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NONSINGING AMPLIFIER

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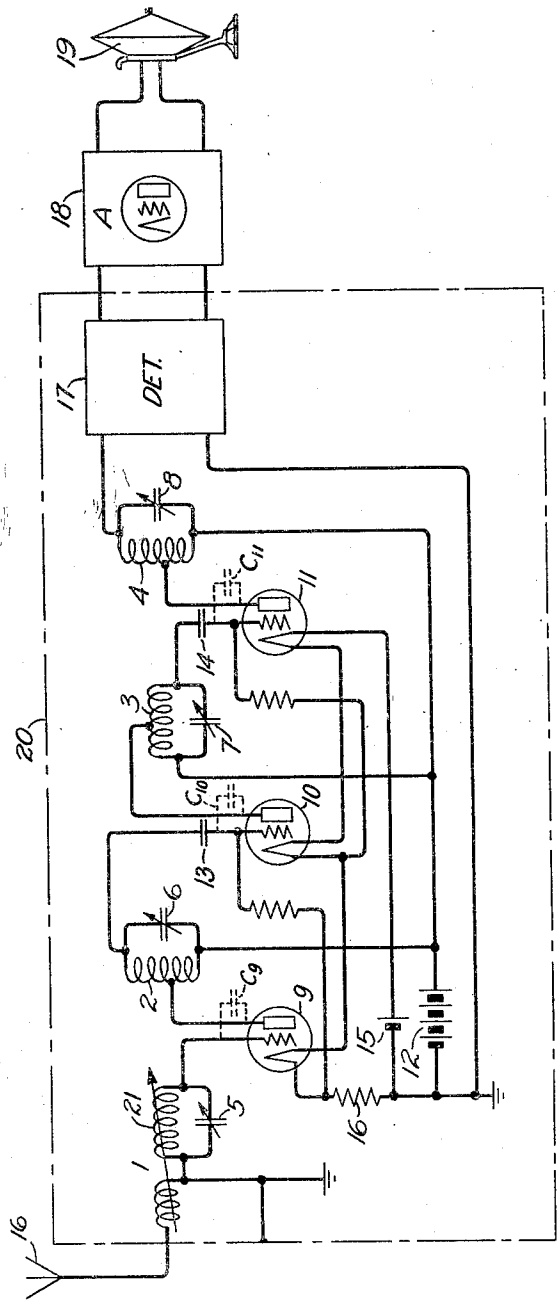

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NONSINGING AMPLIFIER

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This invention relates to high frequency vacuum tube amplifiers and more particularly to improved circuits whereby the operating efficiency of such amplifiers is increased.

It is well known that under certain conditions devices of the type mentioned produce oscillating currents in the circuits associated therewith which will interfere with the efficient transmission, reception, amplification and detection of signals when it is attempted to secure a high degree of amplification by using a plurality of devices connected in cascade.

A general object of the invention is to prevent singing or regeneration in high frequency amplifiers.

It is well known that the production of oscillations by such devices is due to coupling which is present between input and output circuits and that when a plurality of devices are connected in cascade a very small amount of coupling in a certain direction between the output circuit of the last device and the input circuit of a preceding device is sufficient to start production of oscillations.

The prevention of singing due to the inter-electrode capacity requires that the retroactive E. M. F. (or feed back) be zero at all times or else in such phase relation with respect to the input E. M. F. as to produce loss of amplification or degeneration.

Another object of the invention is to provide an amplifying system which will be highly selective, that is, one which will give a high degree of amplification of currents of one particular frequency without producing an appreciable amplification of currents of other frequencies and without the undesired singing or regeneration.

In the construction of multi-stage amplifiers it has been customary as far as possible to shield the different input and output circuits from one another in such a way as to overcome electro-magnetic coupling between the circuits.

Another object of the invention is to eliminate the necessity for separately shielding the individual stages of the amplifier while at the same time placing the amplifier transformers close together so that they are within the stray magnetic fields of each other.

This is accomplished by placing the transformers of the adjacent stages with their centers in line and their axes mutually at right angles to each other and placing the transformers of alternate stages so that a magnetic coupling exists between them in a direction to oppose regenerative feed back.

Preferably an electrostatic shield is employed over the entire radio frequency amplifier. This shield has, however, no bearing on the regeneration action caused by the mutual coupling of alternate circuits. Without the use of an overall shield each transformer would act as an antenna and make volume control difficult, especially when the receiver is located in the proximity of a powerful radio transmitter.

The invention will be better understood by referring to the following description and accompanying drawing showing the preferred form of embodiment, representing a radio receiving circuit comprising three stages of radio frequency amplification, a detector, an audio amplifier and a loud speaker.

In the radio receiver represented by the drawing there are four radio frequency transformers 1, 2, 3 and 4 each associated with a tuning capacity 5, 6, 7 and 8. Three 3-element thermionic discharge devices 9, 10 and 11 are associated with the radio frequency transformers to act as radio-frequency amplifiers. The coils of each transformer are preferably of the single layer type. Transformers 1 and 3 are physically placed with their axes in line so that a magnetic coupling exists between them. Transformers 2 and 4 are physically placed with their axes in line so that a magnetic coupling exists between them and are so placed with respect to transformers 1 and 3 that the centers of transformers 2 and 4 are in line with the centers of transformers 1 and 3 and the axes of transformers 1 and 3 are mutually at right angles with the axes of transformers 2 and 4.

The connections from coils 1, 2, 3 and 4 to the associated space discharge devices are made so that the regenerative feed-back currents due to the internal grid-plate capacities

C_9, C_{10} and C_{11} of space discharge devices 9, 10 and 11 are neutralized by currents in the opposite direction due to the magnetic potential resulting from the magnetic coupling between the transformers. With the connections made to accomplish this result the magnetic coupling between the transformers 1 and 3 and transformers 2 and 4 is in a direction to oppose regenerative feed-back. The distance between the axes of transformers 1 and 3 and between transformers 3 and 4 is adjusted so that the desired amount of degeneration due to the magnetic coupling is obtained. This distance may be such that there will be a certain amount of regeneration, but not sufficient regeneration to cause singing, or the transformers may be placed so that regeneration is completely neutralized.

Plate potential is supplied to the thermionic discharge devices 9, 10 and 11 from a suitable source 12 through the primary windings of transformers 2, 3 and 4. This potential is prevented from reaching the grids of thermionic discharge devices 10 and 11 by means of suitable blocking capacities 13 and 14. The filaments of the thermionic discharge devices 9, 10 and 11 are connected in series and current is supplied to them from a suitable source 15. Suitable grid potential is preferably supplied to the thermionic discharge devices 9, 10 and 11. This is obtained for thermionic discharge device 9 by the drop across resistance 16, for thermionic discharge device 10 by the drop across the filament of thermionic discharge device 9, and for thermionic discharge 11 by the drop across the filament of thermionic discharge device 10. The methods shown of supplying filament current and plate and grid potential to the thermionic discharge devices forms no part of this invention and obviously other means well known to those skilled in the art can be employed. A suitable antenna 16 is connected to transformer 1, a suitable detector 17 is connected to the output of thermionic discharge device 11, a suitable amplifier 18 to the output of the detector and a suitable receiver 19 to the output of the amplifier.

Preferably a grounded electrostatic shield 20 is employed to shield the entire radio frequency amplifier. It may be constructed of any suitable material capable of preventing transformers 1, 2, 3 and 4 from acting as antennæ. Without the use of such a shield volume control is difficult, especially when the receiver is located in the proximity of a powerful broadcasting station.

The operation of the amplifier system described above is as follows: Incoming high frequency signals are impressed on the grid-filament circuit of thermionic discharge device 9 by means of the antenna 16 and high frequency transformer 1 in the usual manner by adjusting the capacity 5 which tunes the circuit 5—21 to resonance with the signal. Capacities 6, 7 and 8 are also adjusted to tune the circuits 2—6, 3—7, and 4—8 to resonance with the incoming signals. The signals impressed on the grid-filament circuit of the thermionic discharge device 9 are amplified by the discharge device and by means of transformer 2 are impressed on the grid-filament circuit of thermionic discharge device 10. Since transformers 1 and 2 have their centers in line and their axes mutually at right angles to each other, no electro-magnetic coupling will exist between them. Due to the internal grid-plate capacity C_9 of the thermionic discharge device 9, there will be an electrostatic coupling between the input circuit and the output circuit which will tend to cause regeneration and singing. The signal voltage in the output circuit of thermionic discharge device 9 is amplified by transformer 2 and thermionic discharge device 10. The signal current in the output circuit of thermionic discharge device 10 induces a voltage across transformer 3 which is connected in the output circuit of this thermionic discharge device. Transformer 3 has been placed so that a magnetic coupling exists between it and transformer 1 in a direction to opposite regenerative feed back. This coupling induces an electro-magnetic potential across transformer 1 which tends to produce a current in transformer 1 in an opposite direction to that caused by the electro-static coupling through capacity C_9. The action caused by the magnetic coupling between the transformers may be termed a degenerative action since it tends to reduce the signal and neutralize the currents caused by the regenerative action due to the internal capacity C_9. Singing is thus prevented in thermionic discharge device 9. In a similar manner the magnetic coupling between transformers 4 and 2 induces an electro-magnetic potential across transformer 2 which prevents singing in thermionic discharge device 10. This action may be continued in any number of stages in which the alternate stages have their transformers magnetically coupled in a reverse direction.

While a single embodiment of the invention has been shown and described in detail, it is understood that the invention is generic in character and is not to be considered as limited to the particular embodiment described since numerous modifications thereof may be made by persons skilled in the art without departing from the spirit of applicant's invention, the scope of which is to be determined by the appended claims.

What is claimed is:

1. In a multi-stage amplifier including a thermionic discharge device in each stage, transformers coupling said discharge devices of adjacent stages, means for preventing un-

desired magnetic coupling between the transformers in adjacent stages, and means for creating magnetic coupling between the transformers in non-adjacent stages in a direction to oppose regeneration.

2. In a multi-stage radio frequency amplifier system, a plurality of thermionic discharge devices connected in tandem, said discharge devices coupled by means of transformers, means for preventing undesired magnetic coupling between the transformers in adjacent stages, and means for creating magnetic coupling between the transformers in non-adjacent stages in a direction to oppose regeneration.

3. The method of balancing the inter-electrode capacity effects of vacuum tubes in a multi-stage transformer coupled radio frequency amplifier system which consists in creating magnetic coupling between said transformers in non-adjacent stages in a direction to oppose regeneration, and preventing magnetic coupling between said transformers in adjacent stages.

4. In an amplifying system, a series of electric discharge devices connected in cascade, each electric discharge device being provided with a tuned input circuit, and an output circuit, whereby inherent capacity coupling may exist, means for balancing out the retro-active E. M. F. due to said inherent capacity, said means comprising means for preventing electro-magnetic coupling between the input and output circuits of each of said electric discharge devices and means for creating magnetic coupling between the input circuit of each of said electric discharge devices and the output circuit of a subsequent electric discharge device in a direction to oppose regeneration.

5. A radio receiving circuit comprising an antenna circuit, a plurality of three-element radio frequency amplifier tubes having plate, grid and filament and connected in cascade, each of said amplifier tubes having associated therewith an inductance, a variable capacity connected in effective shunt to said inductance to tune said inductance to resonance with a signal, a connection from said grid to one end of said inductance, a connection from the other end of said inductance to said filament, a connection from the plate of each of said amplifier tubes to the inductance connected between the grid and filament of the following amplifier tube, said inductances positioned in space as to prevent electromagnetic coupling between the input and output circuits of each electron discharge amplifier tube and to produce electromagnetic coupling between the input circuit of each of said radio frequency amplifier tubes and the output circuit of a subsequent radio frequency amplifier tube in a direction to oppose regeneration.

6. An electrical network containing a plurality of thermionic amplifiers having input and output circuits, each of said thermionic amplifiers having its input circuit adjustably coupled to the output circuit of a succeeding thermionic amplifier to oppose the effect upon said input circuit of currents in the output circuit of the same thermionic amplifier.

7. The method of repeating and amplifying substantially without distortion with a multi-stage ultra audio-frequency amplifier system having elements in the input circuit and elements in the output circuit of each stage which consists in creating magnetic coupling between at least one of the elements of each stage with at least one of the elements of a non-adjacent stage in a direction to oppose regeneration and preventing magnetic coupling between said input and output circuits of the same stage.

8. In a radio receiving system, an antenna circuit inductively coupled to the input circuit of a thermionic discharge device, said input circuit comprising an inductance and a capacitance tuned to resonance with a signal, a second inductance and capacitance coupled between the output circuit of said thermionic discharge device and the input of a second thermionic discharge device to tune the input of said second thermionic discharge device to resonance with a signal, a third inductance and capacitance coupled between the output circuit of said last mentioned thermionic discharge device and the input of a third thermionic discharge device to tune the input of said third thermionic discharge device to resonance with a signal, a fourth inductance and capacitance coupled between the output circuit of said last mentioned thermionic device and the input of a detector circuit, an amplifier circuit and a translating device, said inductances related to prevent electromagnetic coupling between the input and output circuits of each of said thermionic discharge devices and to create magnetic coupling between the input circuit of each of said thermionic discharge devices and the output circuit of a subsequent discharge device in a direction to oppose regeneration.

9. An amplifier for high frequency alternating currents comprising three-element amplifier tubes with tuned grid circuits in which the consecutive tubes are coupled together by transformers, said transformers having sufficiently small magnetic coupling between the transformers connected to the input and output circuits of each individual tube and sufficiently large coupling between transformers connected to the input of one tube and the output of a succeeding tube in a direction to oppose regeneration so that the effective inductive reaction of the grid circuit of a tube in the plate circuit of a preceding tube together with the inductive reaction of the plate circuit itself will always be below

the critical value required to cause the preceding tube to oscillate.

10. In a multi-stage ultra audio-frequency amplifier system having elements capable of interaction by their external magnetic fields, the method of repeating and amplifying substantially without distortion which comprises reducing to a less extent the interaction between elements in alternate stages than the interaction between elements in adjacent stages.

11. The combination in an amplifying system of a plurality of electron discharge amplifiers each of which has an input and an output circuit, energy transforming means connecting the output circuit of each tube with the input circuit of a succeeding tube, means for impressing currents which are to be amplified on the input circuit of one of said amplifiers and means for impressing energy variations produced in the output circuit of said amplifier on the energy transforming means associated with said output circuit, the energy transforming means being so related as to prevent electromagnetic coupling between the input and output circuits of each electron discharge amplifier and to produce electromagnetic coupling between the input circuit of each electron discharge amplifier and the output circuit of an electron discharge amplifier other than that to which said last mentioned input circuit is connected in a direction to oppose regeneration.

In witness whereof, I hereunto subscribe my name this 4th day of December, 1928.

OLINDO O. CECCARINI.