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TECHNICAL INFORMATION

Quick-heating V.H.F. tetrodes and double tetrodes

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CONTENTS

QUICK-HEATING TUBES FOR MOBILE TRANSMITTERS

Our range of double tetrodes has now been extended to include quick-heating tubes. The development of quick-heating tubes was considered necessary because indirectly-heated double tetrodes when used in mobile transmitters for intermittent operation, such as those in taxis, consume power during standby periods. About 80 % of the total standby power is consumed by the heaters of the transmitter tubes. The filaments of quick-heating tubes do not need to be energised during the standby period because 70 % of the normal power can be obtained within half a second of applying the filament and h.t. voltages, as illustrated in Fig.1.

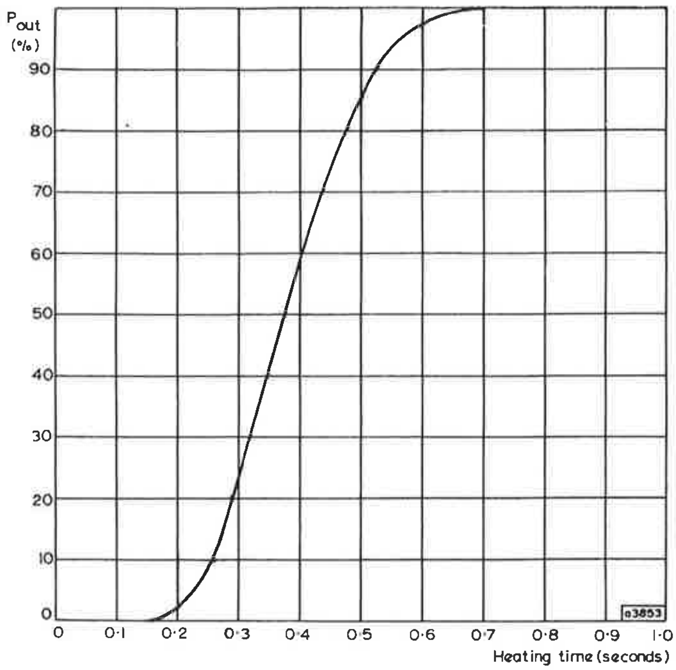


Fig. 1. Graph of output power against heating time.

The life of a tube is related to the aggregate of all the periods during which the cathode is heated and in a typical mobile transmitter the total standby time may be fifty times as great as the total transmission time. It is obvious therefore that the indirectly-heated tubes are only being used to transmit for a small fraction of their life.

The power consumption of transmitter-receivers has already been reduced by the use of transistors in the receiver sections, and this highlights another advantage of quick-heating tubes, which is that the running temperature of the equipment is lower and the problems of providing adequate cooling and of thermal stabilisation of associated semiconductor devices are diminished.

Although it would be possible to use quick-heating tubes where continuous operation is required, such as at the fixed station in a network, it is recommended that indirectly-heated tubes should be used.

FEATURES OF DESIGN

The construction of the majority of double tetrodes, both of the conventional and the quick-heating types, is similar except for the cathode. Some of the types are single-ended whilst others have the anode pins brought out at the top of the tube envelope. In this description the double-ended types with indirectly heated cathodes are considered first.

The base and the top plate are made by means of a pressed powdered-glass technique, the pin connections and some of the electrode supports being embedded in the glass to give extra rigidity. This avoids the use of large supporting micas between the bulb and the electrodes. Such mica brackets would tend to break up under vibration, releasing impurities which could spoil the emission of the cathode. The restricted use of mica also enhances high frequency performance by minimising the possibility of unwanted r.f. damping.

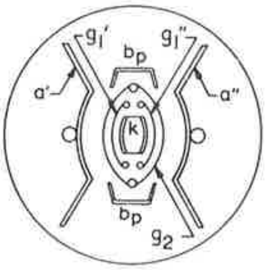


Fig. 2. Electrode layout of tube with indirectly-heated cathode.

Fig.2 shows a cross-sectional view of the electrode assembly. The single indirectly-heated cathode tube is nearly rectangular. Two oxide-coated cathode surfaces are formed on the slightly convex sides of this tube inside which a heater is fitted. Two control grids, also slightly convex to match the shape of the cathode, are mounted opposite the cathode surfaces and are encircled by a common screen grid and by a common beaming plate assembly. The latter assembly is mounted on a metal disc arranged to screen the grid pins from the anodes. When the tubeholder is spaced off from the underside of the chassis in such a way as to make the screening disc level with the chassis, the shielding between the input and output circuits is practically complete and there is little risk of instability. This type of construction is particularly suited to push-pull operation where the common cathode ensures that there is negligible internal cathode impedance, thus preventing cross-coupling. A similar argument applies to the common screen grid.

The cathode, control grid and screen grid assembly is mounted directly on the foot, and the anodes are welded to their lead-out rods which are fixed in the glass top plate. Accurate electrode spacing is maintained, and resistance to shock provided, by locating the central cathode and grid assembly with pins in the powdered glass top.

In all double tetrodes internal neutralisation of the anode-to-grid capacitance is provided. In some instances neutralising capacitors are incorporated whereas in others the desired effect is achieved by careful positioning of the lead-out wires.

Early attempts at making quick-heating tubes were restricted by the convention of designing for a filament supply of 6.3 V or 12.6 V. This resulted in a thin wire filament which possessed significant inductance, and at v.h.f. much of the applied driving voltage was attenuated along it before the "active" region was reached; in consequence the drive power had to be increased excessively. This difficulty is overcome in our quick-heating tubes by using what is known as a "harp" cathode, which consists of a large number of short lengths of oxide-coated tungsten wire connected in parallel and closely spaced, the wires being tensioned by spring-loaded rollers. This gives a cathode having the low thermal mass necessary for quick-heating, low inductance and the electrical characteristics, as far as the other electrodes are concerned, of a solid cathode emitting surface. Being short and under tension, the new filament is also rugged, as it needs to be for mobile operation.

The single-ended types of quick-heating tube are of similar construction to the other quick-heating tubes except that the anode pins are brought out at the base.

PERFORMANCE AND RELIABILITY

VOLTAGE VARIATIONS

The indirectly-heated cathodes of our range of conventional double tetrodes have always been designed to give good performance when the heater voltage is temporarily reduced, for example, when the supply battery is not being charged. The quick-heating tubes also have this feature, enabling them to withstand voltage variations of ±15 % from the nominal. Nevertheless for long life the supply voltage should be set for normal operation at the nominal voltage.

Because of its construction, the harp cathode used in the quick-heating tubes operates at low voltage and high current and cannot, therefore, be operated directly from a 6 V or 12 V battery. Connecting filaments in series with a dropping resistor is not practicable because the low resistance of a cold filament causes most of the applied potential at switch-on to be developed across the dropping resistor, thus limiting the initial surge current and increasing the heating time of the filaments.

The most suitable method of heating the filament is from a winding on the transformer of a transistor d.c. converter. This is easily effected by adding a few turns to the transformer. The output from this transformer, using the conventional system, will be an alternating voltage, rectangular in shape, the r.m.s. value of which is half the peak-to-peak amplitude – that is, assuming very short rise and fall times, equal to the peak amplitude. The frequency of this supply is determined by the design of the converter. The published filament supply voltage refers to a d.c. or r.m.s. value, and, because of the waveform, should be measured on an oscilloscope or a meter which reads r.m.s. values irrespective of waveform, such as a dynamometer or a hot wire meter. If a sinusoidal filament supply is used, its frequency should not exceed 200 c/s.

The time taken by the harp cathode to reach its operating temperature is affected by the applied potential. This applied potential, at the instant at which it is switched on, is greatly reduced when the filament connecting leads and the transformer winding have an appreciable resistance. It is recommended that the leads and the transformer winding have a combined resistance of less than 10 % of the hot resistance of the filament. The warm-up time quoted for these tubes is correct only under this condition.

The filament supply from a winding on a transformer varies directly with the applied input voltage to the converter. Thus, if no stabilisation is used, the filament voltage varies proportionally with the battery voltage of a vehicle.

The battery of a vehicle whose engine is running is being charged, and in temperate climates a nominal 12.6 V battery can increase its potential to 15.0 V. In

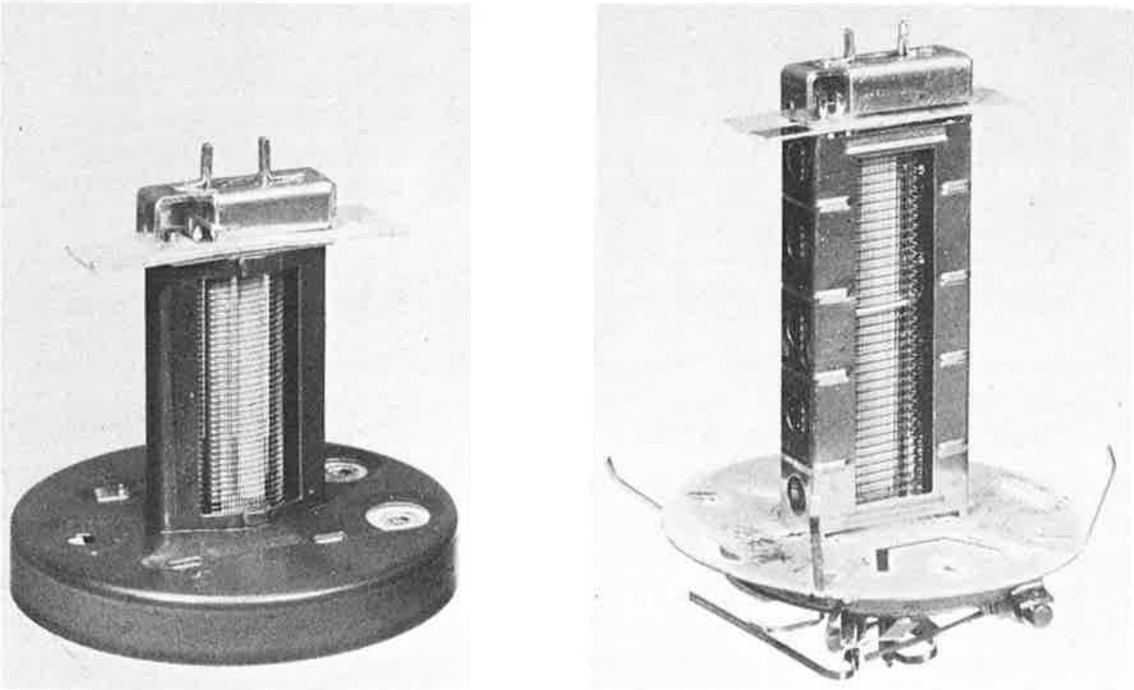


Fig.3. Harp cathode assemblies.

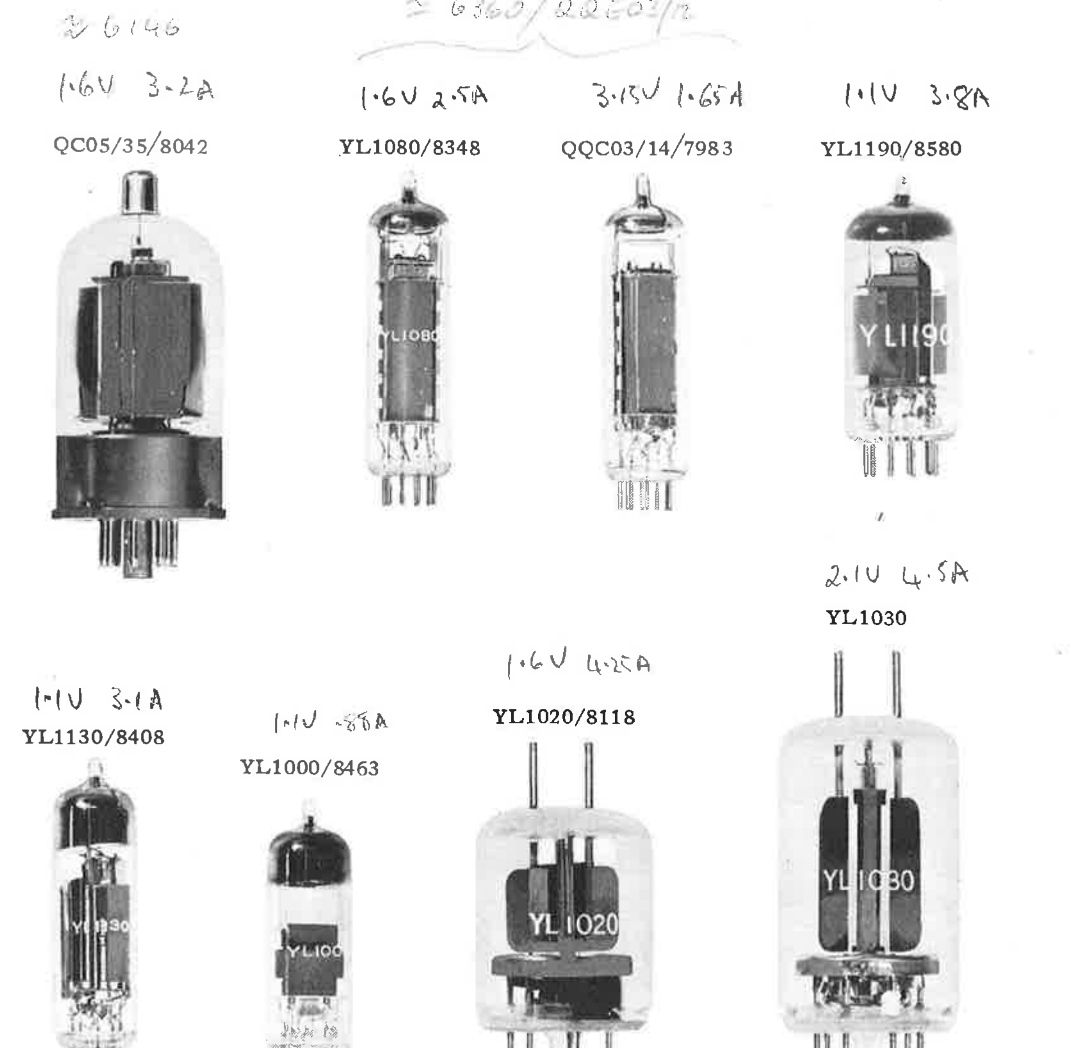


Fig.4. Our range of quick-heating tubes.

≈ 6939 QQE02/5
≈ 6252 QQE03/20
≈ 5894A QQE06/40

arctic conditions (-18 °C or 0 °F and below) the battery potential could be 16 V. With a battery not being charged and in a poor state generally the terminal voltage may be as low as 11.0 V. These are the considerations which have been taken into account in the design of the quick-heating tubes to enable them to withstand voltage variations of ± 15 % from nominal. Thus if an item of equipment is designed to work at a nominal battery potential of 13 V the tubes will accept a range of battery potentials from 11.05 V to 14.95 V.

HUM

Since the frequency of the filament supply may be in the audio range, hum modulation caused by a.c. heating of the filament can occur. This spurious modulation can be reduced by decoupling the screen grid at the supply frequency and by humdinging. Measurements have been made with individual tubes and the results indicate that values of the following order relative to carrier amplitude can be obtained:

with a suitable humdinging arrangement,	-60 dB
with a centre-tapped transformer,	-50 dB
with one side of the filament earthed,	-30 dB.

These results were obtained with optimum drive voltage, optimum interstage coupling and corred tuning. Slight detuning, with a consequent reduction in drive voltage, especially in the grid circuit of an output stage, can increase the hum level by approximately 10 dB.

Where several stages employing humdinging are used, better figures can be achieved, since it is possible to cancel some of the residual hum in one stage by adjustment of the humdinging arrangement on a previous stage.

The filament connecting leads to the tubeholder from the transformer carry a heavy square-wave alternating current and it is important that these leads do not induce currents in the chassis or in other leads and so cause hum. Similar considerations apply to the battery leads to the converter and to the positioning of the transistor power supply transformer.

INDUCTANCE EFFECTS

In order to prevent loss of drive voltage due to the inductance of the filament leads, it is necessary to connect the filament terminals to earth with a good, very low inductance, decoupling capacitor, keeping the lead lengths to a minimum. It has been found desirable to provide a good bypass capacitor to earth for the screen grid especially at frequencies of 470 Mc/s.

TUNING

During tuning and alignment the tubes may be operating continuously for longer periods than they would be in normal use. Although they are designed with a built-in reserve to cater for overloading, care should be taken and it is recommended that a low-power position should be incorporated in the transmitter for use during tuning. After tuning "hot", the transmitter should be switched off and allowed to cool before being finally tuned under simulated intermittent conditions.

FILAMENT LIFE

Switched life tests conducted on quick-heating tubes have shown that switched lives of 25 000 switchings are quite common, while on extended switched life tests 100 000 switchings have been obtained. The filament power supply was similar to that used in normal equipment.

VIBRATION

Samples of quick-heating tubes have been vibrated at 50 c/s, 2.5 g for 32 hours in each of three mutually perpendicular directions and at 50 c/s, 5 g for two hours in each of the three directions. The tubes survived these tests with no change in characteristics. A test is illustrated in Fig. 5.

SHOCK

Samples of quick-heating tubes have been subjected to 1000 shocks at 5 g without any change in characteristics being observed.

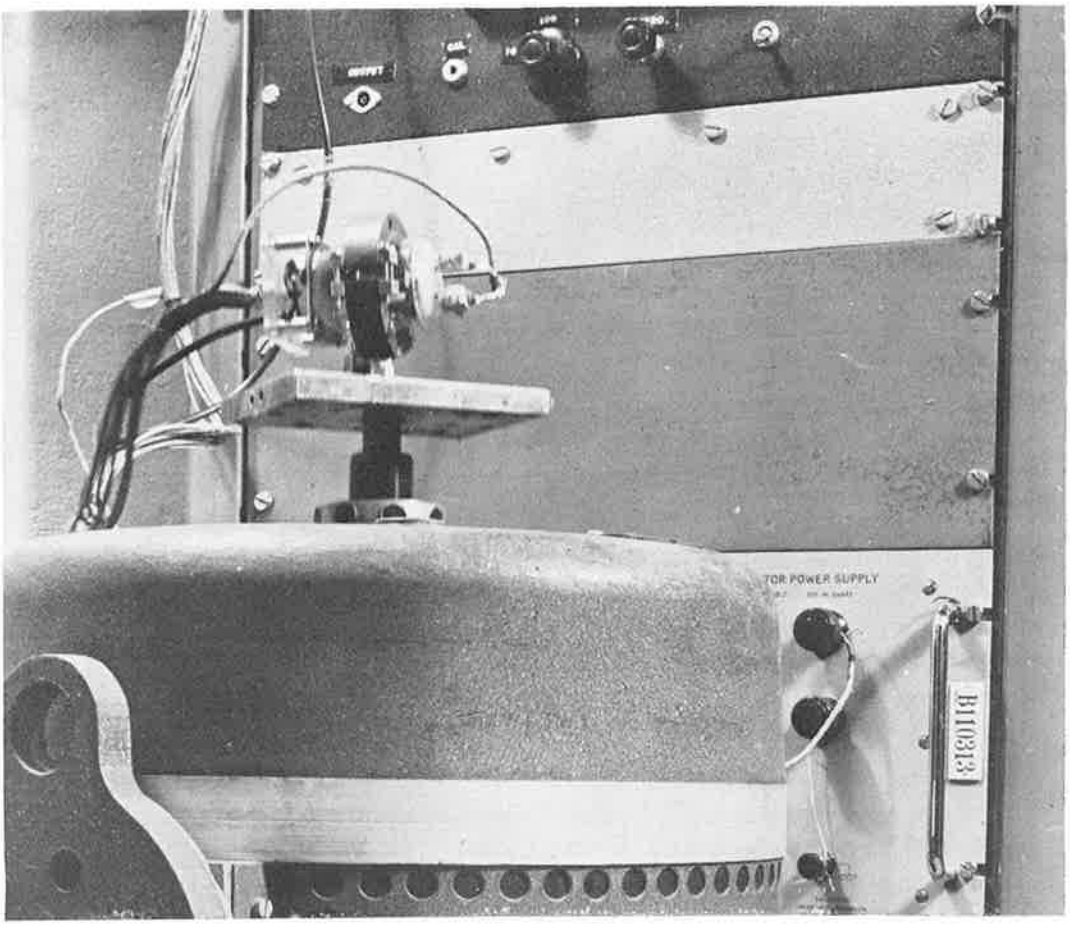


Fig. 5. Quick-heating tube undergoing vibration test.

APPLICATIONS

The range of quick-heating tubes is designed to cover all the stages of mobile transmitters. However, hybrid designs are possible in which the early stages use transistors and the later, higher power, stages use tubes. Suggestions for "all tube" and "hybrid" transmitters are given on the following pages.

The range of quick-heating tubes is complemented by a range of tubes with indirectly-heated cathodes for use at the fixed station in a network. Although they are not direct equivalents of the quick-heating tubes they are similar enough to perform the same functions.

The quick-heating tubes as also the indirectly-heated types and the stages in which they can be used are given in the table on the following page.

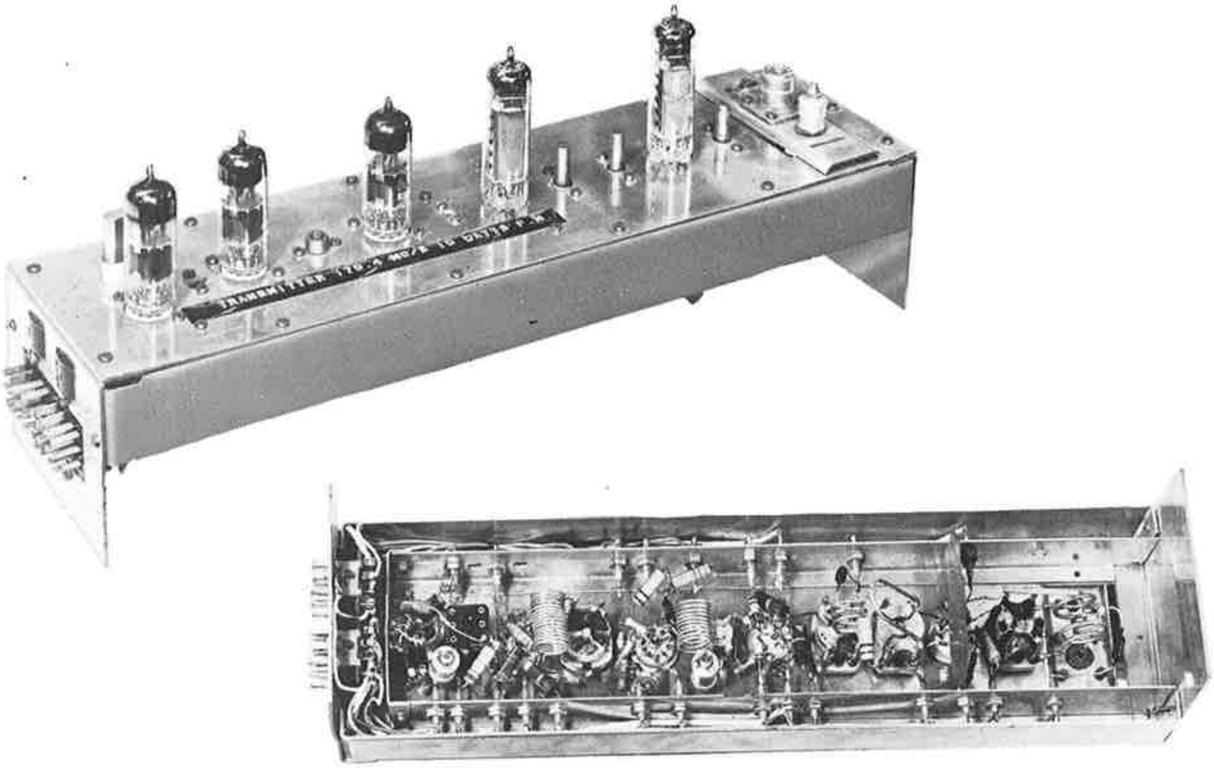


Fig. 6. Experimental transmitter for 175 Mc/s 15 W.

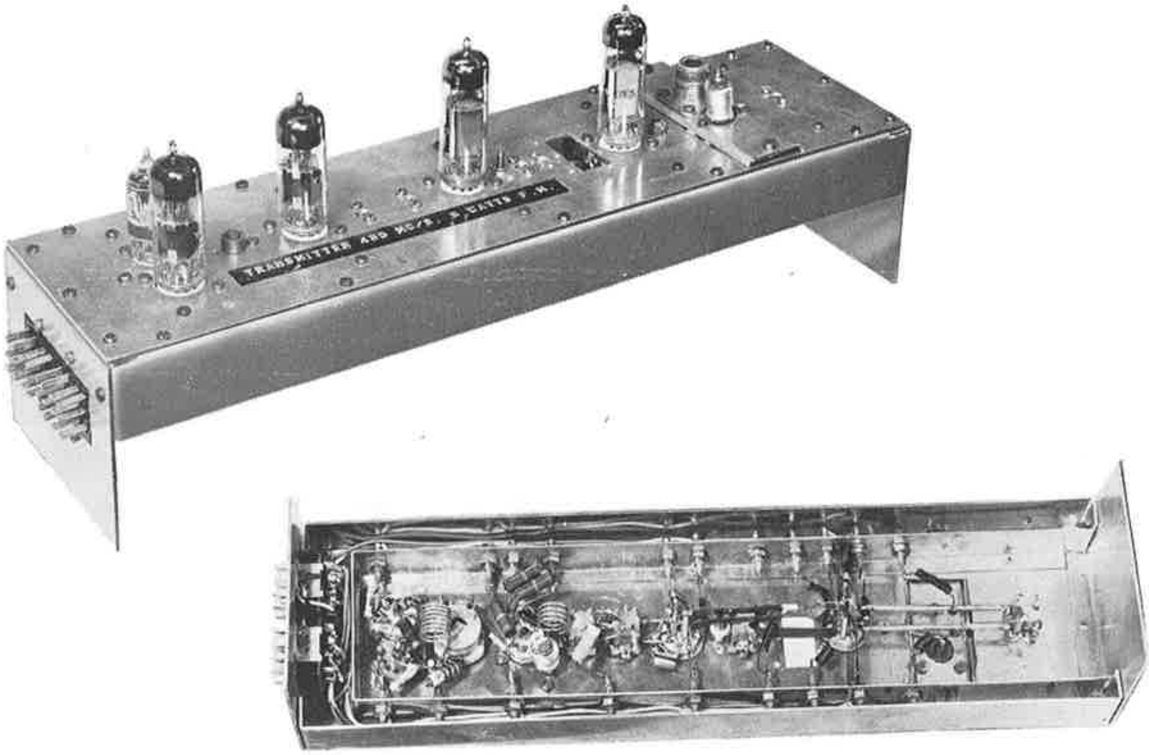


Fig. 7. Experimental transmitter for 480 Mc/s 6 W.

Stages	*quick-heating tubes*	*indirectly heated types*
crystal oscillator	YL1000/8463	QE03/10/5763
early stages of frequency multiplication	YL1000/8463	QE03/10/5763
	YL1080/8348	QQE03/12/6360
	QQC03/14/7983	QQE03/12/6360
penultimate frequency multiplication stages	YL1020/8118	QQE03/20/6252
	YL1080/8348	QQE03/12/6360
	YL1130/8408	QQE02/5/6939
	YL1190/8580	YL1240/8458
final amplifier stages	YL1020/8118	QQE03/20/6252
	YL1030	QQE06/40/5894
	YL1080/8348	QQE03/12/6360
	YL1130/8408	QQE02/5/6939
	YL1190/8580	YL1240/8458
	QC05/35/8042	QE05/40/6146
modulator for a.m.	YL1020/8118	QQE03/20/6252
	YL1030	QQE06/40/5894
	YL1080/8348	QQE03/12/6360
	YL1130/8408	QQE02/5/6939
	YL1190/8580	YL1240/8458
	QC05/35/8042	QE05/40/6146

Most of these tubes are double tetrodes, a construction which lends itself to the use of each half as a frequency multiplier. For example, when used in a trebler-doubler configuration one obtains a frequency multiplication of six times with a single tube. Other combinations are possible depending on the frequencies and power required. The YL1080/8348 is particularly suited to this method of operation.

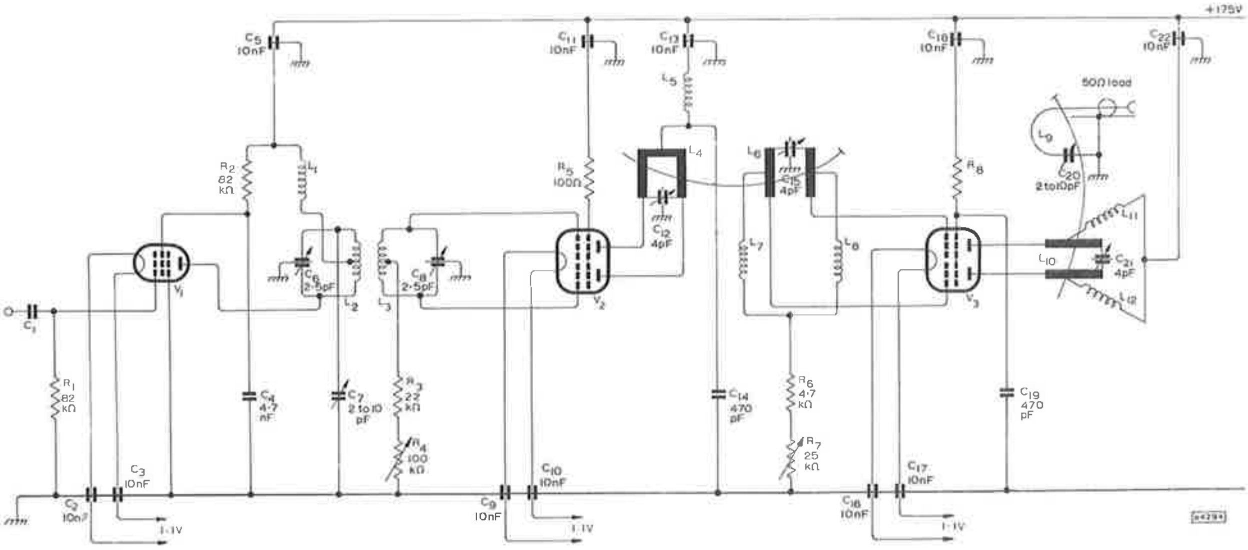
In the pages that follow, details of seven possible output stages are given together with penultimate stages where applicable. Details of two drive units are also given. The examples are basic transmitters and do not include details of the modulation arrangements, the user being left to design a modulation arrangement suited to his particular needs. The figures given are those for maximum output stage efficiency. The circuits given do not exhaust the possibilities of quick-heating tubes and, after the drive units, a number of suggested tube combinations are given which leave the user to design the circuit details. The information in this publication is intended to supplement the more detailed data on the tubes published in Volume 3 of our Handbook.

LIST OF CIRCUIT EXAMPLES

6 W, 480 Mc/s, F.M. TRANSMITTER

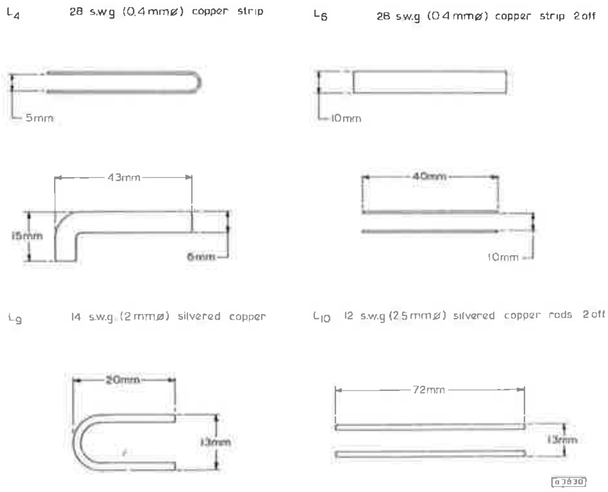
f_{in} = 53.4 Mc/s
$P_{load(driver)}$ = 0.5 to 0.75 W
P_{out} = 8 W
P_{load} = 6 W

YL1000/8463 (V_1) – Frequency Trebler
YL1130/8408 (V_2) – Frequency Trebler
YL1130/8408 (V_3) – R.F. Amplifier



COMPONENT DETAILS

- L_1 r.f. choke; resonant at approx. 160 Mc/s
- L_2 4 turns 18 s.w.g. (1.2 mmϕ) silvered copper, internal diameter 12.5 mm, overall length 10 mm
- L_3 3 turns 18 s.w.g. (1.2 mmϕ) silvered copper, internal diameter 12.5 mm, overall length 18 mm
- L_4 see drawing
- L_5 resonant choke
- L_6 see drawing
- L_7 resonant choke
- L_8 resonant choke
- L_9 see drawing
- L_{10} see drawing
- L_{11} resonant choke
- L_{12} resonant choke



- C_6 butterfly
- C_7 concentric trimmer
- C_8 butterfly
- C_{15} butterfly
- C_{20} concentric trimmer
- C_{21} butterfly

TUBE OPERATING CONDITIONS

	V_1 Frequency Trebler	V_2 Frequency Trebler	V_3 Amplifier	
V_a	175	175	175	V
I_a	27	2 x 22.5	2 x 40	mA
V_{g2}	95	175	175	V
I_{g2}	1	2 x 3	2 x 5.6	mA

	V_1 Frequency Trebler	V_2 Frequency Trebler	V_3 Amplifier	
V_{g1}	-82	-68	-22	V
I_{g1}	1	2 x 0.5	2 x 1.25	mA
R_{g1}	82	*68	*8.8	kΩ

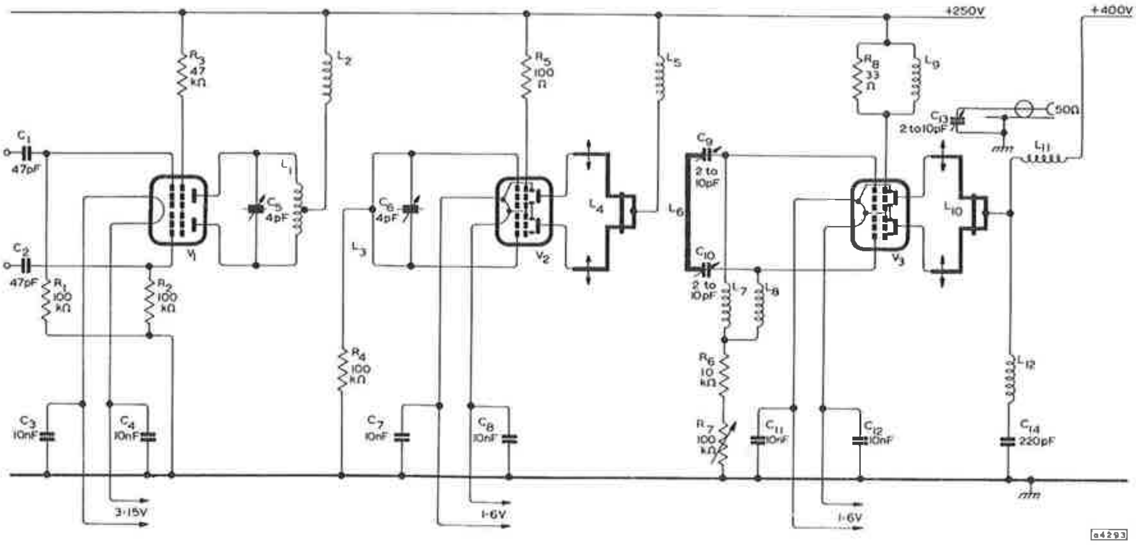
*R_{g1} adjustable

17 W, 460 Mc/s, F.M. TRANSMITTER

f_{in} = 51 Mc/s P_{out} = 21 W

$P_{load(driver)}$ = 0.75 W P_{load} = 17 W

QQC03/14/7983 (V_1) – Frequency Trebler
YL1020/8118 (V_2) – Frequency Trebler
YL1020/8118 (V_3) – R.F. Amplifier



COMPONENT DETAILS

L_1 4 turns of 1.5 mm silver-clad copper wire 15 mm diameter and 22 mm long
L_2 resonant choke
L_3 80 mm of 1.5 mm silver-clad copper wire; space between centres 18 mm
*L_4 120 mm of ¼ in (6.4 mm) diameter brass rod; space between centres 14 mm
L_5 resonant choke
L_6 30 mm of 1 mm gauge 1 cm wide copper strip; space between centres 14 mm
L_7 resonant choke
L_8 resonant choke
L_9 resonant choke
*L_{10} 120 mm of ¼ in (6.4 mm) diameter brass rod; space between centres 14 mm
L_{11} resonant choke

C_5 butterfly
C_6 butterfly
C_{13} concentric trimmer

* Length including anode connectors, fixed short-circuit at remote end of line and adjustable short-circuiting bar for preset tuning.

The anti-parasitic circuit shown connected by a broken line may or may not be required depending on the layout of the equipment.

TUBE OPERATING CONDITIONS

	V_1 Frequency Trebler	V_2 Frequency Trebler	V_3 Amplifier	
V_a	250	250	400	V
I_a	2 x 21	2 x 37.5	2 x 50	mA
V_{g2}	130	250	250	V
I_{g2}	2 x 1.3	2 x 2.5	2 x 2.5	mA

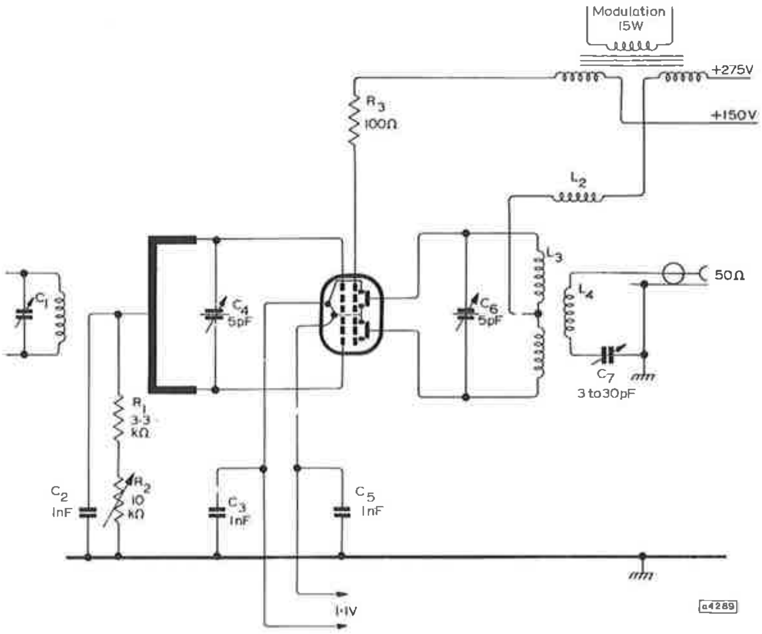
	V_1 Frequency Trebler	V_2 Frequency Trebler	V_3 Amplifier	
V_{g1}	-90	-140	-50	V
I_{g1}	2 x 0.9	2 x 0.7	*2 x 0.5	mA
V_f	3.15	1.6	1.6	V

*R_{g1} adjustable

15 W, 175 Mc/s, A.M. TRANSMITTER

f = 175 Mc/s	P_{out} = 18 W
$P_{load\ (driver)}$ = 300 mW	P_{load} = 15 W

YL1190/8580 — R.F. Amplifier



COMPONENT DETAILS

L_1 hairpin loop; 2 mm silver-clad copper wire 1.8 cm long, spaced by 1.8 cm

L_2 resonant choke

L_3 3 turns 2 mm silver-clad copper wire 2 cm diameter; centre turns open-spaced to allow for load coupling coil

L_4 2 turns of 2 mm diameter silver-clad copper wire 1.75 cm in diameter

Modulation Transformer

Ratio of voltage across screen grid winding of modulation transformer to voltage across anode winding 0.36 : 1

C_3 low inductance

C_4 butterfly

C_5 low inductance

C_6 butterfly

C_7 trimmer

TUBE OPERATING CONDITIONS

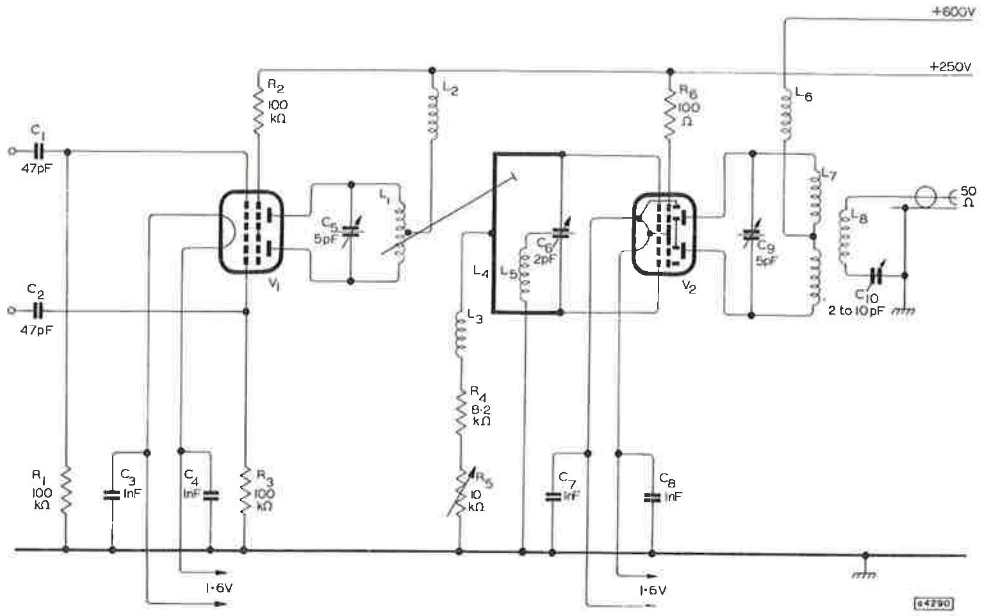
V_a	275	V	I_{g1}	2 x 2.0	mA
I_a	2 x 50	mA	$P_{load\ (driver)}$	300	mW
V_{g2}	150	V	P_{mod}	15	W
I_{g2}	2 x 8.5	mA	$v_{g2(mod)pk}$	100	V
V_{g1}	-20	V			

35 W, 175 Mc/s, F.M. TRANSMITTER

f_{in} = 58.3 Mc/s
$P_{load\,(driver)}$ = 0.5 W

P_{out} = 48 W
P_{load} = 39 W

YL1080/8348 (V_1) – Frequency Trebler
YL1020/8118 (V_2) – R.F. Amplifier



COMPONENT DETAILS

L_1	4 turns of 2 mm silver-clad copper wire 1.4 cm internal diameter and 2 cm long resonant choke
L_2	resonant choke
L_3	resonant choke
L_4	Lecher line 7 cm long spaced 1.5 cm between centres, 1.5 mm silver-clad copper wire
L_5	anti-parasitic choke; 2 turns 22 s.w.g. (0.8 mm ϕ) copper wire; 6 mm diameter. (This may or may not be required depending on the layout.)
L_6	resonant choke
L_7	4 turns 2 mm diameter silver-clad copper wire, 1.5 cm internal diameter and 2.5 cm long; centre turns open-spaced to allow for coupling coil L_7
L_8	2 turns of 2 mm silver-clad copper wire
C_5	butterfly
C_6	butterfly
C_9	butterfly
C_{10}	butterfly

TUBE OPERATING CONDITIONS

	V_1 Frequency Trebler	V_2 R.F. Amplifier	
V_a	250	600	V
I_a	2 x 15	2 x 50	mA
V_{g2}	110	250	V
I_{g2}	2 x 0.7	2 x 4	mA

	V_1 Frequency Trebler	V_2 R.F. Amplifier	
V_{g1}	−50	−60	V
I_{g1}	2 x 0.5	*2 x 0.7	mA
$P_{load\,(driver)}$	0.5	1.5	W

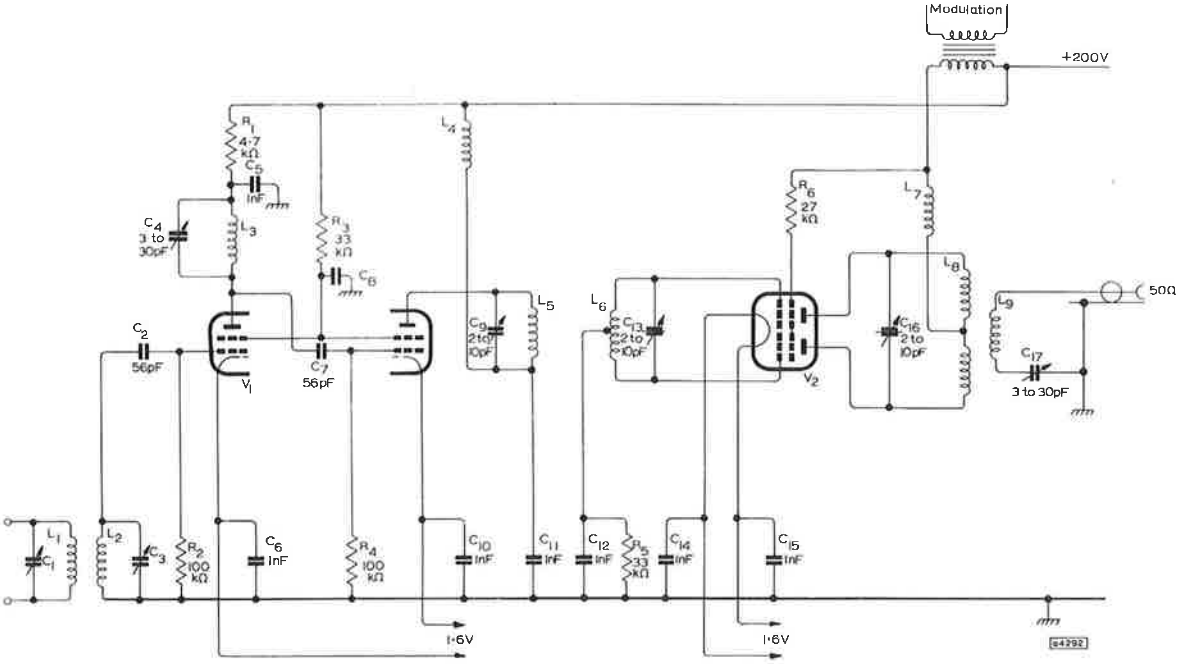
*I_{g1} will vary for different samples of the tube.

8 W, 70 Mc/s, A.M. TRANSMITTER

f_{in} = 11.66 Mc/s		P_{out}	= 10 W
$P_{load\,(driver)}$ = 200 mW		P_{load}	8 W

YL1080/8348 (V_1) – Frequency Trebler/Doubler

YL1080/8348 (V_2) – R.F. Amplifier



COMPONENT DETAILS

L_2, C_3	resonant at 11.66 Mc/s
L_3, C_4	resonant at 35 Mc/s
L_4	resonant choke
L_5	5 turns 0.7 cm silver-clad copper wire, 1.1 cm diameter, 1.8 cm long
L_6	8 turns 0.7 cm silver-clad copper wire, 1.1 cm diameter, 1.8 cm long
L_7	resonant choke
L_8	12 turns 1 mm silver-clad copper wire, 1.4 cm diameter, 3.3 cm long; centre turns open-spaced to allow for coupling coil L_8
L_9	5 turns 1 mm silver-clad copper wire, 1.4 cm diameter, 1 cm long
C_{13}	butterfly
C_{16}	butterfly
C_{17}	trimmer

TUBE OPERATING CONDITIONS

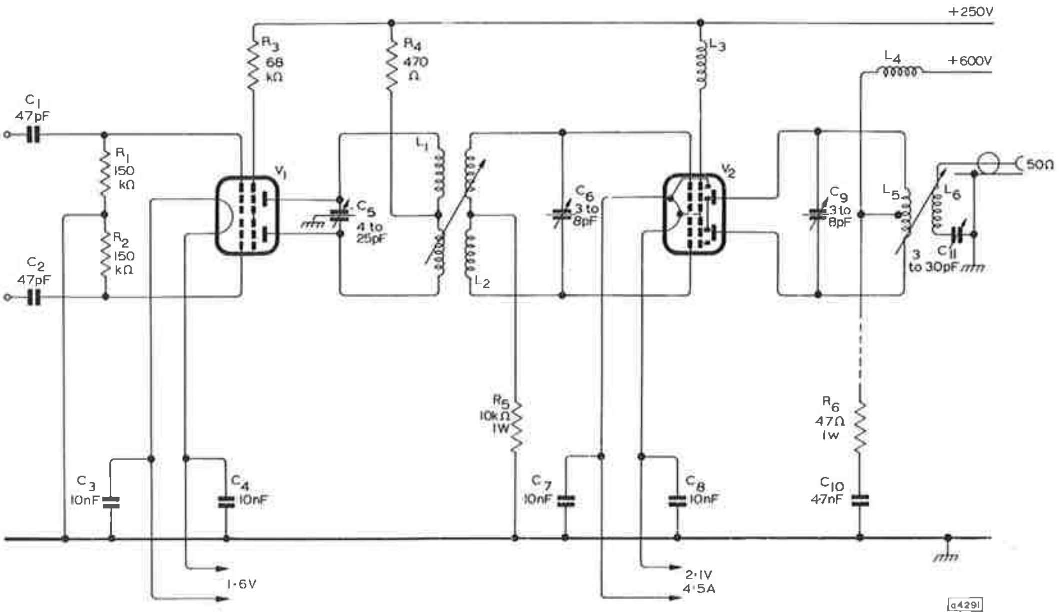
	V_1 Frequency Trebler	V_1 Frequency Doubler	V_2 Amplifier	
V_a	165	200	200	V
I_a	7	7	2 x 33.5	mA
V_{g2}	100	100	130	V
I_{g2}	1.5	1.5	2 x 1.3	mA

	V_1 Frequency Trebler	V_1 Frequency Doubler	V_3 Amplifier	
V_{g1}	-75	-75	-50	V
I_{g1}	0.75	0.75	2 x 0.8	mA
$P_{load\,(driver)}$	200			mW

70 W, 70 Mc/s, F.M. TRANSMITTER

f_{in} = 23.3 Mc/s P_{out} = 87 W
$P_{load\ (driver)}$ = 300 mW P_{load} = 77 W

YL1080/8348 (V_1) – Frequency Trebler
YL1030 (V_2) – R.F. Amplifier



COMPONENT DETAILS

L_1 7 turns 16 s.w.g. (1.6 mm⌀) copper, 7/8 in (22 mm) diameter, 1 in (25 mm) long
L_2 7 turns 16 s.w.g. (1.6 mm⌀) copper, 7/8 in (22 mm) diameter, 7/8 in (22 mm) long
L_3 resonant choke
L_4 resonant choke
L_5 6 turns 1/8 in copper tube, 1¼ in (32 mm) long
L_6 4 turns 1/8 in copper tube, 1 in (25 mm) diameter, 5/8 in (16 mm) long

C_5 butterfly
C_6 butterfly
C_9 butterfly
C_{11} trimmer

The anti-parasitic circuit shown connected by a broken line may or may not be required depending on the layout of the equipment.

TUBE OPERATING CONDITIONS

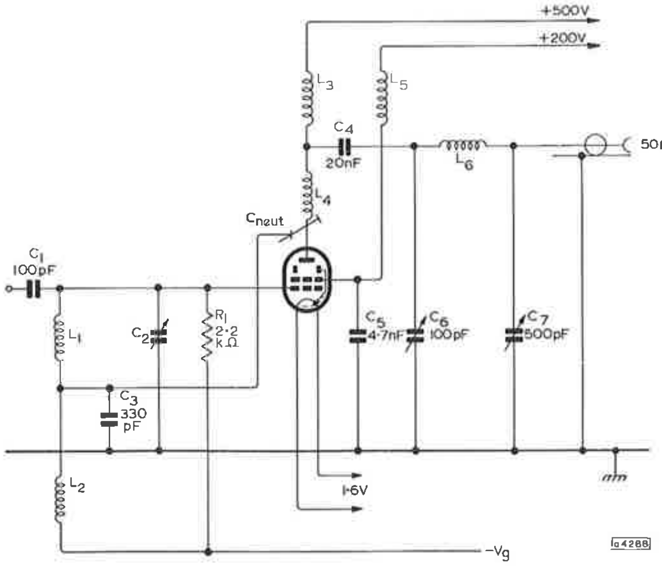
	V_1 Frequency Trebler	V_2 Amplifier	
V_a	240	600	V
I_a	20	2 x 100	mA
V_{g2}	114	250	V
I_{g2}	2 x 1.0	2 x 10	mA
I_{g1}	2 x 0.5	2 x 3.5	mA
R_{g2}	100	–	kΩ

	V_1 Frequency Trebler	V_2 Amplifier	
R_{g1}	2 x 150	10	kΩ
$P_{load\ (driver)}$	0.3	1.5	W
p_a	2 x 1.6	2 x 16.5	W
η_a	36	72.5	%
$\eta_{transfer}$	83	88	%

25 W, 14 Mc/s, S.S.B. TRANSMITTER

f = 14 Mc/s	P_{out} = 34.5 W
$P_{load\,(driver)}$ = 0.25 W	P_{load} = 25 W

QC05/35/8042 – Linear Amplifier



COMPONENT DETAILS

L_1, C_2	resonant at 14 Mc/s
L_2	resonant choke
L_3	resonant choke
L_4	anti-parasitic choke; 4 turns 20 s.w.g. (0.9 mmϕ) ¼ in (6.5 mm) diameter
L_5	resonant choke
L_6	approx. 2 μH; 8 turns 1/8 in copper tube, 4 cm internal diameter, 4 cm long
C_{neut}	copper plate 1¼ in x ¾ in (32 mm x 19 mm) facing anode and adjusted for zero feed-through of drive

TUBE OPERATING CONDITIONS

Class AB_1 RF Power Amplifier for single-sideband suppressed-carrier service.

Ratio of peak to average amplitudes ≥ 1 and < 2

V_a	500	V
V_{g2}	200	V
V_{g1}	–46	V
$I_{a(0)}$	40	mA

MAXIMUM SIGNAL CONDITIONS

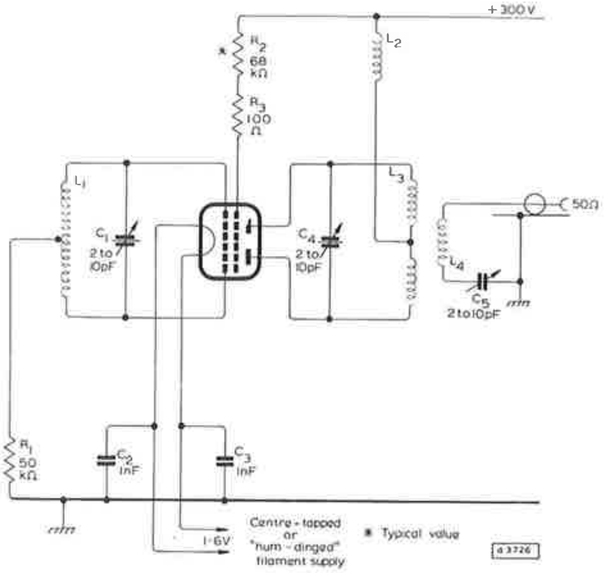
	Single-tone modulation	Two-tone modulation			Single-tone modulation	Two-tone modulation	
I_a	99	73	mA	p_a	15	19.5	W
I_{g2}	9	5	mA	p_{g2}	1.8	1.0	W
I_{g1}	0	0	mA	$P.E.P._{out}$	34.5	34.5	W
$V_{in(pk)}$	40	40	V	η_a	70	47.4	%
$P.E.P._{load\,(driver)}$	0.5	0.5	W	$P.E.P._{load}$	28.5	28.5	W

DRIVER CIRCUIT – TREBLER

f_{in} = 58.3 Mc/s f_{out} = 175 Mc/s

$P_{load\ (driver)}$ = 1.0 W P_{load} = 3.5 W

YL1080/8348 – Frequency Trebler



COMPONENT DETAILS

L_1	10 turns of 1.0 mm silver-plated copper wire 13 mm diameter and 2.2 cm long
L_2	resonant choke
L_3	3 turns of 1.5 mm silver-plated copper wire 18 mm diameter and 2. 5 cm long
L_4	2 turns of 1 mm silver-plated copper wire 15 mm diameter and 0. 5 cm long
C_1	butterfly; rotor not earthed
C_4	butterfly; rotor not earthed
C_5	trimmer
R_2	adjustable to allow for variations of I_{g1} and I_{g2} between tubes

TUBE OPERATING CONDITIONS

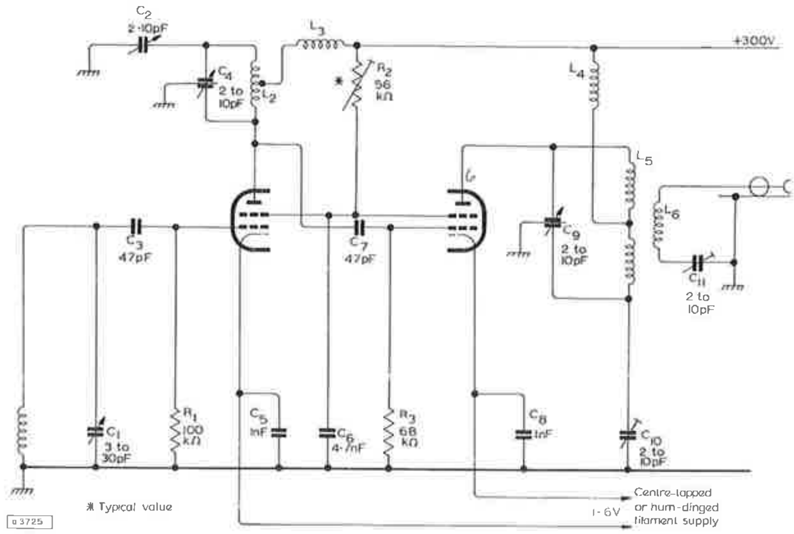
V_a	300 V
I_a	2 x 24 mA
V_{g2}	160 V
I_{g2}	2 x 1.0 mA
V_{g1}	-100 V
I_{g1}	2 x 1.0 mA

DRIVER CIRCUIT – TREBLER/DOUBLER

f_{in} = 29.2 Mc/s f_{out} = 175 Mc/s

$P_{load\,(driver)}$ = 0.5 W P_{load} = 1.5 W

YL1080/8348 – Frequency Trebler/Doubler



COMPONENT DETAILS

L_1	11 turns of 1.0 mm silver-plated copper wire 13 mm diameter and 2 cm long
L_2	6 turns of 1.0 mm silver-plated copper wire 13 mm diameter and 1.5 cm long; centre tapped
L_3	resonant choke
L_4	resonant choke
L_5	3 turns of 1.5 mm silver-plated copper wire 18 mm diameter and 2.5 cm long; centre turns open-spaced to allow for load coupling coil
L_6	2 turns of 1.0 mm silver-plated copper wire 15 mm diameter and 0.5 cm long
R_2	adjustable to allow for variations of I_{g1} and I_{g2} between tubes
C_2	trimmer
C_4	butterfly
C_9	butterfly
C_{10}	trimmer
C_{11}	trimmer

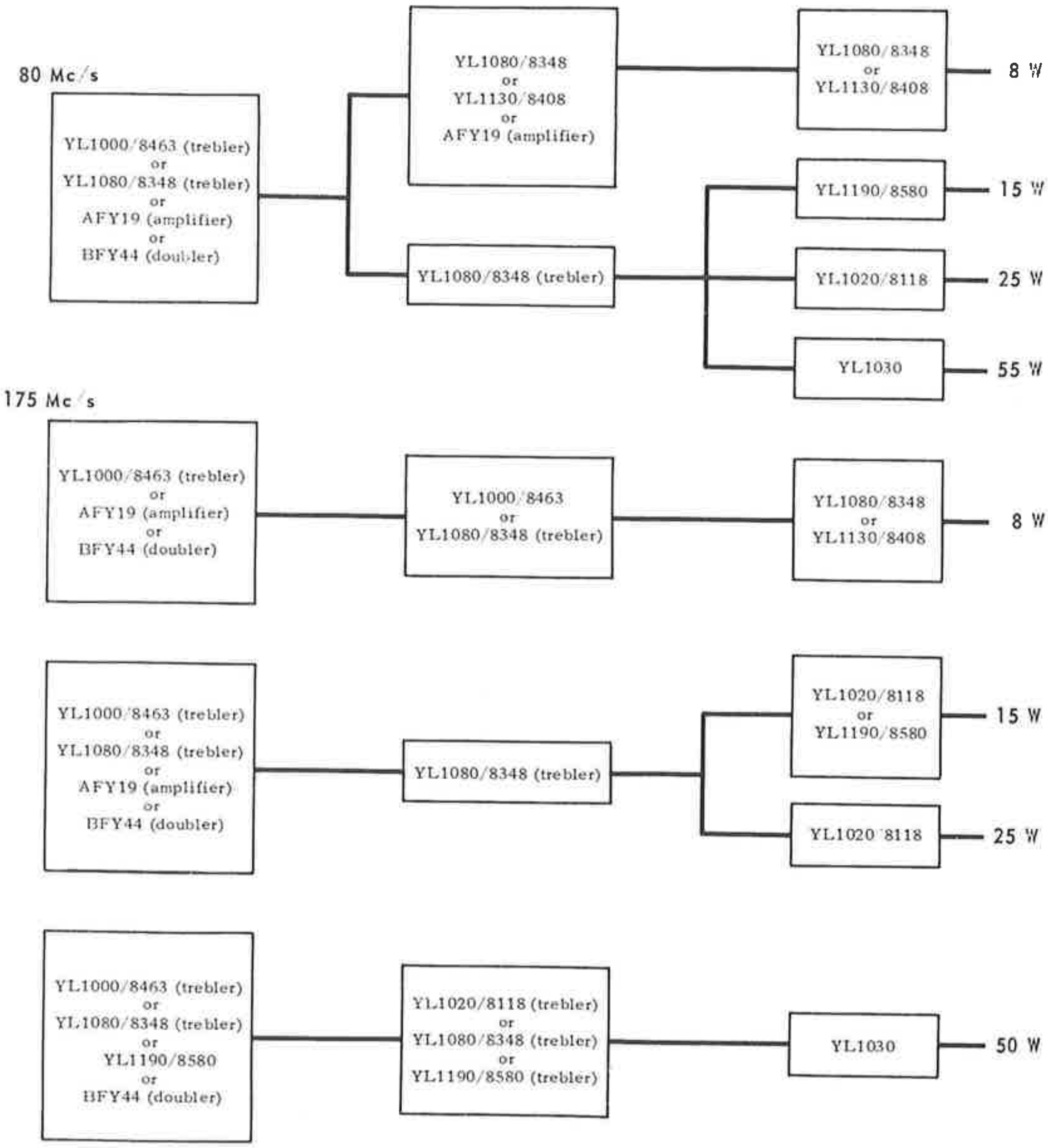
TUBE OPERATING CONDITIONS

	Frequency Trebler	Frequency Doubler	
V_a	300	300	V
I_a	24	20	mA
V_{g2}	160	160	V
$I_{g2\,(tot)}$	2.5	2.5	mA
V_{g1}	−100	−80	V
I_{g1}	1.0	1.2	mA

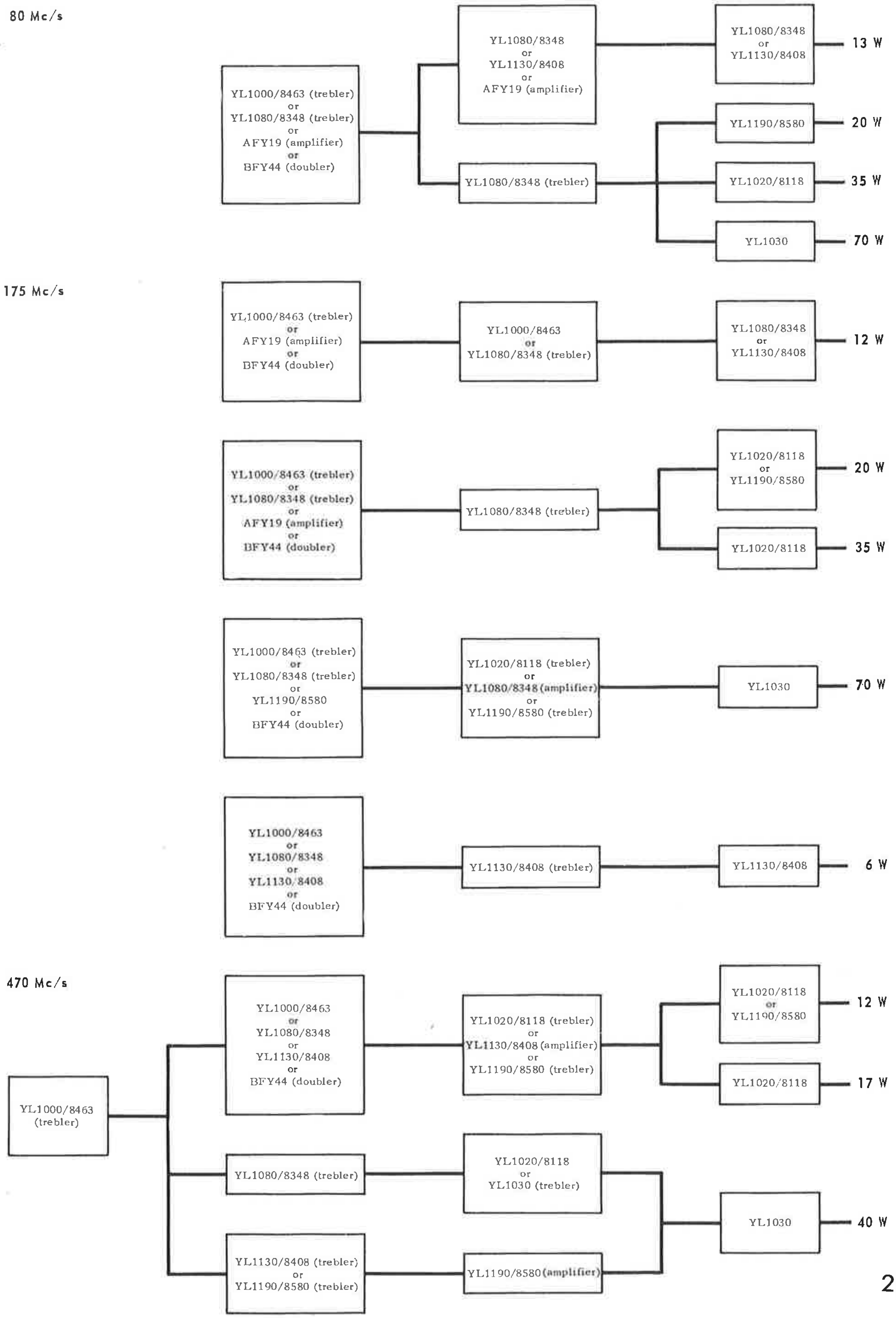
SUGGESTED TUBE COMBINATIONS

These tables show the last three or four stages in a transmitter. Where no function (trebler, doubler or amplifier) is shown in brackets after the type number the tube may be used in either of the three functions. Types AFY19 and BFY44 refer not to quick-heating tubes but to transistors.

COMBINATIONS FOR A.M. TRANSMITTERS



COMBINATIONS FOR F.M. TRANSMITTERS

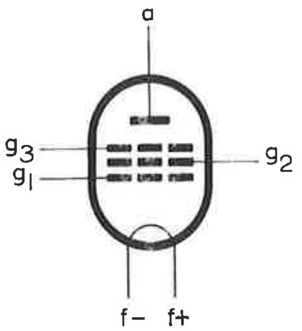


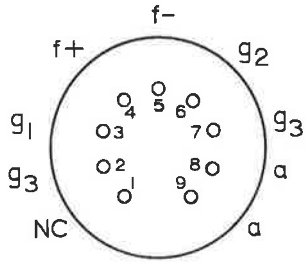
YL1000/8463

ABRIDGED DATA

Quick-heating single-ended power pentode for mobile transmitters 70% power output in less than half a second

	Frequency Doubler	Frequency Trebler	Class C FM Telephony	Class C AM Telephony	
f_{out}	175	175	175	175	Mc/s
P_{load}	2·1	1·3	3·3	3·0	W
f_{max}	200	200	200	200	Mc/s
$V_{a(max)}$	300	300	300	250	V
$p_{a(max)}$	5	5	5	3·3	W





B9A Base

TYPICAL OPERATION

	Frequency Doubler	Frequency Trebler	Class C FM Telephony	Class C AM Telephony	
f	175	175	175	175	Mc/s
V_a	300	250	300	200	V
V_{g2}	150	150	150	150	V
V_{g1}	−90	−100	−35	−35	V
I_a	25	25	30	32	mA
I_{g2}	1·22	1·26	2·08	2.5	mA
I_{g1}	0·34	0·4	0·07	0·18	mA
P_{load}	2·1	1·29	3·3	3·05	W
η_{load}	28	20·7	36·7	47	%
For 100% modulation					
P_{mod}				3·3	W
$V_{g2(pk)}$				120	V

FILAMENT (parallel operation only)

Quick-heating, directly-heated filament. 70% P_{out} in less than 0·5 second.

*V_f (d.c. or r.m.s.)	1·1	V
I_f	880	mA

*The filament has been designed to accept temporary variations in supply voltage of ±15%

CHARACTERISTICS

(measured at $V_a = V_{g2} = 120V$, $I_a = 30mA$, $V_{g1} = -6{\cdot}5V$, $I_{g2} = 2.3mA$)

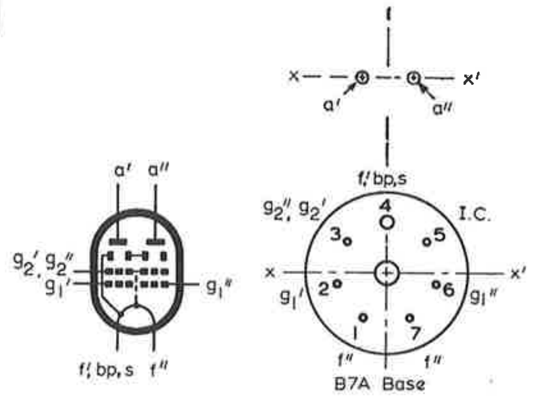
g_m	4·3	mA/V
μ_{g1-g2}	7·0	

YL1020/8118

ABRIDGED DATA

Quick-heating, double-ended, double tetrode for use as amplifier and frequency-multiplier in mobile transmitters
70% power output in less than half a second

	Frequency Trebler	Class C FM Telephony	Class C AM Telephony	
f_{out}	200	200	200	Mc/s
P_{out}	9·0	45	29	W
f_{max}	500	500	500	Mc/s
$V_{a(max)}(f \leq 200Mc/s)$	600	600	500	V
$V_{a(max)}(f = 500Mc/s)$	450	450	370	V
$p_{a(max)}$	2×10	2×10	2×7	W



Contacts 1 and 7 should be strapped together externally to reduce the effective contact resistance.

TYPICAL OPERATION

	Frequency Trebler		Class C FM Telephony		Class C AM Telephony		
f_{out}	200	470	200	470	200	200	Mc/s
V_a	300	300	600	400	300	500	V
V_{g2}	250	250	250	250	250	250	V
V_{g1}	−175	−175	−60	−50	−50	−80	V
I_a	2×45	2×45	2×50	2×50	2×40	2×40	mA
I_{g2}	2×4·0	2×3·5	2×3·0	2×3·0	2×3·5	2×4·0	mA
I_{g1}	2×3·0	2×2·5	2×1·0	2×0·6	2×1·5	2×1·5	mA
$v_{in(pk)}$	2×205	2×205	2×78	—	2×83	2×110	V
p_a	2×9·0	2×10	2×7·5	2x 9·5	2×4·0	2×5·5	W
$P_{load(driver)}$	3·0	5·0	1·5	5·0	1·5	3·0	W
P_{out}	9·0	7·0	45	21	16	29	W
P_{load}	7·0	5·5	35	17	13	22	W
η_a	33	26	75	52·5	67	73	%

CATHODE

Quick-heating directly-heated filament. 70% P_{out} in less than 0·5 second.

*V_f (d.c. or r.m.s.)	1·6	V
I_f	4·25	A
Frequency of filament supply		
Sine wave, max	200	c/s
Square wave	Any	

*The filament has been designed to accept temporary variations in supply voltage of ±15%

CHARACTERISTICS (each section)

(measured at V_a = 300V, V_{g2} = 250V, I_a = 40mA)

g_m	4·0	mA/V
μ_{g1-g2}	9·0	

COOLING

Radiation and convection

Maximum temperatures

Base seals	180	°C
Anode seals	250	°C
Bulb	250	°C

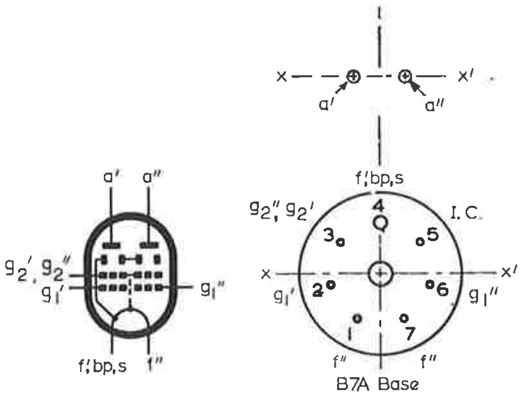
Anode connectors providing a high degree of heat transfer by radiation or conduction should be used.

YL1030

ABRIDGED DATA

Quick-heating, double-ended, double tetrode for use as u.h.f. power amplifier or frequency multiplier in mobile transmitters.
70% power output in less than half a second

	Frequency Trebler	Class C FM Telephony	Class C AM Telephony	
f_{out}	157	180	180	Mc/s
P_{out}	16	85	64	W
f_{max}	500	500	500	Mc/s
$V_{a(max)}$(f = 200Mc/s)	750	750	600	V
$V_{a(max)}$($f \leqslant$ 500Mc/s)	500	500	400	V
$p_{a(max)}$	2×20	2×20	2×14	W



Contacts 1 and 7 should be strapped together externally to reduce the effective contact resistance.

TYPICAL OPERATION

	Frequency Trebler	Class C FM Telephony		Class C AM Telephony		
f_{out}	470	180	180	180	180	Mc/s
V_a	400	400	600	400	600	V
V_{g2}	250	250	250	250	250	V
V_{g1}	−175	−60	−80	−70	−80	V
I_a	2×65	2×100	2×100	2×75	2×75	mA
I_{g2}	2×6·0	2×8·0	2×9·0	2×9·0	2×9·0	mA
I_{g1}	2×2·9	2×3·0	2×3·5	2×2·0	2×2·0	mA
$v_{in(pk)}$	360					V
p_a	2×18	2×13·5	2×17·5	2×10·5	2×13	W
$P_{load(driver)}$	8·0	3·0	4·0	4·0	5·0	W
P_{out}	16	53	85	39	64	W
P_{load}	12	45	75	32	53	W
η_a	31	66	71	65	71	%

CATHODE

Quick-heating directly-heated filament. 70% P_{out} in less than 0·5 second.

*V_f	2·1	V
I_f	4·5	A
Frequency of filament supply		
Sine wave, max	200	c/s
Square wave	Any	

*The filament has been designed to accept temporary variations in supply voltage of ±15%

CHARACTERISTICS (each section)

(measured at V_a = 600V, V_{g2} = 250V, I_a = 40mA)

g_m	4·5	mA/V
μ_{g1-g2}	8·0	

COOLING

Radiation and convection cooled

Maximum temperatures

Base seals	250	°C
Anode seals	180	°C
Bulb	250	°C

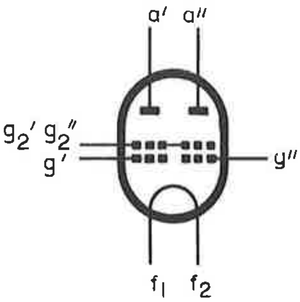
Anode connectors providing a high degree of heat transfer by radiation or by conduction should be used.

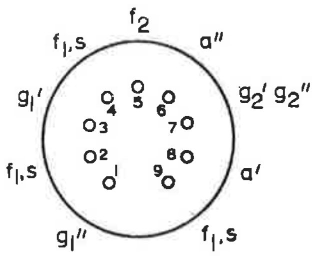
YL1080/8348

Quick-heating single-ended double tetrode for mobile transmitters.
70% power output in less than half a second

ABRIDGED DATA

	Frequency Trebler	Class C FM Telephony	Class C AM Telephony	
f_{out}	200	200	200	Mc/s
P_{out}	5	14·5	8	W
f_{max}	200	200	200	Mc/s
$V_{a(max)}$	300	300	240	V
$p_{a(max)}$	2×5·0	2×5·0	2×3·3	W





B9A Base

TYPICAL OPERATION

	Frequency Trebler		Class C FM Telephony		Class C AM Telephony	
f_{out}	200	200	200	200	200	Mc/s
V_a	300	200	300	200	200	V
V_{g2}	160	160	170	150	130	V
V_{g1}	−100	−100	−40	−40	−50	V
I_a	2×24	2×28·5	2×37·5	2×35	2×33·5	mA
I_{g2}	2×1·0	2×1·5	2×1·2	2×1·1	2×1·3	mA
I_{g1}	2×1·0	2×1·6	2×0·9	2×1·4	2×0·75	mA
$V_{in(g1-g1)pk}$	230	230	110	115	130	V
p_a	2×4.0	2×3.8	2×4·0	2×2·8	2×2·65	W
p_{g2}	2×0·15	2×0·23	2×0·2	2×0·17	0·46	W
$P_{load(driver)}$	1·0	2·0	1·0	1·0	1·0	W
P_{out}	6.4	3.8	14·5	8·4	8·0	W
P_{load}	3·5	2·8	12	7·4	7·0	W
η_a	45	33	65	60	60	%
For 100% modulation						
P_{mod}					6.7	W
$V_{g2(pk)}$					130	V

CATHODE

Quick-heating, directly-heated filament. 70% P_{out} in less than 0·5 second

*V_f (d.c. or r.m.s.)	1·6	V
I_f	~~2·05~~ 2·50	A
Frequency of filament supply		
Sine wave, max	200	c/s
Square wave	Any	

*The filament has been designed to accept temporary variations in supply voltage of ±15%

CHARACTERISTICS (each section)

(measured at $V_a = V_{g2} = 200V$, $I_a = 30mA$)

g_m	3.3	mA/V
μ_{g1-g2}	7.0	

COOLING

Radiation and convection

Maximum temperatures

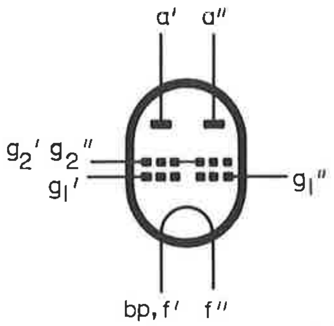
Base seals	120	°C
Bulb	250	°C

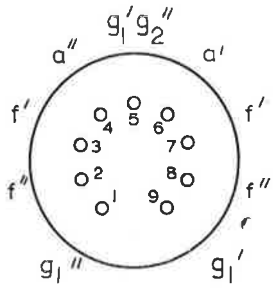
YL1130/8408

ABRIDGED DATA

Quick-heating, single-ended double tetrode for use as amplifier and frequency multiplier in mobile transmitters. 70% power output in less than half a second

	Frequency Trebler	Class C FM Telephony		Class C AM Telephony		
f_{out}	500	200	500	200	500	Mc/s
P_{out}	3·5	16	8·0	9·4	6·6	W
f_{max}	500	500		500		Mc/s
$V_{a(max)}$(f = 200Mc/s)	—	300		240		V
$V_{a(max)}$(f = 500Mc/s)	200	200		200		V
$p_{a(max)}$	2×4·0	2×4·0		2×2·6		W





B9A Base

Filament connections pins 3–7 and 2–8 should be connected in parallel on the socket.

TYPICAL OPERATION

	Frequency Trebler	Class C FM Telephony		Class C AM Telephony		
f_{out}	500	200	500	200	500	Mc/s
V_a	175	275	175	220	175	V
V_{g2}	175	180	175	175	175	V
V_{g1}	−67.5	−20	−22	−35	−30	V
I_a	2×30	2×42.5	2×40	2×32	2×32	mA
I_{g2}	2×4.5	2×7·0	2×6·0	2×4·0	2×3·5	mA
I_{g1}	2×1.2	2×2.6	2×2.3	2×1·2	2×1·2	mA
$V_{in(g1-g1)pk}$	175	65	65	105	100	V
p_a	2×3·5	2×3·5	2×3·0	2×2·4	2×2·3	W
p_{g2}	2×0·8	2×1·2	2×1·0	2×0·8	2×0·8	W
$P_{load(driver)}$	1.5	0.7	1.5	0·6	1·5	W
P_{out}	3·5	16	8.0	9·4	6·6	W
P_{load}	2.0	13	6.5	8·0	5·0	W
η_a	33	68	57	67	59	%
For 100% modulation						
P_{mod}				8·0	6·5	W
$V_{g2(pk)}$				125	125	V

CATHODE

Quick-heating directly-heated filament. 70% P_{out} in less than 0·5 second.

*V_f (d.c. or r.m.s.)	1·1	V
I_f	3·1	A
Frequency of filament supply		
Sine wave, max	200	c/s
Square wave	Any	

*The filament has been designed to accept temporary variations in supply voltage of ±15%

CHARACTERISTICS (each section)

(measured at $V_a = V_{g2} = 175V$, $I_a = 40mA$)

g_m	7·0	mA/V
μ_{g1-g2}	22	

COOLING

Radiation and convection

Maximum temperatures

Base-seals	120	°C
Bulb	225	°C

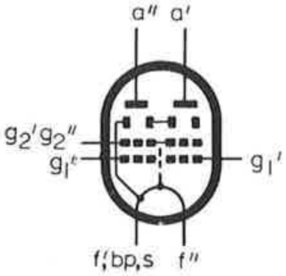
YL1190/8580

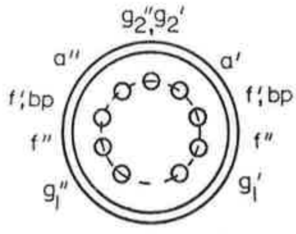
Quick-heating, single-ended, double tetrode for mobile transmitters.

ABRIDGED DATA

70% power output in less than half a second

	Frequency Trebler	Class C FM Telephony		Class C AM Telephony	
f_{out}	500	200	500	200	Mc/s
P_{out}	5·0	33	19	19	W
f_{max}	500	500		500	Mc/s
$V_{a(max)}$(f = 200Mc/s)	400	400		330	V
$V_{a(max)}$(f = 500Mc/s)	300	300		240	V
$p_{a(max)}$	2×8·0	2×8·0		2×5.5	W





B9D (Magnoval) base

Filament connections (pins 3, 7 and 2, 8) should be connected in parallel on the socket.

TYPICAL OPERATION

	Frequency Trebler	Class C FM Telephony		
f_{out}	500	200	500	Mc/s
V_a	250	350	260	V
V_{g2}	170	140	175	V
V_{g1}	-67.5	−13	−22·5	V
I_a	2×45	2×70	2×70	mA
I_{g2}	14	23·5	20	mA
I_{g1}	2×2.5	2×6·5	2×3.25	mA
$V_{in(g1-g1)pk}$	170	85	65	V
p_a	2×8	2×8·0	2×8·0	W
p_{g2}	2.4	3·1	2·7	W
$P_{load(driver)}$	2.2	1·0	2·5	W
P_{out}	6.5	33	19	W
P_{load}	3.0	26	14.0	W
η_a	29	67	52	%

CATHODE

Quick-heating directly-heated filament. 70% P_{out} in less than 0·5 second.

*V_f (d.c. or r.m.s.)	1·1	V
I_f	3·8	A
Frequency of filament supply		
Sine wave, max	200	c/s
Square wave	Any	

*The filament has been designed to accept temporary variations in supply voltage of ±15%

CHARACTERISTICS (each section)

(measured at V_a = V_{g2} = 150V, I_a = 45mA)

g_m	9·5	mA/V
μ_{g1-g2}	22	

COOLING

Radiation and convection

Maximum temperature		
Base seals	120	°C
Bulb	230	°C

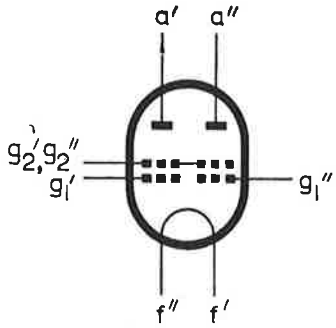
The use of a closed tube shield is not recommended.

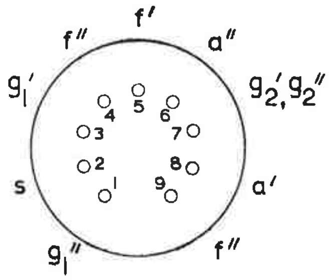
Quick-heating single-ended double tetrode for mobile transmitters.
70% power output in less than one second

QQC03/14/7983

ABRIDGED DATA

	Frequency Trebler	Class C FM Telephony	Class C AM Telephony	
f_{out}	175	200	200	Mc/s
P_{out}	5·0	13·5	10	W
f_{max}	200	200	200	Mc/s
$V_{a(max)}$	330	300	240	V
$p_{a(max)}$	2×5·0	2×7·0	2×4·6	W





B9A Base

Contacts 4 and 9 should bestrapped together externally to reduce the effective contact resistance.

TYPICAL OPERATION

	Frequency Trebler	Class C FM Telephony		Class C AM Telephony	
f_{out}	175	200	200	200	Mc/s
V_a	300	250	200	200	V
V_{g2}	150	175	175	175	V
V_{g1}	−125	−40	−40	−50	V
I_a	2×24	2×45	2×45	2×43	mA
I_{g2}	2×1·0	2×2·1	2×2·6	2×1·5	mA
I_{g1}	2×0·75	2×1·5	2×1·5	2×1·6	mA
$V_{in(pk)}$				130	V
p_a	2×4·7	2×4·5	2×3·5	2×3·6	W
$P_{load(driver)}$	1·2	1·0	1·0	1·25	W
P_{out}	5·0	13·5	11	10	W
P_{load}	4·0	11	9·5	8·0	W
η_a		62	67	57	%
For 100% modulation					
P_{mod}				9·0	W

CATHODE

Quick-heating directly-heated filament. 70% P_{out} in less than 1 second

*V_f (d.c. or r.m.s.)	3·15	V
I_f	1·65	A
Frequency of filament supply		
Sine wave, max	200	c/s
Square wave	Any	

*The filament has been designed to accept temporary variations in supply voltage of ± 15%

CHARACTERISTICS (each section)

(measured at $V_a = V_{g2} = 200V$, $I_a = 30mA$)

g_m	3·2	mA/V
μ_{g1-g2}	7·5	

COOLING

Radiation and convection

Maximum temperatures

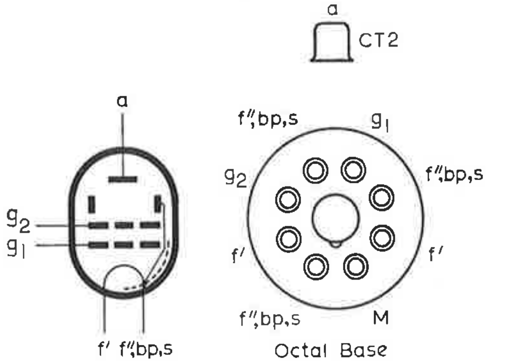
Base seals	120	°C
Bulb	225	°C

QC05/35/8042

Quick-heating, double-ended tetrode for use as v.h.f. power amplifier in mobile transmitters. 70% power output in less than half a second

ABRIDGED DATA

	Class C FM Telephony	Class C AM Telephony	
f_{out}	60	60	Mc/s
P_{out}	65	34	W
f_{max}	175	175	Mc/s
$V_{a(max)}$(f = 175Mc/s)	400	350	V
$V_{a(max)}$(f = 60Mc/s)	650	480	V
$p_{a(max)}$	25	14	W



Connect contacts 1, 4 and 6 together and contacts 2 and 7 together externally to reduce the effective contact resistance.

TYPICAL OPERATION

	Class C FM Telephony		Class C AM Telephony		
f_{out}	60	175	60	60	Mc/s
V_a	600	400	475	400	V
V_{g2}	180	190	135	150	V
V_{g1}	−71	−54	−77	−87	V
I_a	150	150	94	112	mA
I_{g2}	15	15	9·0	12	mA
I_{g1}	2·8	2·2	2·8	3·4	mA
$v_{in}pk$	91	68	95	107	V
p_a	25	25	11	13	W
p_{g2}	2·7	2·9	1·2	1·8	W
$P_{load(driver)}$	2·0	5·0	0·3	0·4	W
P_{out}	65	35	34	32	W
P_{load}	53	28	29	27	W
η_a	73·5	58	75	71	%

CATHODE

Quick-heating directly-heated filament. 70% P_{out} in less than 0·5 second.

*V_f (d. c. or r.m.s.)	1·6	V
I_f	3·2	A
Frequency of filament supply		
Sine wave, max	200	c/s
Square wave	Any	

*The filament has been designed to accept temporary variations in supply voltage of ±15%.

CHARACTERISTICS

(measured at $V_a = V_{g2}$ = 200V, I_a = 100mA)

g_m	7·0	mA/V
μ_{g1-g2}	4·5	

COOLING

Radiation convection

Maximum temperature

Bulb	220	°C

SURVEY OF T.I. BULLETINS

In the series "Technical Information" the following publications have been issued:

1	April 1964	High-power klystrons for band IV/V television transmitters
2	May 1964	Semiconductor integrated circuits for digital applications
3	May 1964	Applications of the photodiode OAP12 and the phototransistor OCP70
4	June 1964*	Cold-cathode trigger tubes – the facts of life
5	June 1964	Application of decade indicator tube ZM1050 in a counter with a counting rate of up to 100 kc/s
6	October 1964	Transient performance of alloy-transistor types derived from the fundamental parameters
7	October 1964	Applications of thermoelectric cooling
8	June 1965	Rectifier diode operation at kilocycle frequencies
9	June 1965	Parallel operation of silicon rectifier diodes
10	August 1965	Gallium-arsenide semiconductor devices
11	September 1965	Electrometer tubes
12	September 1965	Transient performance of heatsinks for power devices
13	September 1965	Choppers and their applications
14	October 1965	Fundamental behaviour of cold-cathode trigger tubes
15	September 1965	Z504S stepping tube – operating principles, reliability and circuit design

*) Superseded by T.I. No.14.

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