Set-up.

When the sweep generator is tuned to sweep the band of frequencies normally passed by the wide-band circuits, a trace representing the response characteristic of the circuits will be displayed on the oscilloscope screen. The calibrator can be used to provide calibrated markers along the response curve for checking the frequency setting of traps, for adjustment of capacitors and inductors, and for measuring the overall bandwidth of the receiver.

When the marker signal from the calibrator is coupled into the circuit under test, a vertical "pip" or marker will appear on the curve. (A typical trace with markers is shown in fig. 2). When the calibrator is tuned to a frequency accepted by the receiver, the position of the marker will indicate the frequency on the sweep trace. The circuit components are then adjusted to obtain the desired wave shape, using the different frequency markers as check points.

The order in which various sections of the television receiver should be aligned may differ with receivers produced by different manufacturers. It is not possible therefore to recommend a single alignment procedure which can be applied with equal success to all television receivers.

The test instruments suggested for use in the visual alignment of television receivers are:—

1. Crystal Calibrated Marker Generator.
2. Cathode Ray Oscilloscope.
3. Television Sweep Generator.
4. Voltohmyst.

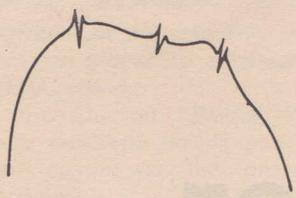


Fig. 2. Trace with markers.

The technical notes given in the following pages are designed for use with the manufacturer's service notes to aid the serviceman in aligning a receiver correctly and efficiently.

Before the alignment of the receiver can be performed it is necessary to make the operation of the automatic gain control ineffective and provide and artificial bias. Fig. 3 shows a typical bias box used for this purpose.

The use of an efficient earthing system in the alignment and adjustment of a television receiver cannot be overstressed. Every care should be taken to make the earthing lead of test probes as short as possible and confined to the section of the receiver under test. Stray fields present along the receiver chassis can introduce an f-m component on the cathode ray oscilloscope trace and cause interference to the response curve being examined.

## TUNER ALIGNMENT

The primary purpose of r-f alignment is to obtain a response curve of proper shape, frequency coverage and gain. Curves for individual channels should be examined and compared with those shown in the manufacturer's service notes.

If a response curve indicates alignment is required, the technician should refer to the alignment curves given in the service notes and follow closely the recommended alignment procedure. Alignment should not be attempted until these preliminary tests have been completed. Furthermore, the serviceman should understand that most tuners are correctly aligned unless they have been tampered with. This knowledge can often prevent misalignment of a good tuner. Most tuners merely require touch up alignment in which relatively few of the adjustments are used.

Generally, complete alignment is required only when an unskilled person with or without proper facilities has worked on the tuner. For a complete alignment of the tuner, it is desirable to follow a specific sequence of adjustments, the sequence depending on the type of tuner.

The complete front end alignment includes alignment of the antenna input circuits and adjustment of the amplifier and r-f oscillator circuits. Adjustments include setting the oscillator frequencies for channels 1 to 10, setting traps to predetermined frequencies and adjustment of tracking with the r-f amplifier.

All these adjustments require that a sweep signal from the sweep generator and marker signal from the crystal calibrated generator be fed into the tuner so that a response curve with markers will be reproduced on the oscilloscope screen.

For complete tuner alignment the tuner should preferably be removed from the receiver. Extension leads for B+, filament and earth connections to the tuner should be made. For final adjustment of oscillator frequencies, the procedure for adjustment may be carried out with covers in position and with the tuner mounted in position.

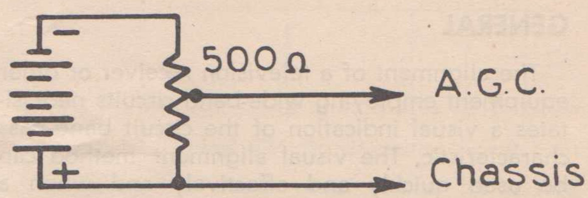



Fig. 3. Bias box.

Connect the sweep generator to the aerial input terminals of the matching, unit taking care to keep the leads to the termination of the sweep output cable as short as possible.

Connect a bias source (see fig. 3) to the a.g.c. terminal of the tuner and set the bias to the voltage recommended by the manufacturers while making adjustments for correct responses.

If the sweep generator is set to operate on channel 7, for example, and 5.5 Mc/s interval markers are superimposed at 182.25 and 185.75 Mc/s, a typical tuner curve for Channel 7 will appear as shown in fig. 4.

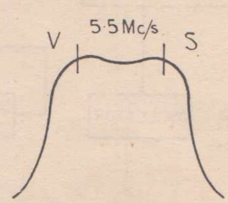



Fig. 4. Typical tuner curve.

The markers on the curve show the separation between the picture and sound carriers. Since the r-f sections of the receiver must pass the full transmitted bandwidth of both sound and picture carrier frequencies, a pass band of approximately 7 Mc/s is required.

The sound and picture carrier frequencies for the Australian Television Channels are shown in the accompanying table.

## AUSTRALIAN TELEVISION CHANNELS

| Channel No. | Picture Carrier Freq. Mc/s. | Sound Carrier Freq. Mc/s. | Osc. Freq. Mc/s. Receiver R-F |
|---|---|---|---|
| 1 | 50.25 | 55.75 | 86.25 |
| 2 | 64.25 | 69.75 | 100.25 |
| 3 | 86.25 | 91.75 | 122.25 |
| 4 | 133.25 | 138.75 | 169.25 |
| 5 | 140.25 | 145.75 | 176.25 |
| 6 | 175.25 | 180.75 | 211.25 |
| 7 | 182.25 | 187.75 | 218.25 |
| 8 | 189.25 | 194.75 | 225.25 |
| 9 | 196.25 | 201.75 | 232.25 |
| 10 | 210.25 | 215.75 | 246.25 |

The tuner oscillator alignment can readily be adjusted by loosely coupling the oscillator to the calibrated signal generator and beating the two signals.

A typical sequence to practice in the alignment of an incremental inductance type r-f tuner of a television receiver is described below:—

1. Connect a bias source to the a.g.c. terminal of the tuner and set the bias to the desired negative voltage (see fig. 5). The bias source should remain connected while making all adjustments for correct response. Connect the vertical input of the C.R.O. direct to the converter grid test point with a shielded lead. Earth the shield at the tuner.

2. Terminate the i-f coaxial cable with a 47 ohm composition resistor.

3. Switch on the power supply to the receiver and adjust voltages to conform to manufacturer's specifications e.g. 265 volts H.T. 6.3 volts filament and –3 volts bias.

4. Switch to the channel nominated for initial alignment (usually Channel 5 or 6) and turn the fine tuning capacitor to the middle of its range.

5. Loop an insulated wire or probe from the r-f input terminal of the calibrator around the glass envelope of the converter valve. Assuming channel 6 has been nominated the oscillator should be adjusted to beat at 211.25 Mc/s.

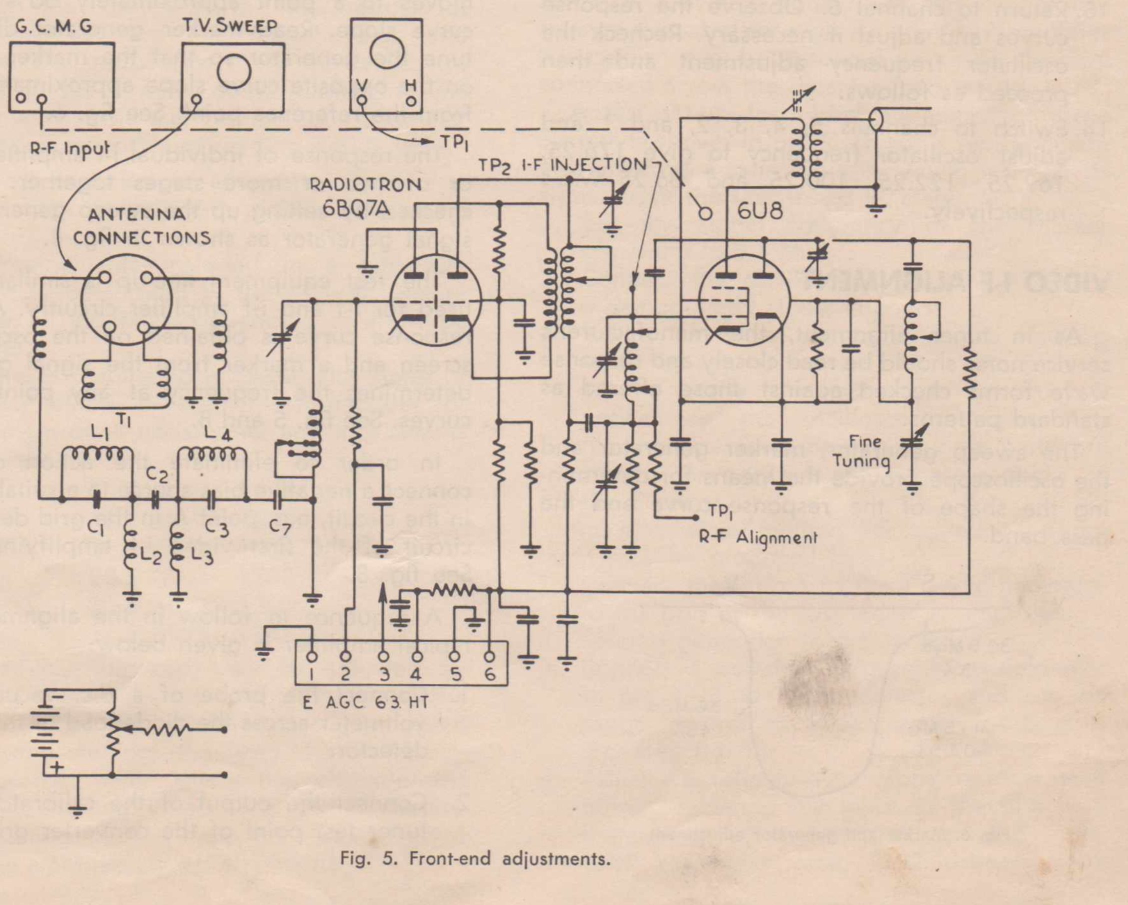



Fig. 5. Front-end adjustments.

6. Switch to channel 10 and adjust the oscillator section inductor to give an oscillator frequency of 246.25 Mc/s.
7. Switch to channel 9 and adjust channel 9 section inductor to give an oscillator frequency of 232.25 Mc/s.
8. Switch to channel 6 again and readjust the circuit capacitor trimmer if necessary for 211.25 Mc/s.
9. Repeat the above procedure until no adjustment is necessary for correct oscillator frequencies on channels 10, 9 and 6 within the desired tolerance. Care should be taken that the presence of the insulated wire loop from the calibrator does not change the frequencies.
10. Switch the tuner and sweep generator to channel 6 and adjust the output to give a response pattern on the C.R.O.
11. Detune the core of the converter i-f transformer when adjusting response curves until no variation of the curve is observed on the C.R.O. Connect 47 ohm resistor at i-f input, if necessary, to remove irregularities in the curve.
12. Switch the tuner and sweep generator to channel 10 and adjust the calibrator to give video and sound markers. Adjust the section inductors for maximum response between video and sound markers.
13. Return to channel 6. Observe the response curves and adjust if necessary. Recheck the oscillator frequency adjustment and then proceed as follows.
14. Switch to channels 5, 4, 3, 2, and 1 and adjust oscillator frequency to give 176.25, 169.25, 122.25, 100.25 and 86.25 Mc/s respectively.

## VIDEO I-F ALIGNMENT

As in tuner alignment, the manufacturer's service notes should be read closely and response wave forms checked against those offered as standard patterns.

The sweep generator, marker generator and the oscilloscope provide the means for determining the shape of the response curve and the pass band.

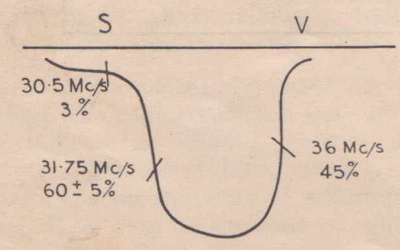



Fig. 6. Marker and generator adjustment.

To obtain an overall picture i-f response curve, connect the direct probe of the oscilloscope across either the diode second detector load resistor or the grid of the first video stage; connect the sweep generator output to the i-f injection test point on the tuner. Adjust the sweep generator to give the required output. Do not overload. Couple the marker generator loosely to the test point via a small capacitor e.g. 25 $\mu\mu$F. See fig. 7.

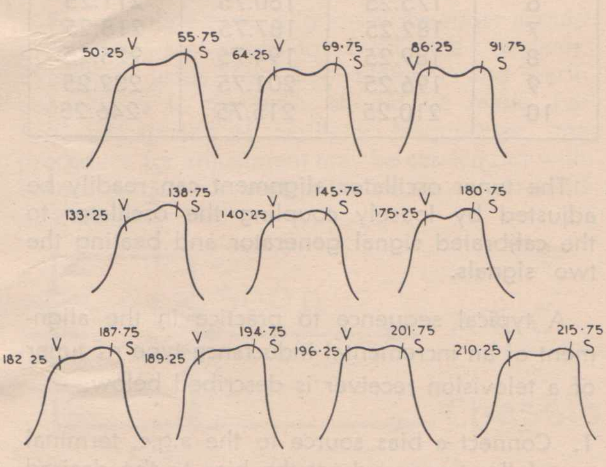



Fig. 7. Typical response curves.

Adjust the marker generator so that the marker moves to a point approximately 50% up the curve slope. Read marker generator dial, then tune the generator so that the marker appears on the opposite curve slope approximately 60% from the reference point. See fig. 6.

The response of individual i-f amplifier stages or of two or more stages together may be checked by setting up the sweep generator and signal generator as shown in fig. 8.

The test equipment line-up is similar to that used for r-f and i-f amplifier circuitry. A sweep response curve is obtained on the oscilloscope screen and a marker from the signal generator determines the frequency at any point on the curves. See fig. 5 and 8.

In order to eliminate the action of a.g.c. connect a negative bias source to a suitable point in the circuit, e.g. point A in the grid decoupling circuit of the first video i-f amplifying valve. See fig. 8.

A sequence to follow in the alignment of a typical amplifier is given below:

1. Connect the probe of a d.c. vacuum tube voltmeter across the diode load of the second detector.

2. Connect the output of the calibrator to the tuner test point of the converter grid circuit

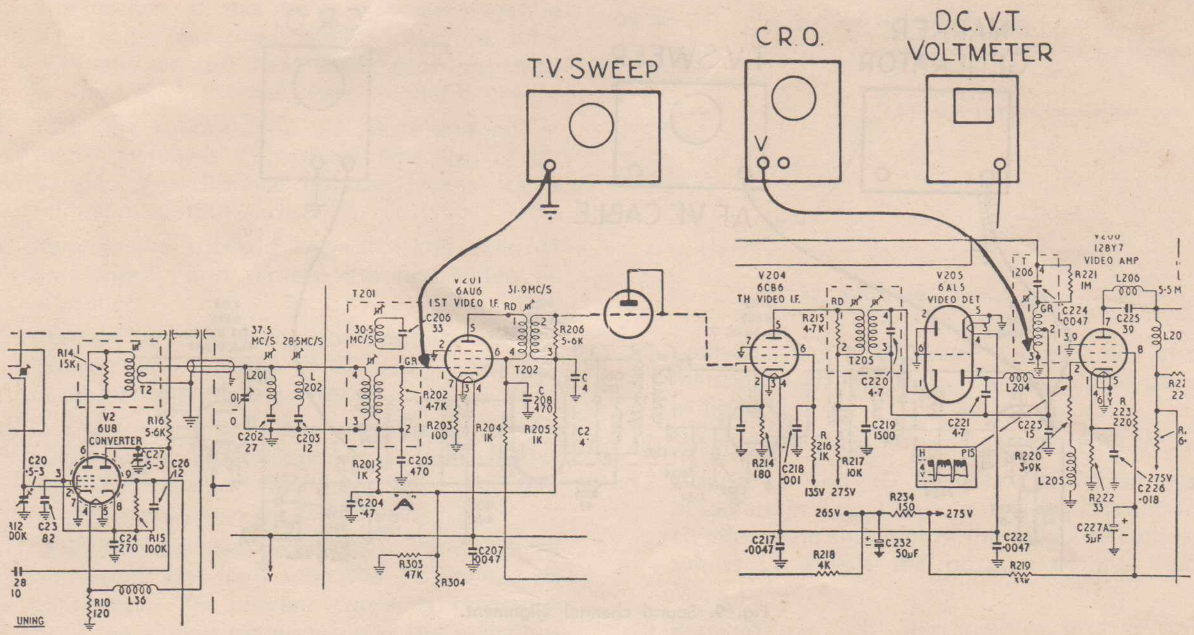



Fig. 8. Checking I.F. response.

through a 1000 $\mu\mu$F capacitor, using short leads. Set the tuner on channel 6. Set the fine tuning control to its mechanical centre and check that the oscillator frequency is 211 Mc/s.

3. Adjust the calibrator to the frequencies recommended by the manufacturer and adjust the transformers in the video i-f amplifier for a peak output, adjusting the input so that the d.c. vacuum tube voltmeter maintains an optimum reading e.g. 3 volts.

Traps are included to attenuate specific frequencies, such as adjacent picture and sound carriers.

The trap circuits included in a television receiver may be located in the r-f unit, picture and sound i-f amplifiers depending on the type of receiver.

Frequencies nominated in the service notes of a particular television receiver manufacturer for the alignment of i-f transformer and trap circuits are listed below:—

| | |
|---|---|
| 33.5 Mc/s | T204 |
| 35.3 Mc/s | T203 |
| 31.9 Mc/s | T208 |
| 28.5 Mc/s | L202 |
| 30.5 Mc/s | T201 |
| 37.5 Mc/s | L201 |

Alternatively the trap may be adjusted by connecting the probe of a d.c. vacuum tube voltmeter across the diode load of the video detector and tuning the trap for minimum voltage on the meter. This is the recommended practice in aligning video i-f amplifier circuits. Any mistuning of the traps may be corrected during the amplifier sweep alignment.

## SOUND I-F AMPLIFIER AND F-M DETECTORS

The alignment of sound i-f amplifiers in both television and f-m receivers is similar. Australian television receivers employ a sound i-f of 5.5 Mc/s. If a sweep signal with this centre frequency is passed through the sound i-f amplifier the pattern may be observed on an oscilloscope connected across the detector load resistor.

A test set-up for visual alignment of these circuits is shown in fig. 9. This is a typical circuit and employs a ratio detector which receives its signal from the last sound i-f stage.

1. Set the signal frequency of the marker generator to 5.5 Mc/s.
2. Connect the oscilloscope at point A where a demodulated signal appears.
3. Adjust the sweep generator to give a sweep width of approximately 1 Mc/s. An S curve similar to the curve shown in fig. 10 will appear on the oscilloscope screen. The marker pips for determining pass band are shown for positive and negative peaks of the S curve.

An alternative method for sound i-f alignment may be produced by:—

1. Connect the output of the marker generator to the grid of the last video i-f amplifier.
2. Set the generator to 5.5 Mc/s.
3. Connect a suitable vacuum tube voltmeter to pin 1 of the ratio detector and set the range control to approximately $+5$ volts d.c. (see fig. 8).
4. Adjust the following transformers for a peak output, reducing the input so that the voltmeter maintains a reading of $+5$ volts: T102 secondary core, T102 primary core,

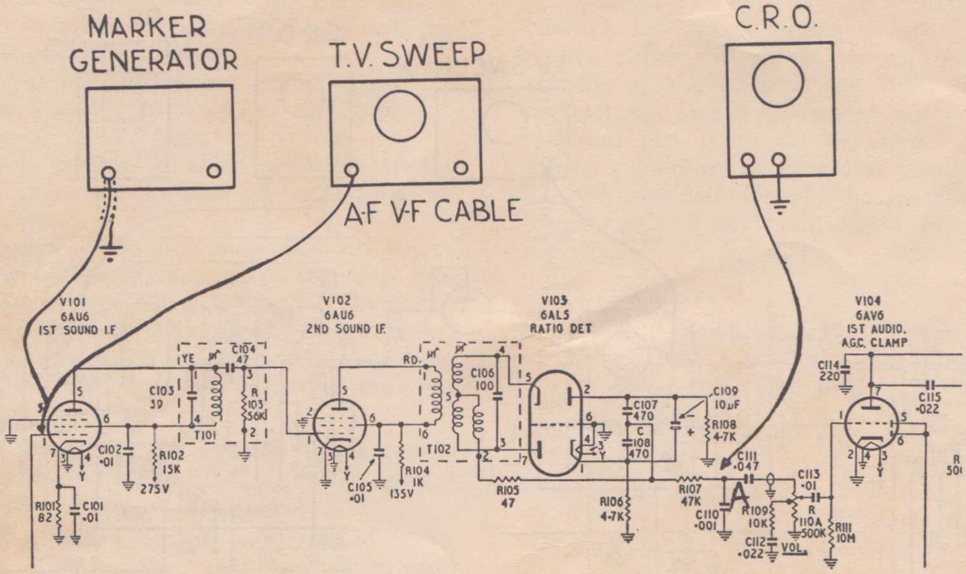


Fig. 9. Sound channel alignment.

T101 core, and T206 core.

5. Disconnect the vacuum tube voltmeter probe from pin 1 and connect it to point A.
6. Readjust T102 secondary core for zero voltage reading on the voltmeter.

## ALIGNMENT OF AERIAL MATCHING UNIT

The aerial matching unit is accurately aligned at the factory and no adjustment of the unit should be attempted in the customer's home, since slight re-adjustment may cause serious attenuation of the signal. The r-f unit is aligned with a particular matching unit in place and if for any reason a new matching unit is installed the r-f unit should be re-aligned.

To align the aerial matching unit:

1. Remove the unit from the r-f tuner and connect the output via a 1000 $\mu\mu$F capacitor to the grid of the second video i-f amplifier (Keep the leads as short as possible).
2. Remove the preceding video i-f valve and connect a variable bias source to eliminate the a.g.c.
3. Connect the marker generator at 46.5 Mc/s to the aerial input socket of the aerial matching unit.
4. Adjust its output until a convenient signal is measured at the grid of the video amplifier.

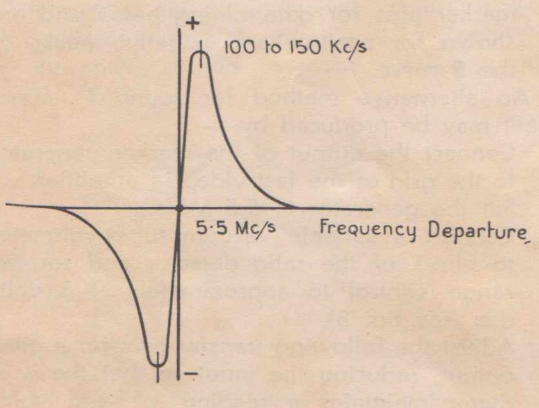


Fig. 10. Detector output.

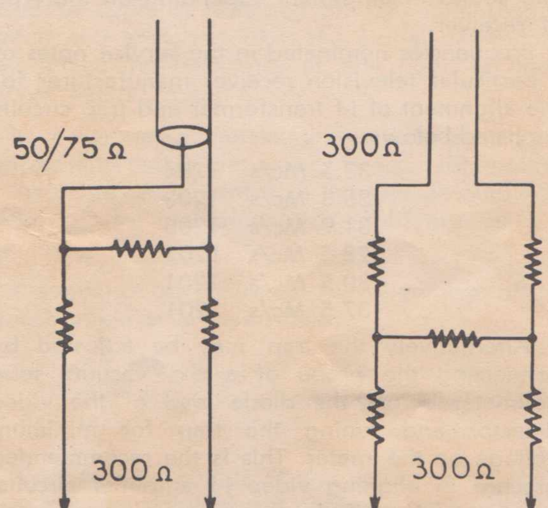


Fig. 11 Resistive pads.

The output at this point may be negative d.c. volts measured with a vacuum tube voltmeter or 400 cycle modulation observed on the C.R.O. if a modulated signal is used.

5. Tune the calibrator to 36 Mc/s and adjust the inductances L1 and L4 (see fig. 5) by varying the distance between turns for a minimum output indication.
6. Remove the 1000$\mu\mu$F capacitor and external bias supply and replace the first video i-f amplifier.
7. Connect a 300 ohm composition resistor between the junction of C3 and L4 (see fig. 5) to earth with short leads.
8. Connect the C.R.O. low capacitance crystal probe across the 300 ohm resistor and turn the C.R.O. gain to maximum (approximately 10 mV r.m.s./inch of deflection).
9. Connect the sweep generator to the matching unit aerial terminals with the 300 ohm line connection. To prevent coupling reactance from the sweep generator into the matching unit, it is advisable to connect a resistance pad (see fig. 11) constructed with short leads to the input terminals.

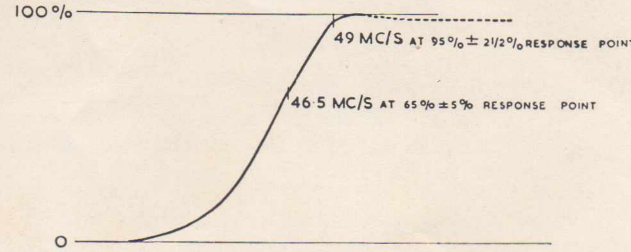



Fig. 12. Aerial coupler response.

10. Connect the calibrator loosely to the matching unit terminals, via one of the pads in fig. 11.
11. Set the generator to sweep from 42-52 Mc/s.
12. Adjust L2 and L3 to obtain the response obtained in fig. 12 (note the adjustment to L3 affects the shoulder of the response curves, whilst L2 affects the position of the 46.5 Mc/s point).
13. Remove the 300 ohm resistor and crystal probe connections. Set L1, L2, L3 and L4 in position and replace covers. Re-connect aerial tuning unit to turret, or r-f tuner.

## ION TRAP MAGNET ADJUSTMENT (Continued from page 20)

and cut-off; the picture-control adjustment will provide a blank raster on the picture tube screen for observation during subsequent adjustments.

4. With the controls set as indicated in (3), apply operating voltages to the tube. As soon as the tube cathode reaches operating temperature, adjust the position of the ion trap magnet by moving it a short distance forward or backward and rotating it slightly until maximum brightness is obtained at the centre of the raster. It is important that this adjustment be made with the brightness control set, as specified in (3) midway between the minimum and maximum positions so as to keep the beam current low. It is equally important that the adjustment of the ion-trap magnet be completed quickly because operation of the picture tube with the ion-trap magnet improperly positioned may damage the tube. With certain picture tubes, particularly those utilizing electrostatic focus, two positions of the ion-trap magnet may be found in which maximum brightness is produced. The correct position is that which is nearer the base of the tube.
5. Focus the pattern and centre it. If a shadow appears at the edge of the raster, check the position of the deflecting yoke to make sure that it bears firmly against the glass funnel and centred on the picture tube neck. If any shadow remains, eliminate it by adjusting the position of the centring magnet. If this adjustment reduces maximum brightness at the centre of the screen or disturbs centring and focus, repeat steps (4) and (5). Never adjust the ion-trap magnet to centre the pattern, never adjust it to eliminate neck shadow if such adjustment reduces the brightness at the centre of the screen.
6. With the picture control in its minimum position, turn the brightness control to its maximum setting and readjust the ion-trap magnet as indicated in (4) until maximum light output at the centre of the raster is again obtained. Bowing of opposite sides of the raster in the same direction may occur if the ion-trap magnet has improper rotational position.
7. Adjust the brightness and picture controls to obtain a picture of normal brightness. Readjust centring and focus if necessary. If this step requires any appreciable change in centring or focus, repeat operation (6) to recheck position of the ion-trap magnet.

**RADIOTRON 5AS4** (Continued from page 42)

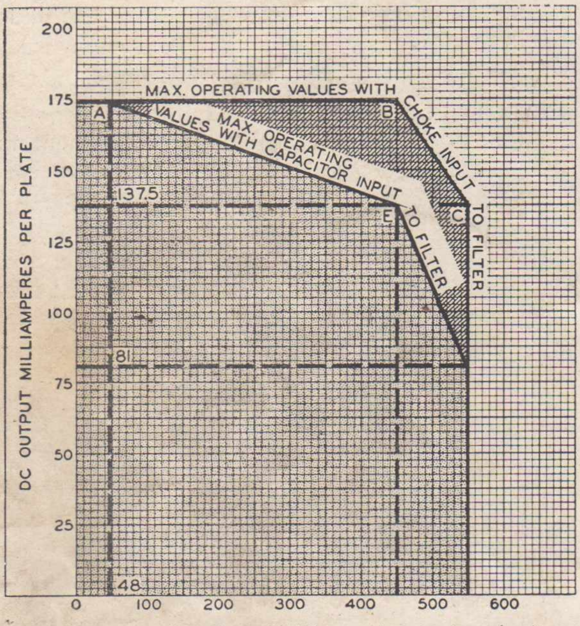
# RATING CHARTS

The points of operation should fall within the proper boundaries on **all** charts for **any** application.

Plate supply voltages are measured with the rectifier tube non-conducting, i.e., with transformer unloaded. This unloaded voltage is used when calculating rectification efficiency.

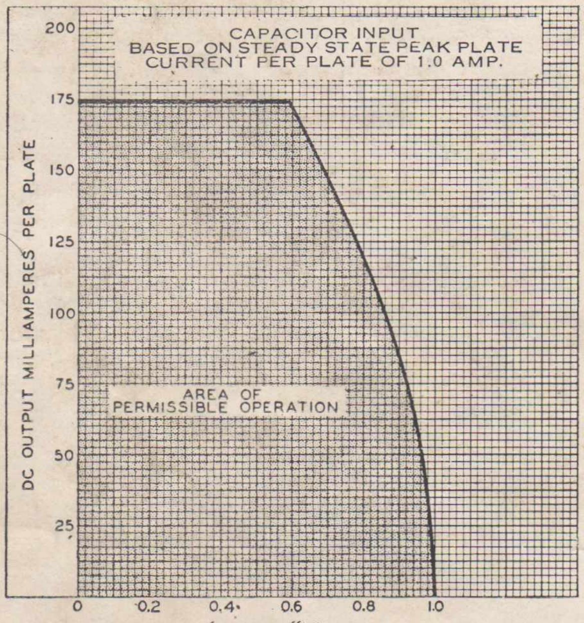
Rating chart 1 presents grahpically the relationships between maximum ac voltage input and maximum dc output current derived from the fundamental ratings for conditions of capacitor input and choke input filters.

Rating chart 2 defines the limit of the steady state peak plate current. Operation within the boundary is permitted.



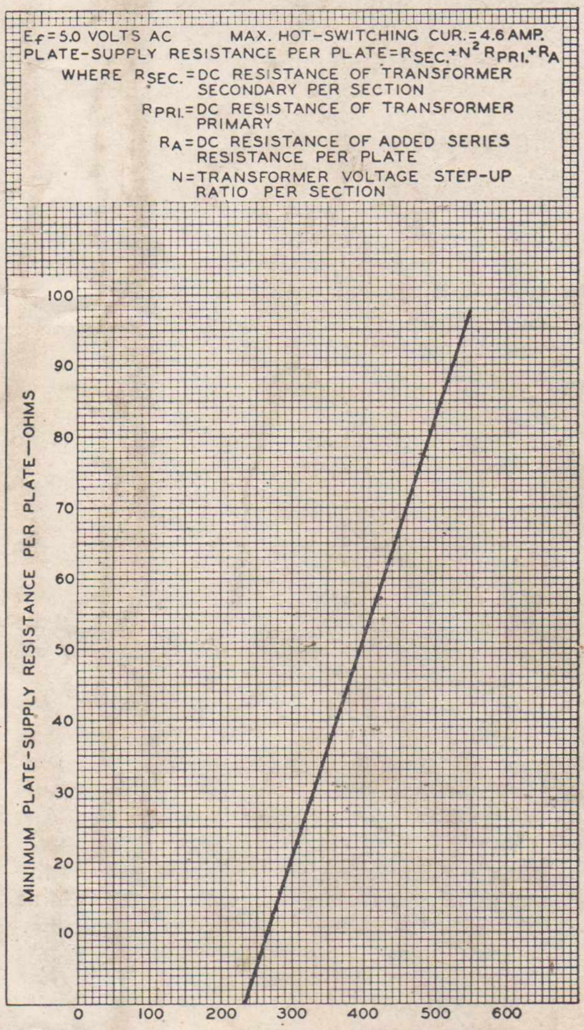

AC plate supply voltage (RMS) per plate (without load)

**rating chart 1**




rectification efficiency

**rating chart 2**




AC plate supply voltage (RMS) per plate (without load)

**rating chart 3**

← rectification efficiency is defined as

$$\frac{\text{DC output voltage at filter input}}{\text{AC plate supply voltage per plate (without load)}}$$