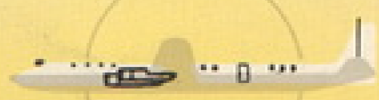
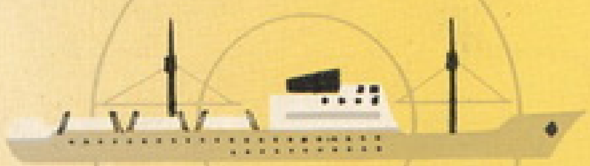
# PHILIPS

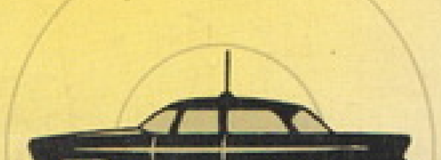




# TRANSMITTING TUBES

## *for mobile equipment*

PHILIPS ELECTRON TUBE DIVISION



# Introduction

The safe and economic use of expensive means of conveyance, such as ships and aircraft, relies largely on radio communication. As far as safety is concerned the use of radio is paramount, but by its use the economy is also greatly served.

It was found a relatively short time ago that under many conditions the efficiency could be served by installing small radio communication equipment in motor vehicles, with police patrol-cars and fire brigades in the leading, and doctors cars, expedition vans, service vehicles, taxicabs and even private cars following.

The size, weight and power consumption of radio communication equipment aboard big ships, such as liners and freighters, are of no great importance. All the other traffic means: aircraft, motor vehicles and also tugboats, fishermen and yachts, are best served with small, light and highly efficient radio communication equipment. In this respect the receiving section creates no great problems, but the transmitters call for highly efficient tubes, so that the required results can be obtained with a minimum of bulk, weight and, last but not least, power drain.

In equipment operating at frequencies below 100 Mc/s, a single tube class C output stage may be chosen. Such a stage may be equipped with the QE 05/40 beam power tetrode, which has an anode dissipation of maximum 25 W when used in intermittent FM telephony service.

For frequencies higher than 100 Mc/s, the R.F. amplifiers are preferably designed as push-pull circuits, which offer the advantages of simple construction and higher efficiency. The input and output capacitances of the tubes are halved and the radiation is low.

In push-pull stages the circuit losses due to the inductances of the leads between the cathodes and the screen grids can be kept small when the two tube systems required are incorporated in a single envelope. These losses can be reduced to an ultimate limit when a common cathode and a common screen grid are used for both tube systems.

This idea was realised first in the QQE 06/40, a heater type double tetrode with an anode dissipation of 2 x 22.5 W in intermittent FM telephony service. It was soon followed by a directly-heated double tetrode QQC 04/15 for 2 x 8 W anode dissipation in intermittent FM telephony service.

The QQE 03/20 is a double tetrode with a base identical to that of the QQE 06/40, but the height of the tube systems and the bulb are smaller. It stands 2 x 10 W anode dissipation.

A new development was introduced with the QQE 03/12, which is a transmitting double tetrode with the appearance of a receiving tube, the envelope being of the noval type. It has been designed for frequencies up to 200 Mc/s and has maximum anode dissipation of 2 x 7 W under intermittent FM telephony service conditions.

A recent development is the QQE 02/5, which has been designed for frequencies up to 500 Mc/s. This tube has been provided with the modern frame grids, and is also contained in a noval envelope. The maximum anode dissipation is 2 x 3.75 W under intermittent FM telephony service conditions.

The Limiting Values and the principal Operating Conditions of the tubes mentioned are given in the following Tables. From these data it is seen that a wide range of frequencies and output powers is covered and that the tubes may be used in AM and FM telephony applications, as frequency multipliers and as A.F. modulator tubes.

The small QQE 02/5 is not published for A.F. Class B applications. The special grid construction makes this tube more expensive than, for instance, the QQE 03/12, so that the latter will be preferred for use as a modulator in small-power V.H.F. transmitters.

In the Tables are entered the Limiting Values under both C.C.S. (Continuous Commercial Service) and I.C.A.S. (Intermittent Commercial and Amateur Service) conditions, together with the Operating Conditions at low and high supply voltages, so that the correct tube for a given frequency and a given output power can easily be selected. For complete information as to the technical data, reference is made to the Tube Handbook, Vol.IV.

The Table for the QE 05/40 contains only the single-tube R.F. applications. The tube may, of course, also be used as an A.F. modulator tube in push-pull class B, but the modulating power thus obtained is far in excess of that required for modulating a single-tube R.F. amplifier, so that these operating conditions have not been entered.

TABLE 1

## PUSH-PULL R.F. CLASS C F.M. TELEPHONY C.C.S.

| LIMITING VALUES (absolute maxima) | QQE 02/5 | QQE 03/12 | QQE 03/20 | | QQE 06/40 | | QQC 04/15 | | |
|---|---|---|---|---|---|---|---|---|---|
| *Frequency* | 500 | 200 | 200 | 600 | 250 | 500 | 186 | 300 | Mc/s |
| *Anode* | | | | | | | | | |
| Voltage | 250 | 300 | 600 | 400 | 750 | 600 | 600 | 450 | V |
| Input power | 2x6 | 2x11.25 | 2x30 | 2x20 | 2x60 | 2x50 | 2x18 | 2x9 | W |
| Dissipation | 2x3 | 2x5 | 2x10 | | 2x20 | | 2x6 | | W |
| Current | 2x45 | 2x45 | 2x50 | | 2x110 | | 2x30 | | mA |
| *Grid No.2* | | | | | | | | | |
| Voltage | 200 | 200 | 250 | | 300 | | 250 | | V |
| Dissipation | 3 | 2 | 3 | | 7 | | 7 | | W |
| *Grid No.1* | | | | | | | | | |
| Voltage | -50 | -150 | -75 | | -175 | | -200 | | V |
| Current | 2x3 | 2x3 | 2x2.5 | | 2x5 | | 2x5 | | mA |
| *Cathode* | | | | | | | | | |
| Current | - | 2x50 | 2x55 | | - | | – | | mA |
| Cathode-to-heater voltage | 100 | 100 | 100 | | 100 | | - | | V |

| OPERATING CONDITIONS | QQE 02/5 | QQE 03/12 | | QQE 03/20 | | | | | QQE 06/40 | | | | QQC 04/15 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Frequency* | *500* | *200* | | *200* | | *400* | | *600* | *200* | *250* | *430* | *500* | *60* | | *186* | | Mc/s |
| *Voltages* | | | | | | | | | | | | | | | | | |
| Anode | 180 | 300 | 200 | 600 | 200 | 400 | 200 | 400 | 600 | 750 | 520 | 500 | 600 | 250 | 600 | 250 | V |
| Grid No.2 | 180 | 175 | - | 250 | 200 | 250 | 200 | 250 | 250 | 250 | 250 | 250 | 200 | 175 | 200 | 175 | V |
| Grid No.1 | -20 | -40 | - | -60 | -30 | -50 | -30 | -50 | -80 | -80 | -80 | - | -80 | -70 | -80 | -70 | V |
| *Resistors* | | | | | | | | | | | | | | | | | |
| Grid No.2(dropping) | - | - | 22 | - | - | - | - | - | - | - | - | - | | | | | kΩ |
| Grid No.1(bias) | 2x27 | - | 15 | - | - | - | - | - | - | - | - | 20 | | | | | kΩ |
| *Currents* | | | | | | | | | | | | | | | | | |
| Anode | 2x27.5 | 2x37.5 | 2x35 | 2x50 | 2x50 | 2x50 | 2x50 | 2x50 | 2x100 | 2x80 | 2x100 | 2x100 | 2x30 | 2x30 | 2x30 | 2x30 | mA |
| Grid No.2 | 12.5 | 2.3 | 2.2 | 8 | 8 | 5 | 6 | 5 | 16 | 17 | 18 | 20 | 6 | 6.5 | 3 | 4.5 | mA |
| Grid No.1 | 2x0.75 | 2x0.9 | 2.7 | 2x0.7 | 2x1 | 2x0.7 | 2x0.5 | 2x0.7 | 2x2.5 | 2x1.5 | 2x2.8 | 2x3 | 2x1.0 | 2x1.8 | 2x1.0 | 2x1.5 | mA |
| *Peak-to-peak grid drive* | 50 | 110 | 115 | | | | | | 200 | 250 | | | 210 | 210 | 210 | 220 | V |
| *Power* | | | | | | | | | | | | | | | | | |
| Input grid No.1 | 2x1.2 | 2x0.05 | 0.14 | 1.5 | <1 | 2 | 1 | - | | | | | 2x0.1 | 2x0.17 | 2x0.1 | 2x0.15 | W |
| Grid No.2 | 2.25 | 0.4 | 0.33 | 2 | 1.6 | 1.2 | 1.2 | 1.26 | 4 | 4.25 | 4.5 | 5 | 1.2 | 1.1 | 0.6 | 0.8 | W |
| Anode input | 2x5 | 2x11.25 | 2x7 | 2x30 | 2x10 | 2x20 | 2x10 | 2x20 | 2x60 | 2x60 | 2x52 | 2x50 | 2x18 | 2x7.5 | 2x18 | 2x7.5 | W |
| Anode dissipation | 2x2.1 | 2x4 | 2x2.8 | 2x6 | 2x3.5 | 2x8 | 2x4.5 | 2x10 | 2x15 | 2x17.5 | 2x19 | 2x20 | 2x4.7 | 2x2.2 | 2x5.2 | 2x2.4 | W |
| *Output* | *5.8* | *14.5* | *8.4* | *48* | *13* | *24* | *11* | *20* | *90* | *65* | *66* | *60* | *26.6* | *10.6* | *25.6* | *10.2* | W |
| *Efficiency* | 58 | 65 | 60 | 80 | 65 | 60 | 55 | 50 | 75 | 71 | 64 | 60 | 74 | 71 | 71 | 68 | % |
| Useful power in load | 5 | 12 | 7.4 | | | | | | | | | | | | | | W |

TABLE 2

## PUSH-PULL R.F. CLASS C FREQUENCY TREBLER C.C.S.

| LIMITING VALUES (absolute limits) | QQE 02/5 | QQE 03/12 | QQE 03/20 | | QQE 06/40 | | QQC 04/15 | | |
|---|---|---|---|---|---|---|---|---|---|
| *Frequency* | 500 | 200 | 200 | 400 | 250 | 500 | 186 | 300 | Mc/s |
| *Anode* | | | | | | | | | |
| Voltage | 250 | 300 | 600 | 400 | 750 | 600 | 600 | 450 | V |
| Input power | 2x4 | 2x7.5 | | | 2x60 | 2x50 | 2x12 | 2x9 | W |
| Dissipation | 2x3 | 2x5 | 2x10 | | 2x20 | | 2x6 | | W |
| Current | 2x30 | 2x30 | 2x45 | | 2x110 | | 2x30 | | mA |
| *Grid No.2* | | | | | | | | | |
| Voltage | 200 | 200 | 250 | | 300 | | 250 | | V |
| Dissipation | 3 | 2 | 3 | | 7 | | 7 | | W |
| *Grid No.1* | | | | | | | | | |
| Voltage | -100 | -150 | -200 | | -175 | | -200 | | V |
| Current | 2x3 | 2x2 | 2x2.5 | | 2x5 | | 2x5 | | mA |
| *Cathode* | | | | | | | | | |
| Current | - | 2x35 | 2x50 | | - | | | | mA |
| Cathode-to-heater voltage | 100 | 100 | 100 | | 100 | | | | V |

| OPERATING CONDITIONS | QQE 02/5 | QQE 03/12 | | QQE 03/20 | | QQE 06/40 | | | QQC 04/15 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Frequency* | *166.6/500* | *67/200* | | *67/200* | *133/400* | *50/150* | | *166/500* | *62/186* | | Mc/s |
| *Voltages* | | | | | | | | | | | |
| Anode | 180 | 300 | 200 | 300 | 300 | 500 | 400 | 400 | 400 | 250 | V |
| Grid No.2 | 180 | 150 | (155) | 250 | 250 | 250 | 250 | 220 | 200 | 200 | V |
| Grid No.1 | - | -100 | - | -175 | -175 | -150 | -150 | -175 | -175 | -175 | V |
| *Resistors* | | | | | | | | | | | |
| Grid No.2(dropping) | 1.2 | - | 15 | - | - | - | - | - | - | - | kΩ |
| Grid No.1(bias) | 2x82 | - | 33 | - | - | - | - | - | - | - | kΩ |
| *Currents* | | | | | | | | | | | |
| Anode | 2x20 | 2x24 | 2x28.5 | 2x45 | 2x45 | 2x60 | 2x73 | 2x70 | 2x24 | 2x30 | mA |
| Grid No.2 | 9.7 | 2 | 3 | 6 | 5.6 | 10 | 16 | 5 | 3 | 6 | mA |
| Grid No.1 | 2x0.9 | 2x1.0 | 2x1.6 | 2x1.5 | 2x1.2 | 2x3 | 2x2.5 | 2x2.5 | 2x0.6 | 2x1.1 | mA |
| *Peak grid-to-grid drive* | 165 | 230 | 230 | - | - | 360 | 360 | - | 430 | 430 | V |
| *Power* | | | | | | | | | | | |
| Input grid No.1 | 1.1 | 0.23 | 0.35 | 2 | 4 | 1.2 | 1 | 8 | 0.24 | 0.44 | W |
| Grid No.2 | 1.65 | 0.30 | 0.46 | 1.5 | 1.4 | 2.5 | 4 | 1.1 | 0.6 | 1.2 | W |
| Anode input | 2x3.6 | 2x7.2 | 2x5.7 | 2x13.5 | 2x13.5 | 2x30 | 2x29 | 2x28 | 2x9.6 | 2x7.5 | W |
| Anode dissipation | 2x2.45 | 2x4.0 | 2x3.8 | 2x8.5 | 2x9.5 | 2x20 | 2x20 | - | 2x6 | 2x5.2 | W |
| Output | 2.35 | 6.5 | 3.8 | 10 | 8 | 20 | 18 | - | 7.2 | 4.6 | W |
| *Efficiency* | 33 | 45 | 33.5 | 37 | 29.5 | 33 | 31 | - | 37.5 | 31 | % |
| *Useful power in load* | 1.8 | 3.5 | 2.8 | - | - | 16 | 14.5 | 10 | - | - | W |

## PUSH-PULL R.F. CLASS C A.M. TELEPHONY

### ANODE AND SCREEN-GRID MODULATION

TABLE 3

| LIMITING VALUES (absolute limits) | QQE 02/5 | QQE 03/12 | QQE 03/20 | | QQE 06/40 | | QQC 04/15 | | |
|---|---|---|---|---|---|---|---|---|---|
| *Frequency* | 500 | 200 | 200 | 400 | 250 | 500 | 186 | 300 | Mc/s |
| *Anode* | | | | | | | | | |
| Voltage | 200 | 240 | 500 | 300 | 600 | 480 | 480 | 360 | V |
| Input power | 2x4 | 2x7.5 | 2x20 | 2x12 | 2x45 | 2x33.5 | 2x11.5 | 2x5.25 | W |
| Dissipation | 2x2 | 2x3.3 | 2x10 | | 2x14 | | 2x4 | | W |
| Current | 2x32 | 2x37.5 | - | | 2x92 | | 2x25 | | mA |
| *Grid No.2* | | | | | | | | | |
| Voltage | 200 | 200 | 250 | | 300 | | 250 | | V |
| Dissipation | 2 | 1.3 | 3 | | { 7[1]) 4.6[2]) | | 4.5 | | W |
| *Grid No.1* | | | | | | | | | |
| Voltage | -50 | -150 | -100 | | -175 | | -200 | | V |
| Current | 2x3 | 2x3 | 2x2.5 | | 2x5 | | 2x5 | | mA |
| *Cathode* | | | | | | | | | |
| Current | - | 2x40 | 2x50 | | | | | | mA |
| Cathode-to-heater voltage | 100 | 100 | 100 | | 100 | | - | | V |
| *Grid No.1-to-cathode Resistance* | | | | | { 50[3]) 25[4]) | | | | kΩ |

| OPERATING CONDITIONS | QQE 02/5 | QQE 03/12 | QQE 03/20 | | | QQE 06/40 | | QQC 04/15 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Frequency* | *500* | *200* | *200* | | *400* | *60* | *250* | *60* | | *186* | Mc/s |
| *Voltages* | | | | | | | | | | | |
| Anode | 180 | 200 | 500 | 300 | 300 | 600 | 600 | 450 | 250 | 250 | V |
| Grid No.2 | 180 | - | 250 | 250 | 250 | 250 | 250 | - | - | - | V |
| Grid No.1 | -20 | - | -80 | -50 | -50 | -80 | -80 | -80 | -70 | -70 | V |
| *Resistors* | | | | | | | | | | | |
| Grid No.2(dropping) | 0.1 | 39+12[5]) | - | - | - | - | - | - | - | - | kΩ |
| Grid No.1(bias) | 2x68 | 33 | - | - | - | - | - | 18 | 10 | 10 | kΩ |
| *Currents* | | | | | | | | | | | |
| Anode | 2x20 | 2x33.5 | 2x40 | 2x40 | 2x40 | 2x75 | 2x75 | 2x25 | 2x19.5 | 2x19.5 | mA |
| Grid No.2 | 9.5 | 2.6 | 8 | 8 | 6 | 20 | 18 | 14 | 11 | 11 | mA |
| Grid No.1 | 2x0.3 | 1.5 | 2x1.0 | 2x1.0 | 2x1.0 | 2x3.8 | 2x1.6 | 2x1.0 | 2x1.5 | 2x1.5 | mA |
| *Peak grid-to-grid drive* | 45 | 130 | - | - | - | 105 | 130 | 83 | 110 | 110 | V |
| *Power* | | | | | | | | | | | |
| Input grid No.1 | 1.0 | 0.1 | 2x3 | 2x1.5 | - | - | - | 1x0.08 | 2x0.15 | 2x0.15 | W |
| Grid No.2 | 1.7 | 0.46 | 2 | 2 | 1.5 | 5 | 4.5 | 2.8 | 1.6 | 1.6 | W |
| Anode input | 2x3.6 | 2x6.7 | 2x20 | 2x12 | 2x12 | 2x45 | 2x45 | 2x11.25 | 2x4.9 | 2x4.9 | W |
| Anode dissipation | 2x1.5 | 2x2.65 | 2x4.5 | 2x3.5 | 2x5.5 | 2x9.5 | 2x13 | 2x2.5 | 2x1.8 | 2x1.9 | W |
| *Output* | *4.2* | *8.1* | *31* | *17* | *13* | *71* | *64* | *17.5* | *6.2* | *6.0* | W |
| *Efficiency* | 58 | 60 | 77.5 | 71 | 54 | 79 | 71 | 77.5 | 63 | 61 | % |
| *Useful power in load* | 3.5 | 7.1 | - | - | - | - | - | - | - | - | W |
| *Modulation* | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | % |
| Modulation power | 4.5 | 6.7 | 20 | 12 | 12 | 45 | 45 | 11.5 | 5 | 5 | W |
| Peak Grid No.2 voltage | - | - | - | - | - | 90 | 90 | - | - | - | V |

[1]) Screen grid modulated via a choke.

[2]) For all other modulation systems.

[3]) Each system.

[4]) Per tube.

[5]) Resistor of 39 kΩ connected to the supply, 12 kΩ to the anode and the screen grid to the interconnection.

## PUSH-PULL A.F. AMPLIFIER AND MODULATOR C.C.S.

TABLE 4

| LIMITING VALUES (absolute limits) | QQE 03/12 without grid current CLASS AB | QQE 03/12 with grid current | QQE 03/20 CLASS B | QQE 06/40 without grid current CLASS B | QQE 06/40 with grid current | UNIT |
|---|---|---|---|---|---|---|
| *Anode* | | | | | | |
| Voltage | 300 | 300 | 600 | 600 | 600 | V |
| Input power | 2x15 | 2x15 | - | 2x60 | 2x60 | W |
| Dissipation | 2x7 | 2x7 | 2x10 | 2x20 | 2x20 | W |
| Current | 2x50 | 2x50 | - | 2x110 | 2x110 | mA |
| *Grid No.2* | | | | | | |
| Voltage | 200 | 200 | 250 | 300 | 300 | V |
| Dissipation | 2 | 2 | 3 | 7 | 7 | W |
| Peak dissipation | 4 | 4 | - | - | - | W |
| *Grid No.1* | | | | | | |
| Voltage | -150 | -150 | -75 | - | - | V |
| Current | 2x4 | 2x4 | - | - | 2x5 | mA |
| Dissipation | - | 2x0.2 | - | - | - | W |
| *Cathode* | | | | | | |
| Current | 2x60 | 2x60 | 2x55 | - | - | mA |
| Peak current | 2x300 | 2x300 | - | - | - | mA |
| Cathode-to-heater voltage | 100 | 100 | 100 | 100 | 100 | V |
| *Grid No.1-to-cathode resistance* | - | - | 50 | 50 | 50 | kΩ |

| OPERATING CONDITIONS | QQE 03/12 without grid current CLASS AB | | QQE 03/12 with grid current | | QQE 03/20 CLASS B | | QQE 06/40 without grid current CLASS B | | QQE 06/40 with grid current | | UNIT |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Voltages* | | | | | | | | | | | |
| Anode | 300 | 200 | 300 | 200 | 500 | 300 | 600 | 300 | 600 | 300 | V |
| Grid No.2 | 200 | 200 | 200 | 200 | 250 | 250 | 250 | 250 | 250 | 250 | V |
| Grid No.1 | -21.5 | -21.5 | -21.5 | -21.5 | -26 | -25 | -27.5 | -26 | -25 | -25 | V |
| *Anode-to-anode load resistance* | 10 | 6.5 | 6.5 | 5.0 | 20 | 11 | 12.5 | 6.5 | 8 | 4 | kΩ |
| Grid drive peak-to-peak | 0 43.5 | 0 43.5 | 0 64 | 0 54 | 0 52 | 0 50 | 0 55 | 0 52 | 0 78 | 0 75 | V |
| *Currents* | | | | | | | | | | | |
| Anode | 2x15 2x36 | 2x15 2x32 | 2x15 2x50 | 2x15 2x41.1 | 2x12.5 2x36.5 | 2x12.5 2x35 | 2x20 2x62 | 2x20 2x56 | 2x25 2x100 | 2x25 2x94 | mA |
| Grid No.2 | 1.2 12.6 | 2.4 14 | 1.2 11.4 | 2.4 19 | 0.7 16.2 | 1.2 19 | 0.9 23 | 2.2 28 | 1.2 26 | 2.8 28 | |
| Grid No.1 | | | 0 2x0.56 | 0 2x0.22 | | | | | 0 2x2.6 | 0 2x2.6 | |
| *Power* | | | | | | | | | | | |
| Anode input | 2x4.5 2x10.8 | 2x3.0 2x6.6 | 2x4.5 2x15 | 2x3.0 2x8.22 | 2x6.25 2x18.25 | 2x3.75 2x10.5 | 2x12 2x37 | 2x6.0 2x16.8 | 2x15 2x60 | 2x7.5 2x28.2 | W |
| Anode dissipation | 2x4.5 2x4.8 | 2x3.0 2x3.1 | 2x4.5 2x6.25 | 2x3.0 2x3.87 | 2x6.25 2x6.5 | 2x3.75 2x3.9 | 2x12 2x12 | 2x6.0 2x5.6 | 2x15 2x17 | 2x7.5 2x9.7 | W |
| Grid No.2 dissipation | 0.24 2.5 | 0.48 2.8 | 0.24 2.3 | 0.48 3.8 | 0.18 4.05 | 0.3 4.75 | 0.2 5.8 | 0.6 7.0 | 0.3 6.5 | 0.7 7.0 | W |
| Output | 0 12 | 0 7 | 0 17.5 | 0 8.7 | 0 23.5 | 0 13.2 | 0 50 | 0 22.5 | 0 86 | 0 37 | W |
| Grid No.1 input | | | | | | | | | 0 2x0.1 | 0 2x0.1 | W |
| *Efficiency* | 56 | 53 | 58 | 53 | 63.5 | 63 | 67.5 | 67 | 71.5 | 65.5 | % |
| Total distortion | 2.5 | 3.2 | 5.0 | 6.0 | 3.5 | 3.5 | 2.4 | 2.9 | 5 | 5 | % |

## PUSH-PULL CLASS B A.F. AMPLIFIER AND MODULATOR WITH QQC 04/15

TABLE 5

| LIMITING VALUES (absolute limits) | C.C.S. | | | | I.C.A.S. | | UNIT |
|---|---|---|---|---|---|---|---|
| *Anode* | | | | | | | |
| Voltage | 600 | | | | 600 | | V |
| Input power | 2x18 | | | | 2x24 | | W |
| Dissipation | 2x6 | | | | 2x8 | | W |
| Current | 2x30 | | | | 2x40 | | mA |
| *Grid No.2* | | | | | | | |
| Voltage | 250 | | | | 250 | | V |
| Dissipation | 7 | | | | 7 | | W |
| *Grid No.1* | | | | | | | |
| Voltage | -200 | | | | -200 | | V |
| OPERATING CONDITIONS | | | | | | | |
| *Voltages* | | | | | | | |
| Filament (d.c.) | 6.3 | | | | 6.3 | | V |
| Anode | 450 | | 250 | | 600 | | V |
| Grid No.2 | 200 | | 175 | | 200 | | V |
| Grid No.1 | -24 | | -20 | | -24 | | V |
| Anode-to-anode load resistance | 20 | | 8 | | 25 | | kΩ |
| *Grid drive* *peak-to-peak* | 0 | 94 | 0 | 100 | 0 | 85 | V |
| *Currents* | | | | | | | |
| Anode | 2x2.8 | 2x32.5 | 2x2.9 | 2x36 | 2x3.0 | 2x33.5 | mA |
| Grid No.2 | 0.32 | 10 | 0.4 | 10 | 0.36 | 9 | mA |
| Grid No.1 | 0 | 2x1.1 | 0 | 2x1.5 | 0 | 2x1.2 | mA |
| *Power* | | | | | | | |
| Anode input | 2x1.3 | 2x14.6 | 2x0.71 | 2x9 | 2x1.8 | 2x20.1 | W |
| Anode dissipation | 2x1.3 | 2x5.6 | 2x0.71 | 2x4.5 | 2x1.8 | 2x6 | W |
| Grid No.2 Dissipation | 0.06 | 2 | 0.07 | 1.75 | 0.07 | 1.8 | W |
| *Output* | 0 | 18 | 0 | 9 | 0 | 28.2 | W |
| *Efficiency* | | 61.5 | | 50 | | 70 | % |
| *Total Distortion* | | 5 | | 5 | | 5 | % |

TABLE 6

## PUSH-PULL R.F. CLASS C F.M. TELEPHONY I.C.A.S.

| LIMITING VALUES (absolute limits) | QQE 02/5 | QQE 03/12 | QQE 03/20 | QQE 06/40 | | QQC 04/15 | | |
|---|---|---|---|---|---|---|---|---|
| *Frequency* | 500 | 200 | I.C.A.S. limiting values are identical to C.C.S. conditions. | 250 | 500 | 186 | 300 | Mc/s |
| *Anode* | | | | | | | | |
| Voltage | 250 | 300 | | 750 | 600 | 600 | 450 | V |
| Input power | 2x7 | 2x15 | | 2x75 | 2x60 | 2x24 | 2x12 | W |
| Dissipation | 2x3.75 | 2x7 | | 2x22.5 | | 2x8 | | W |
| Current | 2x50 | 2x55 | | 2x120 | | 2x40 | | mA |
| *Grid No.2* | | | | | | | | |
| Voltage | 200 | 200 | | 300 | | 250 | | V |
| Dissipation | 3.5 | 2 | | 8 | | 7 | | W |
| *Grid No.1* | | | | | | | | |
| Voltage | -50 | -150 | | -175 | | -200 | | V |
| Current | 2x4 | 2x4 | | 2x5 | | 2x5 | | mA |
| *Cathode* | | | | | | | | |
| Current | - | 2x65 | | - | | - | | mA |
| Cathode-to-heater voltage | 100 | 100 | | 100 | | - | | V |
| *Grid No.1-to-cathode resistance* | | | | 50 | | | | kΩ |

| OPERATING CONDITIONS | QQE 02/5 | QQE 03/12 | | QQE 03/20 | QQE 06/40 | QQC 04/15 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Frequency* | *500* | *200* | | I.C.A.S. operating conditions are identical to C.C.S. conditions. | *250* | *60* | | *186* | | Mc/s |
| *Voltages* | | | | | | | | | | |
| Anode | 200 | 300 | 200 | | 750 | 600 | 250 | 600 | 250 | V |
| Grid No.2 | 200 | 200 | - | | 250 | 200 | 175 | 200 | 175 | V |
| Grid No.1 | -20 | -45 | - | | -80 | -80 | -70 | -80 | -70 | V |
| *Resistors* | | | | | | | | | | |
| Grid No.2 | - | - | 8.2 | | - | - | | - | | kΩ |
| Grid No.1 | 2x27 | - | 15 | | - | - | | - | | kΩ |
| *Currents* | | | | | | | | | | |
| Anode | 2x31 | 2x50 | 2x42 | | 2x90 | 2x40 | 2x40 | 2x40 | 2x40 | mA |
| Grid No.2 | 14 | 3.0 | 3.1 | | 14 | 5.5 | 7.5 | 4.5 | 7.5 | mA |
| Grid No.1 | 2x0.75 | 2x1.5 | 3 | | 2x1.7 | 2x1.2 | 2x2.5 | 2x1.3 | 2x2.0 | mA |
| *Peak grid-to-grid drive* | 50 | 130 | 130 | | 260 | 220 | 230 | 220 | 230 | V |
| *Power* | | | | | | | | | | |
| Input grid No.1 | 1.2 | 2x0.1 | 0.18 | | - | 2x0.12 | 2x0.26 | 2x0.13 | 2x0.26 | W |
| Grid No.2 | 2.8 | 0.6 | 0.55 | | 3.5 | 1.1 | 1.3 | 0.9 | 1.3 | W |
| Anode input | 2x6.2 | 2x15 | 2x8.4 | | 2x67.5 | 2x24 | 2x10 | 2x24 | 2x10 | W |
| Anode dissipation | 2x2.6 | 2x6 | 2x3.4 | | 2x19.5 | 2x6.5 | 2x3.0 | 2x7.2 | 2x3.4 | W |
| *Output* | *7.2* | *18.5* | *10* | | *96* | *35* | *14* | *33.6* | *13.2* | W |
| *Efficiency* | 58 | 62 | 60 | | 71 | 73 | 70 | 70 | 66 | % |
| *Useful power in load* | 6 | 16 | 9 | | - | - | - | - | - | W |

# PUSH-PULL R.F. CLASS C FREQUENCY TREBLER I.C.A.S.

TABLE 7

| LIMITING VALUES (absolute limits) | QQE 02/5 | QQE 03/12 | | QQE 03/20 QQE 06/40 | QQC 04/15 | | UNIT |
|---|---|---|---|---|---|---|---|
| *Frequency* | 500 | 200 | | I.C.A.S. conditions are identical to C.C.S. conditions. | 186 | 300 | Mc/s |
| *Anode* | | | | | | | |
| Voltage | 250 | 300 | | | 600 | 450 | V |
| Input power | 2x5 | 2x10 | | | 2x16 | 2x12 | W |
| Dissipation | 2x3.75 | 2x7 | | | 2x8 | | W |
| Current | 2x40 | 2x42 | | | 2x40 | | mA |
| *Grid No.2* | | | | | | | |
| Voltage | 200 | 200 | | | 250 | | V |
| Dissipation | 3.5 | 2 | | | 7 | | W |
| *Grid No.1* | | | | | | | |
| Voltage | -100 | -150 | | | -200 | | V |
| Current | 2x4 | 2x3 | | | 2x5 | | mA |
| *Cathode* | | | | | | | |
| Current | - | 2x45 | | | | | mA |
| Cathode-to-heater voltage | 100 | 100 | | | | | V |
| OPERATING CONDITIONS | | | | | | | |
| *Frequency* | *166.6/500* | *67/200* | | I.C.A.S. conditions are identical to C.C.S. conditions. | *62/186* | | Mc/s |
| *Voltages* | | | | | | | |
| Anode | 200 | 300 | 200 | | 400 | 250 | V |
| Grid No.2 | 200 | 150 | 175 | | 200 | 200 | V |
| Grid No.1 | - | -100 | - | | -175 | -175 | V |
| *Resistors* | | | | | | | |
| Grid No.2(dropping) | 1.2 | - | 4.7 | | - | - | kΩ |
| Grid No.1(bias) | 2x82 | - | 22 | | - | - | kΩ |
| *Currents* | | | | | | | |
| Anode | 2x22.5 | 2x32.5 | 2x39 | | 2x32.5 | 2x40 | mA |
| Grid No.2 | 11 | 3.5 | 5.2 | | 4 | 6.5 | mA |
| Grid No.1 | 2x0.9 | 2x1.9 | 2x2.3 | | 2x1.1 | 2x1.5 | mA |
| *Peak grid-to-grid drive* | *165* | *240* | *230* | | *430* | *430* | V |
| *Power* | | | | | | | |
| Input grid No.1 | 1.1 | 0.45 | 0.52 | | 0.44 | 0.6 | W |
| Grid No.2 | 2.05 | 0.53 | 0.91 | | 0.8 | 1.3 | W |
| Anode input | 2x4.5 | 2x9.7 | 2x7.8 | | 2x13 | 2x10 | W |
| Anode dissipation | 2x3.05 | 2x5.8 | 2x5.55 | | 2x8 | 2x6.9 | W |
| *Output* | 2.95 | 7.8 | 4.5 | | 10 | 6.2 | W |
| *Efficiency* | 33 | 40 | 29 | | 38.5 | 31 | % |

PUSH-PULL R.F. CLASS C, ANODE AND SCREEN-GRID MODULATION I.C.A.S.

TABLE 8

| LIMITING VALUES (absolute limits) | QQE 02/5 | QQE 03/12 | QQE 03/20 | QQE 06/40 | | QQE 04/15 | | UNIT |
|---|---|---|---|---|---|---|---|---|
| *Frequency* | 500 | 200 | I.C.A.S. conditions are identical to C.C.S. conditions. | 250 | 500 | 186 | 360 | Mc/s |
| *Anode* | | | | | | | | |
| Voltage | 200 | 240 | | 600 | 480 | 480 | 360 | V |
| Input power | 2x5 | 2x10 | | 2x50 | 2x40 | 2x15.5 | 2x7 | W |
| Dissipation | 2x2.5 | 2x4.6 | | 2x15 | | 2x5 | | W |
| Current | 2x40 | 2x46 | | 2x100 | | 2x32 | | mA |
| *Grid No.2* | | | | | | | | |
| Voltage | 200 | 200 | | 300 | | 250 | | V |
| Dissipation | 2.3 | 1.3 | | 8 | | 4.5 | | W |
| *Grid No.1* | | | | | | | | |
| Voltage | -50 | -150 | | -175 | | -200 | | V |
| Current | 2.4 | 2x4 | | 2x5 | | 2x5 | | mA |
| *Cathode* | | | | | | | | |
| Current | - | 2x52 | | - | | - | | mA |
| Cathode-to-heater voltage | 100 | 100 | | 100 | | - | | V |
| *Grid No.1-to-heater resistance* | | | | 50[3]<br>25[4] | | | | kΩ |
| OPERATING CONDITIONS | | | | | | | | |
| *Frequency* | *500* | *200* | I.C.A.S. conditions are identical to C.C.S. conditions. | *60* | *250* | *60* | *186* | Mc/s |
| *Voltages* | | | | | | | | |
| Anode | 180 | 200 | | 600 | 600 | 250 | 250 | V |
| Grid No.2 | [1] | [2] | | 250 | 250 | - | - | V |
| Grid No.1 | -20 | - | | -80 | -80 | -70 | -70 | V |
| *Resistors* | | | | | | | | |
| Grid No.2 (dropping) | 0.1[1] | 33+12[2] | | - | - | 10 | 10 | kΩ |
| Grid No.1 (bias) | 2x27 | 15 | | - | - | - | - | kΩ |
| *Currents* | | | | | | | | |
| Anode | 2x27.5 | 2x43 | | 2x83 | 2x83 | 2x26.5 | 2x26.5 | mA |
| Grid No.2 | 12.5 | 3.1 | | 16 | 16 | 9 | 9 | mA |
| Grid No.1 | 2x0.75 | 3.3 | | 2x4 | 2x1.7 | 2x1.8 | 2x1.5 | mA |
| *Peak grid-to-grid drive* | 50 | 130 | | 105 | 130 | 110 | 110 | V |
| *Power* | | | | | | | | |
| Input grid No.1 | 1.2 | 0.2 | | - | - | 2x0.18 | 2x0.15 | W |
| Grid No.2 | 2.25 | 0.54 | | 4 | 4 | 1.5 | 1.5 | W |
| Anode input | 2x5 | 2x8.6 | | 2x50 | 2x50 | 2x6.6 | 2x6.6 | W |
| Anode dissipation | 2x2.25 | 2x3.7 | | 2x10.5 | 2x14.5 | 2x2.5 | 2x2.7 | W |
| *Output* | *5.8* | *9.8* | | *79* | *71* | *8.2* | *7.8* | W |
| *Efficiency* | 58 | 57 | | 79 | 71 | 62 | 59 | % |
| *Useful power in load* | 5 | 8.8 | | | | | | W |
| *Modulation* | 100 | 100 | | 100 | 100 | 100 | 100 | % |
| Modulation power | | 8.6 | | 50 | 50 | 7 | 7 | W |
| Peak grid No.2 voltage | | | | 90 | 90 | | | V |

[1]) Connected to the anode side of the modulation transformer.

[2]) The 33 kΩ resistor is connected to the supply, the 12 kΩ resistor to the anode side of the modulation transformer. The interconnection is connected to the screen-grid.

[3]) Each system.

[4]) Per tube.

TABLE 9

## QE 05/40 SINGLE-TUBE CLASS C R.F. AMPLIFIER

| LIMITING VALUES (absolute limits) | F.M. Telephony | | Anode and screen-grid modulation | | F.M. Telephony | | Anode and screen-grid modulation | | Unit |
|---|---|---|---|---|---|---|---|---|---|
| *Frequency* | 60 | 175 | 60 | 175 | 60 | 175 | 60 | 175 | Mc/s |
| *Anode* | | | | | | | | | |
| Voltage | 600 | 320 | 480 | 285 | 750 | 400 | 600 | 320 | V |
| Input power | 67.5 | 45 | 45 | 30 | 90 | 60 | 67.5 | 45 | W |
| Dissipation | 20 | | 13.3 | | 25 | | 16.7 | | W |
| Current | 140 | | 117 | | 150 | | 125 | | mA |
| *Grid No.2* | | | | | | | | | |
| Voltage | 250 | | 250 | | 250 | | 250 | | V |
| Dissipation | 3 | | 2 | | 3 | | 2 | | W |
| *Grid No.1* | | | | | | | | | |
| Voltage | -150 | | -150 | | -150 | | -150 | | V |
| Current | 3.5 | | 3.5 | | 4 | | 4 | | mA |
| *Cathode* | | | | | | | | | |
| Cathode-to-heater voltage | 135 | | 135 | | 135 | | 135 | | V |
| Grid No.1-to--cathode resistor | 30 | | 30 | | 30 | | 30 | | kΩ |
| OPERATING CONDITIONS | | | | | | | | | |
| *Frequency* | *60* | *175* | *60* | | *60* | *175* | *60* | | Mc/s |
| *Voltages* | | | | | | | | | |
| Anode | 600 | 320 | 475 | | 750 | 400 | 600 | | V |
| Grid No.2 | 150 | 180 | 135 | | 160 | 190 | 150 | | V |
| Grid No.1 | -58 | -51 | -77 | | -62 | -54 | -87 | | V |
| *Currents* | | | | | | | | | |
| Anode | 112 | 140 | 94 | | 120 | 150 | 112 | | mA |
| Grid No.2 | 9 | 10 | 6.4 | | 11 | 10.4 | 7.8 | | mA |
| Grid No.1 | 2.8 | 2.0 | 2.8 | | 3.1 | 2.2 | 3.4 | | mA |
| *Peak grid drive* | 73 | 64 | 95 | | 79 | 68 | 107 | | V |
| *Power* | | | | | | | | | |
| Input grid No.1 | 0.2 | 3 | 0.3 | | 0.2 | 3 | 0.4 | | W |
| Grid No.2 | 1.4 | 1.8 | 1.0 | | 1.8 | 2.0 | 1.2 | | W |
| Anode input | 67.5 | 45 | 45 | | 90 | 60 | 67.5 | | W |
| Anode dissipation | 15.5 | 20 | 11 | | 20 | 25 | 15.5 | | W |
| *Output* | *52* | *25* | *34* | | *70* | *35* | *52* | | W |
| *Efficiency* | 77 | 55.5 | 75.5 | | 78 | 58 | 77 | | % |
| *Modulation* | | | 100 | | | | 100 | | % |
| Power | | | 23 | | | | 34 | | W |

# Operational Notes

*Limiting Values and Operating Conditions*

It should be noted that the Limiting Values given at the head of each Table are absolute limits. They have been given in order to enable the equipment manufacturer to provide reasonable margins to safeguard the tube against occasional fluctuations of all kinds (thereby giving the best guarantee for a satisfactory life). It is obviously in the user's own interest to keep below these limits; they should never be exceeded for fear of damaging the tube or shortening its effective life.

When operating a tube, all the limits will not necessarily be met simultaneously, but nevertheless none of the individual limits should ever be exceeded.

To give an indication of the capabilities of the tube, the Tables of Operating Conditions include some of the maxima, no reserves having been made for component tolerances and voltage variations. The equipment designer must make allowance for these tolerances and for possible excession of the nominal ratings when in normal operation, by selecting a tube type that can give the required performance at somewhat less than full ratings. Some examples of divergence from nominal are: tolerances and drift in components, variation of supply voltage; overdrive when a tube is replaced due to lack of re-adjustment in the driver output; and change of load impedance, arising for example from frequency-band switching on a common aerial.

When in some cases it is desired to depart from the published conditions, the anode voltage rather than the current should be reduced to obtain best performance, particularly at high frequencies. The output of the tube is shared between the circuit losses and the aerial power. The circuit resistance gives rise to losses of a value $P = V^2/R$, in which $R$ is the circuit resistance. It obviously pays to make the voltage $V$ as low as possible. On the other hand, the conversion efficiency of a tube decreases with the voltage, so an optimum range of anode voltage can be found for a given circuit and frequency, which is generally in the range of published operating conditions depending upon the circuit quality.

*Bulb and seal temperatures*

The maximum permissible temperature of the base pins, where they are sealed in the glass, is 120 °C for the QQE 02/5 and QQE 03/12. Both tubes can withstand a maximum bulb temperature of 225 °C. For the QQE 03/20 and the QQE 06/40 the following temperature limits apply: for the base pins at the seal 180 °C and for the bulb and the anode seals, 200 °C.

There are four major effects of heat which make it necessary to keep the operating temperatures below the prescribed limits.

(1) When the temperature of the pins is high, there is a risk of the glass cracking at the glass-to-metal seals due to slight differences in coefficients of expansion.

(2) At high temperatures the thermal gradient along the length of the pin may give rise to unequal expansion and hence to air leak.

(3) When the base glass is heated excessively and a high potential difference is applied between the pins, an electrical current flows through the glass and electrolysis may occur, which can affect the composition of the glass around one of the pins, so that a risk of air leak arises.

(4) Should the glass bulb be heated beyond 260 °C, gas may be liberated in sufficient quantity to spoil the emissivity of the cathode by cathode poisoning.

Therefore the equipment designer should consider his proposed loading level for the tube, the heat dissipation of nearby components, and the heat transfer properties of the complete equipment. Temperature measurements should be carried out with the tube operating in the completely assembled transmitter with all the shields and covers in place, delivering maximum output under the highest possible ambient temperature conditions and during the longest duty cycle for which the equipment is designed.

The actual temperature of the glass close to the pins and on the bulb can be conveniently measured by means of temperature-sensitive lacquers, such as "Tempilac"*), which change appearance at specific temperatures. It is important, when using such lacquers, to shake long and vigorously before application, to ensure that the sediment clays and pigments are all taken up into the suspension. The makers point out that it is also important not to contaminate the contents of one bottle with that of another through using the same brush.

The method of measuring the temperatures by means of temperature-sensitive pencils is, in general, not recommended because the change in colour is also a function of time.

With the noval tubes, cooling is usually obtained by radiation and convection. The use of closed screening cans is not allowed. With the QQE 03/20 and the QQE 06/40, natural cooling is sufficient at the voltage and frequencies shown in the Table below.

TABLE 10

| QQE 03/20 | QQE 06/40 |
|---|---|
| 600 V at *f* = 150 Mc/s | 750 V at *f* = 100 Mc/s |
| 500 V at *f* = 200 Mc/s | 600 V at *f* = 150 Mc/s |
| 300 V at *f* = 430 Mc/s | 300 V at *f* = 430 Mc/s |

Above these limits it may be necessary to direct a flow of air (up to 150 l/min) on the top of the bulb, to keep the seal and bulb temperature within the permitted limits.

If forced-air cooling cannot be applied for such reasons as cost or space, then, perhaps, the operating conditions of the tube must be set lower. A flow of cool air must always be allowed to reach both the top and the base of the tube, and suitable apertures must

*) Made by the Tempil Corporation, 11 W 25th street, New-York 10, N.Y.

be provided in the transmitter enclosure to assist natural convection or forced draught.

Cooling of the base pins and also of the anode pins of the larger tubes is promoted by the connectors in the tube socket and the anode connectors. For the latter, type 40623 is recommended. Connecting leads with a large surface (metal strip or tube) soldered to the base connectors in the tube socket are to be preferred to insulated copper wire, both from a point of view of cooling and of R.F. losses.

*Grid dissipation*

The grids consist of fine wire and do not have such large safety factors as the anodes. So the input power to these electrodes must be kept well under control. The screen-grid current is very sensitive to anode loading, and a low anode current can result in an excessive screen-grid current. A screen-grid current meter is thus essential during adjustment of an experimental circuit, and reduction of anode and/or screen-grid voltages is recommended.

When the screen grid is fed from a separate supply, switching arrangements must ensure that the anode voltage is applied first, otherwise the screen grid will draw excessive current and become overheated. When the same supply source is used for the anodes and screen grid, either alternative method may be used: feeding via a series resistor or a voltage divider. For optimum performance,

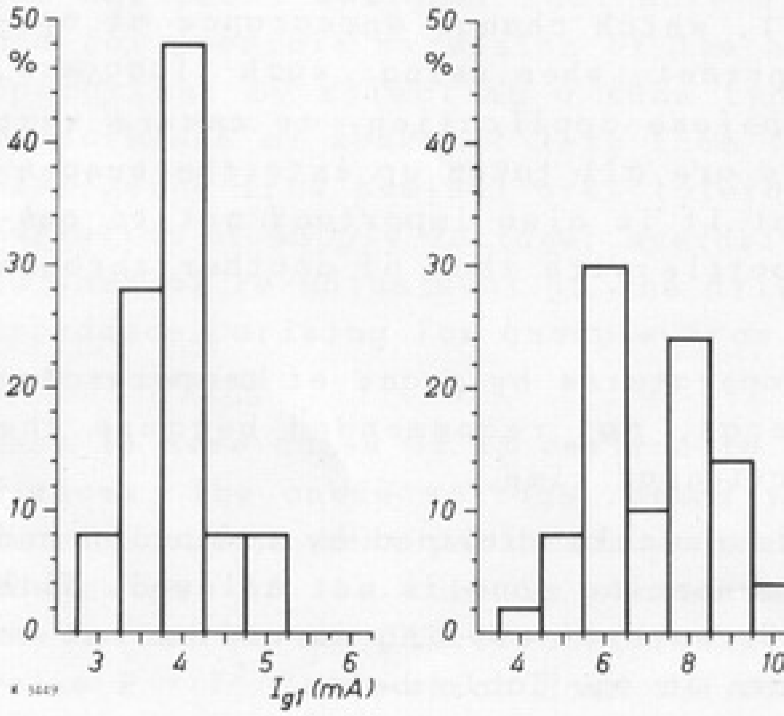



Fig.1. Graphs showing the spread in grid current ($I_{g1}$) and in screen-grid current ($I_{g2}$) measured on a batch of QQE 03/20 double tetrodes at a frequency of 150 Mc/s. The tubes were adjusted to an anode voltage of 500 V, a screen-grid voltage of 200 V and a grid bias of -60 V. The anode current was 100 mA. The currents measured are plotted horizontally, the percentage of tubes showing that current vertically.

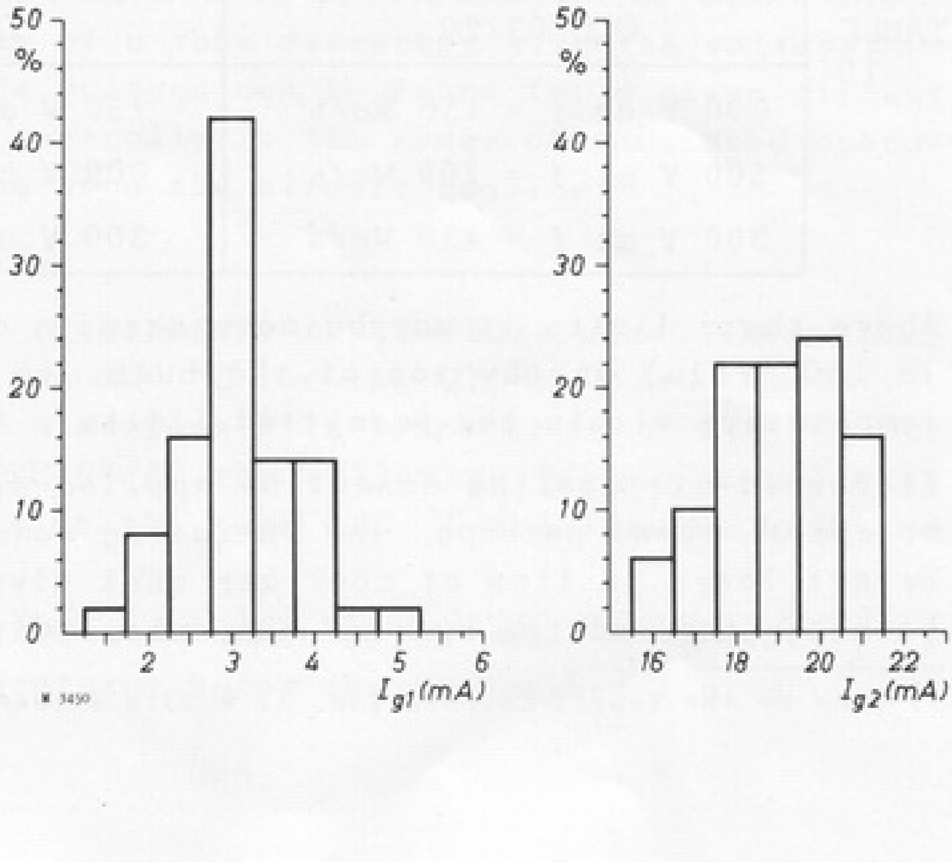



Fig. 2. As Fig. 1, but measured on a batch of QQE 06/40 double tetrodes, at an anode voltage of 400 V, screen-grid voltage of 250 V and a grid bias of -60 V. The anode current was 200 mA.

however, fixed voltage conditions are preferred because of the reduced tolerances.

With a series resistor any change of screen-grid current results of course in a change of screen-grid voltage. To maintain the output performance of the tube, the control-grid conditions should be modified to match the new screen-grid voltage. These variations are easily noticed when adjustments are being made, but it is not generally realised that a similar effect occurs when tubes are replaced in a pre-set transmitter. There is, unfortunately, a certain spread in the control-grid characteristics, which cannot be avoided except at prohibitive cost. To a smaller extent this also applies to screen-grid currents (see Figs 1 and 2). When series resistors are employed the electrode voltages are apt to be different from tube to tube, resulting in under-drive and low power output in one case and over-drive and excessive anode and screen-grid currents in the other.

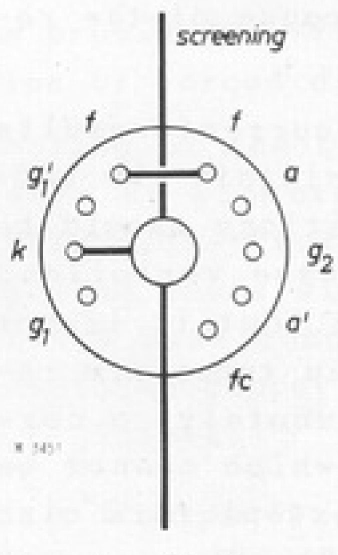
Optimum performance of the tube can be obtained by making the screen- and control-grid resistors adjustable, as far as the driver and/or output stage is concerned. Another measure is to insert an adjustable cathode resistor. Fixed resistors may be fitted when the lower standard of performance can be accepted.

At the higher frequencies the increased resistance of the control grid causes additional heating which, for long life, should be kept to a minimum by ensuring that the R.F. drive is not higher than is sufficient for the intended function. It is easy to go wrong in this respect when using grid leak biasing, because the drive may be set higher and higher with little increase in anode current, due to the automatic bias which is directly derived from the driving voltage. The R.F. component of the grid input power, however, will have increased with the square of the R.F. voltage, and might have become excessive.

The value of the grid bias is given by the product of the direct grid current and the resistance in the grid circuit. The resistance should be as low as possible and the resultant grid bias should never need to exceed the value given in the "Typical Operating Conditions". It has already been stated that the grid currents vary a little from tube to tube. It is therefore impractical to drive always to one stated value of $I_{g1}$. Adequate drive is better indicated by the ratio of $I_{g2}$ to $I_a$ given in the published operating conditions. The final criterion should be the maximum anode efficiency for the lowest screen-grid current. Serious overdrive is certainly present when the rate of change of the screen-grid current increases rapidly with the drive.

*Screening*

For stable operation the input circuits of the tube must be screened from the output circuits. For the QQE 03/20 and the QQE 06/40 this can easily be done by mounting the tube socket about 18 mm below a 52 mm hole in the chassis, so that, when the tube is inserted in the socket, the internal screening disc will be in the same plane as the chassis, forming a virtual continuation of the latter. When the tube is horizontally mounted in closed compartments, the tube may be mounted in the same way on the partition screen between one compartment and the other.




With the QQE 02/5 and the QQE 03/12, which are single-ended tubes, screening is obtained by connecting the screen across the tube socket where it is soldered to the central spigot as shown in Fig.3.

Fig.3. Screening across the tube socket of QQE 02/5 and QQE 03/12 double tetrodes when the tube is used as R.F. amplifier.

It should be noted that usually screening from input and output circuits is only required when the tube is operated as an R.F. amplifier. For frequency trebler operation screening is as a rule not found to be necessary.

*Asymmetry*

For stability of an R.F. push-pull amplifier it is necessary that R.F. currents, flowing in any part of the circuit that is common to the grid and the anode circuits, are low. This requires good balance so that nominal centre-points of circuits are indeed practically at zero potential difference. In practice, the ideal condition of absolute balance is not easily met, and a slight harmless asymmetry will usually be present with double tubes. There are external and internal causes for asymmetry. The former can be prevented by very careful and symmetric circuit lay-out. Causes of internal asymmetry are: slight differences in the capacitances of the electrode system, in internal inductances, in the transit times and in the characteristics.

As a rule class C adjustment is not very critical as to asymmetry in characteristics, in contrast to class B operation. In the latter case individual adjustment of the grid bias is recommended if distortion has to be kept low.

Extensive tests have been carried out on an experimental transmitter with QQE 03/12 tubes, which revealed that much can be done by simple measures in the circuit to reduce the influence of the effects of asymmetry. The measures are fundamental, so that they apply also to other types of double tetrode. They are described below.

*(a) Centre tapping on the anode coil*

When the anode circuit is perfectly symmetrical, it makes no difference whether the anode supply is connected directly to the tapping of the coil or via a bypassed choke, the centre being at zero potential. However, when some asymmetry occurs - which usually will be the case - and the centre tapping of the anode coil is bypassed, part of the R.F. power will flow to earth via the capacitor and be lost. Therefore the anode circuit should be fed via a choke that is not bypassed. It is advisable to wind the anode supply choke or resistance wire, or to connect a 47 Ω or a 100 Ω resistor in parallel with a copper-wire choke, to prevent parasitic oscillations.

When transmission line circuits are mounted near the chassis, the two tube sections and the two anode lines sometimes operate in parallel with respect to chassis, to form an unbalanced circuit at some undesired frequency. Such a tendency can be effectively smothered by connecting the mid-point of the twin line to chassis via a series connection of a 47 Ω resistor and a 200 pF capacitor.

*(b) Bypassing of the screen grid*

If the anode circuit is fed correctly as described under (*a*), it is immaterial whether the screen grid is bypassed or not. Some designers are inclined to feed the screen grid via a choke and to

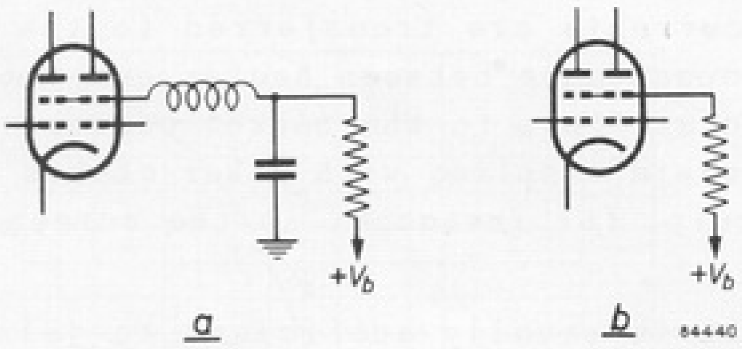



Fig.4. The screen grid is sometimes fed via a bypassed dropping resistor and a series choke (*a*) which gives occasionally satisfactory results but may give rise to instability. As a rule the circuit of (*b*) with unbypassed dropping resistor gives the best stability.

obtain the required voltage from a bypassed resistor, as shown in Fig.4. This circuit gives occasionally satisfactory results, but may give rise to parasitic oscillations. As a rule the best results are obtained with an unbypassed dropping resistor.

*(c) Grid circuit*

One of the aspects of asymmetry is some difference in control-grid capacitance of the tube sections, because this may lead to unequal driving voltages. Experiments reveal that this form of asymmetry is practically annihilated when the centre tapping of the grid

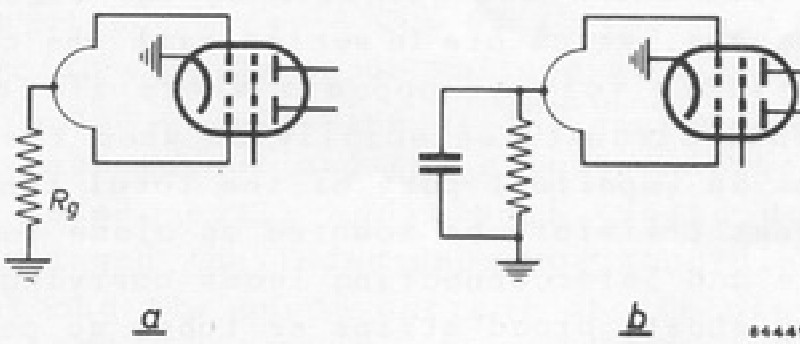



Fig.5. From a point of view of balancing the input capacitances of the double tetrode the circuit of (*b*) with a bypassed grid leak is to be preferred to that of (*a*) in which a single unbypassed grid leak is used.

coil or transmission lines is capacitively connected to earth (see Fig.5). In this case a single grid leak may be used for the two grids. With this circuit the driving voltages in the coil-halves become substantially equal and independent of the input capacitance of each tube section, provided the coupling to the input stage is tight, and the circuit lay-out symmetrical.

*(d) Cathode connections*

Coils in the cathode circuit, bypassed or not, may give rise to parasitic oscillations and affect the stability.

Experience has shown that it is advisable to make the cathode contacts the earthed points in the circuits. Such a common-cathode contact should be tied directly to the chassis by a strip of copper foil, about ½ cm wide and as short in length as possible, e.g. 1 cm. When cathode bias is used this strip is replaced by a bypass capacitor of low selfinductance and which must have very short connecting strips.

*(e) Heater connections*

For operation above 300 Mc/s the heaters should be fed via chokes, otherwise R.F. currents are transferred to the heaters via the interelectrode capacitance between heater and cathode. The chokes should be mounted as close to the socket contacts as possible and placed so as to avoid coupling with other chokes that may be present in the circuit, for instance, in the screen grid or cathode leads.

Below 300 Mc/s it is usually sufficient to join one heater pin direct to the cathode R.F. return connection and to decouple the other to the cathode by means of a small 500 pF ceramic capacitor, the connection wires of which being cut to the shortest possible length.

It should be noted that the recommended measures mentioned under (*a*) to (*d*) apply in general to a frequency of 200 Mc/s. At higher frequencies the use of chokes, for example, cannot always be avoided for obtaining sufficient power gain. Moreover, grid leaks must often be connected close to the tube sockets so that a common bypassed grid leak cannot be used.

## R.F. CIRCUIT DESIGN

To obtain satisfactory performance in the V.H.F. and the U.H.F. regions, careful attention should be given to the design and layout of the circuits.

The connections from the tuned circuits to the tube can have considerable inductances, which are in series with the circuits. Hence not all the available voltage appears where it is wanted, viz. across the external circuit, especially so when the internal tube capacitance forms an important part of the total tuning capacitance. Components must therefore be mounted as close to the tube terminals as possible and interconnecting leads carrying R.F. currents must be formed by short, broad strips or tubes so positioned as to have the minimum parasitic capacitance. These connectors and the circuits should preferably by plated with silver or gold to reduce their R.F. resistance.

Another condition for maximum efficiency is that the capacitance-in-circuit should be as low as possible. The interelectrode capacitances of the double tetrodes have been kept to a minimum, but even so, for frequencies above 150 Mc/s, it is preferable that no extra circuit capacitance should be added. Variable inductance tuning is therefore recommended. For fixed-frequency operation, provided the inductance is exactly designed, a small amount of trimming capacitance can be useful for taking up differences between tubes and load reactances. The essential feature of the trimmer is a low capacitance at minimum setting, 1 pF or even less. Since 10 pF at 200 Mc/s is a resistance of only 80 Ω, with low circuit reactances and normal "loaded quality factors" the impedance in series with the tube can become comparable with or even lower than that of the tube itself, so that only a small proportion of the voltage appears across the external circuit, and the overall efficiency becomes very low.

For example, when endeavouring to tune over the range from 200 Mc/s to 400 Mc/s with a capacitor of 3 pF to 150 pF and a fixed inductance, less power may be obtained at 200 Mc/s than at 400 Mc/s.

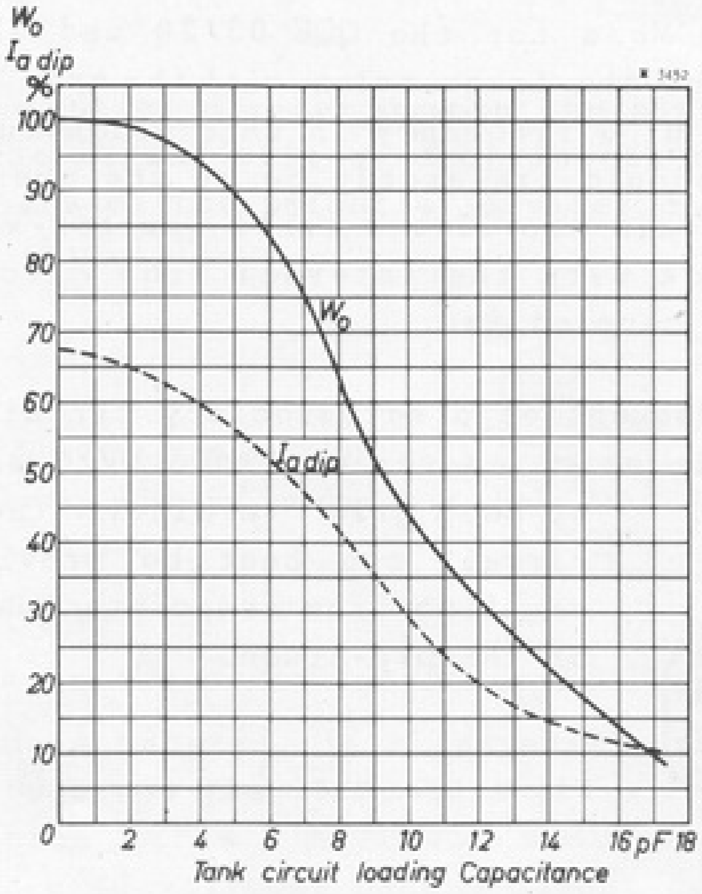



Fig.6. Graph showing the output power ($W_0$) and the anode current dip ($I_{adip}$) plotted as a percentage against the tank circuit loading capacitance.

Fig.6 demonstrates the effect of variations in the *L/C* ratio on the power conversion at 200 Mc/s. A QQE 03/20 was used as an R.F. amplifier at 200 Mc/s, with an anode voltage of 500 V, a screen-grid voltage of 250 V, and a grid bias of -50 V. The circuit was tuned with a variable inductance, and the output and the anode current were measured. Subsequently additional tuning capacitance was brought in circuit and the inductance was accordingly decreased. The power output and the anode current at the dip were measured again, and so on. The result is plotted in Fig.6, in which the power output ($W_0$) and the anode current at the dip ($I_{adip}$), are plotted as a percentage against the tank circuit loading capacitance. These curves illustrate clearly the superiority of variable inductance-tuning to tuning with a variable capacitor.

At U.H.F. the anode circuit almost inevitably becomes a balanced line circuit, consisting either of a pair of rods tuned by a short-circuiting bridge at the electrical $\lambda/4$ distance, or of a hairpin loop with a trimmer capacitor at the anode terminals. Since extra capacitance should be avoided, the adjustable line should give higher efficiency, provided the wiping contacts of the bridge are well de-

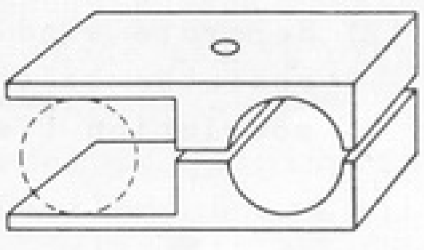


Fig.7. Sliding bridge for inductive pre-set tuning.

signed. A sketch of a suitable sliding bridge is shown in Fig.7. For spot frequency tuning, the problem of designing suitable wipers can be avoided by moving a prism-shaped dielectric or conductor in and out of the space between the lines, to vary the *L/C* ratio per unit length of line. Thus the capacitance of the tube at the high-potential end will have more or less effect on the fixed length of the line, which will thereby effectively have a variable electrical length.

The grid assemblies have natural frequencies of about 500 Mc/s for the QQE 02/5, 400 Mc/s for the QQE 03/20 and 320 Mc/s for the QQE 06/40, which are the frequencies with the grid base pins short-circuited. To work at a frequency in this neighbourhood the external grid circuit should preferably be of the open-end, half-wave type (see Fig.8). This provides a tuned quarter-wave circuit connected back to back with the internal tube circuit so that the drive power may be coupled in.

At still higher frequencies a satisfactory circuit is a loop or a silver-plated strip which is series tuned by a miniature trimmer at each grid terminal. The input to this circuit can best be provided by inductive coupling from a separate tuned anode circuit of the pre-stage.

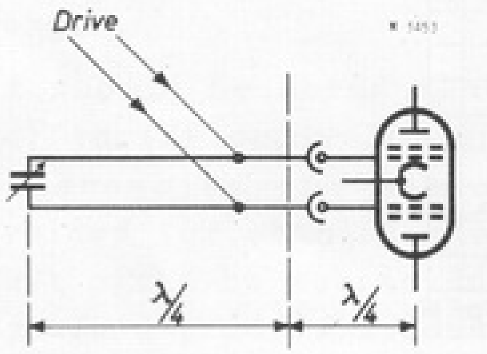



Fig.8. Open-end, half-wave grid circuit.

*Amplitude modulation of anode and screen-grid voltages in class C push-pull amplifiers*

It is possible to modulate effectively the grid bias voltage, the screen-grid voltage or the anode voltage, but for 95 % modulation with low distortion the anode and screen-grid voltages should be modulated together. For the low powers involved there seems little need to consider other methods, although for special purposes operation as a class B amplifier has been successful with a modulated drive signal.

Modulation of the anode voltage may be applied by any of the usual methods, and the screen-grid voltages can be modulated by any of the following:

(1) Series resistor from the anode d.c. supply. Since the anode current is modulated, the screen-grid current tends to vary reciprocally, with consequent modulation of the voltage obtained via the screen-grid series resistor. Complete modulation of an amplifier cannot be achieved by this method.

(2) Separate winding on the modulation transformer with series resistor to the H.T. line. The resistor must be bypassed at modulation frequencies (Fig.9).

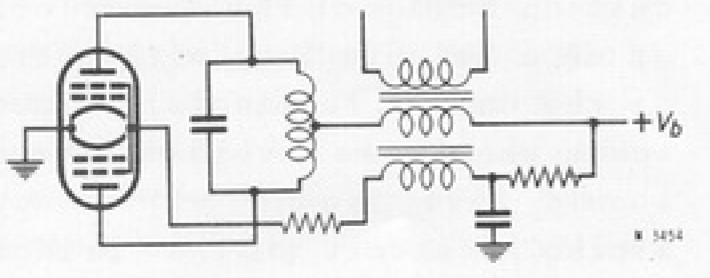



Fig.9. Circuit for anode and screen-grid modulation with separate winding on the modulation transformer and series resistor to the H.T. line.

(3) Series resistor from a tapping on the modulation transformer or choke. The resistor must be bypassed, otherwise the modulation is nullified by the changes of current through the resistor (Fig.10).

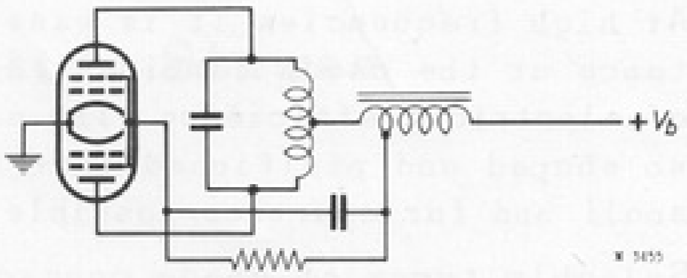



Fig.10. Anode and screen-grid modulation with tapped choke and bypassed series resistor.

(4) Resistive potential divider across the modulation transformer or choke. The direct voltage drop is controlled by the upper and lower limbs of the potential divider operating effectively in parallel (Fig.11).

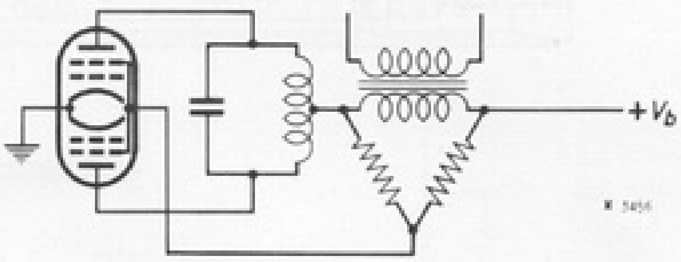



Fig.11. Anode and screen-grid modulation with potentiometer tapping across the modulation transformer.

(5) Series choke in the screen-grid supply line.

Whichever method is adopted, it is necessary to maintain adequate bias, drive voltage and power for full class C operation, in order to keep distortion below 2 % at the modulation peaks where the anode and screen-grid voltages become almost doubled. Furthermore, a grid leak must be used so that the bias adjusts itself to prevent overdrive at low modulation levels.

It has been observed that distortion, which may be as much as 3 % in a bad case, can be caused by R.F. feedback, particularly with high-$Q$ interstage circuits that are slightly detuned. Broadband circuits are therefore recommended, but the essential requirement is to avoid feedback, by using extensive screening and by decoupling the supply lines where they enter and leave the circuit compartments. It is also helpful in some cases to apply a small degree of modulation to the driver. This may conveniently by applied by interconnecting the screen grids of the amplifier and driver tubes by a suitable resistor, 100 kΩ, for example.

*Anode connectors for the QQE 03/20 and QQE 06/40*

Much care should be exercised in the choice of a suitable form of anode connector. Firstly, it should be capable of making good electrical contact in order to avoid local heating through arcing or high resistance. Apart from the risk of damage to the tube, any power dissipated in a bad contact is wasted. Secondly, the connector should make good thermal contact with the anode pin in order to conduct heat away from the glass-to-metal seal.

The equipment designer has considerable freedom in joining the anode pin connector to his circuit, but the method chosen will influence the design of the connector When a flexible lead of small gauge is to be used the connector itself should have a large surface area to cool the pin by radiation. On the other hand, when it is desired to connect the tube directly to the circuit, perhaps on account of a high operating frequency, the connector need not be so large since the circuit elements can be designed to form the necessary heat sink. However, mechanical stress must be avoided on the glass-to-metal seal to prevent fatigue and collapse.

At high frequencies it is essential to keep the residual capacitance at the anode terminals as low as possible in the interests of electrical efficiency. The anode connectors should therefore be so shaped and positioned that the areas facing each other are as small and far apart as possible.

Suitable types of anode connector are shown in Fig.12. The connector shown in Fig.12*b* - type 40623 - is designed to form an integral part of the anode tuning line, and thus avoids serious discontinuities.

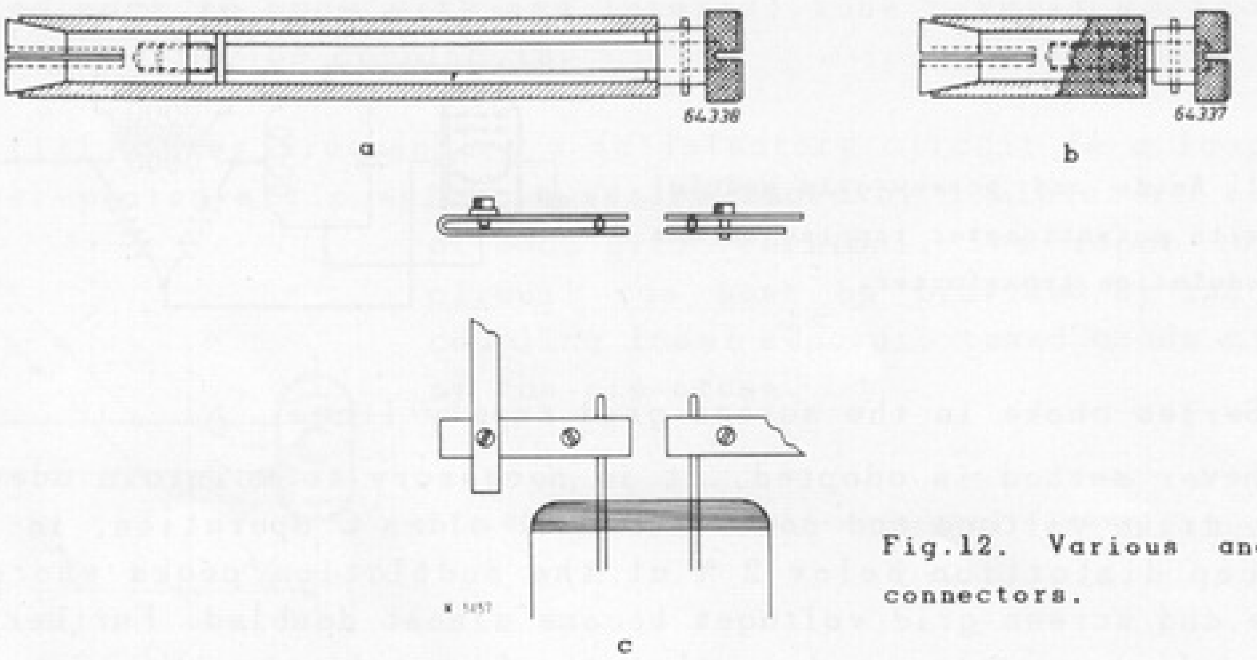



Fig.12. Various anode connectors.

*Tube sockets*

To keep the circuit losses low at high frequencies, adequate care should be paid to the tube sockets. Parallel and series losses should be distinguished. The former depend on the insulating material used, and on its form and dimensions. The input resistance of a tube operating at 500 Mc/s, for example, is fairly low, so that the parallel losses caused by the insulating material are less important than might be expected.

The series losses at high frequencies are much more serious. In the higher frequency range the use of series capacitors cannot be avoided with the eyemark to reduce the effect of the input capacitance of the tube. A current node will in such a circuit be situated in the vicinity of the contacts of the tube socket and the base pins of the tube. Under these conditions even a relatively low contact resistance between the tube socket contacts and the base pins will cause considerable loss of power.

The contacts of the tube sockets designed for high frequencies must therefore be rather heavy and of solid construction, so that contact resistance is very low. As far as the QQE 03/20 and the QQE 06/40 are concerned, the tube socket type 40202 meets all the requirements set to high-frequency operation. For the QQE 02/5, type B 8.700.19 is recommended for U.H.F. operation. The latter tube should not be used with metal retainers with a view to loss of output power. The QQE 03/12, which is not recommended for use at frequencies higher than 200 Mc/s, may be used with the 5908/36 tube socket and with the type 40647 tube retainer.

# Basic Transmitter Stages

Several of the foregoing comments are illustrated in the basic circuits of Figs 13 to 17. These show amplifier stages, some with fixed supply voltages, others with dropping resistors, for operation below 125 Mc/s and at 400 Mc/s. The points of difference are in the form of the tuned-grid and tuned-anode circuits, in the method of coupling-in the drive voltage, and in the alternative methods of deriving screen-grid and control-grid voltages.

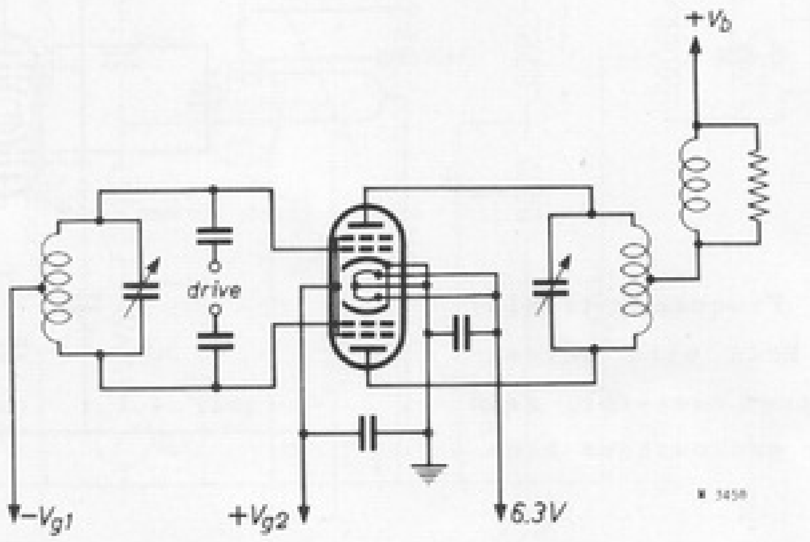



Fig.13. Basic circuit of an R.F. amplifier with a double tetrode for use below 125 Mc/s.

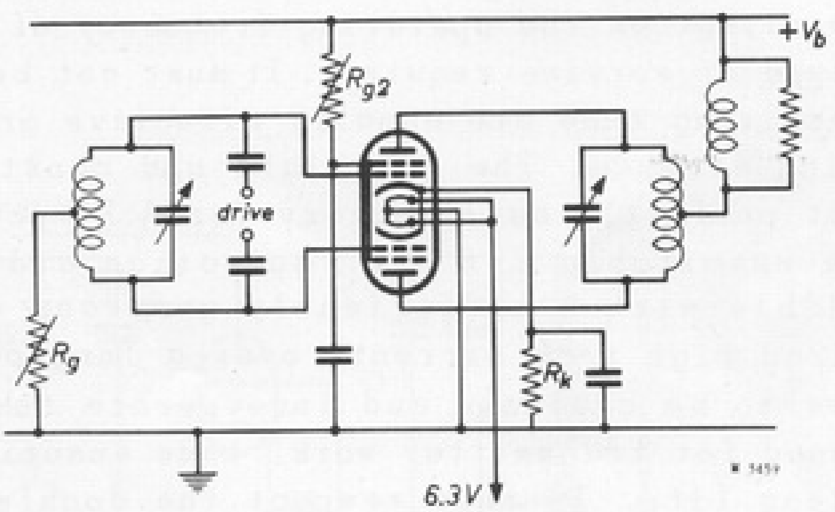



Fig.14. Basic circuit of an R.F. amplifier with screen-grid dropper resistor, grid resistor and with cathode bias for use below 125 Mc/s.

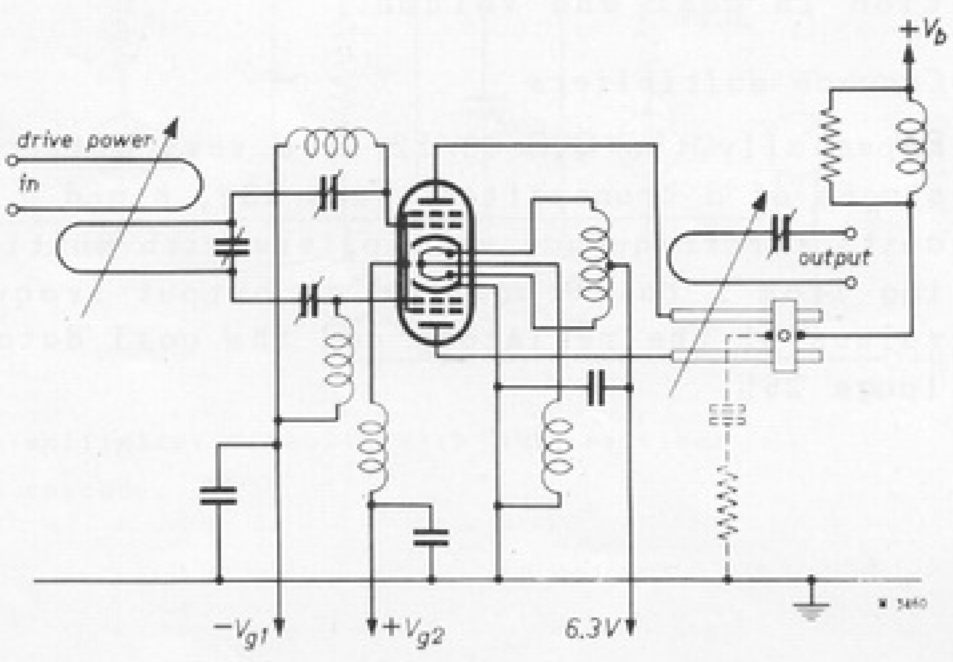



Fig.15. R.F. amplifier with fixed supply voltages for 400 Mc/s and higher.

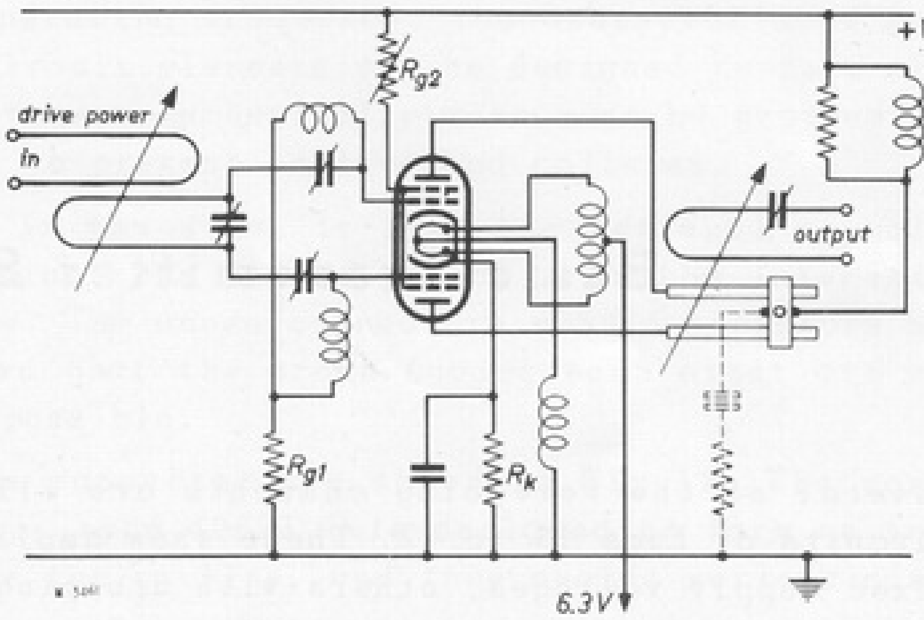



Fig.16. R.F. amplifier with screen-grid dropper resistor, grid resistor and cathode bias, for 400 Mc/s and higher.

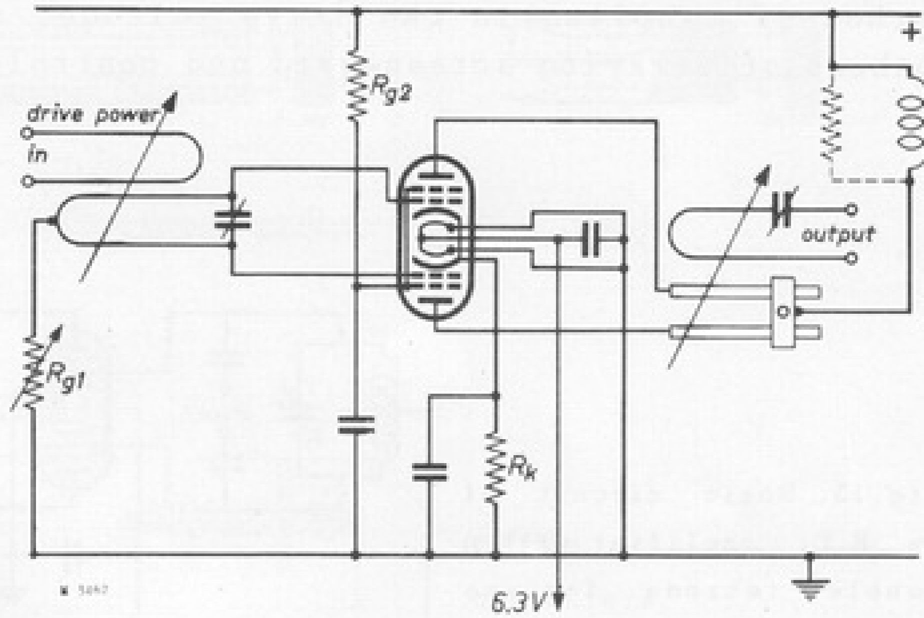



Fig.17. Frequency trebler for 400 Mc/s with screen-grid dropper resistor, grid resistor and cathode bias

The choice of tubes for frequency multiplier stages depends to a large extent on the operating frequency of the output stage and on the type of service required. It must not be assumed that all types of receiving tube are equally effective or satisfactory in transmitting service. The materials and construction of many types, whilst perfectly satisfactory for A.F. power stages, render them quite unsuitable for R.F. operation and only seldom a type is available with a sufficiently generous cathode to provide the required high peak currents over a long period of service. It is better to be cautious and incorporate tubes that are especially designed for transmitter work, thus ensuring consistent operation and long life. In this respect the double tetrodes offer a good solution by using them in cascade connection, which leads to reduction in cost and volume.

*Cascade multipliers*

Especially the QQE 03/12 is a very attractive tube in the early stages of a transmitter. Figs 18*a*, *b* and *c* give some possible circuits for frequency multipliers with multiplication factors ranging from 2 to 16 and for an output frequency of $66\frac{2}{3}$ Mc/s. The values of the resistors and the coil data are given in Table 11 (page 26).

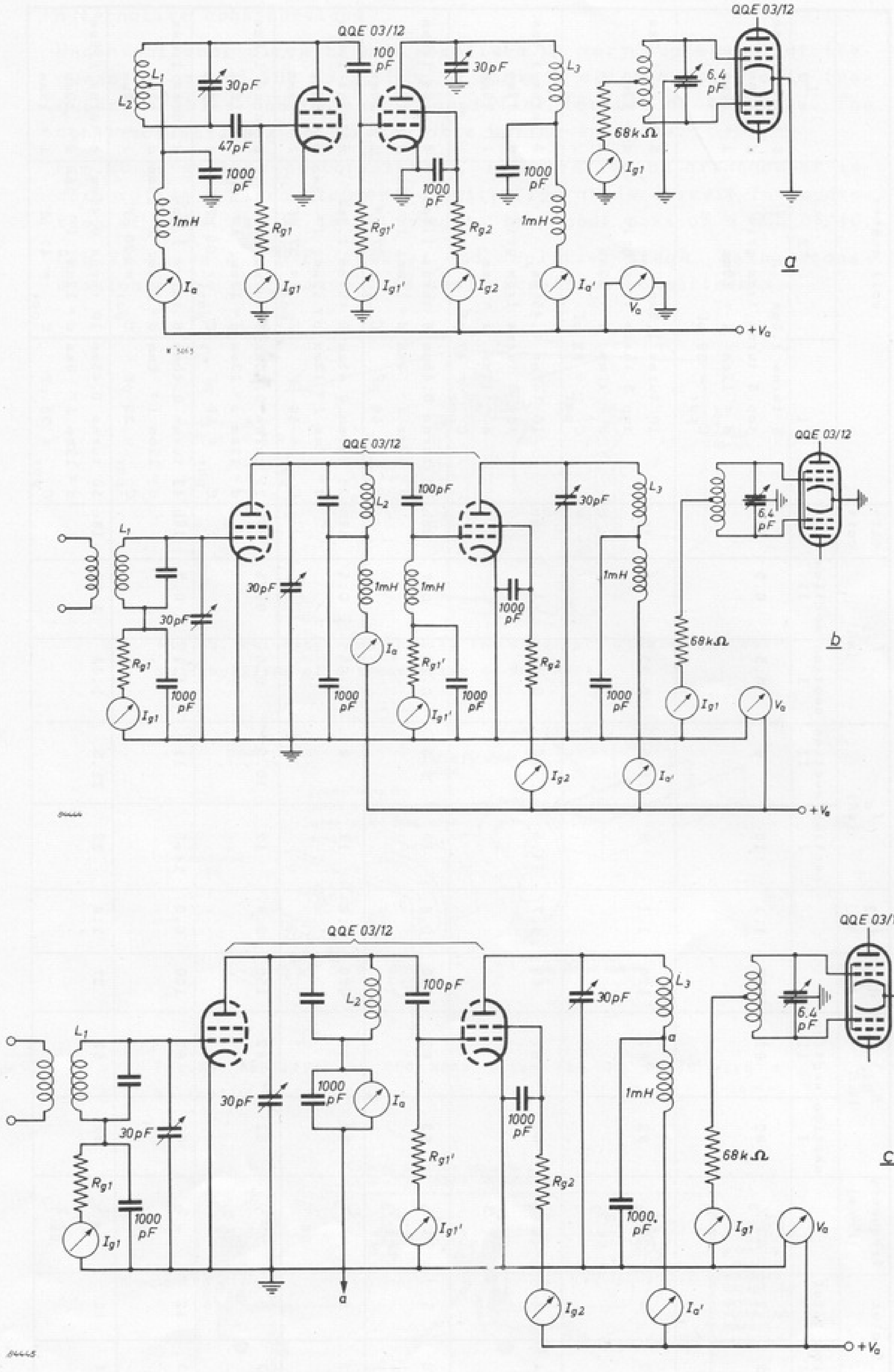



Fig.18. Frequency multiplier circuits with two sections of a QQE 03/12 in cascade.

| multiplying factor | | | frequency (Mc/s) | $R_{g1}$ (kΩ) | | $R_{g2}$ (kΩ) | $I_{g2}$ (mA) | $I_a$ (mA) | | $I_{g1}$ (mA) | | circuit | coil number | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| section I | section II | total | | section I | section II | | | section I | section II | section I | section II | fig. no. | $L_1$ | $L_2$ | $L_3$ |
| 1 oscillator | 2 | 2 | 33 1/3<br>66 2/3 | 82 | 82 | 120 | 1.1 | 10 | 9 | 0.5 | 0.9 | 18a | 8 turns 1.8mm<br>tap 3 turns from grid<br>$d$ = 12mm $l$ = 19mm<br>$C_{par}$ = 39 pF | | 8 turns 1.8mm<br>$d$ = 12mm<br>$l$ = 19mm |
| 1 oscillator | 3 | 3 | 22 2/9<br>66 2/3 | 82 | 82 | 120 | 1.1 | 9 | 10.5 | 0.33 | 1 | 18a | 10 turns 1.8mm<br>tap 3 turns from grid<br>$d$ = 12mm $l$ = 22mm<br>$C_{par}$ = 82 pF | | 8 turns 1.8mm<br>$d$ = 12mm<br>$l$ = 19mm |
| 1 oscillator | 4 | 4 | 16 2/3<br>66 2/3 | 82 | 82 | 68 | 1.7 | 11.5 | 12 | 0.45 | 1.1 | 18a | 10 turns 0.45 mm<br>tap 3 turns from grid<br>$d$ = 12mm $l$ = 5mm<br>$C_{par}$ = 47 pF | | 8 turns 1.8mm<br>$d$ = 12mm<br>$l$ = 19mm |
| 3 | 2 | 6 | 11 1/9<br>66 2/3 | 82 | 82 | 150 | 0.8 | 13 | 9.5 | 0.75 | 0.7 | 18b | 15 turns 0.45mm<br>$d$ = 12mm $l$ = 8mm<br>$C_{par}$ = 68 pF | 8 turns 1.8mm<br>$d$ = 12mm; $l$ = 19mm<br>$C_{par}$ = 27 pF | 8 turns 1.8mm<br>$d$ = 12mm<br>$l$ = 19mm |
| 4 | 2 | 8 | 8 1/3<br>66 2/3 | 82 | 82 | 220 | 0.6 | 11 | 8 | 0.85 | 0.5 | 18b | 25 turns 0.45mm<br>$d$ = 12mm $l$ = 13mm<br>$C_{par}$ = 56 pF | 8 turns 1.8mm<br>$d$ = 12mm; $l$ = 19mm<br>$C_{par}$ = 27 pF | 8 turns 1.8mm<br>$d$ = 12mm<br>$l$ = 19mm |
| 3 | 3 | 9 | 7 11/27<br>66 2/3 | 82 | 82 | 150 | 0.8 | 12 | 10.5 | 0.6 | 0.85 | 18b | 25 turns 0.45mm<br>$d$ = 12mm $l$ = 13mm<br>$C_{par}$ = 68 pF | 8 turns 1.8mm<br>$d$ = 12mm; $l$ = 19mm<br>$C_{par}$ = 100 pF | 8 turns 1.8mm<br>$d$ = 12mm<br>$l$ = 19mm |
| 4 | 3 | 12 | 5 5/9<br>66 2/3 | 82 | 82 | 120 | 0.9 | 14.5 | 11 | 1.1 | 0.7 | 18b | 42 turns 0.45mm<br>$d$ = 12mm $l$ = 8mm<br>$C_{par}$ = 33 pF | 8 turns 1.8mm<br>$d$ = 12mm; $l$ = 19mm<br>$C_{par}$ = 120 pF | 8 turns 1.8mm<br>$d$ = 12mm<br>$l$ = 19mm |
| 4 | 4 | 16 | 4 1/6<br>66 2/3 | 82 | 82 | 27 | 2.4 | 22 | 21.5 | 1.35 | 1.25 | 18c | 50 turns 0.45mm<br>$d$ = 12mm $l$ = 8mm<br>$C_{par}$ = 33 pF | 10 turns 0.45mm<br>$d$ = 12mm; $l$ = 5mm<br>$C_{par}$ = 47 pF | 8 turns 1.8mm<br>$d$ = 12mm<br>$l$ = 19mm |

*Alternative constructions*

Unconventional circuits can sometimes be very successful at frequencies around 500 Mc/s. Fig. 19 shows a cut-away view of a frequency trebler and an output amplifier for use at 490 Mc/s. The construction leads to considerable saving in space.

Fig. 20 is another pictorial view, illustrating an arrangement incorporating a fixed-frequency "butterfly" anode circuit for operation at 500 Mc/s. It is attached to the anode pins of a QQE 06/40.

Fig. 21 shows a V.H.F. trebler and amplifier stage, using transmission lines compressed into small screening compartments.

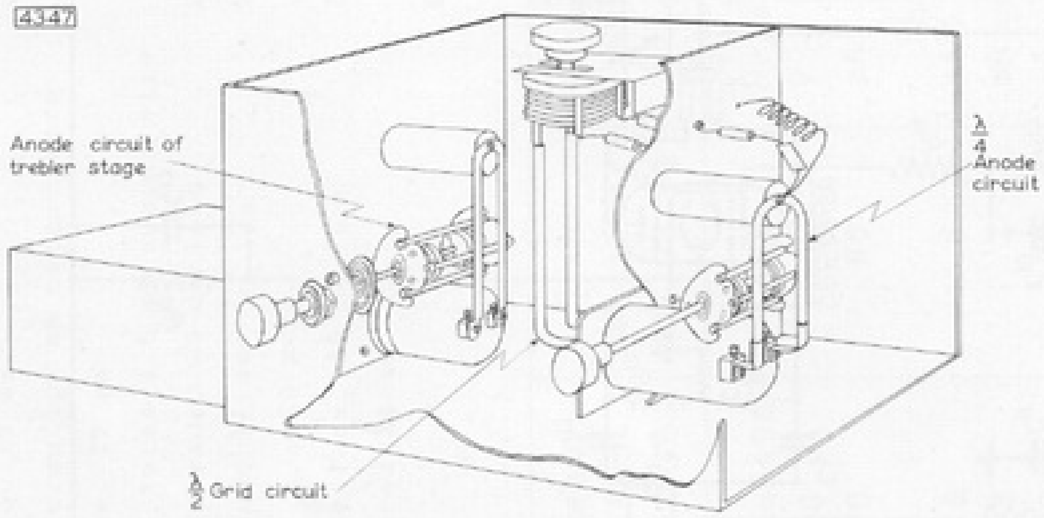



Fig. 19. Cut-away view showing the frequency trebler and output amplifier of a transmitter at 490 Mc/s.

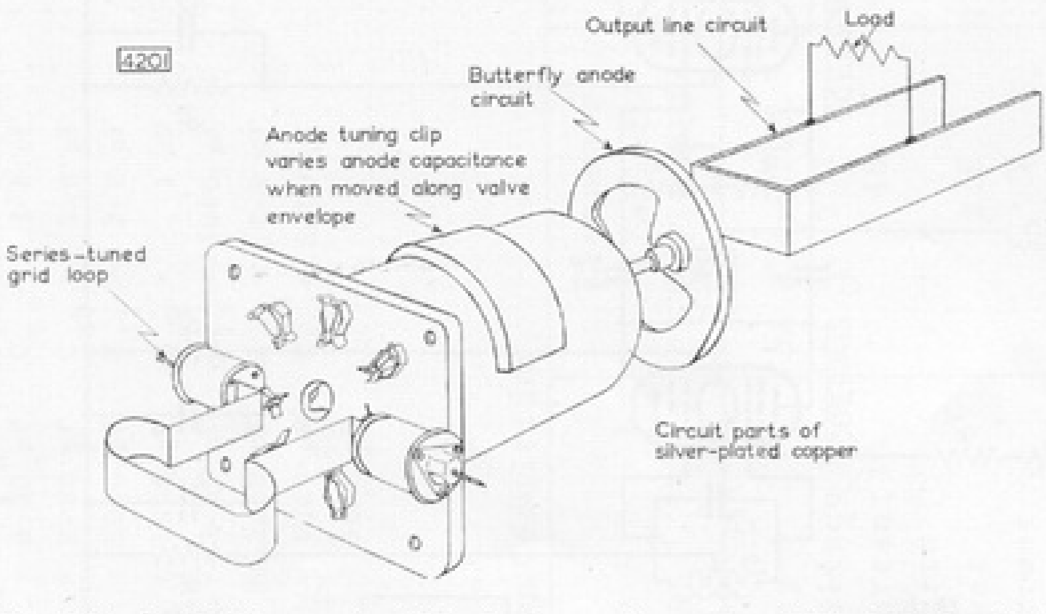



Fig. 20. Amplifier at 500 Mc/s using the QQE 06/40 with a butterfly anode circuit.

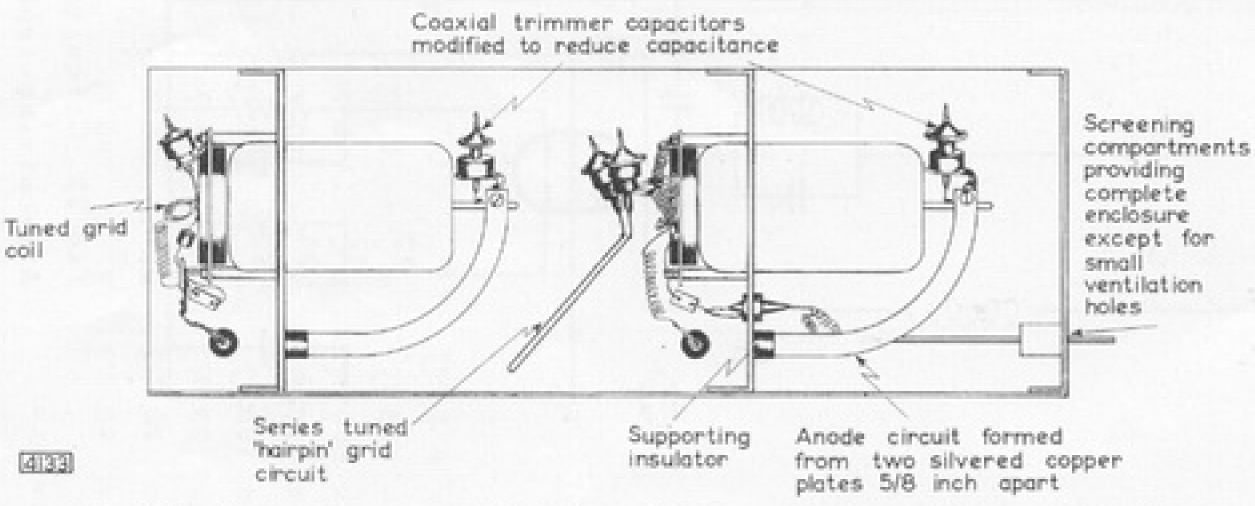



Fig. 21. Compact arrangements of transmission line circuits for frequency trebler and amplifier stages of a transmitter at 400 Mc/s.

*Transmitter circuits*

This chapter is concluded with four circuit diagrams of complete transmitters with double tetrodes of which all the important data, as far as the QQE tubes are concerned, are given in the comprehensive captions (Figs 22 to 25).

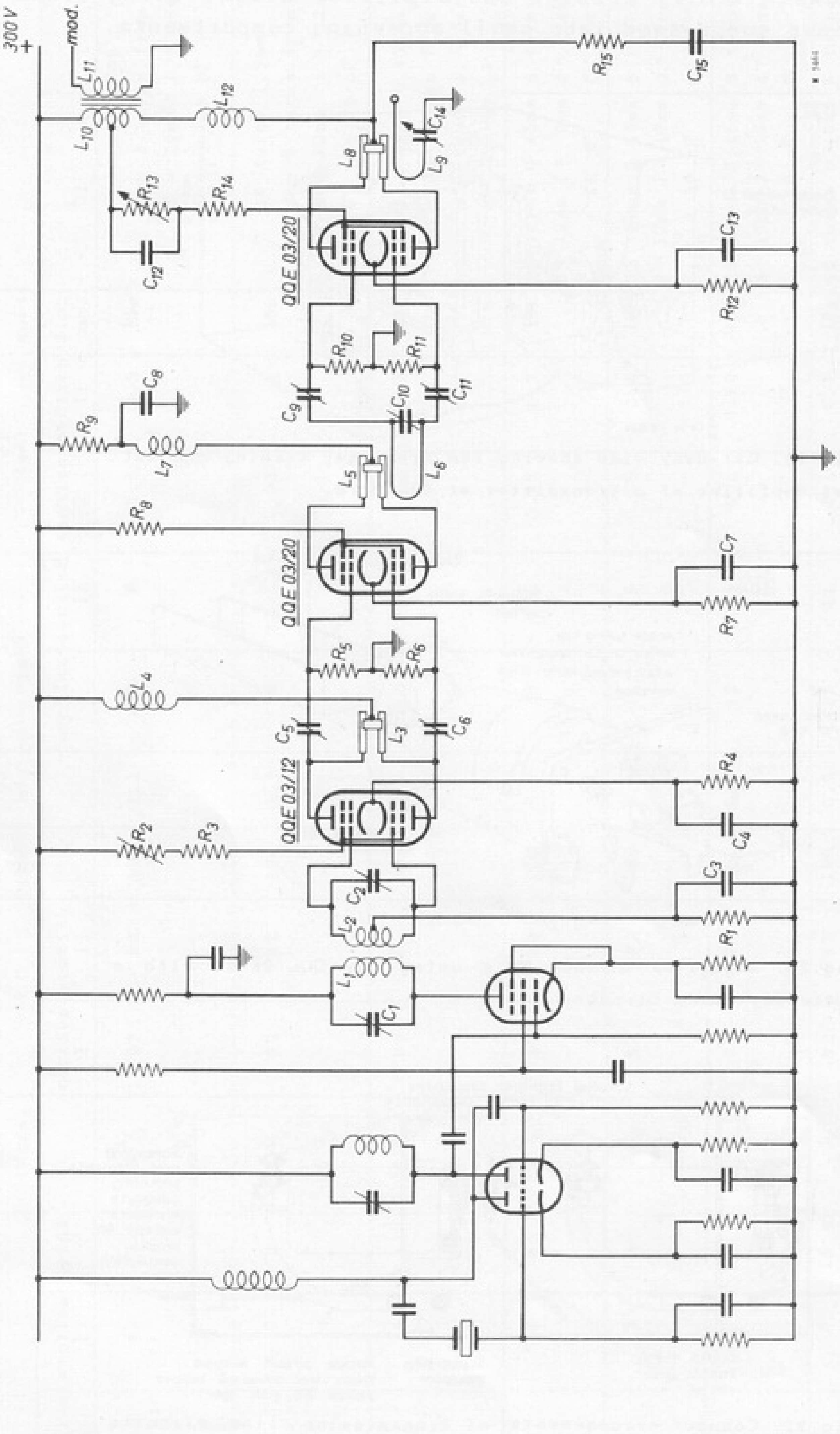



Fig.22. Circuit diagram of an A.M. transmitter operating at 490 Mc/s, with 10 W useful output. A receiving-type double triode has been used as oscillator/doubler from 13.6-27.2 Mc/s. A small power pentode operates as doubler from 27.2 to 54.4 Mc/s.
The operating conditions of the double tetrodes are given below.

## VALUES OF COMPONENTS

**Resistors**

$R_1$ = 82 kΩ
$R_2$ = 50 kΩ
$R_3$ = 33 kΩ
$R_4$ = 100 Ω
$R_5$ = 100 kΩ
$R_6$ = 100 kΩ
$R_7$ = 180 Ω
$R_8$ = 8.2 kΩ
$R_9$ = 150 Ω
$R_{10}$ = 39 kΩ
$R_{11}$ = 39 kΩ
$R_{12}$ = 100 Ω
$R_{13}$ = 10 kΩ
$R_{14}$ = 4.7 kΩ
$R_{15}$ = 47 Ω

**Capacitors**

$C_1$ = 3-30 pF
$C_2$ = 3-30 pF
$C_3$ = 5000 pF
$C_4$ = 5000 pF
$C_5$ = 3-30 pF
$C_6$ = 3-30 pF
$C_7$ = 5000 pF
$C_8$ = 5000 pF
$C_9$ = 2-8 pF
$C_{10}$ = 2-8 pF
$C_{11}$ = 2-8 pF
$C_{12}$ = 1 μF
$C_{13}$ = 5000 pF
$C_{14}$ = 2-8 pF
$C_{15}$ = 5000 pF

**Transformers**

$L_1$ diam. 19 mm
4 turns 1.6 mm copper wire
$L_2$ diam. 19 mm
2½ turns 1.6 mm copper wire
$L_3$ 8 mm rods, 20 cm long
spaced 16 mm
$L_4$ r.f.c. 160 Mc/s
$L_5$ 8 mm rods, 10 cm long
spaced 14 mm
$L_6$ Hair-pin loop of
2.5 mm wide copper
strip 9 cm long
spaced 13 mm
$L_7$ r.f.c. 500 Mc/s
$L_8$ 8 mm rods, 10 cm long
spaced 14 mm
$L_9$ hair-pin of 2 mm copper wire
9 cm long spaced: 14 mm
$L_{10}L_{11}$ modulation transformer

### Operating Conditions

| | Frequency trebler QQE 03/12 | Frequency trebler QQE 03/20 | Power amplifier QQE 03/20 | |
|---|---|---|---|---|
| Frequency | 54.4 to 163.3 | 163.3 to 490 | 490 | Mc/s |
| Anode voltage | 300 | 300 | 300 | V |
| Anode current | 48 | 90 | 80 | mA |
| Screen grid current | 2.5 | 6 | 6 | mA |
| Grid current | 2 | 3 | 2 | mA |
| Cathode current | 52.5 | 99 | 88 | mA |
| Tube output power | - | - | 13 | W |
| Output power in load | - | - | 10 | W |

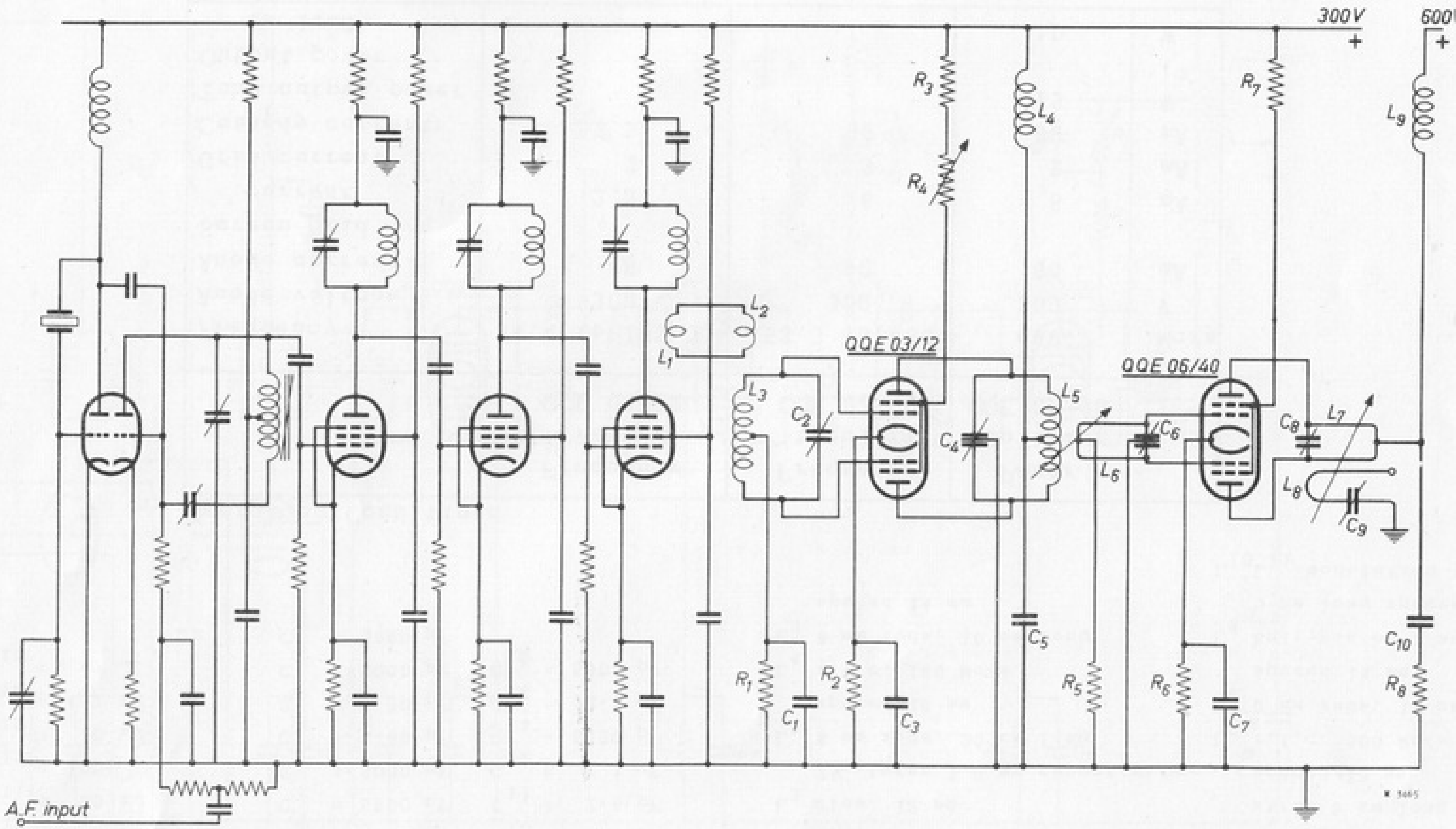



Fig.23. F.M. transmitter with QQE 06/40 power amplifier operating at 175 Mc/s with 72 W output. The early stages and the oscillator are equipped with one double triode and three receiving-type power pentodes. Frequency modulation is obtained in one section of the double triode. The pentodes are used as treblers from 3.24 Mc/s to 38.3 Mc/s. A QQE 03/12 double tetrode is also used as trebler and is link-coupled to the preceding pentode. The power stage is equipped with a QQE 06/40.

## VALUES OF COMPONENTS

**Resistors**

$R_1$ = 47 kΩ
$R_2$ = 100 Ω
$R_3$ = 47 kΩ
$R_4$ = 50 kΩ
$R_5$ = 8.2 kΩ
$R_6$ = 100 Ω
$R_7$ = 2.7 kΩ
$R_8$ = 47 Ω

**Capacitors**

$C_1$ = 5000 pF
$C_2$ = 2-8 pF
$C_3$ = 5000 pF
$C_4$ = 0-10 pF
$C_5$ = 5000 pF
$C_6$ = 1-10 pF
$C_7$ = 5000 pF
$C_8$ = 1-10 pF
$C_9$ = 2-8 pF
$C_{10}$ = 5000 pF

**Transformers**

$L_1L_2$ 1 turn loop 19 mm diameter
$L_3$ 6 turns 1.6 mm copper wire air spaced, 19 mm diameter 25.4 mm long
$L_4$ 35 turns, 0.7 mm enamelled copper wire, 6.3 mm diameter close-wound
$L_5$ 3 turns, 19 mm diameter 1.6 mm silverplated copper wire
$L_6$ hair-pin of 2 mm copper wire 51 mm long 13 mm spaced
$L_7$ hair-pin loop of 2 mm copper wire, 10 cm long spaced 13 mm
$L_8$ hair-pin loop of 3.25 mm copper wire, 20 cm long spaced 13 mm.
$L_9$ 35 turns, 0.7 mm enamelled copper wire, 6.3 m diameter close-wound

Operating Conditions

| | QQE 03/12 Frequency trebler | QQE 06/40 Power amplifier | |
|---|---|---|---|
| Frequency | 58.3 to 175 | 175 | Mc/s |
| Anode voltage | 300 | 600 | V |
| Anode current | 46 | 200 | mA |
| Screen-grid current | 2 | 19 | mA |
| Grid current | 52 | 226 | mA |
| Cathode current | 52 | 226 | mA |
| Tube output | | 90 | W |
| Useful power in load | | 72 | W |

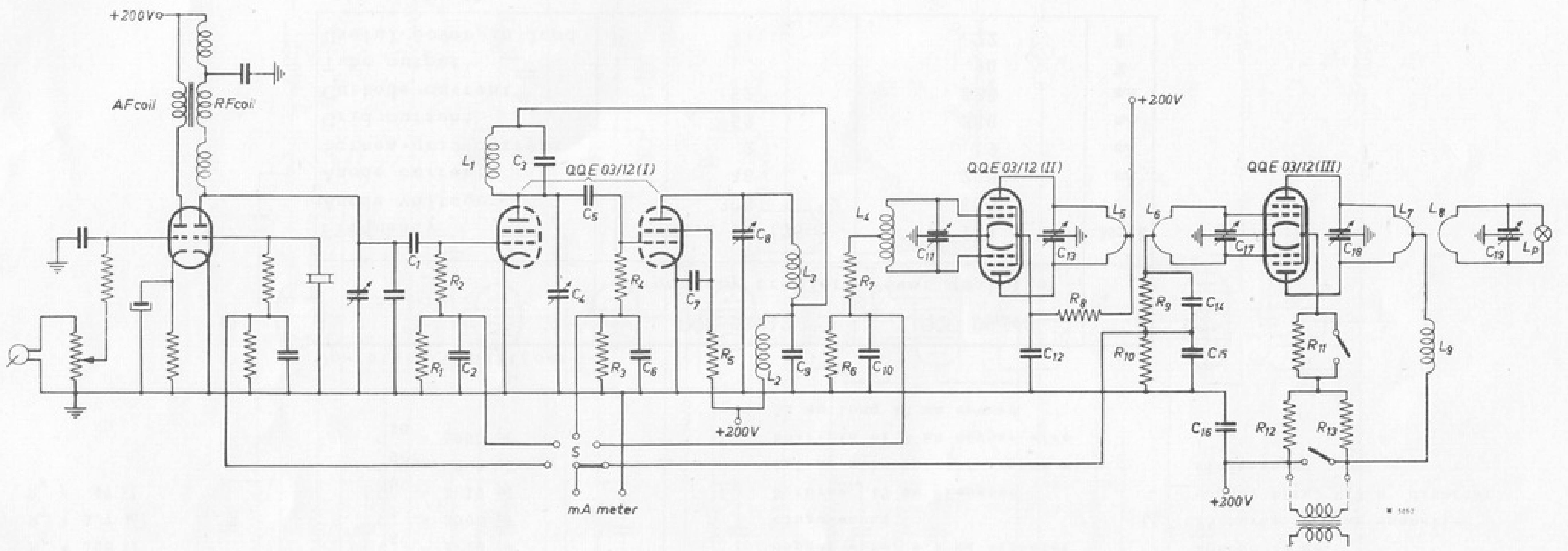



Fig. 24., AM or FM transmitter with three QQE 03/12 double tetrodes operating at 200 Mc/s with 7 W useful output power.

The oscillator/frequency modulation is equipped with a receiving type double triode, operating at 4.18 Mc/s.

The first QQE 03/12 operates as a frequency multiplier by 16, the second as a trebler and the third as a power amplifier.

# VALUES OF COMPONENTS

**Resistors**

| | | | |
|---|---|---|---|
| $R_1$ = | 1 kΩ | $R_8$ = | 68 kΩ |
| $R_2$ = | 82 kΩ | $R_9$ = | 33 kΩ |
| $R_3$ = | 1 kΩ | $R_{10}$ = | 1 kΩ |
| $R_4$ = | 82 kΩ | $R_{11}$ = | 120 kΩ |
| $R_5$ = | 27 kΩ | $R_{12}$ = | 39 kΩ |
| $R_6$ = | 1 kΩ | $R_{13}$ = | 12 kΩ |
| $R_7$ = | 68 kΩ | | |

**Capacitors**

| | | | |
|---|---|---|---|
| $C_1$ = | 150 pF | $C_{11}$ = | 6.4 pF |
| $C_2$ = | 1000 pF | $C_{12}$ = | 1000 pF |
| $C_3$ = | 47 pF | $C_{13}$ = | 6.4 pF |
| $C_4$ = | 25 pF | $C_{14}$ = | 100 pF |
| $C_5$ = | 150 pF | $C_{15}$ = | 1000 pF |
| $C_6$ = | 1000 pF | $C_{16}$ = | 1000 pF |
| $C_7$ = | 1000 pF | $C_{18}$ = | 6.4 pF |
| $C_8$ = | 25 pF | $C_{19}$ = | 6.4 pF |
| $C_9$ = | 1000 pF | | |
| $C_{10}$ = | 1000 pF | | |

**Transformers**

$L_1$ 10 turn, 0.45 mm enamelled copper wire. Diameter 12 mm, length 5 mm

$L_2$ R.F.C. 1 mH

$L_3$ 8 turns, 0.45 mm enamelled copper wire. Diameter 12 mm length 19 mm

$L_4$ 8 turns, 0.45 mm enamelled copper wire. Diameter 12 mm length 19 mm

$L_5$ hair-pin loop; 1.8 mm copper wire length 60 mm, width 18 mm

$L_6$ hair-pin loop 1.8 mm copper wire length 40 mm, width 18 mm

$L_7$ hair-pin loop; 1.8 mm copper wire; length 60 mm, width 18 mm

$L_8$ hair-pin loop; 1.8 mm copper wire; length 50 mm width 18 mm

Operating Conditions

<table>
<tr><th></th><th>QQE 03/12(I) first section</th><th>QQE 03/12(I) second section</th><th>QQE 03/12(II) trebler</th><th>QQE 03/12(III) power amplifier</th><th></th></tr>
<tr><td>Frequency</td><td>4.18-16.72</td><td>16.72-66.88</td><td>66.88-200.64</td><td>200.64</td><td>Mc/s</td></tr>
<tr><td>Anode voltage</td><td>200</td><td>200</td><td>200</td><td>200</td><td>V</td></tr>
<tr><td>Anode current</td><td>22</td><td>21.5</td><td>34</td><td>67</td><td>mA</td></tr>
<tr><td>Screen-grid current</td><td colspan="2">4</td><td>1.1</td><td>2.6</td><td>mA</td></tr>
<tr><td>Grid current</td><td>1.35</td><td>1.25</td><td>1.65</td><td>1.5</td><td>mA</td></tr>
<tr><td>Cathode current</td><td colspan="2">50.1</td><td>36.75</td><td>71.1</td><td>mA</td></tr>
<tr><td>Tube output</td><td></td><td></td><td></td><td>8</td><td>W</td></tr>
<tr><td>Useful power in load</td><td></td><td></td><td></td><td>7</td><td>W</td></tr>
</table>

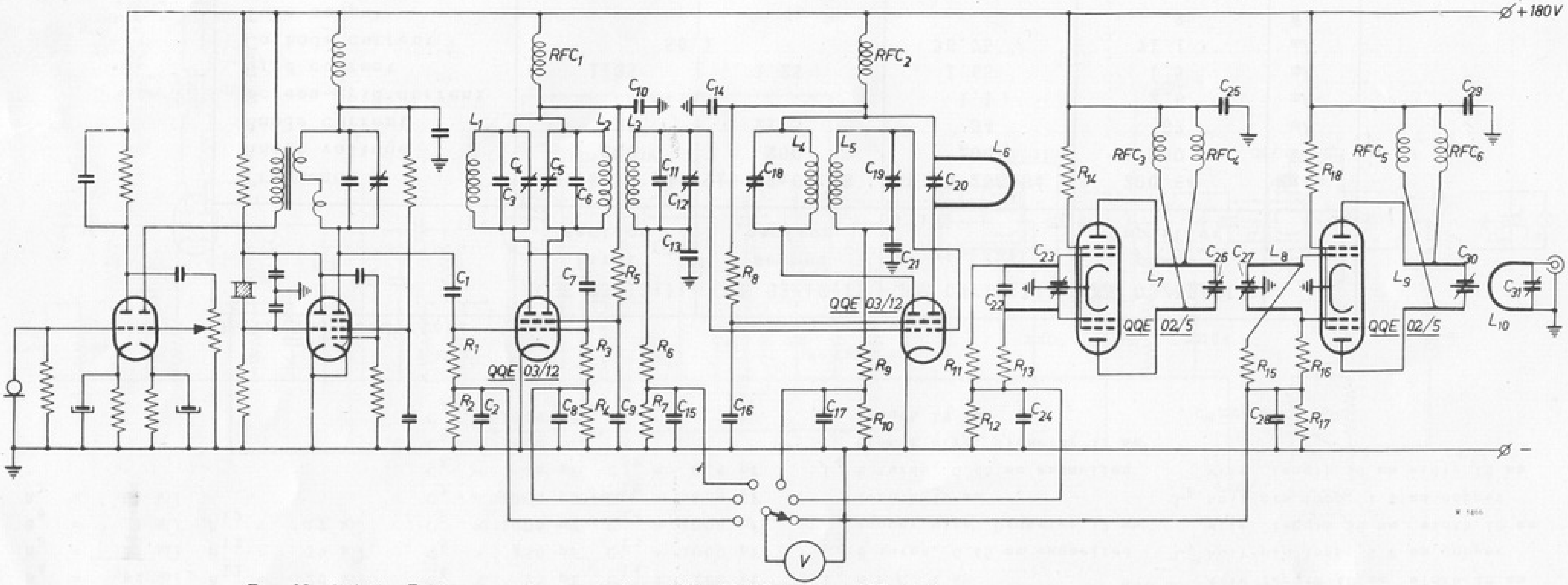



Fig.25. Mobile F.M. transmitter with two QQE 03/12 and two QQE 02/5 double tetrodes for the 460 470 Mc/s band. The transmitter is equipped with a receiving-type double triode as microphone amplifier and a triode-pentode as oscillator and buffer stage.

The oscillator frequency is 4.81 Mc/s.

The QQE 03/12 double tetrodes operate in cascode as doublers and one quadrupler. The QQE 02/5 (I) operates as trebler and the QQE 02/5 (II) as power amplifier.

## VALUES OF COMPONENTS

**Resistors**

| | |
|---|---|
| $R_1$ = 82 kΩ | $R_{10}$ = 1 kΩ |
| $R_2$ = 1 kΩ | $R_{11}$ = 150 kΩ |
| $R_3$ = 82 kΩ | $R_{12}$ = 1 kΩ |
| $R_4$ = 1 kΩ | $B_{13}$ = 150 kΩ |
| $R_5$ = 47 kΩ | $R_{14}$ = 100 Ω |
| $R_6$ = 82 kΩ | $R_{15}$ = 27 kΩ |
| $R_7$ = 1 kΩ | $R_{16}$ = 27 kΩ |
| $R_8$ = 10 kΩ | $R_{17}$ = 1 kΩ |
| $R_9$ = 82 kΩ | $R_{18}$ = 100 Ω |

**Capacitors**

| | |
|---|---|
| $C_1$ = 1500 pF | $C_{17}$ = 1000 pF |
| $C_2$ = 1000 pF | $C_{18}$ = 25 pF |
| $C_3$ = 22 pF | $C_{19}$ = 25 pF |
| $C_4$ = 25 pF | $C_{20}$ = 25 pF |
| $C_5$ = 25 pF | $C_{21}$ = 1500 pF |
| $C_6$ = 22 pF | $C_{22}$ = 390 pF |
| $C_7$ = 1500 pF | $C_{23}$ = 6.4 pF |
| $C_8$ = 1000 pF | $C_{24}$ = 1000 pF |
| $C_9$ = 1500 pF | $C_{25}$ = 1000 pF |
| $C_{10}$ = 1500 pF | $C_{26}$ = 6.4 pF |
| $C_{11}$ = 18 pF | $C_{27}$ = 6.4 pF |
| $C_{12}$ = 25 pF | $C_{28}$ = 1000 pF |
| $C_{13}$ = 1500 pF | $C_{29}$ = 1000 pF |
| $C_{14}$ = 1500 pF | $C_{30}$ = 6.4 pF |
| $C_{15}$ = 1000 pF | $C_{31}$ = 7 pF |
| $C_{16}$ = 1500 pF | |

**Transformers**

$L_1$ 24 turns enamelled copper wire 0.4 mm; former diameter 12 mm length 11 mm

$L_2$ and $L_3$ each 11 turns enamelled copper wire 0.5 mm; on one former of 12 mm diameter length 12 mm spacing 12 mm

$L_4$ and $L_5$ each 3 turns enamelled copper wire 1.5 mm; on one former of 12 mm diameter. Length 5 mm, spacing 5 mm

$L_6$ hair-pin loop of 2 mm copper wire; length 60 mm, width 18 mm

$L_7$ copper rods, diameter 2 mm, length 80 mm, spacing 18 mm

$L_8$ copper rods, diameter 5 mm, length 80 mm, spacing 18 mm

$L_9$ copper rods as $L_7$

$L_{10}$ copper rods as $L_8$

$L_{11}$ hair-pin loop, length 50 mm, width 18 mm

Operating Conditions

| | QQE 03/12(I) | | QQE 03/12(II) | | QQE 02/5 | QQE 02/5 | |
|---|---|---|---|---|---|---|---|
| | First section doubler | Second section doubler | First section quadrupler | Second section doubler | Tripler | Power amplifier | |
| Frequency | 4.81-9.62 | 9.62-19.24 | 19.24-76.96 | 76.96-153.92 | 153.92-461.76 | 461.76 | Mc/s |
| Anode voltage | 180 | 180 | 180 | 180 | 180 | 180 | V |
| Anode current | 7.7 | 7.7 | 23 | 23 | 37 | 55 | mA |
| Screen-grid current | 2.7 | | 2.1 | | 8.3 | 11 | mA |
| Grid current | 0.7 | 1.8 | 1.5 | 1.5 | 1.4 | 1.6 | mA |
| Tube output power | | | | | | 6 | W |
| Output power in load | | | | | | 5.3 | W |

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Printed in Holland

20/745/D/E-2-'59