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JB/ab

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THE RF POWER AMPLIFIER

1. Mode of operation

The rf power amplifier operates in class AB configuration with grounded cathode and is equipped with a tetrode. Grounded cathode configuration is used because of the low drive power requirements. The drive for the grounded cathode amplifier is necessary only to provide for the proper operation and excitation of the tube. Since none of the driver power is passed along to the output, there is no interaction between the input and the output. Furthermore, as the internal plate-to-grid feedback of a tetrode is much lower than that of a triode, due to the shielding effect of the screen grid, the advantage of this circuit configuration becomes apparent.

Class AB operation is considered as a good compromise between high plate efficiency and good linearity. The class A power amplifier can be operated with very low distortion, but at the same time the plate efficiency is very low. The efficiency of conversion of d-c to r-f power is one of the important matters to be considered. The d-c power which is not converted to useful output power is dissipated in heat. This heat represents wasted power and yields increased operating costs, and requires increased blower ratings. The class B amplifier has a higher plate efficiency but at the same time it generates more harmonics. Thus we have decided to use class AB operation.

In the worst case the dissipation in the ferrite rings will be 45 kW and the losses due to the beam loading will be 10 kW. Thus the power amplifier must deliver 55 kW. Since the plate efficiency of the class AB amplifier is about 60 percent, a 50 kW tube will be sufficient. Nevertheless, the Eimac 4CW 100000 will be used in order to have more margin for experiments. In addition, there is no difference in purchase price.

2. Matching the amplifier to the cable

The aim is to achieve a passband of f = 2.7 - 9.55 MHz and a definite stop band above 9.55 MHz by means of a filter with Chebyshev behaviour. An estimate of the required order of approximation yields that with the maximum allowable variation of the input impedance, the related reflection factor r = 5 percent in the passband, and the specified magnitude response in the stop band, a filter of order n = 5 will be satisfactory. The use of a filter with an odd value of n allows the input capacitance of the tube to be included in the filter. Thus we have only four elements, i.e. two inductances and two capacitances.

The values of these four elements and of the resistor can be determined easily by use of explicit formulae. For the value of the resistor we obtain 43 ohms. The consequence of this small resistance is a rather high input power of about 3 kilowatts. The matching of this filter with an input impedance of 43 ohms requires a transformer. In our case we use an autotransformer, because it must transfer both the rf-power and the grid bias, which are supplied via a long cable. An autotransformer can be converted into an ideal transformer and an associated ladder network. The ideal transformer is assumed to have unity coupling, i.e. there is no leakage-impedance drop. The elements of the ladder network can be incorporated in the preceding filter network.

3. The output circuit

Since the power amplifier is located near the cavity, the cavity itself acts as a load, and we have no special matching problems. Nevertheless, it must be noted that there will occur a transformation of the input impedance of the cavity due to the line which connects the power amplifier with the plate, the plate choke and the coupling capacitance.

It must be noted that the plate choke is in shunt with the cavity. Its inductance must be at least 100 microhenries and its dimensions must be determined so that the series resonant frequency is outside the frequency range of the amplifier. It is very difficult to meet these requirements. Therefore it was decided to split the choke into two series components, 50 microhenries each. It is also important to determine the parallel resonant frequency of the choke due to its stray capacitance. The parallel resonant frequency must be slightly above the highest operating frequency of the amplifier.

A further point of interest is the magnitude of the current necessary to charge and to discharge the output capacitance which is of the order of 85 picofarads. With this value of the capacitance and a peak voltage swing of 12 kilovolts, the plate peak charging will be 64 amperes at 10 megahertz. The coupling capacitance must handle both the resistive current of the order of 10 amperes and this high reactive current. Furthermore, this capacitance, whose value is prescribed to be 12 nanofarads, must handle the dc-plate voltage of 13 kilovolts. In order to meet these requirements, it was decided to use several capacitors, which can handle easily the reactive power.

4. Reliability

Since the rf power amplifier is located inside the ring, there will be two interchangeable stages, in order to maintain high reliability. In the event of failure the amplifiers are switched by means of rf relays, one for the d-c plate voltage and the other for the rf-power. These two relays as well as the screen grid relay are vacuum relays. The input circuit will be a coaxial relay in order to adapt the cable to the input impedance of the autotransformer.

Fig. 1 shows a complete circuit diagram for the two amplifiers and the elements associated herewith.

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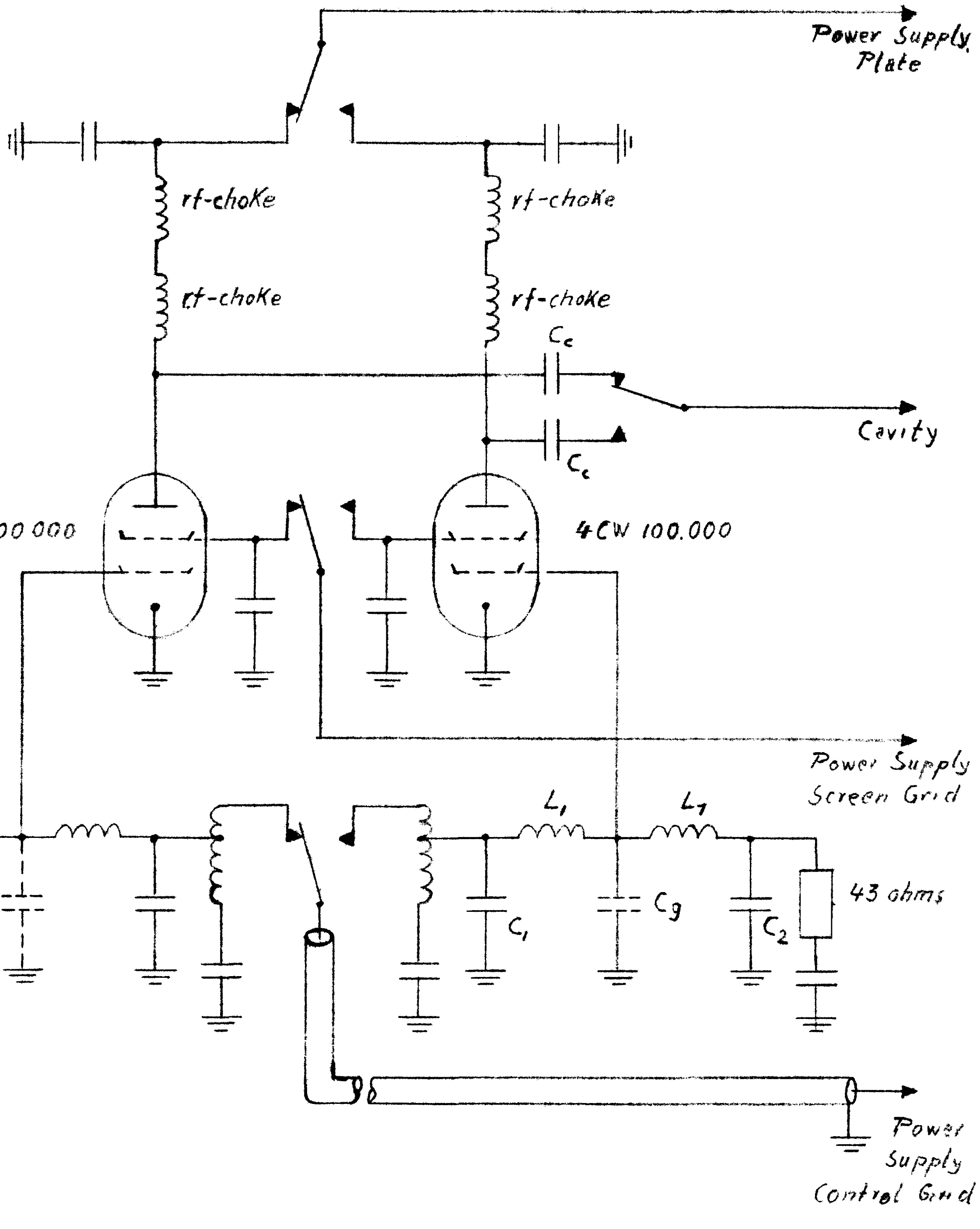

Fig. 1: Circuit diagram