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RADIOTRONICS

Volume 17 April 1952 No. 4

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RADIOTRONICS

Volume 17 **April, 1952** **Number 4**

By the way—

Here are some pertinent facts about the latest RCA release featured in this issue—

RCA-6146 is a small, sturdy, v-h-f beam power amplifier having high efficiency and high power sensitivity. It is designed for use as an r-f power amplifier and oscillator as well as an a-f power amplifier and modulator in both mobile and fixed equipment. The 6146 has a maximum plate dissipation of 25 watts under ICAS conditions in modulator service and in c.w. service. In the latter service, it can be operated with full input to 60 Mc/s and with reduced input to 175 Mc/s.

Because of its high power sensitivity and high efficiency, the 6146 can be operated with relatively low plate voltage to give large power output with small driving power.

Small in size for its power-output capability, the 6146 has a rugged button-stem construction with short internal leads, a T-12 bulb, triple base-pin connections for grid No. 3 and cathode (both joined to internal shield inside the tube) to permit effective r-f grounding, and an octal base with short metal sleeve having its own base-pin terminal. The sleeve shields the input to the tube and isolates it from the output circuit so completely that no other external shielding is required. Separation of input and output circuits is accomplished by bringing the plate lead out of the bulb to a cap opposite the base.

Back issues of Radiotronics prior to 1952 are no longer available.

Information published in Radiotronics concerning new RCA releases is intended for information only, and present or future Australian availability is not implied.

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Our cover illustration shows miniature Radiotron valve bases being checked for glass strain under polarized light, at the A.W.V. Works, Ashfield.

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Heater-Induced Hum in *Audio Amplifiers*

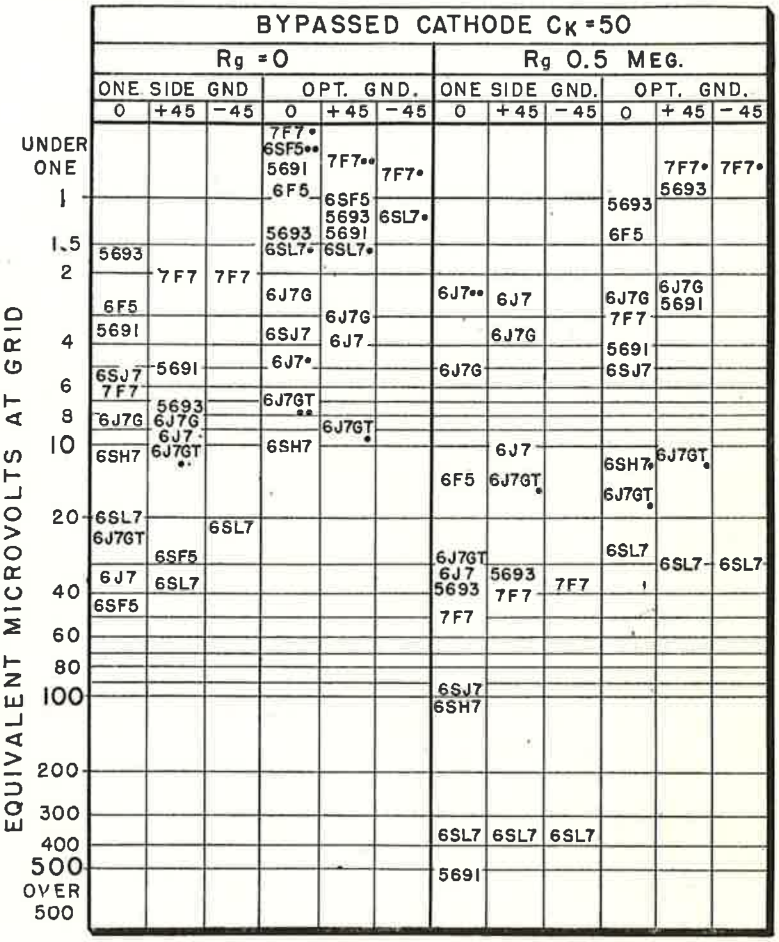


Fig. 1. Levels of heater-induced hum in eleven tube types with bypassed cathodes in various amplifier arrangements. Vertical position of the tube on the chart indicates 60 cycle hum in equivalent microvolts at grid for several circuit variations.

By suitable choices of tubes and circuitry, heater induced 60-cycle hum in a.c. operated low-level amplifiers can be reduced to less than 1 microvolt. Less fortunate tube and circuit combinations may give heater-hum levels of more than 500 microvolts.

These are conclusions of a limited investigation of heater hum recently made at the U.S. National Bureau of Standards and the study has yielded useful practical data for designing such amplifiers. Emphasis was on cataloguing heater hum characteristics of various tubes and circuit arrangements, rather than on investigating the causes of the hum.

Eleven tube types, in various circuit arrangements, have been studied so far. Included were single triodes 6F5 and 6SF5; dual triodes 6SL7, 7F7, and 5691; and pentodes 6J7, 6J7G, 6J7GT, 6SJ7, 5693, and 6SH7. In general, only 4 to 6 tubes of each type were checked, although tubes of several manufacturers were included wherever possible. Data were discarded for occasional individual tubes which, in showing wide deviations from the mean, were not believed representative.

Circuits were varied with respect to cathode bypass capacitance, heater return tie point, heater return potential, and grid circuit resistance. The cathode resistor was either bypassed with a 50 μF capacitor or left unbypassed. Input grid resistance was either zero or 0.5 megohm. The heater return was either to one side of the heater, or through the adjustable arm of a 100-ohm potentiometer placed across the heater supply and adjusted for minimum 60-cycle output. Heater return potential was either to ground, to 45 volts positive, or to 45 volts negative. Hum measurements were made with various combinations of these circuit variations.

In the test set-up, the 60-, 120-, and 180-cycle hum components of the output of the amplifier under study were measured on a vacuum-tube voltmeter, using appropriate amplification and filtering. At the same time, wave form was observed on a

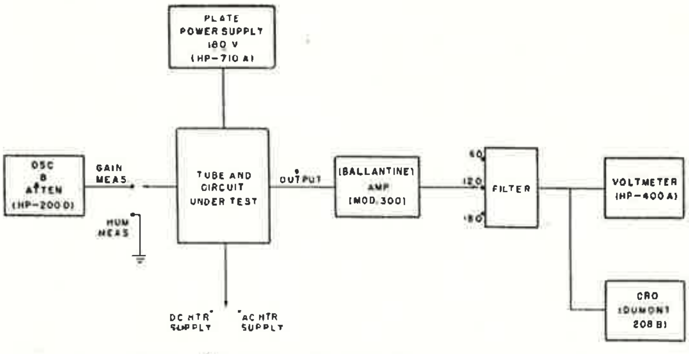
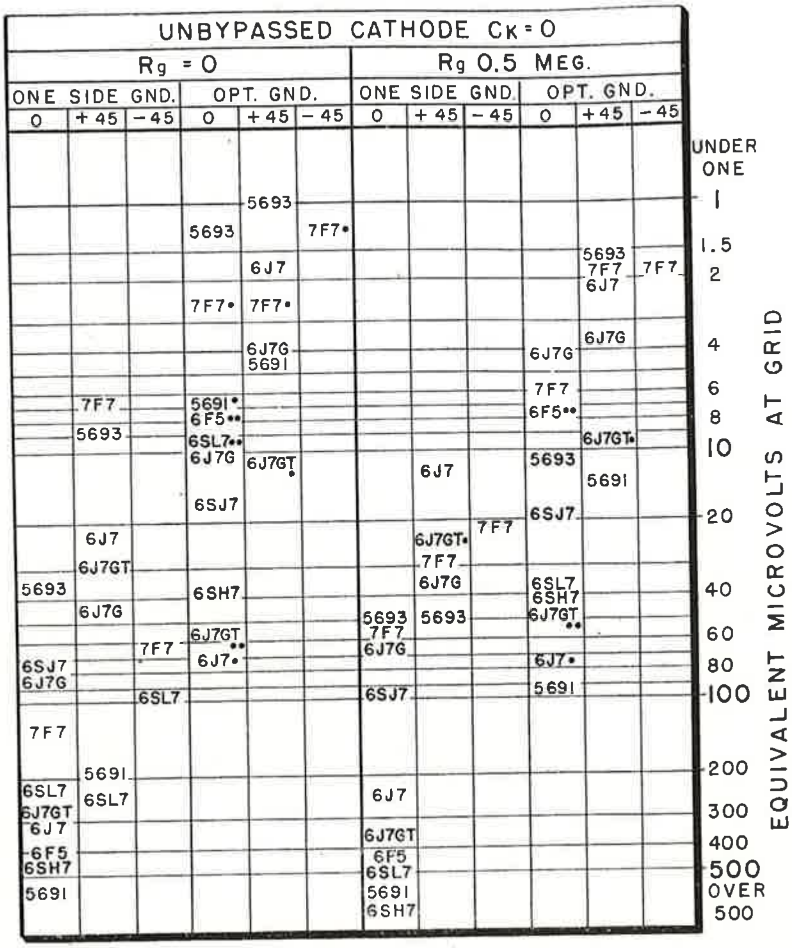


Fig. 3. Block diagram of complete arrangement for measuring hum level.

Reprinted from "Tele-Tech", with permission from Caldwell-Clements, Inc.

Fig. 2. Chart similar to that shown in Fig. 1 except that cathode circuits are unbypassed.



cathode-ray oscilloscope. Gain was measured by applying a known signal to the grid of the test amplifier; hum level could then be expressed in terms of equivalent microvolts at the grid. Provision was made for switching from a.c. to d.c. heater supply for calibration and comparison.

To obtain the desired measurements of heater-induced hum, external a.c. hum was reduced to a negligible value, using recognized shielding precautions; heater leads were twisted and shielded and kept away from the grid circuit, which was also shielded.

Circuit components were based on median values given in manufacturer's manuals. Preliminary checks indicated that hum is not significantly affected by the usual variations, in components; plate, screen, and cathode resistors, and cathode and screen bypass capacitors; required to match different load impedances.

The most hum-free amplifiers investigated so far at NBS used either of several triodes (6F5, 6SF5, 7F7, or 5691) or a pentode (5693), in a circuit including bypassed cathode, heater grounded through an adjustable potentiometer, and low grid impedance. Wide hum differences were found for different tube types, as well as for different circuit arrangements. Apparently, however, the 60-cycle equivalent input hum of almost any tube type tested, whether triode or pentode, can be reduced to 10 microvolts by suitable circuitry; and all of the triodes tested could be brought below 2 microvolts.

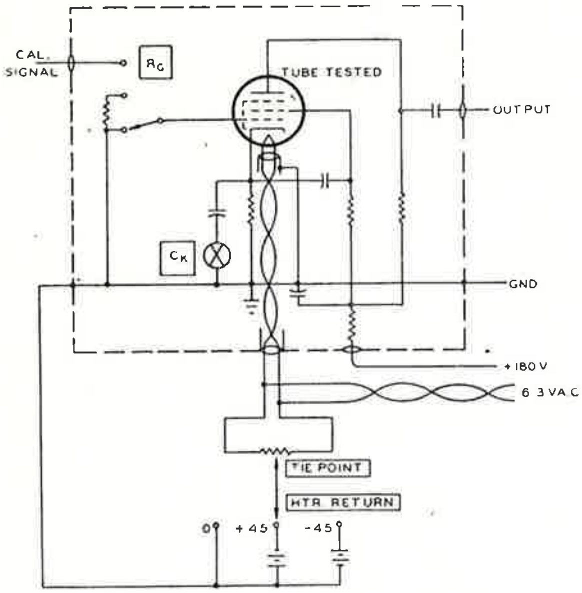


Fig. 4. Typical low-level amplifier circuit used in these measurements.

The NBS figures are for the 60-cycle components alone and are therefore not fully comparable with figures given in the literature, which generally include harmonics. The 60-cycle components were measured because of their importance in low-level power-frequency amplifiers, often required in instrumentation applications. Some of the low 60-cycle values measured at NBS were accompanied by harmonics no greater or even substantially less than the 60-cycle figure; in other instances the harmonics were many times greater than the 60-cycle component.

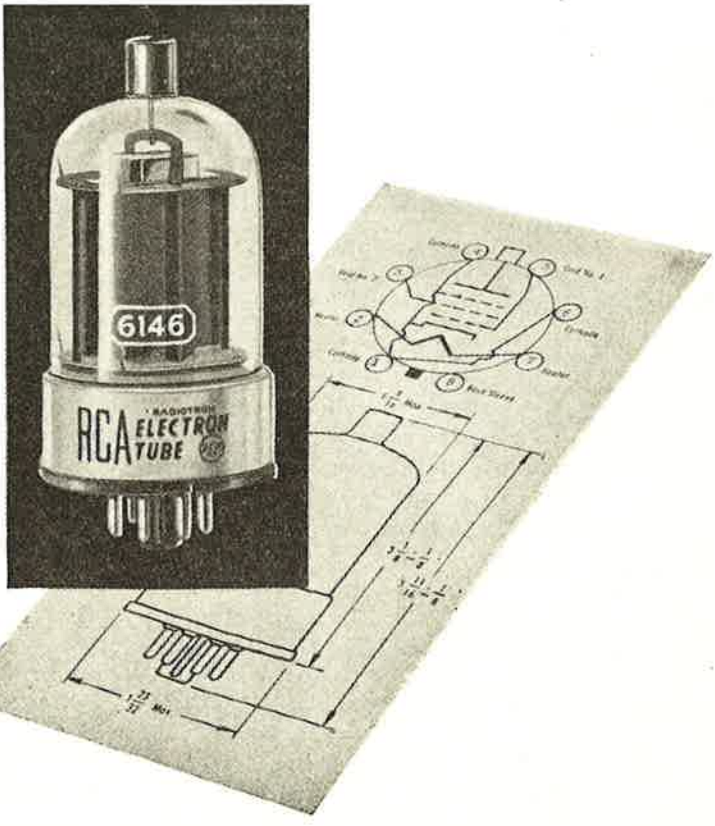
The general effects of the circuit variations were not unexpected. Without the cathode bypass condenser, hum was of course much greater; a sufficiently large bypass capacitor is obviously desirable for all low-hum applications. Return of the heater circuit through an adjustable potentiometer connected across the heater supply, when adjustment was optimum, reduced the hum to as little as 1/20 or even 1/50 of the initial value. Returning the heater circuit through 45 volts, either positive, or negative but preferably positive, reduced hum somewhat in most cases. Increased grid circuit resistance tended to give greater hum in triodes, while in pentodes hum in general either showed no change or else decreased with increased resistance.

New

RCA Releases

6146

VHF BEAM POWER AMPLIFIER



This information also applies to RCA-6159, which is identical with RCA-6146 except for its heater rating of 26.5 ± 10% volts, 0.3 ampere.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current at 6.3 volts	1.25	amperes
Transconductance, for plate volts = 200, grid-No. 2 volts = 200, and plate ma. = 100	7000	μmhos
Mu-Factor, Grid No. 2 to Grid No. 1 for plate volts = 200, grid-No. 2 volts = 200, and plate ma. = 100	4.5	
Direct Interelectrode Capacitances:*		
Grid No. 1 to Plate	0.22 max.	μμf
Input	13.5	μμf
Output	9	μμf

Mechanical:

Mounting Position	Any
Overall Length	3-11/16" ± 1/8"
Seated Length	3-1/8" ± 1/8"
Maximum Diameter	1-23/32"
Bulb	T-12
Cap	Small (JETEC No. C1-1)
Base	Large-Wafer Octal 8-Pin with Sleeve No. R-6876 (JETEC No. B8-86)
Bulb Temperature (At hottest point)	220 max. °C

AF POWER AMPLIFIER & MODULATOR--Class AB_1†

Triode Connection--Grid No. 2 Connected to Plate

Maximum Ratings, *Absolute Values:*

	CCS•	ICAS••	
DC PLATE VOLTAGE	400 max.	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT**	90 max.	90 max.	ma
MAX.-SIGNAL PLATE INPUT**	35 max.	35 max.	watts
PLATE DISSIPATION**	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation:

Values are for 2 tubes

DC Plate Voltage	250	400	400	volts
DC Grid-No. 1 Voltage	-50	-100	-100	volts
Peak AF Grid-No. 1-to-Grid-No. 1 Voltage°	100	200	200	volts
Zero-Signal DC Plate Current	110	80	80	ma
Max.-Signal DC Plate Current	144	136	136	ma
Effective Load Resistance (Plate to plate)	5000	8000	8000	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	watts
Total Harmonic Distortion	5	4.6	4.6	%
Max.-Signal Power Output (Approx.)	8	19	19	watts

Maximum Circuit Values (CCS or ICAS Conditions):

Grid-No. 1-Circuit Resistance:°°		
With fixed bias	0.1 max.	megohm
With cathode bias	0.5 max.	megohm

AF POWER AMPLIFIER & MODULATOR--Class AB_1†

Maximum Ratings, *Absolute Values:*

	CCS•	ICAS••	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No. 2 (SCREEN) VOLTAGE	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT**	125 max.	135 max.	ma
MAX.-SIGNAL PLATE INPUT**	60 max.	85 max.	watts

Maximum Ratings (Cont'd):

	CCS●	ICAS●●	
MAX.-SIGNAL GRID-No.2 INPUT**	3 max.	3 max.	watts
PLATE DISSIPATION**	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	400	500	600	volts
DC Grid-No.2 Voltage▲	190	180	190	volts
DC Grid-No.1 (Control-Grid) Voltage:				
With fixed-bias source	-40	-40	-45	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	80	80	90	volts
Zero-Signal DC Plate Current	86	70	60	ma
Max.-Signal DC Plate Current	228	220	200	ma
Zero-Signal DC Grid-No.2 Current	2	1.4	1	ma
Max.-Signal DC Grid-No.2 Current	30	19.5	30.5	ma
Effective Load Resistance (Plate to plate)	4000	5000	7500	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	watts
Total Harmonic Distortion	8	8	8	%
Max.-Signal Power Output (Approx.)	55	70	82	watts

Typical ICAS Operation:

Values are for 2 tubes

DC Plate Voltage	600	750	volts
DC Grid-No.2 Voltage▲	200	200	volts
DC Grid-No.1 (Control-Grid) Voltage:			
From fixed-bias source	-50	-50	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	100	100	volts
Zero-Signal DC Plate Current	52	57	ma
Max.-Signal DC Plate Current	239	227	ma
Zero-Signal DC Grid-No.2 Current	1.2	1	ma
Max.-Signal DC Grid-No.2 Current	25.2	27.5	ma
Effective Load Resistance (Plate to plate)	5500	8000	ohms
Max.-Signal Driving Power (Approx.)	0	0	watts
Total Harmonic Distortion	7.5	5.7	%
Max.-Signal Power Output (Approx.)	94	120	watts

Maximum Circuit Values (CCS or ICAS Conditions):

Grid-No.1-Circuit Resistance:°°		
With fixed bias	0.1 max.	megohm
With cathode bias	Not recommended	

AF POWER AMPLIFIER & MODULATOR--Class AB$_2$#

Maximum Ratings, *Absolute Values*:

	CCS●	ICAS●●	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT**	125 max.	135 max.	ma
MAX.-SIGNAL PLATE INPUT**	62.5 max.	90 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT**	3 max.	3 max.	watts
PLATE DISSIPATION**	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	400	500	600	volts
DC Grid-No.2 Voltage▲	175	175	165	volts
DC Grid-No.1 (Control-Grid) Voltage:				
From fixed-bias source	-40	-40	-45	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	86	87	99	volts
Zero-Signal DC Plate Current	63	64	31	ma
Max.-Signal DC Plate Current	232	242	207	ma
Zero-Signal DC Grid-No.2 Current	1.5	1.2	0.7	ma
Max.-Signal DC Grid-No.2 Current	28	26	31	ma
Max.-Signal DC Grid-No.1 Current	0.3	0.3	0.5	ma
Effective Load Resistance (Plate to plate)	4000	5000	7500	ohms
Max.-Signal Driving Power (Approx.)◆	0.03	0.03	0.05	watt
Total Harmonic Distortion	9.7	9.7	9.7	%
Max.-Signal Power Output (Approx.)	60	81	90	watts

Typical ICAS Operation:

Values are for 2 tubes

DC Plate Voltage	600	750	volts
DC Grid-No.2 Voltage▲	185	165	volts
DC Grid-No.1 (Control-Grid) Voltage:			
From fixed-bias source	-50	-45	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	113	101	volts
Zero-Signal DC Plate Current	41	35	ma
Max.-Signal DC Plate Current	270	240	ma
Zero-Signal DC Grid-No.2 Current	0.9	0.6	ma
Max.-Signal DC Grid-No.2 Current	29	21	ma
Max.-Signal DC Grid-No.1 Current	0.8	0.7	ma
Effective Load Resistance (Plate to plate)	5500	8000	ohms
Max.-Signal Driving Power (Approx.)◆	0.1	0.07	watt
Total Harmonic Distortion	11	10	%
Max.-Signal Power Output (Approx.)	115	130	watts

Maximum Circuit Values (CCS or ICAS Conditions):

Grid-No.1-Circuit Resistance:◆		
With fixed bias	30000 max.	ohms
With cathode bias	Not recommended	

PLATE-MODULATED RF POWER AMPLIFIER--Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum Ratings, *Absolute Values*:

	CCS●	ICAS●●	
DC PLATE VOLTAGE	480 max.	600 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	250 max.	250 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-150 max.	-150 max.	volts
DC PLATE CURRENT	117 max.	125 max.	ma
DC GRID-No.1 CURRENT	3.5 max.	4.0 max.	ma
PLATE INPUT	45 max.	67.5 max.	watts
GRID-No.2 INPUT	2 max.	2 max.	watts
PLATE DISSIPATION	13.3 max.	16.7 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation:

DC Plate Voltage	400	475	600	volts
DC Grid-No.2 Voltage●	150	135	150	volts
From a series resistor of	21500	26500	37500	ohms
DC Grid-No.1 Voltage★	-85	-85	-85	volts
From a grid resistor of	28300	28300	28300	ohms
Peak RF Grid-No.1 Voltage	100	99	100	volts
DC Plate Current	112	94	113	ma
DC Grid-No.2 Current	11.6	12.8	12	ma
DC Grid-No.1 Current (Approx.)	3	3	3	ma
Driving Power (Approx.)	0.3	0.3	0.3	watt
Power Output (Approx.)	34	33	52	watts

Maximum Circuit Values (CCS or ICAS Conditions):

Grid-No.1-Circuit Resistance‡	30000 max.	ohms

RF POWER AMPLIFIER & OSC.--Class C Telegraphy□ and RF POWER AMPLIFIER--Class C FM Telephony

Maximum Ratings, *Absolute Values*:

	CCS●	ICAS●●	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	250 max.	250 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-150 max.	-150 max.	volts
DC PLATE CURRENT	140 max.	150 max.	ma
DC GRID-No.1 CURRENT	3.5 max.	4.0 max.	ma
PLATE INPUT	67.5 max.	90 max.	watts

	CCS●	ICAS●●	
GRID-No.2 INPUT.	3 max.	3 max.	watts
PLATE DISSIPATION. . . .	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode .	135 max.	135 max.	volts
Heater positive with respect to cathode .	135 max.	135 max.	volts

Typical Operation as Amplifier up to 60 Mc:

	CCS	CCS	ICAS	ICAS	
DC Plate Voltage	500	600	600	750	volts
DC Grid-No.2 Voltage⊕⊕ .	170	150	180	160	volts
From a series resistor of. .	29200	40200	28000	40100	ohms
DC Grid-No.1 Voltage■. .	-85	-85	-85	-85	volts
From a grid-No.1 resistor of. .	28300	28300	28300	28300	ohms
From a cathode resistor of. .	570	670	510	620	ohms
Peak RF Grid-No.1 Voltage	99	100	102	100	volts
DC Plate Current	135	113	150	120	ma
DC Grid-No.2 Current . .	11.3	11.2	15	14.7	ma
DC Grid-No.1 Current (Approx.). .	3	3	3	3	ma
Driving Power (Approx.).	0.3	0.3	0.3	0.3	watt
Power Output (Approx.) .	50	52	69	69	watts

Typical Operation as Amplifier at 175 Mc:

	CCS	ICAS	
DC Plate Voltage	320	400	volts
DC Grid-No.2 Voltage⊕⊕ .	180	200	volts
From a series resistor of. .	15500	22200	ohms
DC Grid-No.1 Voltage■. .	-54	-54	volts
From a grid resistor of	30000	30000	ohms
From a cathode resistor of. .	360	335	ohms
Peak RF Grid-No.1 Voltage	70	70	volts
DC Plate Current	140	150	ma
DC Grid-No.2 Current . .	9	9	ma
DC Grid-No.1 Current (Approx.). .	1.8	1.8	ma
Driving Power (Approx.).	2	3	watts
Power Output (Approx.) .	25	35	watts

Maximum Circuit Values (CCS or ICAS Conditions):

Grid-No.1-Circuit Resistance‡. . . . 30000 max. ohms

MAXIMUM RATINGS vs OPERATING FREQUENCY

OPERATING FREQUENCY Megacycles per second	MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE & PLATE INPUT			
	TELEPHONY		TELEGRAPHY	
	Class C Plate-Modulated		Class C Unmodulated	
	Voltage	Input	Voltage	Input
60	100	100	100	100
80	84	92	84	92
125	65	78	65	78
150	58	72	58	72
160	56	70	56	70
175	53	67	53	67

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

(Preliminary)

	Note	*Min.*	*Max.*	
Heater Current	1	1.175	1.325	amperes
Grid-No.1-to-Plate Capacitance. .	2	-	0.22	μμf
Input Capacitance. . .	2	11.1	15.9	μμf
Output Capacitance . .	2	6.8	11.3	μμf
Plate Current.	3	45	83	ma
Grid-No.2 Current. . .	3	-	4	ma
Useful Power Output. .	4	47.5	-	watts

Note 1: With 6.3 volts ac on heater.

Note 2: With no external shield. Base sleeve (pin No.8) is grounded.

Note 3: With 5.5 volts ac on heater, dc plate voltage of 300 volts, dc grid-No.2 voltage of 200 volts, and dc grid-No.1 voltage of -33 volts.

Note 4: In a single-tube self-excited oscillator circuit, and with 5.5 volts ac on heater, dc plate voltage of 600 volts, dc grid-No.2 voltage of 180 volts, grid-No.1 resistor of 0.030 ± 10% megohm, max. dc plate current of 112 ma., dc grid-No.1 current of 2 to 2.5 ma., and frequency of 15 Mc.

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* With no external shielding and base sleeve connected to ground.

† Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● Continuous Commercial Service.

●● Intermittent Commercial and Amateur Service.

** Averaged over any audio-frequency cycle of sine-wave form.

o The driver stage should be capable of supplying the No.1 grids of the class AB_1 stage with the specified driving voltage at low distortion.

oo The type of input-coupling network used should not introduce too much resistance in the grid-No.1 circuit. Transformer or impedance coupling devices are recommended. When grid No.1 is operated in the negative region with fixed bias, the dc grid-No.1-circuit resistance should not exceed the specified value of 0.1 megohm. For higher values of dc grid-No.1-circuit resistance, cathode bias is required. Under no circumstances should the total dc grid-No.1-circuit resistance exceed the specified value of 0.5 megohm.

▲ Preferably obtained from a separate source or from the plate-voltage supply with a voltage divider.

Subscript 2 indicates that grid-No.1 current flows during some part of the input cycle.

♦ Driver stage should be capable of supplying the specified driving power at low distortion to the No.1 grids of the AB_2 stage. To minimize distortion, the effective resistance per grid-No.1 circuit of the AB_2 stage should be held at a low value. For this purpose, the use of transformer coupling is recommended. In no case, however, should the total dc grid-No.1-circuit resistance exceed 30000 ohms when the 6146 is operated at maximum ratings. For operation at less than maximum ratings, the dc grid-No.1-circuit resistance may be as high as 100000 ohms.

⬮ Obtained preferably from a separate source modulated with the plate supply, or from the modulated plate supply through a series resistor.

★ Obtained from grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

‡ When grid No.1 is driven positive and the 6146 is operated at maximum ratings, the total dc grid-No.1-circuit resistance should not exceed the specified value of 30000 ohms. If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply. For operation at less than maximum ratings, the dc grid-No.1-circuit resistance may be as high as 100000 ohms.

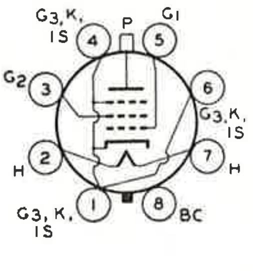
□ Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

⊕⊕ Obtained preferably from a separate source, or from the plate-supply voltage with a voltage divider, or through a series resistor. A series grid-No.2 resistor should be used only when the 6146 is used in a circuit which is not keyed. Grid-No.2 voltage must not exceed 400 volts under key-up conditions.

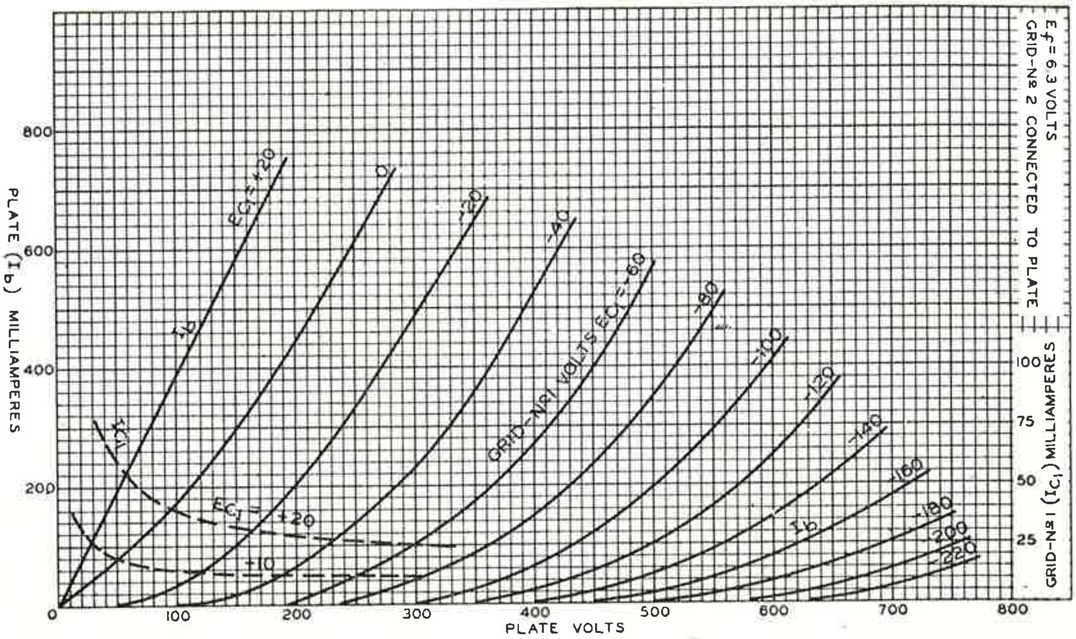
■ Obtained from fixed supply, by grid-No.1 resistor by cathode resistor, or by combination methods.

SOCKET CONNECTIONS

Bottom View



PIN 1: CATHODE, GRID NO.3, INTERNAL SHIELD
PIN 2: HEATER
PIN 3: GRID NO.2
PIN 4: SAME AS PIN 1
PIN 5: GRID NO.1
PIN 6: SAME AS PIN 1
PIN 7: HEATER
PIN 8: BASE SLEEVE
CAP: PLATE



Operating considerations

The *maximum ratings* in the tabulated data for the 6146 are limiting values above which the serviceability of the 6146 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

Heavy leads and conductors together with suitable insulation should be used in all parts of the r-f plate tank circuit so that losses due to r-f voltages and currents may be kept at a minimum. At the higher frequencies, it is essential that short, heavy leads be used for circuit connections in order to minimize lead inductance and losses.

The *bulb* becomes hot during operation. To insure adequate cooling, therefore, it is essential that free circulation of air be provided around the 6146.

The *plate* shows no color when the 6146 is operated at full ratings under either CCS or ICAS conditions. Connection to the plate should be made with a flexible lead to prevent any strain on the seal at the cap.

The *driver stage* for the 6146 in either class C telephony or telegraphy service should have considerably more output capability than the typical tube driving power shown in the tabulated data in order to permit considerable range of adjustment and also to provide for losses in the grid-No. 1 circuit and the coupling circuits.

This recommendation is particularly important near the maximum rated frequency where there are other losses of driving power, such as circuit losses, radiation losses, and transit-line losses.

Highest operating efficiency in high-frequency service, and therefore maximum power output, will be obtained when the 6146 is operated under load conditions such that the maximum rated plate current flows at the plate voltage which will give maximum rated input.

Push-pull or parallel circuit arrangements can be used when more radio-frequency power is required than can be obtained from a single 6146. Two 6146's in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits.

When two or more tubes are used in the circuit, precautions should be taken to insure that each tube draws the same plate current.

During standby periods in intermittent operation, it is recommended that the heater voltage be maintained at normal operating value when the period is less than 15 minutes; and that it be reduced to 80% of normal when the period is between 15 minutes and 2 hours. For longer periods, the heater voltage should be turned off.

(Continued on page 76)

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● About the Editor and Contributors

Mr. F. Langford-Smith is a graduate of Sydney University, where he distinguished himself by gaining first class honours in Mechanical and Electrical Engineering, and coming top of the honours list in Electrical Engineering. He then spent four years in England gaining practical experience, and became Factory Engineer in one of the four largest radio valve factories in England—Cosmos Works, Brimsdown—manufacturers of Mazda and Ediswan valves. On his return to Australia in 1932 he joined the staff of Amalgamated Wireless Valve Co. Pty. Ltd., where he has continued ever since, except for a business visit to U.S.A. and Canada in 1935. He has edited all three previous editions of the Radiotron Designer's Handbook, and has been editor of Radiotronics from its inception until the end of 1950.

Mr. B. Sandel, A.S.T.C., was transferred from the A.W.A. Research Laboratory to the position of engineer in charge of the A.W.V. Applications Laboratory, which position he held from 1945 to 1948. He contributed over five chapters to the new edition of the R.D.H. and a number of his articles were published in Radiotronics. He is now on the engineering staff of the State Electricity Commission, Victoria.

Mr. E. Watkinson, A.S.T.C., A.M.I.E. (Aust.), S.M.I.R.E. (Aust.), is one of the leading radio receiver designers in Australia, and his wide experience has enabled him to make a valuable contribution to the R.D.H. He is in charge of the Circuit Design Laboratory, A.W. Valve Works, Ashfield.

Dr. G. Builder, B.Sc., Ph.D., F.Inst.P., is world famous for his work on the ionosphere, and was for some years in charge of the A.W.A. Research Laboratory. He has specialised on certain aspects of power transformer design and on voltage-regulating transformers.

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Mr. N. V. C. Cansick, B.Sc., who has been with the A.W. Valve Company for the past 15 years, is in charge of Quality Control Engineering. Valve design and test equipment maintenance are also under Mr. Cansick's general direction, as are life testing, rating and production testing.

Mr. I. C. Hansen, M.I.R.E. (U.S.A.), is a New Zealander who has also had radio experience in England and U.S.A. He has been editor of Radiotronics since January, 1951, and handles all technical enquiries regarding valves and valve applications.

Mr. R. Ainsworth, A.S.T.C., has been responsible for much of the sub-editing work in the new edition of the R.D.H. He is also in charge of A.W.V. Technical Publications and sub-editor of Radiotronics.

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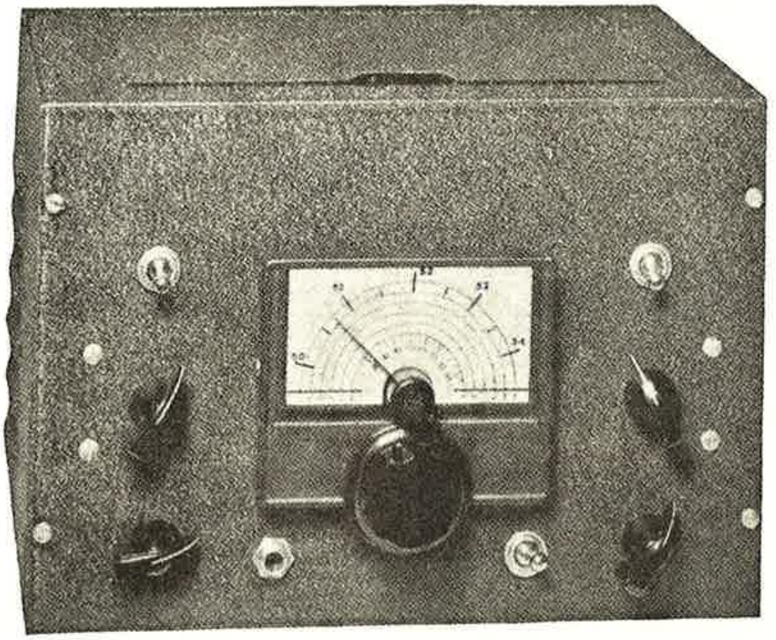

Fig. 1. Front panel view of six-metre receiver. Controls in bottom row, left to right, are audio gain, headphone jack, a.v.c. switch and r-f gain. The BFO control and switch are at upper left, and ANL control and switch at upper right.

A receiver designed and built for a single amateur band may seem like a luxury to many amateurs, but this is not the case when the high-frequency bands are considered. Band-switching can be accomplished on frequencies between 50 and 150 megacycles. In fact, many commercial band-switching receivers now include the six-metre band. However, inclusion of more than one band on any receiver means that the design is a compromise, and the higher the frequency considered, the greater the compromise.

This does not mean that it is simple to design a one-band receiver, but it does mean that the designer can devote his efforts to producing a receiver which has maximum performance over a narrow range of frequencies. Usually this means a superior receiver and, strangely enough, a simpler receiver.

This six-metre receiver about to be described is simple, has low current drain, and yet has a noise figure of between 5 and 7 db. Most important of all, it is not difficult to build. The average amateur should have no trouble putting it together and making it work properly.

Reprinted from Ham News by courtesy of A.G.E., and with acknowledgments to International General Electric.

Design considerations

Basically, the idea was to get a six-metre receiver that was sensitive enough to do serious DX work, and yet be simple to build and low in cost. Because this receiver might be used for mobile work, power-supply drain became a consideration.

Six miniature tubes are used, two of them twin-triodes and one a twin-diode. This gives the receiver the equivalent of nine tubes. All of the popular superhet. functions are included: a.v.c., BFO and noise limiter. In order to keep the design simple, no trick circuits are employed. Sensitivity is achieved by the proper choice of the input circuit and r-f amplifier tube.

The idea of double conversion, that is, the use of two different i-f frequencies, was discarded because it would add to the complexity of the receiver. The receiver as designed could use more selectivity — most receivers can — but until the six metre band becomes more heavily populated, the selectivity achieved in this receiver is adequate.

In order to keep the six-metre receiver independent of the a.c. line, the power supply has been eliminated. For home use a separate a.c. power supply can be employed, and for mobile use a vibrator power supply is adequate. The voltage

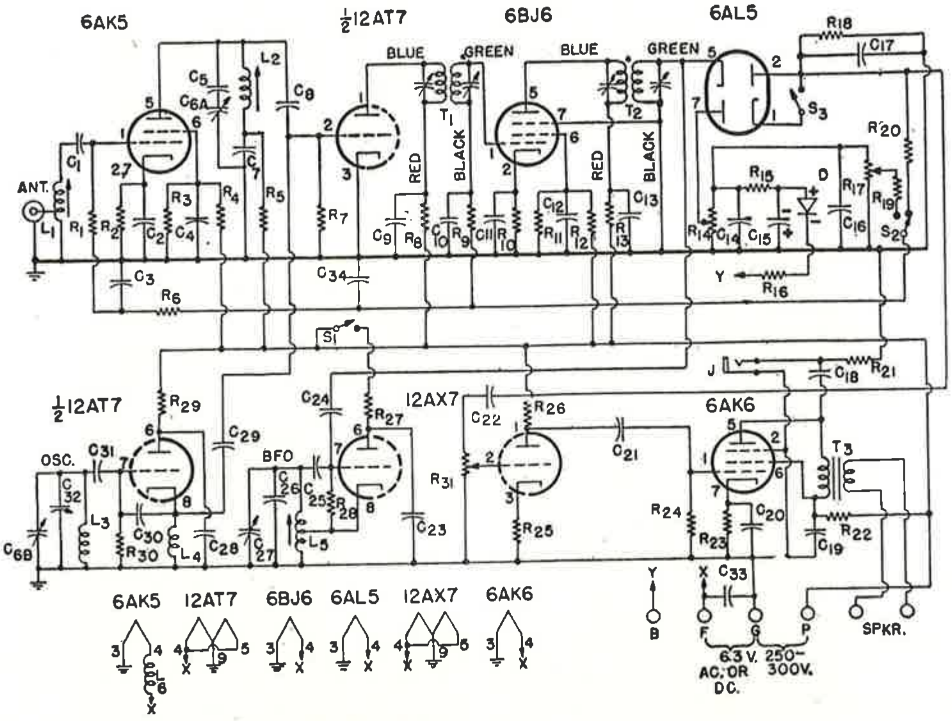

Fig. 2. Circuit diagram of six-metre receiver.

CIRCUIT CONSTANTS

(All resistors and capacitors = 20% tolerance unless specified otherwise.)

C_1, C_{17}, C_{26}	100 $\mu\mu$F mica or general purpose ceramic (Sprague 19C11.)
C_2, C_3, C_4, C_{12}	1000 $\mu\mu$F mica, paper or high-K ceramic (Sprague 19C1)
C_5	10 $\mu\mu$F zero-temperature coefficient ceramic (Sprague 19C3)
C_6A, C_6B	Split-Stator variable, 12 $\mu\mu$F per section (Millen 23912C)
C_7, C_8, C_{28}	1000 $\mu\mu$F mica or general purpose ceramic (Sprague 29C21)
C_9, C_{10}, C_{11}, C_{13}, C_{16}, C_{23}, C_{33}, C_{34}	5000 $\mu\mu$F mica, paper or high-K ceramic (Sprague 29C1)
C_{14}, C_{15}	50 μF 25 volt electrolytic (Sprague TA-50)
C_{18}, C_{21}, C_{22}	0.05 μF 400 volt paper (Sprague 68P10)
C_{19}	8 μF 450 volt electrolytic (Sprague UT-8)
C_{24}, C_{29}	2 $\mu\mu$F ceramic (see text)
C_{25}	50 $\mu\mu$F mica or general purpose ceramic (Sprague 19C28)
C_{27}	10 $\mu\mu$F variable, single-spaced (Cardwell ZR-10-AS)
C_{30}	5 $\mu\mu$F mica or general purpose ceramic
C_{31}	10 $\mu\mu$F mica or general purpose ceramic (Sprague 19C19.)
C_{32}	15-120 $\mu\mu$F mica compression trimmer (El Menco 302-M)
D	Crystal diode GEX 34
J	Open-circuit phone jack
L_1	12 turns No. 26 A.W.G. (27 S.W.G.) enamel wire close-wound on slug-tuned coil form $\frac{3}{8}$ in. in diameter. Tap 2 turns from ground end (Millen No. 69042 coil form)
L_2	5 turns No. 26 A.W.G. (27 S.W.G.) enamel wire close-wound on slug-tuned coil form, $\frac{3}{8}$ in. in diameter (Millen No. 69042 coil form)
L_3	4 turns No. 14 A.W.G. (16 S.W.G.) wire $\frac{1}{2}$ in. in diameter space-wound
L_4, L_6	6-metre R-F choke made by winding 44 turns No. 30 A.W.G. (33 S.W.G.) enamel wire, close-wound, on $\frac{5}{16}$ in. diameter, one megohm, 2-watt resistor
L_5	36 turns No. 36 A.W.G. (40 S.W.G.) enamel wire close-wound on slug-tuned form $\frac{3}{8}$ in. in diameter. Tap 9 turns from ground end (Millen No. 69042 coil form)
R_1, R_9, R_{27}, R_{28}, R_{30}	100,000 ohm, $\frac{1}{2}$ watt
R_2	220 ohm, $\frac{1}{2}$ watt

CIRCUIT CONSTANTS — (Continued)

R_3	39,000 ohm, 1 watt (= 10%)
R_4, R_{12}	39,000 ohm, 2 watt (= 10%)
R_5	19,500 ohm, 4 watt (two 39,000 ohm, 2 watt = 10%, resistors in parallel)
R_6	10,000 ohm, ½ watt
R_7, R_{21}	1.0 megohm, ½ watt
R_8, R_{29}	4,700 ohm, 2 watt
R_{10}	68 ohm, ½ watt
R_{11}	68,000 ohm, 2 watt
R_{13}	10,000 ohm, 2 watt
R_{14}	20,000 ohm potentiometer
R_{15}	2,200 ohm, ½ watt
R_{16}	22 ohm, ½ watt
R_{17}, R_{31}	250,000 ohm potentiometer
R_{18}	220,000 ohm, ½ watt
R_{19}	2.2 megohm, ½ watt
R_{20}	4.7 megohm, ½ watt
R_{22}	6,000 ohm, 4 watt (two 12,000 ohm, 2 watt = 10%, resistors in parallel)
R_{23}	470 ohm, 1 watt
R_{24}	0.47 megohm, ½ watt
R_{25}	3,300 ohm, ½ watt
R_{26}	330,000 ohm, ½ watt
S_1, S_3	SPST toggle switch
S_2	SPDT toggle switch
T_1, T_2	465 kc. I-F transformers altered as per text
T_3	Output transformer, 10,000 ohms to voice coil

required is not critical (225 to 300 volts) and the current drain is low (50 to 65 mils.).

Mobile aspect

It might seem strange to say that a receiver which is housed in a 10 by 7 by 8 inch cabinet is suitable for mobile work, but such is the case. Recent trends in mobile and emergency work have been to keep the transmitting and receiving equipment as an integral unit, yet one which is not mounted in any particular car.

This system has several advantages. For example, assume that the receiver, transmitter and vibrator power supply are mounted on a piece of wood which will fit comfortably on the front seat beside the driver. Two clip leads can be used for the battery connection or a special lead can be used which will plug into the cigarette lighter socket. All that is needed now is an antenna (assuming a relay is used to switch the antenna from transmitter to receiver).

The antenna may be mounted on the car, or the antenna may be mounted on an insulating board which fits or clamps over the glass on one of the car windows. In the latter case, the entire station is completely independent of the automobile.

Only an independent station installation of this sort can be considered to be a true emergency station. Any car which is available serves as the home for a station of this sort. Any six-volt car battery serves as a prime source of power. Thus the station can be used in an attic, in a medical centre, or even in the top of a tree. A mobile rig mounted in a car can only go where a car can go, while an independent station can go anywhere that human hands can carry it.

Circuit details

Refer to the circuit diagram, Fig. 2. The 6AK5 miniature tube serves as a pentode r-f amplifier. The input circuit is broad-band; that is, when L_1 is correctly tuned, the r-f stage will operate properly over the range 50-54 megacycles. In order to maintain a low noise figure and broad-band characteristics, it is vital that the proper antenna be used. For the constants shown a 50 ohm antenna is correct. A 75 ohm antenna can also be used if some change in the band-pass characteristics can be tolerated.

The 6AK5 tube feeds a 12AT7, one half of which serves as the local oscillator, and the other half acting as the mixer. Both the oscillator and mixer have tuned circuits, with C_{6A} tuning the mixer grid and C_{6B} tuning the oscillator grid. The oscillator section is a Colpitts oscillator. This type of circuit is used so that a coil tap is not required. The r-f choke required in the cathode circuit is relatively simple to provide at this frequency. The oscillator is designed to work on the high side of the received signal, for reasons which will be discussed subsequently.

A single 6BJ6* acts as the i-f amplifier, operating at 5.0 megacycles. The reason for the choice of this frequency is worth discussing at this point. As previously mentioned, double conversion was ruled out in the design of this receiver. The receiver must tune over a range of four megacycles. If the intermediate frequency is lower than two megacycles, images will be found in the 50-54 megacycle band. What about using an intermediate frequency of 2500 kilocycles? This could be done, but it presents problems. For example, the oscillator would be on 52.5 megacycles when the receiver was tuned to 50 megacycles. The r-f section is broad-band, so that any leakage of signal from the oscillator into the r-f stage would tend to block the receiver and make it insensitive to 50 megacycle signals.

Another problem is that of coupling the oscillator to the mixer grid. It was felt that the average ham would have some difficulty with tracking if 2.5 megacycles were to be used as the intermediate frequency.

It would be possible to use ten megacycles as an intermediate frequency, but the receiver would have much less selectivity than one using five megacycles. To sum up, 5.0 megacycles was selected because the image problem, overload problem and coupling problem were minimized, and because it is possible to get reasonable selectivity and gain with only one i-f stage.

*** 6BA6 is a suggested Australian alternative miniature.**

It is possible to add a second i-f stage and achieve additional selectivity. This was not done because the advantages were outweighed by the disadvantages. Another i-f tube would be required, and the plate current for this tube, added to the current already required, would bring the total current requirements for the receiver well above the fifty milliampere figure desired. The additional gain would not be sufficient to permit the use of only one audio stage, and if the second i-f stage were used more care would be needed to keep the i-f system adequately shielded.

A bias source is used in this receiver for the noise-limiter system and for complete control of r-f gain. This bias is obtained by rectifying the 6.3 volt filament supply with a small germanium diode. This rectifier works from either an a.c. or a d.c. source, so that mobile operation is possible. An explanation of this will be given later.

The use of such a bias system permits the r-f gain of the receiver to be reduced to zero (this is not true of a self-biased r-f gain system). The i-f stage uses a remote-cutoff tube, which means that the gain of the r-f system decreases faster than the gain of the i-f system, when the r-f gain control, R_{17}, is adjusted to progressively lower gain settings. The effect keeps the front-end from overloading. It would be desirable, from the cross-modulation standpoint, to have a remote-cutoff tube in the r-f amplifier stage, but such a tube would give a poorer noise figure, so the sharp-cutoff tube is used.

One section of a 6AL5 serves as the diode second detector, and the other half acts as the diode for the noise limiter circuit. The limiter is a parallel clipper circuit whose clipping level is adjusted by means of the potentiometer R_{14}. The bias voltage available is more than sufficient to provide a complete range of clipping level. Use of the noise limiter will be discussed later.

When the arm of S_2 is connected to R_{19}, the r-f gain control is in use, and when the arm of S_2 is connected to R_{20} the a.v.c. system is in action. The noise limiter is turned on by connecting together 1 and 2 of the 6AL5 through S_3.

One-half of a 12AX7 twin-triode is used in the beat-frequency oscillator circuit. The circuit shown is a Hartley oscillator. A Colpitts oscillator could have been used, but it seemed easier, at this frequency, to use a tapped-coil Hartley than to provide the cathode choke required for the Colpitts circuit.

The other half of the 12AX7 tube serves in the first audio amplifier stage. This tube was selected because it is a high-gain tube, yet requires only a moderate amount of current. The output stage uses a 6AK6*, which provides a watt or so of power for the loudspeaker. A word of precaution about the output stage. If earphones are used, make certain that the loudspeaker is connected to the speaker terminals, or, if you do not wish to use the speaker, connect a ten-ohm two-watt resistor across the speaker terminals. The secondary of the output transformer must always be properly terminated if damage to the transformer is to be avoided.

Constructional details

It is recommended that the mechanical layout shown in the photographs and sketches be followed exactly. A receiver operating on the six-metre band is capable of giving a lot of trouble unless care is taken with parts placement and lead length. The layout shown was used only after a great deal of thought had been put into getting an efficient and well-planned placement of parts.

The cabinet selected for the six-metre receiver is seven inches high, ten inches wide and eight inches deep. The chassis used is a standard seven by nine by two inch chassis. In order to maintain a symmetrical panel layout and yet have correct parts placement, the chassis is attached to the panel so that the top of the chassis is three inches from the top of the panel. This leaves two inches below the bottom of the chassis, on the panel, for the mounting of parts, and places the main tuning dial high enough so that tuning is convenient.

The exact placement of parts is indicated in the layout sketches and the photographs. Small holes are not indicated on the sketches, but the location of the major components is shown. The position of the main tuning dial is not indicated, because this will depend upon the type of variable condenser used (C_6) and the type of dial used. The dial shown is a Millen No. 10039.

Inasmuch as five-megacycles i-f transformers of the desired type are virtually unobtainable, it is necessary to purchase 465 kilocycle i-f transformers and convert them. Practically any low-frequency i-f transformer is suitable which does not have an iron-core form. Burned-out transformers would be ideal, as long as the mica trimmer condensers in them are in good condition. The transformers used in this receiver are Meissner "Plastic" I-F Transformers. The transformers are 1¼ inches square and 2½ inches high and are rated for the frequency range from 400 to 550 kilocycles. Three types are available: input, output and interstage, any of which can be used because you are going to remove the coils anyway. The numbers of these three transformers are: 16-6658, 16-6659 and 16-6660.

Regardless of the type of transformer you procure, make certain that you do **not** get an iron-core unit. Further, try to get transformers that have a coil-form ⅜ or ½ inch in diameter. The coil-form in the Meissner transformers just described has a ⅜ inch diameter. It is necessary to enlarge this to ½ inch diameter, but this is easily done by winding the form with paper until it is the right diameter, then putting on a final layer of transparent tape. Now, follow the sketch of the winding shown in Fig. 8, and wind each coil with 40 turns of No. 30 A.W.G. (33 S.W.G.) silk or enamel wire. The spacing between coils is ⅜ inch, as shown, and the wire is close-wound. The 40 turns of close-wound No. 30 A.W.G. (33 S.W.G.) wire should just take up the ⅜ inch winding space shown. For proper connections, follow the color coding shown in the

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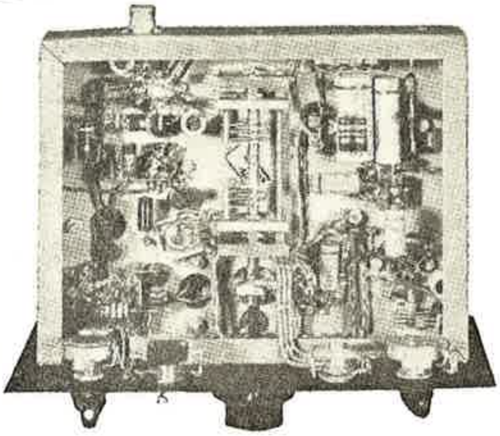
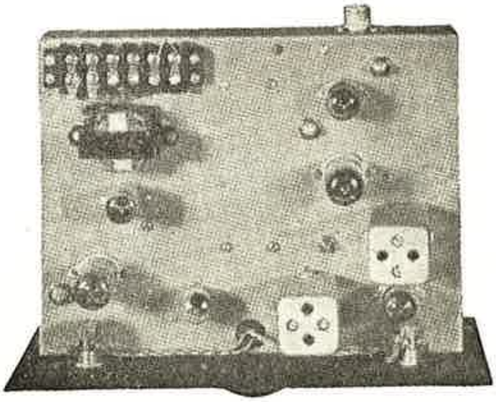
*** 6AM5 is a suggested alternative miniature.**





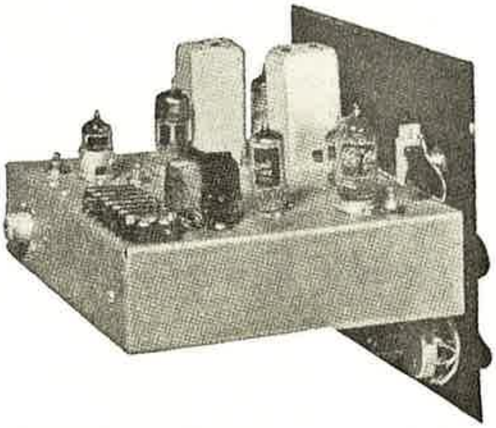


Fig. 3 (Top). Underchassis view of six-metre receiver.
Fig. 4 (Middle). Top view of six-metre receiver.
Fig. 5 (Bottom). Side view of six-metre receiver

circuit diagram and that shown in Fig. 8. After the coils are wound a small amount of cement may be applied to them to hold the wire in place.

The capacitor which couples the oscillator energy into the mixer C_{29}, and the capacitor used for BFO injection, C_{24}, are specified as 2 $\mu\mu$F ceramic condensers. It is possible to use a pair of twisted wires in place of the ceramic condensers. This might even be preferred in the case of C_{24}, because the BFO injection can be varied by means of the twisted-wire condenser until injection is optimum. Some experimentation may be needed on C_{29} also, although this is not as critical as C_{24}.

The bottom view of the receiver, Fig. 3, shows that shielded wire has been used for the leads that go to the earphone jack and to the audio gain control, R_{31}. This is advisable in order to prevent feedback between the audio and the i-f portions of the receiver. Shielded wire is also used for the connections to the noise limiter switch, S_3, as may be seen in the top view of the receiver Fig. 4.

If the cabinet used has a solid back it will be necessary to drill two clearance holes in this back to pass the coaxial connector and the wire leads going to the terminal board.

Component parts

Practically none of the parts used in this receiver are critical. Five resistors are specified with a tolerance of ten per cent., but all other parts can have a twenty per cent. tolerance. The manufacturer's name and part number are shown in the Circuit Constants list wherever practical. Use of the flat ceramic condensers specified is recommended because they permit you to maintain short lead lengths in the wiring. Further, they take up very little space.

When purchasing these new flat ceramic condensers bear in mind that they come in three general types: (1) those suitable only for bypassing applications (and some coupling applications) where the capacitance stated is a guaranteed minimum value only; (2) those suitable for general purpose use as alternates for foil-mica condensers; and (3) those suitable for use in resonant or frequency-determining circuits. The information given under Circuit Constants should enable you to obtain the right condenser for each particular job. The Sprague type numbers given are those of the condensers actually used in the receiver pictured.

The Millen coil form specified for coils L_1, L_2 and L_5 uses a powdered-iron slug. Brass-slug coil forms can be used, but the coils will probably require a different number of turns if this is done.

Final adjustments

Terminal "B" on the terminal board supplies either an a.c. or a d.c. voltage to the bias rectifier. If the receiver is to be used with a.c. on the filaments, connect a strap from terminal "B" to terminal "F", and "G". If a 6-volt battery is to be used for the filament source, terminal "B" can stay connected to terminal "F" if the **negative** of the battery is connected to the junction of terminals "B" and "F", and the positive terminal of the battery is connected to terminal "G".

It is essential that a negative d.c. voltage be applied to terminal "B" in order that the bias rectifier will pass the direct current and supply bias for the r-f gain control and the noise limiter. If the receiver is used in a car where the negative of the battery is connected to ground, then it will be necessary to use a bias battery in order to obtain bias. In other words, terminal "G" on the receiver is the ground terminal. The receiver ground must be grounded to the automobile ground, which means that in the case stated above, the negative 6 volt supply is at ground potential. The positive 6 volt terminal of the battery can be connected to terminal "F" and still supply filament power, but terminal "B" must be disconnected in this case, otherwise bias voltage would not be developed. However, a small 7.5 volt bias battery can be used, with its negative terminal connected to "B" and its positive terminal to "G". Inasmuch as most cars have the positive side of the battery grounded, it is unlikely that you will encounter the few types of cars with a negative ground system.

To test the receiver connect either an a.c. or a d.c. source to terminals "F" and "G" and check to make sure that all filaments are lit. Then connect the negative of the high voltage supply to "G" and the positive voltage to "P". Connect a speaker across the "SPKR" terminals or use a ten-ohm two-watt resistor in place of the speaker. Connect an antenna to the input, and the receiver is ready to operate.

If you have a grid-dip meter its use is highly recommended. Set L_1 to 52 megacycles with the grid-dip meter. Set C_6 to mid-scale and adjust C_{32} until the oscillator is operating at 57 megacycles, as shown by the grid-dip meter. Now check the frequency of L_2 and adjust the slug in L_2 until it is resonant at 52 megacycles. (All the tubes should be in place when the above adjustments are being made.) If a grid-dip meter is not available, it will be necessary to provide a 52 megacycle signal with a signal generator or with your transmitter, and peak the circuits for the best output when the receiver is operating.

Turn on the receiver, and connect an output meter across the speaker terminals — either a speaker or a load resistor should still be in place. Use a grid-dip meter as a signal source at 52 megacycles, or use some source of signal until the output meter shows a deflection. For this test the a.v.c. switch should be in the "off" position. Use the r-f gain control to set the level or the output meter to some convenient point. Also, the noise limiter switch, S_3, and the BFO switch, S_1, should be in the "off" position. Now, increase the intensity of the r-f signal, either by moving the grid-dip oscillator closer to the receiver, or by advancing the gain on the signal generator, and make certain that the output meter shows an increase in reading when the r-f signal is increased. This is merely to check that the receiver is not overloading. If the output meter does not show an increase in gain, you are using too much r-f signal. In this case, decrease the r-f signal until a slight increase in the r-f signal shows up as a slight increase on the output meter.

Once the above conditions are satisfied, you may align the intermediate transformers in a rough manner by adjusting the four trimmers in the i-f transformers for maximum deflection of the output meter. The two i-f transformers will now be operating approximately on the same frequency, so the next step is to set this frequency to 5.0 megacycles. Use a signal generator capable of operation on 5.0 megacycles. Connect the output of this signal generator to pin 2 of the 12AT7 through a 100 $\mu\mu$F condenser, and advance the control on the signal generator until you get a suitable deflection on the output meter. Now adjust the four trimmers in the two i-f transformers again, in order to get a maximum reading on the output meter. If the output meter tends to go off-scale, reduce the input by the control on the signal generator. The i-f strip should now be aligned.

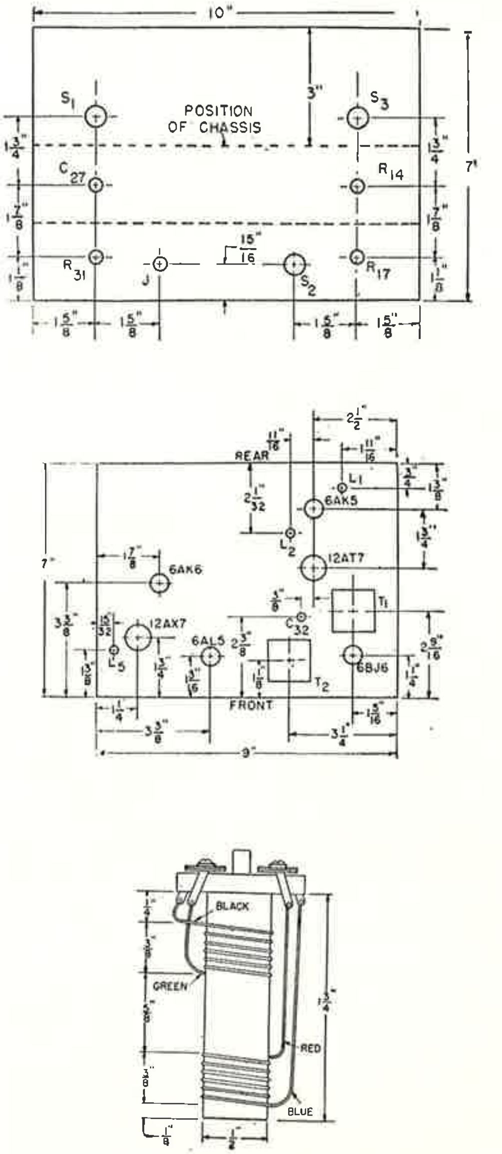


Fig. 7 (Middle). Chassis layout.
Fig. 6 (Top). Front panel layout.
Fig. 8 (Bottom). Detail of i-f coil winding.

Next, remove the i-f signal generator and put a signal into the receiver with an r-f signal generator, and if you are using an adjustable condenser of twisted wire for C_{29}, adjust this until you get a maximum signal in the output meter. This capacitance can be too low or too high, so search for the optimum point.

The next step is to turn on the BFO and tune the receiver to the frequency of the signal generator, and listen to the beat-note obtained. Adjust C_{24}, assuming you are using a twisted-wire capacitor, until the beat note is the desired strength. Tune C_{27}, the BFO pitch control, to make certain that you have adequate range. If you do not hear a beat, adjust L_5 until a beat appears. Tune L_5 slowly, as the frequency change is quite rapid when tuning this coil. Obviously, a speaker or earphones must be used for this test. The receiver should now be ready to put on the air.

Operating information

Use a good antenna, and one with the proper impedance. When properly constructed, this receiver should have a noise figure of about 6 db, which means that it is a very sensitive receiver. As stated before, the i-f bandwidth is not as sharp as some might like it, but it is adequate unless you run into severe QRM conditions. The actual bandwidth will be between 25 and 40 kilocycles, to the half-power point.

The noise limiter is the threshold type, which means it must be adjusted according to the strength of the received signal. If you experience noise, turn on switch S_3 and advance R_{14} until the noise is just equal to the received signal. If the control is advanced further, you will clip the signal as well as the noise. After a little experience you will be able to use the noise limiter control easily, and you will realize the advantage you have in being able to decrease the noise to the point where it is no louder than the received signal.

THE IMITATION OF NATURAL SOUNDS

By Daniel W. Martin

Life's repertoire of natural sounds consists largely of complex types rather than simple ones. Consequently the realistic imitation of most sounds is difficult, because of the complexity of instrumentation required. One of the frequently used devices in the radio sound-effects kit is a small door, complete with latch and frame, for creating the entrance and exit sounds of the dramatic characters. Often the easiest way to create the sound effect desired is to use the original, natural source or a miniature model of it.

Why should close simulation of natural sounds be so difficult? Techniques and instruments for sound recording, spectrum analysis and waveform oscillography have developed rapidly within the last twenty years, so that very detailed information on a sound can now be obtained. A realistic imitation of a sound would seem to require only the production of each of the simple components of the original complex sound in the correct amount and at the right times.

This approach has been successfully used, but seldom with simplicity of instrumentation for synthesis, and only occasionally with a simulation which cannot rather easily be distinguished from the original sound. Several examples, discussed below, will illustrate the point.

1. Impulsive noises

The simplest explosion wave, that of a bare charge in an unbounded medium, consists first of a sharply rising pressure wavefront, then a gradually decreasing pressure, followed by a rarefaction of lesser magnitude and fluctuations about the mean or static pressure. The important factor here is wave shape.

In explosions from firearms the shape of the wave becomes complicated by shock-excited resonances of the chambers which confine the explosion during the propulsion of the missile. Indoor explosion waves are modified by room acoustics. Even when an explosion is out-of-doors, reflected waves from nearby objects and distant hillsides alter the wave shape. Recall the variety of sounds produced by various weapons, from a revolver to a cannon, by explosions created by man and those occurring in nature, like the clap of thunder and the cracking of a falling tree. Perhaps the realistic imitation of impulsive noises can be most easily accomplished by constructing models, after all.

2. Random noises

In recent years this class of sound has been produced by several different electronic means, and has been very useful in the simulation of aerodynamic noises and in psychological masking experiments. Some random noises contain spectral prominences having pitch, although the tuning is generally not very sharp. The pitch of an aerodynamic noise seems to be an aural indication of the mean velocity of flow, an increase in pitch signifying greater speed. Many natural sounds, including some insect noises, the falling of rain, the pounding of surf, are in this category.

3. Simple musical tones

The flute, as an example of tonal simplicity, is widely known because it was the favorite instrument of D. C. Miller, who pioneered in the science of musical sounds. A harmonic analysis of a flute-tone reveals little but fundamental in the wave. Yet how poorly the output of a good laboratory oscillator resembles a flute tone.

How does one recognize the flute when it takes the theme in an orchestral passage? As much by its breathiness of tone as by its purity. The tuning fork can be said to have a truly simple tone, but its musical importance is limited to the function of tuning. Musical tones must be complex in order to be interesting.

4. Steady-state musical tones

It is in this class of sound that the creation of somewhat similar qualities of tone by widely different methods has been most successful. The pipe organ is the classic example, yet its successive waves are less nearly identical than the waves of some of the electronic types of organ.

Synthesis from a limited series of approximate harmonics was one practical approach to the imitation of the steady-state tones of existing musical instruments. A fully realistic synthesis of complex tones requires a very large number of individual harmonic components. Consequently a method was developed in which a highly complex oscillator wave was modified spectrally in various ways to yield different types of tone. It is possible, of course, to create a variety of wave forms from different types of oscillator circuits, but this leads to great multiplicity of equipment. Another way to achieve complexity and versatility of effect, with simplicity of method, is to scan many different waveforms with a single scanning means, each waveform having been created by harmonic synthesis.

5. Percussive musical tones

Percussive tones consist of vibrations at the natural frequencies of the vibrating system excited by the percussion. In general, these frequencies do not lie exactly in a harmonic series, and in some cases there is no resemblance to harmonics at all. Thus the imitation of these sounds requires frequency components which can be varied independently of each other, as well as envelope control corresponding to the mode of percussion and to the various damping rates existing at the different natural frequencies. This is much more difficult to accomplish than the simulation of steady-state musical tone.

6. Human voice

Because speech and singing are complex combinations of pitched tones and unpitched noises, the human voice is considered the most difficult single source of sound to imitate realistically. In spite of this, outstanding attempts have been made, notably at Bell Laboratories, to imitate the voice. The talking Voder, demonstrated at the New York World Fair, was a spectacular example of imitation of complex sound. Its electrical complexity, and the time required to train the operators who made it talk, might be expected to discourage anyone from attempting the invention of a singing Voder or of a synthetic symphony. However, some of the most optimistic patent disclosures of recent years, in the electronic musical instrument field, claim not only to imitate fully the natural forms of music, but to surpass them. The creation of new sounds, unknown to man and to nature, lies, fortunately, outside the scope of this article.

New RCA Releases

(Continued from page 68)

Radiotron 17QP4 is a 17-inch, all-glass, rectangular picture tube featuring a cylindrical Filterglass faceplate with toric inner surface and utilizing magnetic focus. It has a picture size of $14\frac{3}{8}''$ x $10\frac{13}{16}''$ with slightly curved sides and rounded corners.

The cylindrical outer surface of the Filterglass faceplate effectively reduces in the vertical plane any reflections of bright objects as compared to the reflections produced by a spherical contour. In addition, the neutral light-absorbing material incorporated in the Filterglass faceplate reduces ambient-light reflections from the phosphor and reflections within the faceplate itself in a much higher ratio than it reduces the directly viewed light of the picture. As a result, improved picture contrast is obtained.

The toric inner surface of the faceplate affords a practical compromise between a cylindrical inner surface and a spherical inner surface generally desired for yoke design and for required bulb strength with minimum weight.

The 17QP4 has an external conductive bulb coating which with the internal conductive coating forms a supplementary filter capacitor; an ion-trap gun requiring an external, single-field magnet; a design-centre maximum ultor-voltage rating of 16,000 volts; a diagonal deflection angle of 70°; a horizontal deflection angle of 65°; and a weight of 19 pounds approximately.

Radiotron 5CP12 is a 5-inch, cathode-ray tube designed particularly for those oscillographic applications, such as short-range radar service, where grid No. 1 is pulse-modulated to provide a temporary record of electrical phenomena. It utilizes the medium-long persistence screen P12.

Because of its medium-long persistence, the 5CP12 is especially useful where low- and medium-speed recurring phenomena are to be observed. The phosphorescence decays exponentially with a time constant of about 120 milliseconds; consequently, the low-level phosphorescence is of relatively short duration. As a result of this characteristic, the 5CP12 provides high contrast between new and old information with change in target position — a feature making the 5CP12 suitable for short-range radar equipment involving medium-speed recurrent phenomena.

Like the 5CP1-A, 5CP7-A, and 5CP11-A — other 5C-types which differ only in their respective phosphors — the 5CP12 has unusually high spot intensity, high grid-modulation sensitivity, and high deflection sensitivity. It utilizes electrostatic focus and electrostatic deflection; a "zero-first-anode-current" gun; and a post-deflection accelerator.