July 23, 1929. V. M. GRAHAM 1,721,991

SIGNALING SYSTEM

Filed Aug. 7, 1925

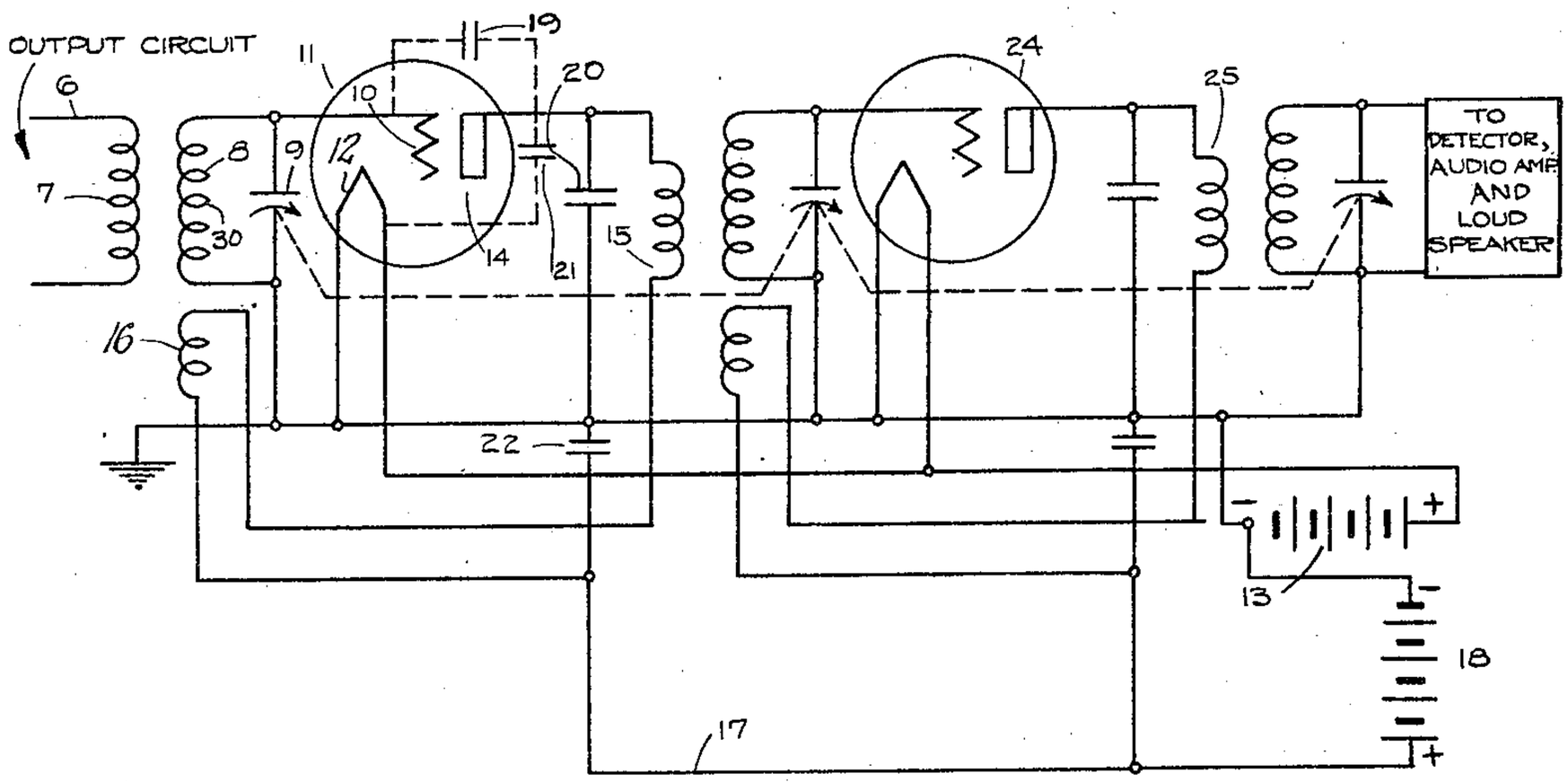

FIG. 1

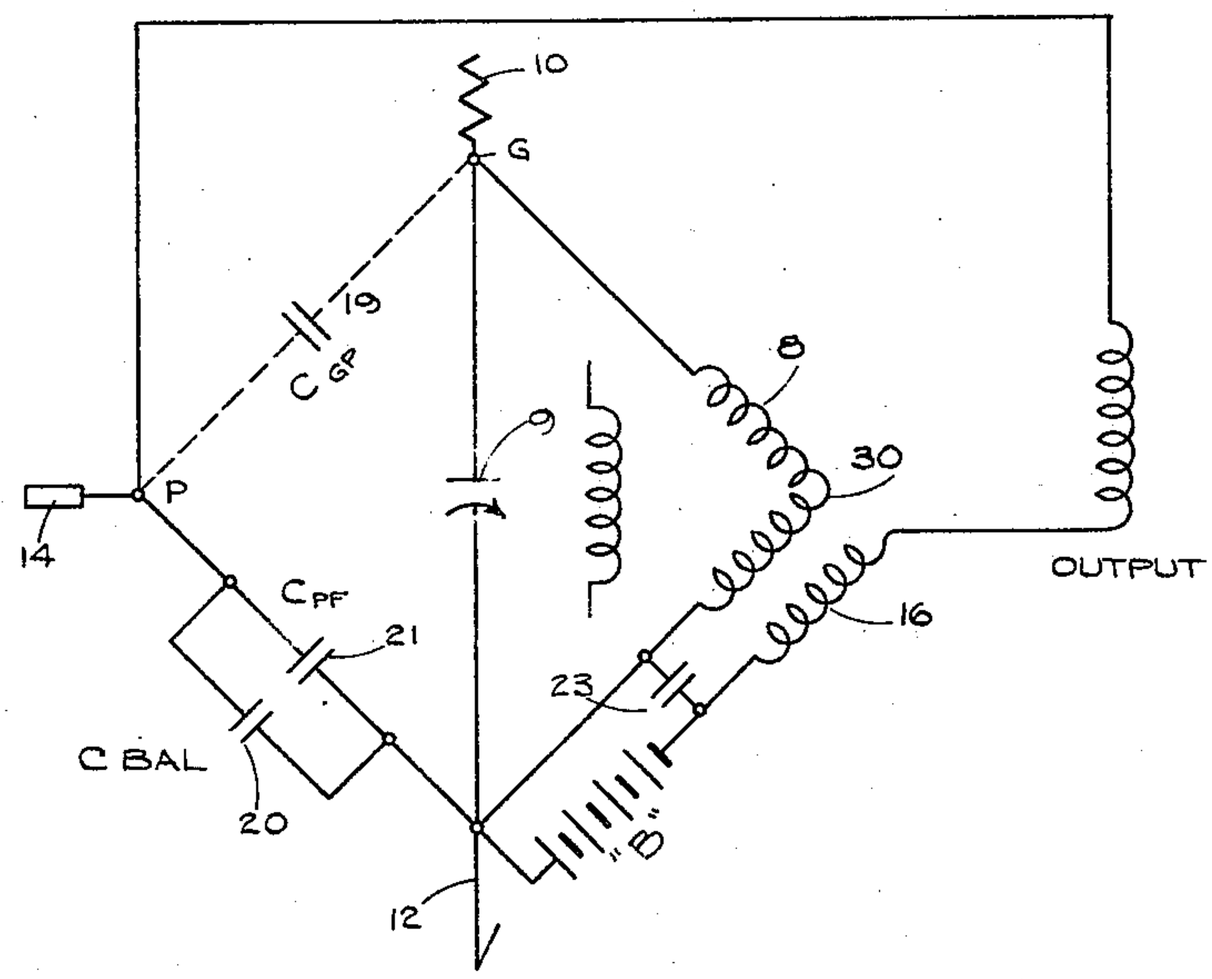

FIG. 2

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UNITED STATES PATENT OFFICE.

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SIGNALING SYSTEM.

Application filed August 7, 1925. Serial No. 48,824.

This invention relates to signaling systems and more particularly to signaling systems in which radio-frequency amplification is employed.

It has long been recognized that radio-frequency amplification of incoming signals prior to their detection and translation into audible signals, possesses certain advantages, but due to the fact that when it is employed even in a single stage, undesirable oscillations arising from inherent capacity couplings, such as that between the grid and plate of the thermionic tube in each stage, mask the signals, such circuits, unless properly modified, are very unsatisfactory.

In order to eliminate the mentioned undesirable coupling and thereby prevent disturbing oscillations, several arrangements have been proposed. Among these arrangements it has been suggested that circuits and elements of a thermionic amplifier be arranged, as an impedance bridge with the input and output circuits connected to conjugate pairs of points in said bridge. When former arrangements have been extended for use in a multi-stage amplifier, it was necessary to individualize the tuning elements of each stage, either by providing a separate tuning condenser with its own control or to insulatedly separate the rotor units of the condenser of the several stages on a common rotor shaft. This last arrangement is an unsatisfactory one from a mechanical stand-point, because it necessitates an insulating bushing for joining the shafts of the two rotor units, and is also unsatisfactory from a manufacturing stand-point, because of the difficulty in assembling and electrically aligning the electrical condensers.

In accordance with the present invention, it is proposed to provide a multi-stage tuned radio-frequency amplifier in which various elements of each stage are arranged in an impedance bridge with the input circuit connected across two opposite pairs of points of the bridge and the output circuit connected across the other two points and where in the rotor units of the tuning elements need not be individualized electrically.

Other features of the invention will appear from the detailed description and appended claims.

In the drawings Fig. 1 represents two stages of a multi-stage tuned radio-frequency amplifier and a portion of a detector unit. Fig. 2 is a diagrammatic showing of one radio frequency stage representing the circuit of the invention arranged in the conventional form of an impedance bridge.

Referring to Fig. 1, 6 indicates an output circuit of a vacuum tube including in series with the primary winding 7 of a coupling transformer. The secondary winding 8 of this transformer with the variable condenser 9 are connected to form a well known tuned input circuit across the grid 10 and the filament 12 of thermionic tube designated 11, which may be heated from the common source of heating battery 13. The output circuit of the thermionic tube 11 extends from the plate 14 thereof, through the primary winding 15 of a second transformer and thence through the winding of a coil 16 closely coupled to the lower portion of the secondary winding 8, thence through the conductor 17 and the plate battery to one side of the filament heating system. As is well known there is present an inherent capacity between the elements of a thermionic tube such as the grid 10 and the plate 14, which serves to couple the output circuit to the input circuit of the tube effecting regeneration and resulting undesirable oscillation. In order to compensate for this undesirable capacity and thereby eliminate regeneration, a fixed condenser 20 is provided between one side of filament 12 and the plate 14 to cooperate with other elements and circuits of the stage. The circuits just described are so arranged and have their constants so selected that they constitute an impedance bridge.

This arrangement of the circuits is best understood by reference to Fig. 2, wherein corresponding parts are indicated by the same reference characters and in which the inherent capacity 19 forms one arm, while the compensating condenser 20 in parallel with the inherent capacity 21 existing between the plate and filament of the thermionic tube forms the other arm of an impedance bridge. The other two arms of the bridge include the secondary winding 8, which may be considered as being electrically separated into two parts at point 30. In this bridge, the grid and the filament are connected at diagonally opposite points, while the plate is connected to

a point on the bridge diagonally opposite the point 30 on the coil 8. The input circuit of the thermionic tube is connected at two diagonally opposite points on the bridge, that is between the grid and filament, while the output circuit of the thermionic tube is connected to the remaining two diagonal points on the bridge. This exists as a conductive connection at one end to the plate and an inductive connection to an intermediate point 30 on the coil 8, connected inductively through the coil 16, although conductively the output circuit is connected through the coil 16 and the plate battery 18 to the filament 12.

Since the arms of the bridge are so selected that they are balanced, any difference of potential across the plate and the intermediate point 30 of the coil 8 will have no effect on the input circuit connected across the other two equi-potential points on the bridge.

The primary winding 15 of the transformer included in the output circuit of the vacuum tube 11 serves to couple this thermionic tube to the input circuit of a second thermionic tube 24 in a succeeding stage of radio-frequency amplification, arrangement and the operation of which are a duplication of those previously described and need not be repeated. The output circuit of the thermionic tube 24 includes the primary winding 25 of a transformer, whose secondary winding is included in the tuned input circuit of a third thermionic tube, which may be another stage of radio-frequency amplification or may be a thermionic detector. It will be understood, that while only two radio-frequency stages are shown in this disclosure, three or more may be used in practice depending upon the care in the mechanical and electrical design of the amplifier.

It will be noted that the rotor units of all the tuning condensers of the several tuned stages are indicated as having their rotors connected to a common conductor, however, in actual practice these rotors are mounted on a common conducting shaft, indicated by a dotted connection between the rotors in Fig. 1, by which they may be simultaneously adjusted by means of a single control. An electrical condenser of the type suitable for use in the present circuits and in which the rotor elements of the several condenser units are mounted on a common conducting shaft, is shown in the application of R. H. Manson, Serial No. 693,382, filed February 16, 1924. The condenser structure of this application shows special vernier controls, which may or may not be necessary in the circuit arrangement of this disclosure, depending upon the care in arranging the electrical circuits and in selecting their electrical constants.

The present disclosure is merely typical of one form of applicant's invention and is not to be considered as limiting this invention, except as specified in the appended claims.

What I claim is:

1. The method of radio-frequency amplification in a multi-stage amplifier, in which the input circuit of each amplifier is tuned to the frequency of the incoming signal, which consists in arranging the circuits and amplifying elements of each stage as a fixed impedance bridge, connecting the input circuit of each stage to one set of conjugate points on its impedance bridge, connecting the output circuit of each stage to another set of conjugate points on its bridge, simultaneously tuning the input circuits by adjustable impedances one in each stage and conductively connecting said adjustable impedances together.

2. The method of radio-frequency amplification in a multi-stage amplifier, in which the input circuit of each stage is tuned to the frequency of the incoming signal, which consists in arranging the circuits and amplifying elements of each stage to form a fixed impedance bridge, connecting the input circuit of each stage to one set of conjugate points on the impedance bridge, connecting the output circuit to another set of conjugate points on said bridge, employing impedances adjustable in common and conductively connecting said impedances together.

3. In an amplifying system including a plurality of stages, amplifying elements and a variable tuning element for each stage, circuits for connecting the elements of each stage in a fixed four-arm impedance bridge, and a means conductively connecting the tuning elements of several stages, whereby the same may be simultaneously varied.

4. In an amplifying system, a plurality of stages, transformers for coupling said stages, an electron discharge device and associated circuits in each stage to form a fixed four-arm impedance bridge, other circuits connected to said impedance bridges and including input circuits, each tuned by a condenser having a stator and a rotor, means conductively connecting the rotors of several stages, whereby they may be simultaneously adjusted.

5. In an amplifier, an electron discharge tube having cathode, plate and grid electrodes with inherent capacity existing therebetween, an impedance bridge connecting said electrodes, the inherent capacity between the grid and the plate electrodes forming one arm of said bridge, a compensating condenser connected between said plate and cathode electrodes in parallel with the inherent capacity between said last mentioned electrodes forming a second arm of said bridge, an input circuit including a secondary winding of a transformer connected between the grid and cathode to form the other two arms of said bridge, an output circuit connecting said plate and

cathode, and a coil in said output circuit conductively connected to an intermediate point on said secondary winding.

6. In an amplifier; a plurality of amplifying stages; a transformer coupling said stages; each stage being provided with a tuning element, an electron discharge tube having cathode, grid and plate electrodes with inherent capacity existing there-between, an impedance bridge connecting said electrodes, the inherent capacity between the grid and the plate electrodes forming one arm of said bridge, a compensating condenser connected between said plate and cathode electrodes in parallel with the inherent capacity between said last mentioned electrodes, forming a second arm of said bridge, an input circuit including a secondary winding of an input transformer connected between the grid and cathode to form the other two arms of said bridge, an output circuit connecting said plate and cathode, and a coil in said output circuit inductively connected to an intermediate point on said secondary winding; and common conducting means in said tuning elements.

7. In a signaling system, a plurality of amplifying stages, an electron discharge device in each stage, an input circuit and an output circuit for each electron discharge device, a transformer having a primary winding in an output circuit of one electron discharge device and a secondary winding in the input circuit of an adjacent electron discharge device, a variable condenser having a stator and a rotor element, connected in multiple of each secondary winding to tune its input circuit, a compensating condenser connected between the plate and the cathode of each electron discharge device, a coil in the output circuit of each electron discharge device, said coil being inductively coupled to an intermediate point on the secondary winding in the input circuit of said electron discharge device, and a shaft for conductively connecting and simultaneously adjusting said rotor units.

8. In a signaling system, a plurality of amplifying stages, an electron discharge device in each stage provided with filament, grid and plate electrodes with inherent capacity existing between said electrodes, an output circuit for each electron discharge device, connected between its plate and its cathode, an input circuit for each electron discharge device connected between its grid and its cathode, a transformer having a primary winding in the output circuit of one electron discharge device and a secondary winding in the input circuit of an adjacent electron discharge device, a condenser provided with a stator and a rotor element connected in parallel with the secondary winding in each input circuit to tune the same variably, a compensating condenser connected between the plate and the cathode of each electron discharge device, a coil in each output circuit inductively connected to an intermediate point on the preceding secondary winding to divide said winding electrically into two parts, said compensating condenser and the two parts of said primary winding functioning as an impedance bridge in each stage to eliminate inherent capacity between the grid and plate thereof.

9. In a signaling system, a plurality of amplifying stages, an electron discharge device in each stage provided with cathode, grid and plate electrodes, with inherent capacity existing between said electrodes, an output circuit for each electron discharge device, connected between its plate and its cathode, an input circuit for each electron discharge device connected between its grid and its cathode, a transformer having a primary winding in the output circuit of one electron discharge device and a secondary winding in the input circuit of an adjacent electron discharge device, a condenser provided with a stator and a rotor element connected in parallel with the secondary winding in each input circuit to tune the same variably, a compensating condenser connected between the plate and the cathode of each electron discharge device, a coil in each output circuit, inductively connected to an intermediate point on the preceding secondary winding to divide said winding electrically into two parts, said compensating condenser and the two parts of said primary winding functioning as an impedance bridge in each stage to eliminate inherent capacity between the grid and plate thereof, and a common conducting shaft for adjusting said rotor units simultaneously.

In witness whereof, I hereunto subscribe my name this sixth day of August A. D. 1925.

VIRGIL M. GRAHAM.