June 1, 1937. N. M. RUST ET AL 2,082,517

THERMIONIC VALVE AMPLIFIER

Filed June 7, 1935

Fig. 1

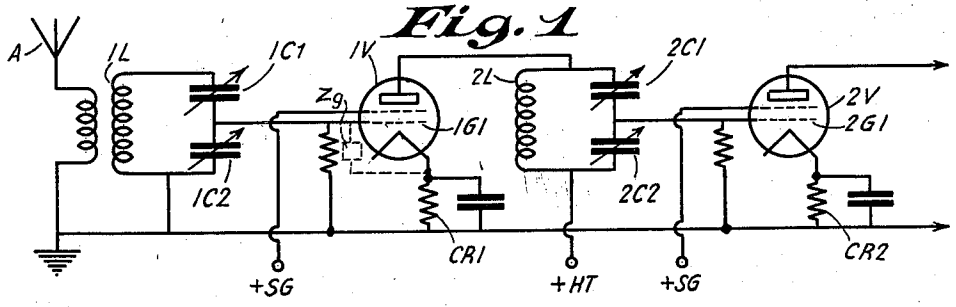


Fig. 2

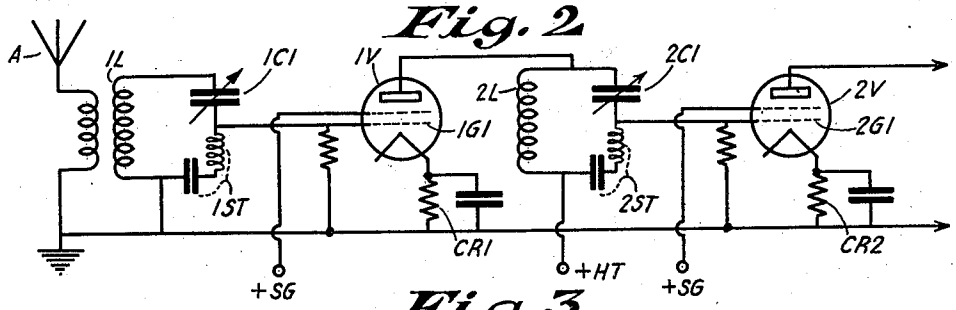


Fig. 3

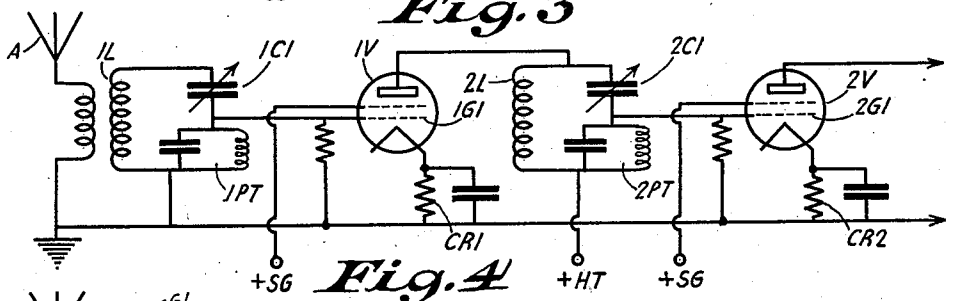


Fig. 4

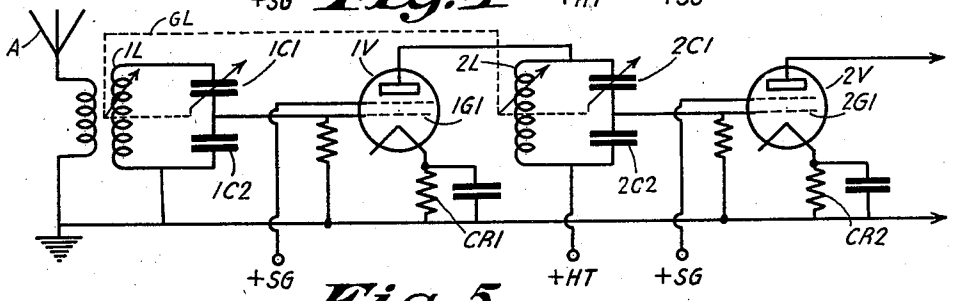
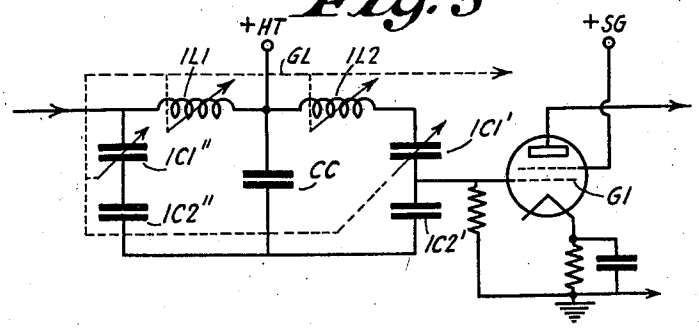


Fig. 5



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THERMIONIC VALVE AMPLIFIER

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In Great Britain May 28, 1934

2 Claims. (Cl. 179—171)

This invention relates to thermionic valve amplifiers, and more specifically to tuned high frequency thermionic valve amplifiers.

The invention has for its object to provide an improved tuned amplifier by which high gain and good selectivity can be obtained.

More specifically the invention has for its object to avoid the limiting effects of a difficulty to be described later herein and which hitherto has prevented the obtaining of as high a selectivity and as high an amplification as might be desired for multi-stage thermionic valve amplifiers, such as tuned radio frequency amplifiers.

In order that the invention may be better understood certain relations existing in a radio frequency thermionic valve amplifier stage will first be described. If the valve in such a stage has an external anode impedance, that is to say a load impedance Z_o; an input impedance (control grid-cathode) Z_g as shown in Fig. 1; an anode impedance i. e. internal impedance, R_p; and an anode-control grid capacity C_{gp} of reactance X_c it may be shown that

$$Z_g=\frac{R_pZ_o-jX_c(R_p+Z_o)}{R_p+(\mu+1)Z_o}$$

$$\therefore Z_g=\frac{R_pZ_o-j\frac{1}{\omega C_{gp}}(R_p+Z_o)}{R_p+(\mu+1)Z_o}$$

where ω is 2 π times the frequency and μ is the amplification factor of the valve. Now in such a case although the control grid-anode capacity C_{gp} may be quite small (as it is in the case of a screen grid valve) it will be clear from the formulae given above, that Z_g may become so small as to be comparable in magnitude to the ordinary impedances of the circuits employed if μ or Z_o or their product is large with respect to

$$\frac{1}{\omega C_{gp}}(R_p+Z_o).$$

This is quite commonly the case with screen grid valves for in such valves μ is usually high and Z_o will also be high if good quality inductance coils are used with the ordinary values of tuning condenser common in radio receivers.

It will also be clear that Z_g will generally be lowest at the highest frequencies since

$$\frac{1}{\omega C_{gp}}$$

is inversely proportional to frequency. If Z_o is a resistive load, as it is when the anode circuit of the valve is in tune, Z_g will be equivalent to a resistance shunted by a condenser and the equivalent condenser will detune the grid circuit of the said valve, while the equivalent resistance will increase its damping so that the selectivity of the whole stage is impaired. If, however, Z_o is an inductive load (as it may quite easily be if the stage is one of two stages which are uni-controlled for tuning purposes and the "ganging" is not quite accurate) Z_g may become equivalent to a negative resistance in parallel with a condenser and if this negative resistance is lower than the dynamic resistance of the grid circuit, the stage as a whole will become unstable.

The effect described above and sometimes known as the Miller effect, presents a serious difficulty in high frequency thermionic valve amplifiers, and more particularly in cascade connected screen grid valves and similar amplifiers where valves feed into load impedances of high value and are of high amplification factors.

According to this invention in its broadest aspect a high frequency valve amplifier having a tuned grid circuit has its cathode-grid space "tapped down" upon said tuned circuit, i. e. in effect connected across only a part thereof.

In this way, by suitably choosing the "tap down ratio" (i. e. the ratio between that portion of the tuned circuit connected between cathode and grid and the whole tuned circuit) it is possible to make the effect upon the circuit of the impedance Z_g practically negligible, and thus to avoid the deleterious effects due to capacity "thrown back" from the anode to the grid, and accordingly obtain an increase both in stability and selectivity. In carrying out this invention the tapping down is effected capacitatively, i. e. by connecting the grid-cathode circuit across a "tap down condenser" which is in series with another condenser in the tuned circuit (these two condensers replacing the usual single condenser of the tuned circuit) and, in general the impedance of this tap down condenser (which is effectively in parallel with the impedance Z_g) must, at the frequency to which the circuit is tuned, be considerably smaller in value than the impedance Z_g, to secure the correct "tap down" condition. The ratio of these two impedances is preferably kept constant at all operating frequencies.

In the drawing:

Fig. 1 shows an amplifier circuit employing the invention,

Figs. 2, 3, 4 show respectively different modifications of the circuit in Fig. 1, and

Fig. 5 shows a band pass amplifier using the invention.

Referring to Fig. 1 the multi-stage cascade connected radio frequency tuned thermionic valve amplifier therein shown comprises screen grid valves (1V: 2V) the control grids (1G1:2G1) of the valves being connected each to a preceding tuned circuit.

In accordance with this invention each tuned circuit is constituted by an inductance (1L; 2L) shunted by two condensers (1C1, 1C2; 2C1, 2C2) in series and the control grid of each valve is connected to a point between the two series condensers. Of these two series condensers that (1C2: 2C2) which is nearer the cathode side of the tuned circuit is large relative to the main tuning condenser, which is the condenser in series therewith. In many cases, owing to the fact that the impedance of the larger condenser falls as the frequency rises, a sufficiently close approximation to the theoretically required conditions can be obtained by making this large condenser of fixed value, but in other cases it may be desirable to make this large condenser (1C2; 2C2) variable and to gang control it with the main tuning condenser (1C1: 2C1) and, if desired, with condensers in the other tuned circuits of the whole amplifier. CR1 and CR2 represents the usual capacity shunted resistance combinations for self-biasing; A represents an aerial or other source of signals to be amplified; and +SG and +HT represent screen grid and anode potential supply terminals respectively. The impedance Z is shown in dotted lines in Fig. 1, and represents the cathode to control grid impedance of amplifier 1V. The representation is not shown in connection with the remaining amplifiers of the drawing, but it will be understood that it exists in such amplifiers in the same manner as shown in connection with amplifier 1V.

In the modification shown in Fig. 2, the arrangement of Fig. 1 is modified by replacing the members 1C2 and 2C2 by series tuned circuits (1ST; 2ST) each resonant at a frequency above the tuning range of the amplifier so as always to present capacitative impedances, while in the modification shown in Fig. 3 parallel tuned circuits (1PT; 2PT) are employed, these circuits being resonant at a frequency below the tuning range so that again they always present capacitative impedances. In both Figs. 2 and 3 the tuned circuits may be fixed or variable and in the latter case may be gang controlled, but in any case their tuning must always be such, relative to the frequency to be amplified, that their impedances are capacitative.

The feature of "tapping down" the grid upon what is in effect a capacity potentiometer, may be embodied in cases in which the tuned circuits are tuned by variation of inductance instead of, or as well as, variation of capacity and Fig. 4 shows an embodiment where variable inductance tuning is used. As in the previous embodiments gang control may be provided if desired and such control is represented in Fig. 4 by the broken line GL.

The invention is also applicable to arrangements wherein, in place of using simple tuned circuits, band pass tunable circuit arrangements are employed. For example in one such case illustrated in Fig. 5 the control grid G1 of a screen grid valve is tapped upon a band pass tuned circuit consisting of two variable inductances 1L1, 1L2, a variable condenser 1C1', a larger fixed condenser 1C2', a second similar fixed condenser 1C2'' and a second variable condenser 1C1'' all in series in a loop circuit in the order stated, may be employed, the two variable condensers being similar and the junction point of the two inductances being connected to the junction point of the two large fixed condensers through a further fixed condenser CC. The two variable inductances and the two variable condensers are gang controlled for tuning purposes as indicated by the broken line GL and may, if desired, be gang controlled with similar components provided in another band pass tunable circuit arrangement elsewhere in the amplifier. The screen grid valve has its control grid G1 connected to the junction point of the condensers 1C1' and 1C2' and the junction of the other variable condenser 1C1'' with the variable inductance 1L1 adjacent thereto is connected to the anode of a preceding valve (not shown) or to some other source of signals to be amplified. Where the said source is the anode of a preceding valve, anode potential may be applied thereto as shown from a point HT+ through a load connected to the junction point of the two variable inductances 1L1 and 1L2.

It is found that the invention enables high selectivity and high gain to be obtained in multi-stage radio frequency tuned amplifiers, and is, therefore, of great advantage in broadcast receivers, the feature of "tapping down" providing a very substantial practical improvement. It is to be understood that, particularly where the invention is applied to very high frequency multi-stage amplifiers, careful screening and decoupling arrangements, as known per se, should be provided to prevent undesired stray couplings between various parts of the amplifier.

It is to be understood that although in the illustrated embodiments four-electrode screen grid valves are shown, the invention is not limited to the use of this type of valve, for pentodes, triodes, or other suitable types of amplifying valve may be employed.

What is claimed is:

1. A tunable high frequency amplifier circuit comprising an electron discharge tube of the screen grid type, a source of high frequency signals to be amplified, a signal input network coupling said source to the input electrodes of the tube, said input network comprising a coil in shunt with a path including at least two capacitative impedances in series, the tube input electrodes being connected solely across one of the impedances to substantially minimize the effect of the impedance between the input electrodes upon the input network, the other impedance being smaller in capacity value than said one impedance and being adjustable to vary the tuning of the amplifier over a desired frequency range, the magnitude of said one impedance being substantially smaller than that of said input impedance at any frequency to which said input network is tuned, and an output circuit coupled to the output electrodes of the tube.

2. A tunable high frequency amplifier circuit comprising an electron discharge tube of the screen grid type, a source of high frequency signals to be amplified, a signal input network coupling said source to the input electrodes of the tube, said input network comprising a coil in shunt with a path including at least two capacitative impedances in series, the tube input electrodes being connected solely across one of the impedances to substantially minimize the effect of the impedance between the input electrodes

upon the input network, the other impedance being smaller in capacity value than said one impedance and being adjustable to vary the tuning of the amplifier over a desired frequency range, the magnitude of said one impedance being substantially smaller than that of said input impedance at any frequency to which said input network is tuned, and an output circuit coupled to the output electrodes of the tube, said one impedance consisting of a coil and condenser which are resonant at a frequency outside the tuning range of the amplifier.

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