Dec. 26, 1933. P. O. FARNHAM 1,941,393

DYNATRON CIRCUITS

Filed Sept. 18, 1931

Fig. 1.

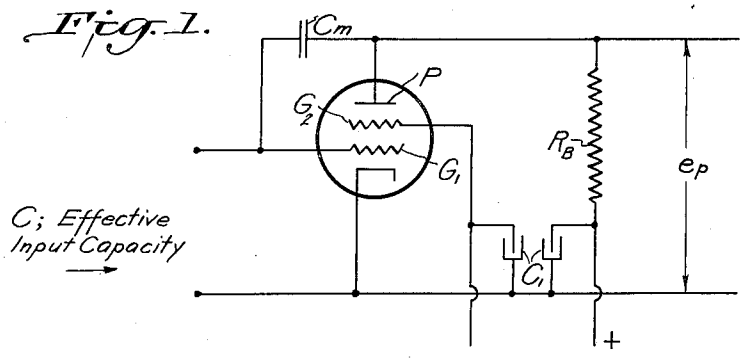
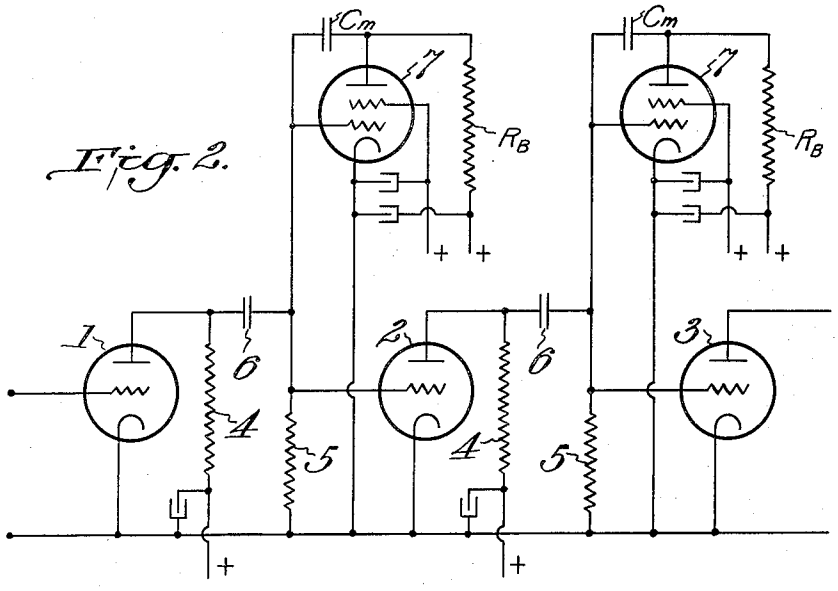


Fig. 2.



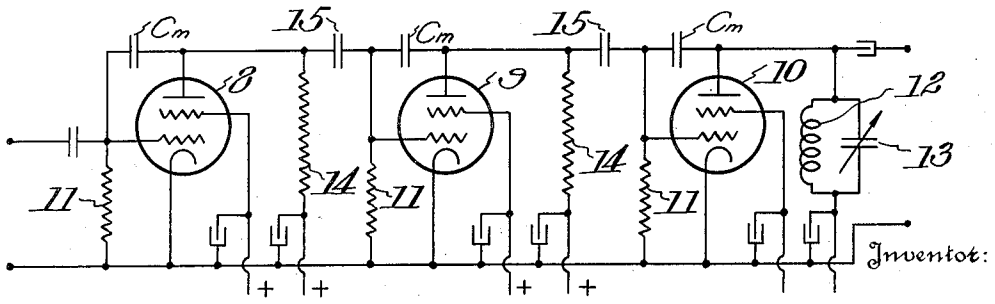


Fig. 3.

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DYNATRON CIRCUITS

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Serial No. 563,635

11 Claims. (Cl. 179—171)

This invention relates to dynatron circuits and particularly to methods of and arrangements for introducing a negative capacity into a circuit to neutralize, either entirely or in part, the positive capacity of that circuit.

In the operation of resistance coupled amplifiers, the gain decreases with increasing frequency since the inherent grid-cathode capacity of the amplifier is shunted across the input terminals and presents a progressively lower impedance as the frequency is increased. By introducing a negative capacity into the tube input circuit to neutralize the positive capacity already present, the gain of the amplifier will be independent of frequency.

An object of the present invention is to provide methods of and circuit arrangements for counteracting or suppressing the capacity of a circuit by the introduction of a negative capacity. Further objects are to provide methods of and circuit arrangements by which a dynatron amplifier will reflect a negative capacity into the input circuit of the dynatron. Other specific objects are to provide a resistance coupled amplifier, of one or more stages, which exhibits some degree of selectivity in that the input capacity of the tube or tubes is neutralized at the frequency of the desired signal.

These and other objects of the invention will be apparent from the following specification when taken with the accompanying drawing in which:

Fig. 1 is a circuit diagram of an amplifier stage which may be operated in accordance with the invention, and

Figs. 2 and 3 are circuit diagrams of amplifier circuits embodying the invention.

The circuit arrangement illustrated in Fig. 1, differs from the conventional tetrode amplifier having a resistive load R_B in the plate circuit of tube in that an external coupling capacity C_m is provided between the plate P and control grid G_1. The plate and screen grid G_2 are energized from appropriate direct current sources, not shown, and these circuits are by-passed for signal frequencies by condensers C_1.

As indicated by the legend, the stage has an effective input capacity C, as viewed looking into the input terminals of the stage, and the value of this capacity C may be determined mathematically. Assuming that, at the frequency of a signal voltage, the square of the plate load (R^2_B) is negligible in comparison with the square of the reactance of the coupling capacity

$$\left(\frac{1}{\omega C_m}\right)^2,$$

an analysis of the stage will show that the effective input capacity is equal to:

$$C=C_m(1+\mu A_v),$$

when the energizing potentials are such that the stage functions as a customary or positive resistance amplifier, and is equal to:

$$C=C_m(1-\mu A_v),$$

when the stage functions as a dynatron or negative resistance amplifier; where μ is the voltage amplification factor of the tube between control grid, and plate, and A_v is the magnitude of the ratio (without regard to sign) of plate load resistance R_B to the sum of the plate load resistance R_B and the tube plate resistance r_p:

$$A_v=\left[\frac{R_B}{R_B+r_p}\right]$$

The significance of these equations is that, due to the amplifying action of the tube, a capacitive reactance is reflected into the input circuit by the coupling capacity C_m, which reflected capacity is always positive when the stage operates as a positive resistance amplifier, and which, in the case of the dynatron, will usually be negative since μA_v is normally considerably greater than unity.

In deriving these equations, the positive capacitive reactance across the input terminals, either the inherent tube capacity alone or that plus added circuit capacity, was ignored as such positive capacity does not enter into the mathematical analysis for the value of the effective input capacity due to the coupling capacity C_m. The inherent and any other positive input capacity must be added to the reflected input capacity C to obtain the total input capacity of the tube.

It will be apparent that, for dynatron operation, the circuit elements may be so chosen that the reflected capacity just neutralizes the positive capacity, thus giving the input impedance

the characteristics of a pure resistance. The loss in input voltage arising from the by-passing action of the grid-cathode capacity at the higher frequencies is therefore eliminated, and uniform gain results at all frequencies for which R^2_B is negligible compared with

$$\left(\frac{1}{\omega C_m}\right)^2.$$

The magnitude of the reflected negative capacity is determined by C_m and the plate load R_B, since the voltage e_p in the dynatron plate circuit is dependent upon the plate load. In one satisfactory arrangement for frequencies from 100 to 7000 cycles when using a screen grid tube of the commercial 224 type with 180 volts on the screen and 45 volts on the plate, the coupling capacity C_m was about 50 micromicrofarads, the plate load R_B was about 7000 ohms, and the negative capacity reflected into the input circuit was about 150 micromicrofarads.

The negative capacity reflected into the dynatron input circuit may be impressed upon another circuit, as shown in Fig. 2, to neutralize the positive capacity of that circuit, or the dynatron may act itself as the signal amplifier, as shown in Fig. 3.

In Fig. 2, the three tubes 1, 2 and 3 are coupled to the plate resistances 4 and input resistances 5 of adjacent tubes by condensers 6 to constitute a cascaded resistance-coupled amplifier of the usual positive plate resistance type. To neutralize the inherent and positive capacity across the input terminals of tubes 2 and 3, the input circuits of the dynatrons 7 are connected across the grid and cathode terminals of amplifier tubes 2, 3, the dynatron stages having resistive plate loads R_B and coupling capacities C_m so related as to cancel out all or any desired part of the input capacities of the amplifiers.

While such circuit arrangements are possible when it is desired to employ an amplifier of the usual positive resistance type, a simpler arrangement in which the dynatrons serve also as the amplifiers is usually preferable.

Such an arrangement is illustrated in Fig. 3, in which the tubes 8, 9, 10 have such energizing potentials that the tubes function as dynatron or negative resistance amplifiers. The several tubes have grid resistances 11, and the last tube 10 has a tuned plate circuit comprising an inductance 12 and variable condenser 13, while the preceding stages have plate resistances 14 (corresponding to resistance R_B of Fig. 1). The stages are coupled by condensers 15, and in each stage a coupling capacity C_m is provided between the plate and control grid of the dynatron.

The coupling capacity C_m of tube 10 is so chosen that, for the resonant frequency of the tuned circuit 12, 13, i. e., when the plate load impedance is resistive, the inherent input capacity of the final stage is neutralized. At this particular frequency, the plate load of the preceding tube 9 is also a pure resistance, but at other frequencies, the plate load of the final tube has too low a value of resistive component to neutralize the shunt capacity effects normally present in the input circuit of the final tube. For this reason, the transmission of frequencies off resonance from the control grid of tube 9 to the control grid of tube 10 will be greatly decreased, i. e., will be decreased to whatever value it would have with the shunt capacity effects present. This same argument would then apply to the falling off of transmission back through the preceding stages when the impressed frequency differs from the resonant frequency of the final circuit.

Although the plate load of the final tube may have either capacitive or inductive components of reactance for frequencies off resonance and although these reactive components will reflect negative or positive resistance into the input circuit, such effects will be small compared to that of the now unneutralzed shunt capacities in lowering the transmission.

Other applications of the invention will be apparent to those familiar with the design of alternating current networks.

I claim:

1. In the operation of a dynatron stage, the method of introducing a negative capacity into the input circuit of the dynatron, which comprises including a resistive load in the plate circuit, and capacitively coupling the plate and control grid of the dynatron.

2. The method of employing a dynatron stage having input terminals connected to the control grid and cathode thereof to introduce a negative capacity between two points in a circuit, which comprises connecting across said points the input terminals of the dynatron stage, imparting a resistive plate load to the dynatron stage, and capacitively coupling the dynatron control grid and plate.

3. Apparatus for producing a negative capacity effect, comprising a vacuum tube and means for impressing on the elements thereof potentials effective to impart a negative plate resistance to said tube, a resistive load in the anode circuit of said tube, and an external capacity coupling the anode and control grid of said tube.

4. Means for producing a negative capacity effect, comprising a vacuum tube and means for impressing on the elements thereof potentials effective to impart a negative plate resistance to said tube, a resistive load in the tube plate circuit, and a capacity coupling the plate and control grid of said tube, said capacity having a reactance substantially greater than the impedance of said resistive load.

5. The combination with an alternating current circuit, of means for introducing a negative capacity between two points in said circuit; said means comprising a dynatron having the grid and cathode elements thereof connected to the respective points, a resistive load in the plate circuit of said tube, and a capacity between the dynatron plate and grid, said capacity having a reactance substantially in excess of the impedance of said load.

6. The combination with a vacuum tube and associated input and output circuits, of means reducing the capacity effectively across one of the said circuits; said means comprising a dynatron having the input circuit thereof connected across the said circuit of said tube, and means producing a negative capacity across the input circuit of said dynatron.

7. The combination with a circuit having a capacitive impedance between two points in said circuit, of means for suppressing the effects of said capacitive impedance, said means comprising a dynatron having the grid and cathode terminals thereof connected to the respective points in said circuit, and a resistive load in the plate circuit of said dynatron.

8. In a dynatron circuit, a tube having the elements thereof subjected to energizing potentials effective to impart a negative plate resistance to said tube, and means for establishing

a negative capacity between the cathode and a grid element of said tube, said means comprising a resistive plate load and a capacitive coupling between the tube plate and the grid element.

9. The combination with a tube and means energizing the same to function as a dynatron, of a tuned load in the plate circuit of said tube, and a capacitive coupling between the dynatron plate and control grid, said coupling having a reactance of an order substantially greater than the impedance, at resonance, of said tuned load.

10. The combination with a transmission system including a plurality of dynatrons cascaded by resistance coupling, of capacity between the plate and control grid of each dynatron, and a resistive load in the plate circuit of the last dynatron in said system, the square of the resistance of said load being negligible in comparison with the square of the impedance of said capacities.

11. The invention as set forth in claim 10, wherein said resistive load in the plate circuit of the last dynatron is a parallel tuned impedance.

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