RADIOTRONICS

AMALGAMATED WIRELESS VALVE COMPANY LIMITED

TECHNICAL BULLETIN No. 66 ISSUED 26TH AUGUST, 1936

IN THIS ISSUE:—

1K6 new 2 volt duo-diode Pentode valve.

Receiver circuits incorporating Radiotron 1K6.

RADIOTRON 1K6: 2 volt duo-diode Pentode valve.

New Radiotron release gives four times gain of older types. Ideal Driver for 19 Class B Stage.

Radiotron 1K6 is an Australian-designed battery valve designed to supersede type 1B5, and is the latest addition to the new Radiotron range of non-microphonic battery valves. In combination with types 1C4, 1C6, 1D4 and 19, Radiotron 1K6 gives unexcelled receiver performance. The 1K6 in the battery series corresponds to the 6B7 in the A.C. series, and provides a stage gain not far short of that given by the 6B7. A stage gain of 60 times or more is provided by this new valve with negligible harmonic distortion.

RESISTANCE COUPLED PENTODE

As a resistance coupled audio amplifier Radiotron 1K6 is remarkably efficient. Its high gain eliminates the frequent necessity for setting the volume control to maximum and as a consequence the set is capable of receiving a higher percentage of modulation without distortion (see Radiotronics Technical Bulletin No. 62, page 5, under heading Radiotron 6F5).

Any receiver designed for the 1B5 may be changed over to the 1K6 with the greatest ease. The 1K6 uses the same base and arrangement of pins as the 1B5 except that the control grid is taken to the top cap and the screen is taken to the vacated base pin. With this slight wiring alteration and with the correct screen voltage applied, no other alteration in the receiver is required. The bias to be used on the 1K6 (–1.5 volts) is the same as that generally used with the 1B5. With normal receiving conditions the volume control will be worked at a lower setting than with the 1B5, due to the higher gain of the 1K6, so that the audio gain will be identical. On very weak stations, however, the volume control may be turned up so as to utilise the full sensitivity of the 1K6.

SCREENED DIODES ELIMINATE DISTORTION

The two diodes of the 1K6 are very carefully screened in order to prevent I.F. voltage from getting into the audio amplifier. Without such screening, particularly on strong signals, the audio amplifier may be overloaded with I.F. When using a valve with unscreened diodes it is essential to bypass heavily both grid and plate of the valve and even then a certain amount of distortion is caused through unavoidable coupling inside the valve. In the 1K6 the screening is adequate to prevent coupling inside the valve and with an efficient I.F. filter between the diodes and the control grid very little I.F. will get through to the plate circuit. It must be stressed, however, that the grid lead must be short or thoroughly screened from I.F. in order to prevent pick-up of this nature.

DIODES AT OPPOSITE ENDS OF FILAMENT

The diodes of the 1K6 are arranged one at each end of the filament in order to provide one which is ideal for detection and the other which gives delayed A.V.C. This arrangment is identical with that used in Radiotron 1B5. It is essential to distinguish between the two diodes, the one at the *negative* end of the filament being the correct one for detection. There is no advantage in connecting the two diodes together, and if only one diode is required this should be the one at the negative end of the filament, the other diode being returned preferably to the positive end of the filament.

The diodes in the 1K6 are highly efficient and there is no risk of overloading even with a large I.F. input.

1K6 AS ECONOMICAL DRIVER FOR 19 CLASS B

Radiotron 1K6 has been provided with "sharp cut-off" characteristics, so that it can be connected as a triode. A "super-control" pentode valve makes a very inefficient triode when plate and screen are tied together, but the 1K6 makes an extremely good triode under these conditions. The grid bias used is –4.5 volts so as to suit a standard bias battery, this same voltage being recommended for the 1K6 (triode), 1D4 and 19. The plate current as a triode is 2 milliamperes which is the optimum for driving Radiotron type 19 with a plate-to-plate load of 20,000 ohms. Due to the higher amplification factor of the 1K6 (triode) as compared with the 30, an input voltage of 4.5 volts peak to the 1K6 gives a power output sufficient to drive the 19 as compared with an input of 7.5 volts peak with the 30. If, however, a larger power output is desired, such as that obtained from a 19 with a load of 10,000 ohms plate to plate, the 30 is preferable as a driver but must be operated at a higher plate current and input voltage.

The 1K6 (triode) may be used for any transformer coupled amplifier application, its plate resistance being 16,500 ohms under the usual conditions of operation.

1K6 AS R.F. OR I.F. AMPLIFIER

Radiotron 1K6 is very versatile in its applications, and functions admirably as R.F. or I.F. amplifier on fixed bias. For example, if two I.F. stages are desired, the second stage should be operated on fixed bias and the 1K6 may well be used in this position. An obvious advantage of this arrangement is that the I.F. is kept completely away from the audio system.

The pentode unit of Radiotron 1K6 is very similar to the 1C4, and the external dimensions are identical, apart from the number of pins in the base. The same dome shield construction has been adopted and a standard shield can is recommended.

1K6 AS RESISTANCE-COUPLED TRIODE

Radiotron 1K6 may be employed, if so desired, as a resistance-capacity-coupled triode, its performance in this application being very similar to that of existing types of duo-diode-triodes. Although the stage gain is considerably less than that as a pentode there is a simplification due to the absence of a screen supply and the advantages due to the diode screening are retained. In this application the screen and plate are tied together.

ADVANTAGES OVER SUPER-CONTROL

A pentode valve having a super-control characteristic when used as a resistance coupled amplifier is critical in its screen and bias voltages. A valve such as the 6B7S which has a long grid-base and which operates on a high plate voltage (250 volts supply) is quite satisfactory, owing to its operation with self-bias, but when applied to a battery receiver on 135 volts supply and fixed bias the operation is much more critical. Not only is the adjustment of voltages more critical, but the maximum voltage output for limited distortion is lower in the case of a super-control valve. Finally, a super-control valve is not capable of satisfactory operation as a triode.

EXTREME RIGIDITY

Advantage has been taken in the introduction of this new type to provide an entirely new and extremely rigid construction. All electrodes are very strongly braced and noise caused by looseness of electrodes has been reduced to negligible proportions. The filament is supported at five points and being heavier than in the 1B5 is even less microphonic.

SIMPLE RULE FOR VOLTAGE ADJUSTMENTS R.C.C. PENTODES

When any sharp cut-off R.F. pentode valve such as the 1K6 is used as a resistance coupled amplifier it is very easy to estimate the correct operating conditions. The rule is—

> "Adjust the screen and bias voltages until the plate current is one-half that which would flow when the plate is short-circuited to the filament."

In the case of the 1K6 on 135 volts with 0.25 megohm load, the short-circuited current will be 135 ÷ 250,000 which is .00054 amp. or 0.54 mA. The correct adjustment is when the plate current is one-half of this short circuit current, that is 0.27 mA. The operating conditions show 0.25 mA., but since with the 1K6 the adjustment is not critical, this shows a very satisfactory degree of accuracy. If the required output voltage is only small, say for example about 5 volts peak, the plate current can vary appreciably from the value given without any noticeable distortion, but as the output voltage increases the correct adjustment becomes more important.

In this adjustment it is preferable first to set the bias to a suitable value with regard to the grid input voltage and then to adjust the screen voltage until the plate current reaches the correct figure. This rule cannot be applied indiscriminately to triodes valves but will be found a reasonable approximation in most cases.

A.V.C. IMPROVEMENTS

The A.V.C. circuit used in this receiver is unique and should be studied carefully so that its advantages are appreciated. The only "shunting" of the detector diode load at low volume control settings is that due to the 1.5 megohm resistor R_{10} and the filter condensers C20 and C21 and since these are in parallel with an effective load of not more than 0.25 megohm their effect is slight. This improvement results in lower harmonic distortion. The A.V.C. diode is fed from the primary of the second I.F. transformer for two reasons. Firstly, this reduces the shunting of the detector diode, and secondly it provides rather higher A.V.C. voltages and consequently a better A.V.C. characteristic. The disadvantage involved in this arrangement is a reduction in selectivity and some loss in sensitivity, but the sensitivity is so good in any case that the loss is not important. The reduction in selectivity is more important and must be considered in conjunction with other characteristics of the circuit. If two I.F. stages are used there will be no problem in this regard, but with a single I.F. stage a compromise must be adopted between selectivity, distortion and A.V.C. characteristic. Circuit A52 gives extremely low distortion, an exceptionally good A.V.C. characteristic and moderate selectivity. Improved selectivity could be obtained with looser coupling in the *first* I.F. transformer.

BATTERY RECEIVERS USING RADIOTRON 1K6

In order to illustrate the application of Radiotron 1K6, two typical circuits have been developed in the Laboratory of Amalgamated Wireless Valve Co. Ltd. The first of these is a 5-valve set using 1D4 pentode output, and the second has 6 valves giving Class B output. In each case Radiotron 1K6 is used as the second detector and high gain resistance coupled pentode amplifier, but in the Class B receiver an additional 1K6 is used as a driver for the 19.

SPECIAL A.V.C. CIRCUITS

In each of these receivers a special A.V.C. circuit is used which has been developed for this application, and which prevents overloading and consequent distortion on strong signals.

If it is desired to omit the R.F. stage the control for the R.F. stage may be transferred to the 1C6 without any difficulty, since both operate at zero bias. On the broadcast band this arrangement should not give any trouble, but on the short-wave band there will be appreciable frequency drift due to the A.V.C. action and it is not recommended for this reason. An R.F. stage is strongly recommended in all cases where good performance is desired, both on the broadcast band and on short waves.

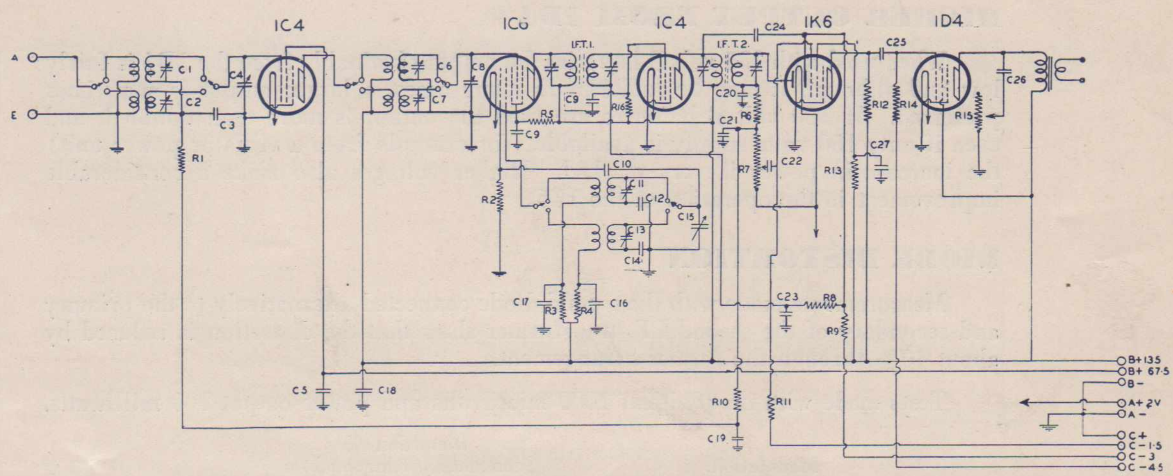
Both circuits use a single I.F. stage and for this reason the selectivity and sensitivity are not so good as would be given by a receiver with two I.F. stages. This difference is more noticeable on the short-wave band than on broadcast frequencies.

FIVE VALVE RECEIVER

In this circuit (A52) one Radiotron 1C4 is used as an R.F. amplifier on zero bias (minimum) with A.V.C., the 1C6 is used on fixed zero bias as converter, and a second 1C4 is used as a single I.F. amplifier on –3 volts minimum bias with A.V.C. and 4 volts delay. The screen supply for the I.F. stage is obtained through a dropping resistor from 135 volts so as to give a fairly long grid base. The second detector is the new Radiotron 1K6. One diode of the 1K6 acts as detector and also provides A.V.C. on the R.F. stage, while the other diode, which is coupled to the *primary* of the second I.F. transformer, provides A.V.C. for the I.F. stage. The screen supply for the 1K6 is obtained through a dropping resistor from 135 volts.

TONE CONTROL — BEST POSITION

The 1D4 output pentode is used in conventional fashion, but it should be noted that the tone control (if one is fitted) should be connected in the plate circuit of the 1D4 as shown, and not in the plate circuit of the 1K6 nor in the grid circuit of the 1D4. A tone control as shown in the circuit has the advantages that it decreases the distortion and has a much less effect on the volume.



RADIOTRON CIRCUIT A52

C1—5-20 μμF Mica Trimmer Condenser.
C2—5-20 μμF Mica Trimmer Condenser.
C3—.05 μF Paper Tubular Condenser.
C4—14-410 μμF Variable Condenser.
C5—.1 μf Paper Tubular Condenser.
C6—5-20 μμF Mica Trimmer Condenser.
C7—5-20 μμF Mica Trimmer Condenser.
C8—14-410 μμF Variable Condenser.
C9—.1 μF Paper Tubular Condenser.
C10—100 μμF Mica Condenser.
C11—5-20 μμF Mica Trimmer Condenser.
C12—400 μμF Mica Condenser + 10-50 μμF Mica Trimmer Condenser.
C13—5-20 μμF Mica Trimmer Condenser.
C14—6000 μμF Mica Condenser.
C15—14-410 μμF Variable Condenser.
C16—.1 μF Paper Tubular Condenser.
C17—.1 μF Paper Tubular Condenser.
C18—.25 μF Paper Tubular Condenser.
C19—.05 μF Paper Tubular Condenser.
C20—200 μμF Mica Condenser.
C21—200 μμF Mica Condenser.
C22—.05 μF Paper Tubular Condenser.
C23—.05 μF Paper Tubular Condenser.
C24—200 μμF Mica Condenser.
C25—.05 μF Paper Tubular Condenser.
C26—.02 μF Paper Tubular Condenser.
C27—.1 μF Paper Tubular Condenser.
C28—.005 μF Paper Tubular Condenser.
T.—See Text.
R1—100,000 Ohms.
R2—50,000 Ohms.
R3—50,000 Ohms.
R4—20,000 Ohms.
R5—60,000 Ohms.
R6—100,000 Ohms.
R7—500,000 Ohms Potentiometer.
R8—1.5 Megohms.
R9—1.5 Megohms.
R10—1.5 Megohms.
R11—1.5 Megohms.
R12—250,000 Ohms.
R13—1 Megohm.
R14—500,000 Ohms.
R15—100,000 Ohms Potentiometer.
R16—100,000 Ohms.
R17—1 Megohm Potentiometer.

INTERMEDIATE FREQUENCY 465 KC.

2 VOLT DUAL WAVE BATTERY RECEIVER

AMALGAMATED WIRELESS VALVE CO. LTD., SYDNEY

CHOICE OF LOUDSPEAKER—Impedance variation complicates matching

The correct load resistance for the 1D4 is 15000 ohms, but in matching a loudspeaker to the 1D4 care must be taken to allow for the rise in the impedance of the loudspeaker at frequencies above 400 cycles. It will be found that loudspeakers rated at 15000 ohms have an impedance over the most important frequency range considerably above the rated impedance, and for this reason it may be found that better results will be obtained from one having a nominal impedance of about 12000 ohms. The final choice must always be made on a listening test, but if a speaker impedance curve is available it should considerably simplify the selection.

HIGHER OUTPUT FROM 1D4

When used with 135 volt B batteries the output obtainable from the 1D4 is fairly low and although it may be sufficient in many cases, a larger output is sometimes preferred. If 180 volt B batteries are used the output is more than doubled, and even if only 150 volts supply is available (for example from a vibrator power unit) the increase in power is very marked. Higher voltages also make a considerable improvement in the operation of the 1C6.

DIODE DISTORTION

Measurements made with the second diode connected alternatively to the primary and secondary of the second I.F. transformer show that the distortion is reduced by about 40% through the former arrangement.

Tests made with input signal 1000 microvolts and power output 100 milliwatts.

Modulation. %	Distortion % Second diode connected to: Primary	Secondary
30%	3.0	4.5
40%	3.5	4.7
50%	3.5	5.0
60%	3.5	6.5
70%	5.0	10.5
80%	7.5	14.7
90%	10.5	17.5
100%	13.0	21.0

These measured values of distortion include distortion in all stages and not only in the diode, but the improvement effected by connecting the second diode to the primary of the I.F. transformer is very clearly shown.

EFFECT OF LARGE SIGNAL INPUTS ON DISTORTION

Due to the improved A.V.C. circuit and to good diode emission, the distortion usually found on large signal input voltages has been very much reduced. Over the greater portion of input voltage range the total distortion is less than 5% and rises to 7.5% at 0.5 volt input and 8.5% at 1.0 volt input. These measurements were made with the input modulated 30% and at an output of 100 milliwatts.

Battery Drain **Circuit A52**

STAGE	VALVE	Current M.A. B.C.	S.W.
RF	1C4	3.4	3.4
Converter	1C6	3.5	4.5
I.F.	1C4	2.0	2.0
2nd Det.	1K6	0.35	0.35
Output	1D4	7.5	7.5
Total Drain	—	16.75	17.75

Coils

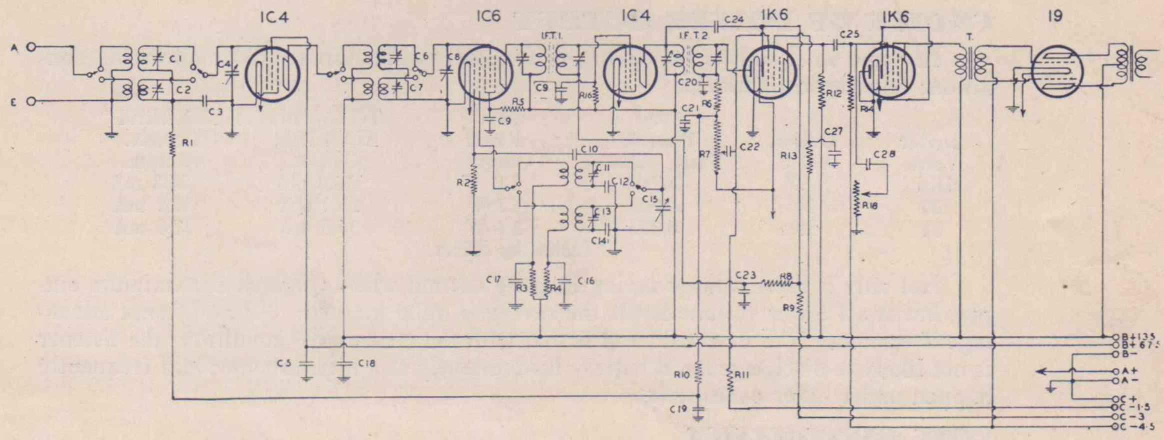
The coils used in circuits A52 and A62 are the same as those described in Radiotronics Technical Bulletin, No. 63, page 3 (Circuit A51).

Sensitivity

The sensitivity of the 5-valve circuit (A52) is slightly poorer than that of the 6-valve circuit (A62), due to the lower audio gain, but the individual stage gains and noise levels are identical.

Selectivity **(Circuit A52 and A62)**

Ratio	1000 to 1
Bandwidth ..	35 K.C. at 600 K.C.
	44 K.C. at 1000 K.C.
	50 K.C. at 1400 K.C.



RADIOTRON CIRCUIT A62

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INTERMEDIATE FREQUENCY 465 KC

2 VOLT DUAL WAVE BATTERY RECEIVER

AMALGAMATED WIRELESS VALVE CO. LTD., SYDNEY

SIX VALVE RECEIVER.

This circuit (A62) is essentially the same as that of the 5 valve receiver apart from the output system. Two Radiotrons 1K6 are used, the first as a resistance coupled audio amplifier, and the second as a driver for the 19. The Class B output has important advantages over a small pentode valve, not only in power output, but also in B battery economy and low distortion. Up till the release of the 1K6 the most widely used driver valve has been type 30, but this suffers from the disadvantage that a large bias battery (about 9 volts) is required and in addition it is rather insensitive. Radiotron 1K6 operates as a driver on –4.5 volts bias and is much more sensitive than type 30. Its plate current of 2.0 mA is sufficient to drive the 19 when used with a load of 20,000 ohms plate to plate.

CLASS B OUTPUT

Although a small pentode valve is generally used on the smaller sets, Class B is very much to be preferred, due to its higher power output, lower B battery drain and lower harmonic distortion. Considerable latitude is possible in the design of a Class B stage and the constants can be arranged to suit the requirements. Although the 19 is rated to deliver 2.1 watts maximum, the B battery drain under these conditions is extremely heavy. Even when the volume is turned down to a low level the B battery drain is still considerably heavier than it would be if designed for a lower maximum volume. Consequently many designers prefer to limit the output to one watt so as to gain this increased economy of plate current in both driver and output stages.

CHOICE OF POWER OUTPUT

In order to illustrate the saving in B battery gain, three typical operating conditions have been tabulated.

Driver Valve	Output Valve	Load Plate to Plate ohms	Max. Power Output	TOTAL PLATE CURRENT* At 1.0 Watt Output	At max. Output
IK6	19	20,000	1.0 W	16.8 mA	16.8 mA
30	19	10,000	1.75W	25.0 mA	31.0 mA
31	19	6,000	2.1 W	36.0 mA	47.0 mA

* Including driver.

Not only is there a large saving in plate current when operated at maximum output, but at all lower volume levels the saving is quite marked. An additional advantage if economy is to be considered is that with the "economy" conditions the listener is not likely to discharge the B battery inadvertently at a high rate as could frequently happen under other conditions.

LOW DISTORTION

The use of Radiotrons 1K6 and 19 as recommended in this Bulletin not only makes an economical output system, but one which has very low distortion. The measured distortion with this arrangement is actually less than that given by most A.C. receivers.

It should be realised that distortion can arise in the earlier stages as well as in the output stage. In order to give the least distortion possible under all conditions, the distortion in the earlier stages must be low at all aerial input voltages likely to be experienced. It is for this reason that such an A.V.C. system has been adopted. Diode "shunt" loading has been reduced to a minimum through the coupling from the primary of the I.F. transformer to the A.V.C. diode in place of the more usual arrangement. This permits the reception of high percentages of modulation without appreciable distortion and is essential for good fidelity.

Battery Drain Circuit A62

STAGE	VALVE	No signal current mA B.C.	S.W.
R.F.	1C4	3.4	3.4
Converter	1C6	3.5	4.5
I.F.	1C4	2.0	2.0
2nd Det.	1K6	0.35	0.35
Driver	1K6	2.0	2.0
Output	19	1.4	1.4
Total drain	—	12.65	13.65
Total drain at steady output of 300 M.W.		18.95	19.95
1 watt*		26.45 mA	27.45 mA

* This output would never occur in normal usage except on momentary peaks.

Sensitivity and Stage Gain Circuit A62

Position	Frequency	Sensitivity	Stage Gain	Noise level 5μV
I.F. Grid	465 K.C.	6000μV		
Converter Grid	465 K.C.	96μV	62.5	
	600 K.C.	110	54.5	
	1000 K.C.	110	54.5	
	1400 K.C.	105	57	
	465 K.C.	75	80	
	6 M.C.	115	52.2	
	10 M.C.	105	54.5	
	15 M.C.	100	60	
R.F. Grid	600 K.C.	5.8μV	19.0	
	1000 K.C.	6.5	17.0	
	1400 K.C.	8.1	12.9	
	6 M.C.	26	4.4	
	10 M.C.	16	6.25	
	15 M.C.	18	5.55	
Aerial Terminal	600 K.C.	.8μV	7.25	30%
	1000 K.C.	1.0	6.5	23%
	1400 K.C.	.9	9.0	25%
	6 M.C.	6.5	4.0	
	10 M.C.	5.7	2.8	
	15 M.C.	5.5	3.3	