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THE PRINCIPLES OF NEUTRODYNING APPLIED TO A FEW TYPES OF TRANSMITTING CIRCUITS.

The following notes discuss the principles of neutrodyning as applied to a few types of transmitter circuits, and the method usually adopted in obtaining correct adjustment.

Before considering practical applications it may be as well to obtain a clear idea of what neutrodyning is and what it will and will not do.

The anode and grid of a transmitting valve may be looked upon as the two plates of a condenser between which there is a varying voltage when the valve is in operation. A capacity current will therefore flow between them. Neutrodyning consists in either balancing out or diverting this current from the tuned grid circuit through which it would otherwise flow and to which it would, in most cases, supply energy tending to maintain oscillations.

In its application to transmitters neutrodyning is essential with short-wave multi-stage master oscillator controlled circuits where, obviously, there would be no master oscillator control if any of the stages could self-oscillate. Such circuits are being adopted for naval high-power shore stations.

Neutrodyning is not a specific cure for all self-oscillating troubles. It will not balance out the effects of stray capacity and inductive coupling, except in special cases. It cannot balance out such factors as reaction, due to internal resistance of the source of supply.

Circuits.

The anode/grid capacity reaction will first be considered for the two simple types of amplifier stages shown in Figs. 1 (a) and 1 (b).

For the case represented by Fig. 1 (a), the anode voltage is exactly 180° out of phase with the grid voltage because there is no inductance in the anode circuit. In Fig. 2 V is the anode voltage; v the grid voltage, and A = V - v the voltage difference between anode and grid. A capacity current I will therefore flow between anode and grid and will lead A by 90°. As shown by the figure this current lags exactly 90° behind the grid voltage v and can, therefore, supply no power to the grid circuit. This circuit will not, therefore, self-oscillate.

For the case represented by Fig. 1 (b), the anode voltage V is not 180° out of phase with the grid voltage v because the anode circuit contains an external reactance w L in series with the valve resistance. If the reactance is very large compared with the valve resistance or vice versa (not a useful amplifier circuit), the conditions will approximate to those shown in Fig. 2, and the circuit will not self-oscillate. Fig. 3 shows the position between these extremes. The current I leads the anode to grid voltage A by 90°. But since this voltage A is not 180° out of phase with the grid voltage v, the current I will not be 90° out of phase with the grid voltage, and will supply power to it tending to maintain oscillations.

METHODS OF NEUTRODYNING.

Anode Circuit neutrodyned.

Fig. 4 shows a single valve amplifier unit with tuned anode and grid circuits.

Redraw the anode circuit A, B, C, D, E, F as shown in Fig. 5.

Imagine now the filament carrying no current and the anode tuning condenser F as a generator applying high frequency voltage to the points A B of the bridge. The neutrodyne condenser E can be adjusted so that the voltage drop across it is exactly equal to the voltage drop across the arm A C. There will then be no voltage measured between the points D C. No currents from the generator F will therefore flow through the grid tuned circuit which is connected to the points C D in series with the condenser K (Fig. 4). The grid tuned circuit will have no tendency to oscillate.

Imagine now the grid tuned circuit as a generator applying high frequency voltage to the points C D. If the balance has not been disturbed there will be no voltage between the points A B. The anode tuned circuit A C B F will therefore have no tendency to oscillate. The set has been neutrodyned, that is, it will not self-oscillate in operation through valve interelectrode capacity coupling. In the above reasoning, it has been assumed that the bridge arms are all of negligible resistance.

One serious disturbing factor has been left out of consideration in the discussion. The valve anode current flows through the limb C B and is approximately 90° out of phase with the tuned anode oscillating current. In operation there will therefore always be a small high-frequency voltage difference between points C and D, and so a small amount of feed back current into the tuned grid circuit.

Since the best setting of the neutrodyne condenser is critical, it follows that the setting will have to be adjusted with change of wavelength in an efficient circuit as the anode current does not change in proportion.

Grid Coil neutrodyned.

Fig. 6 shows a different method of neutrodyning the same type of circuit.

In operation there is a high-frequency voltage between points A and C (anode and filament). Within the valve the anode and grid can be looked upon as the plates of one condenser and the grid and filament as the plates of another. External to the valve two other condensers are connected in series (A B and B C) between points A and C. They therefore form a bridge and as there is no resistance in any limb, it will be possible to adjust the external condensers so that there is no high frequency potential difference between points B and D. No current will therefore flow between them through the grid tuned circuit and the set is neutrodyned.

The disturbing factor in this case is the grid leak resistance which shunts the grid to filament capacity in addition to which the grid to filament path within the valve, has a resistance value varying with the excitation. These upset the phase relationships of the bridge so that it is not possible with condensers alone to get a zero voltage difference between points B and D. This method is not one of any great value.

Fig. 6A shows an alternative circuit. The characteristics of normal transmitting valves differ from receiving valves in that the grid swings positive so that grid current flows. This current flows through only half the grid tuning coil and causes unbalance The circuit of Fig. 6 does not suffer from this cause.

Double-Acting Neutrodyned Amplifier.

One circuit of this type is shown in Fig. 7. It has great advantages over the other two described and is the type used in high power transmitters.

The equivalent bridge circuit in this case is formed by the anode to grid capacity of the valves and the neutrodyne condensers. It is shown in Fig. 8.

The oscillatory voltage generated is across the anodes of the two valves; that is, points A and B. Since there is no resistance in the circuit it is possible to adjust the neutrodyne condensers so that there is no voltage between the points C and D across which the tuned ci
[illegible] connected. The set is then neutrod

The advantage of this type of circuit lies in its symmetry. The inter-electrode effect is really that of a condenser shunted by a high resistance, but in double acting circuits the resistances almost balance out, the valves being in corresponding arms of the equivalent bridge. The correct setting of the neutrodyne condensers would be independent of the oscillating frequency were it not for the fact that the stray capacity to earth, etc., of the corresponding parts in the circuit differ because limitations of space prevent absolutely symmetrical assembly.

Method of Adjusting the Neutrodyne Condensers.

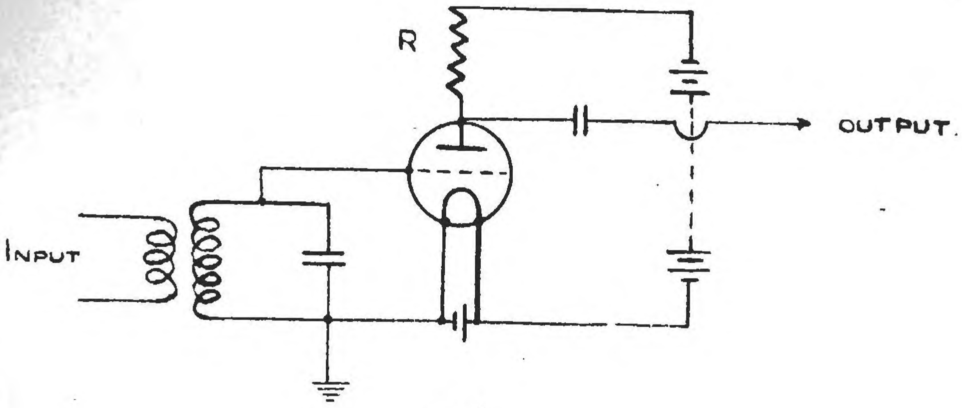
In a large multi-stage master-oscillator controlled set, the correct setting of the neutrodyne condensers, especially for the later stages, is a delicate operation. The last stage is usually on the verge of self-oscillation due to stray inductive coupling with previous stage. Feed back through the inter-electrode capacity of the valves must be eliminated. The best practical method of adjustment is as follows:-

Tune the master oscillator to the required wavelength. Set the neutralising condensers of the second stage to their minimum value. Close the anode supply switch and tune for maximum current. Open the anode switch, insert a milliammeter in the tuned circuit, when a small current will be indicated. This is the feed back current from the master oscillator. Adjust the neutralising condensers slowly keeping them of approximately equal value until the small current indicated in the milliammeter falls to zero. If the neutralising condensers are correctly set no current should be indicated for any setting of the tuned circuit condenser in the second stage. Disconnect the milliammeter, close the anode switch and retune for maximum current. The re-adjustment should be slight.

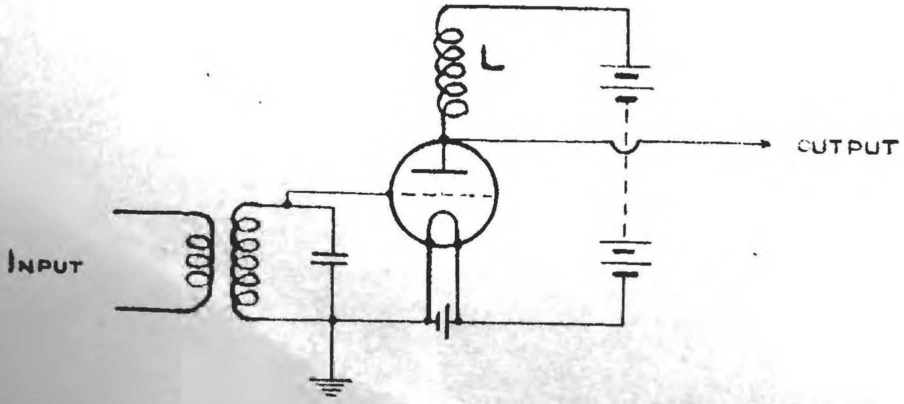
In sets under construction a milliammeter with shunt is used in the tuned circuits and the shunt disconnected by a push button switch for neutrodyning.

In the high power stages it is sometimes necessary to insert a small resistance in series with the neutrodyne condensers and adjust these to get zero current after minimum current has been obtained by adjusting the condenser. These resistances form part of the designed set and should not require re-adjustment for varying wavelengths.

A similar procedure has to be followed in neutrodyning the other two forms of circuit described.



(a)



(b)

FIG. 1.

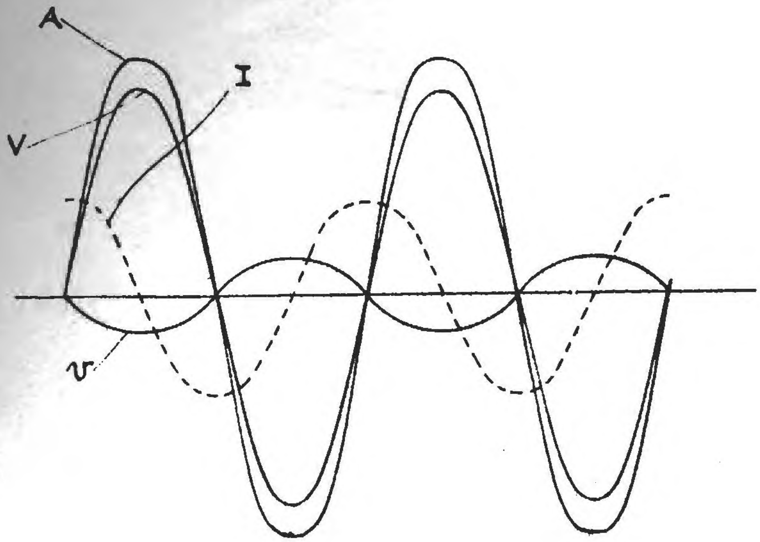


FIG. 2.

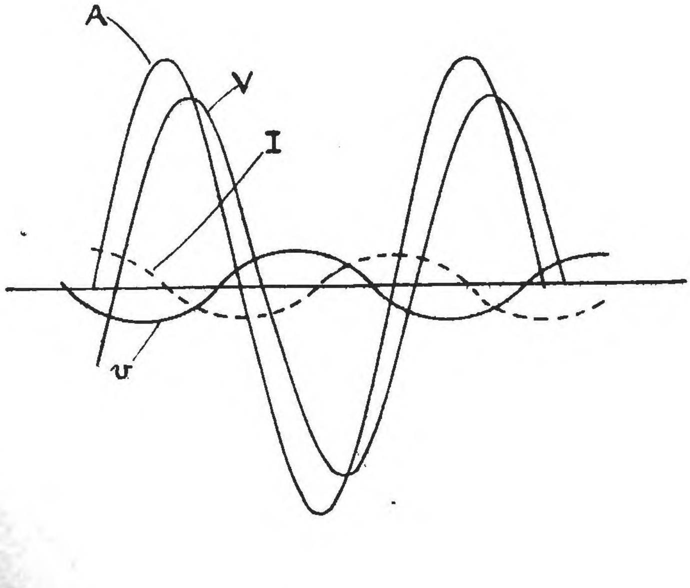


FIG. 3.

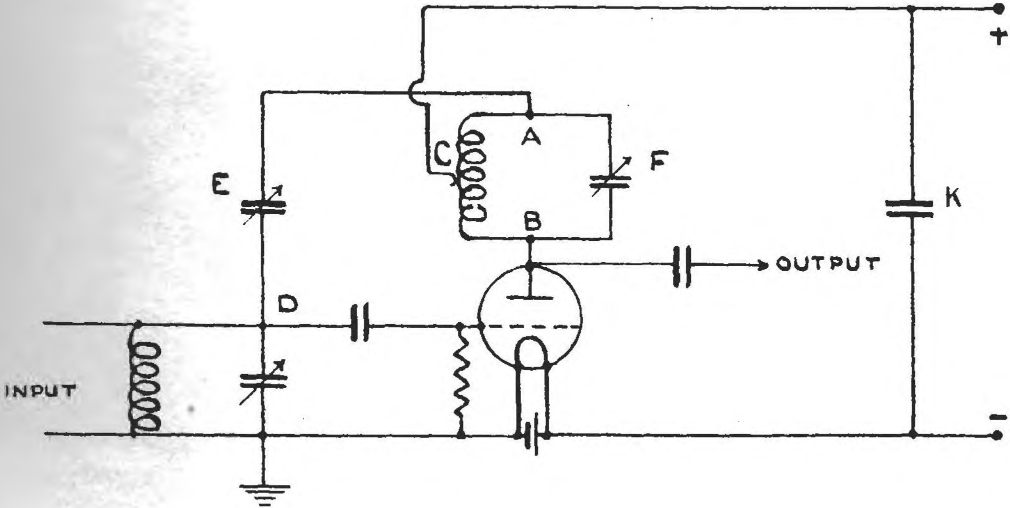
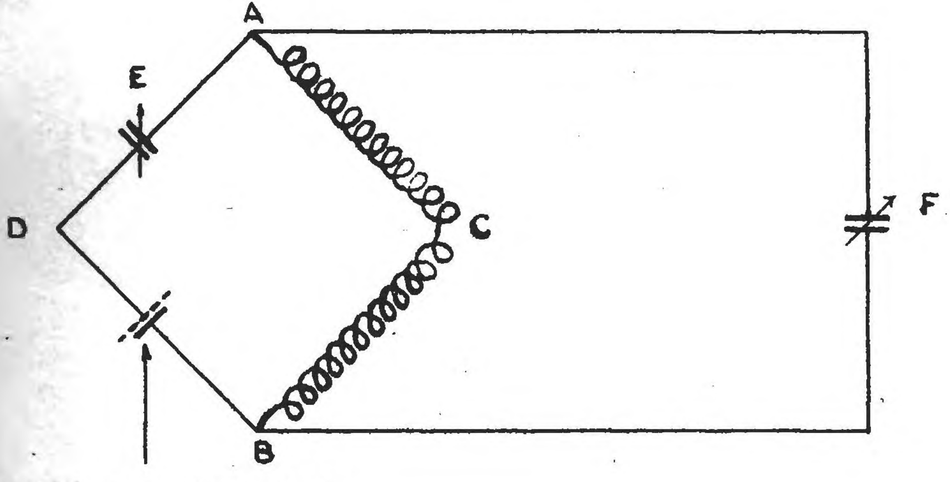


FIG. 4.



VALVE GRID AND ANODE AS A CONDENSER.

FIG. 5.

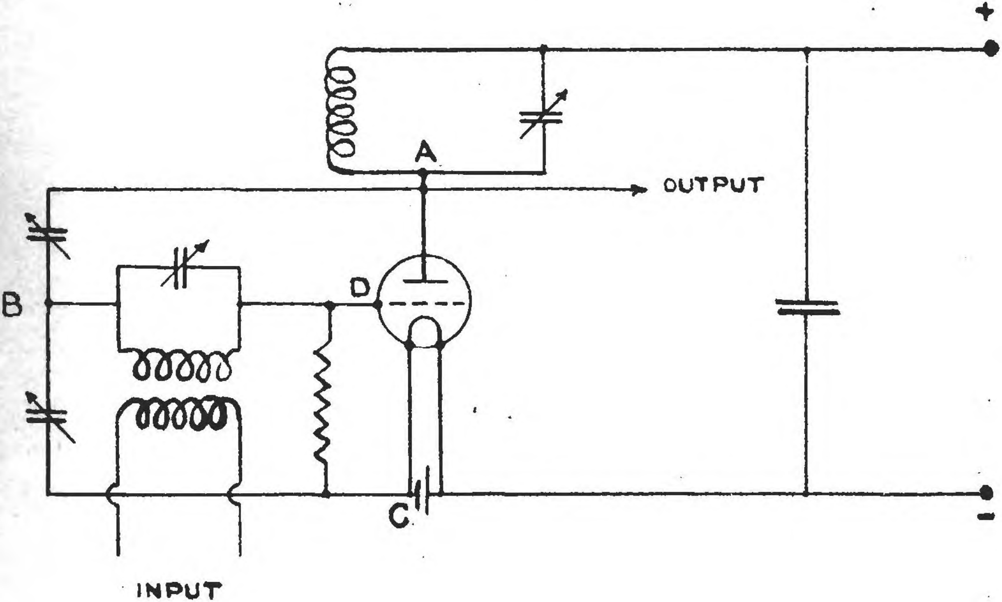


FIG. G.

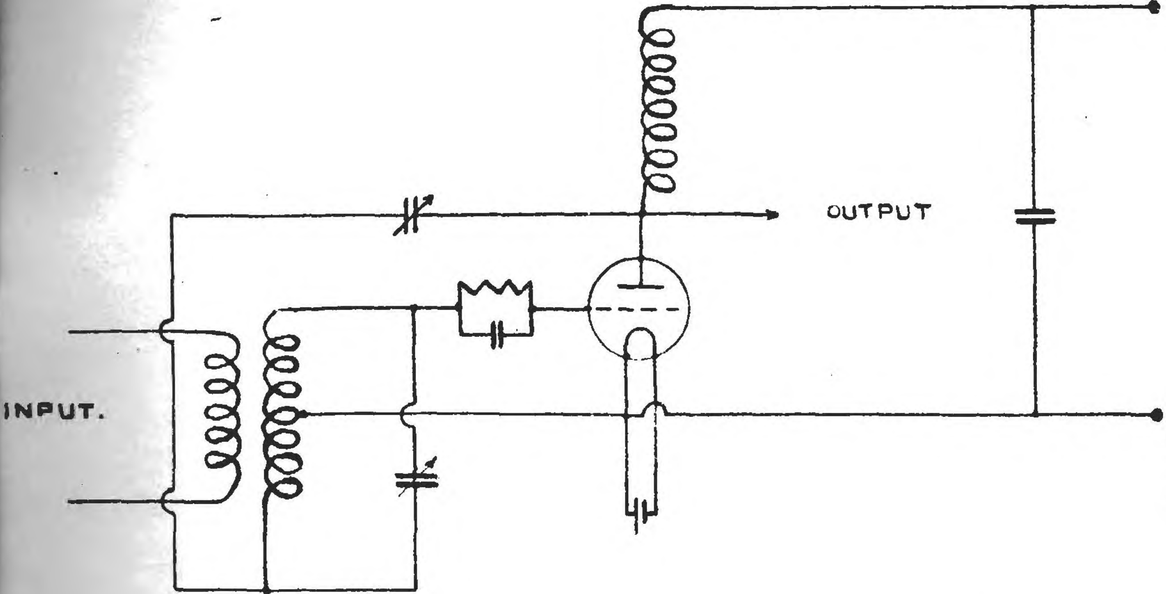


FIG G.(a.)

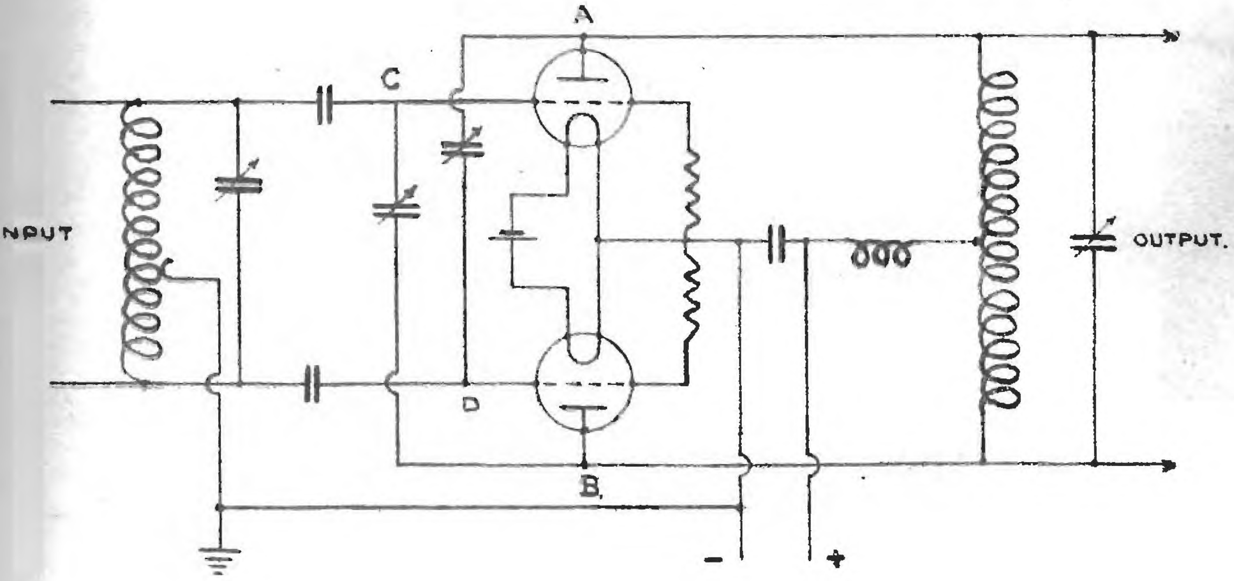


FIG. 7.

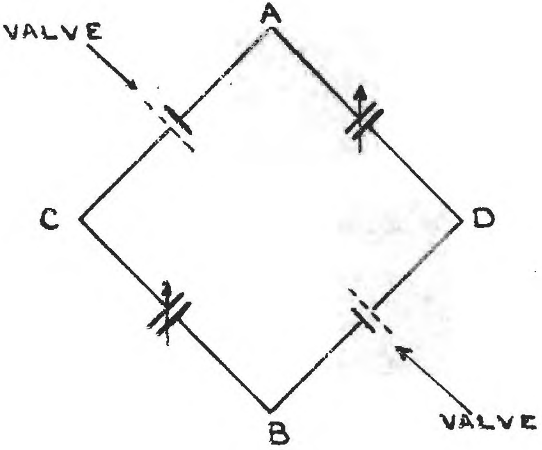


FIG. 8.

amount of feed back current into the tuned grid circuit.

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