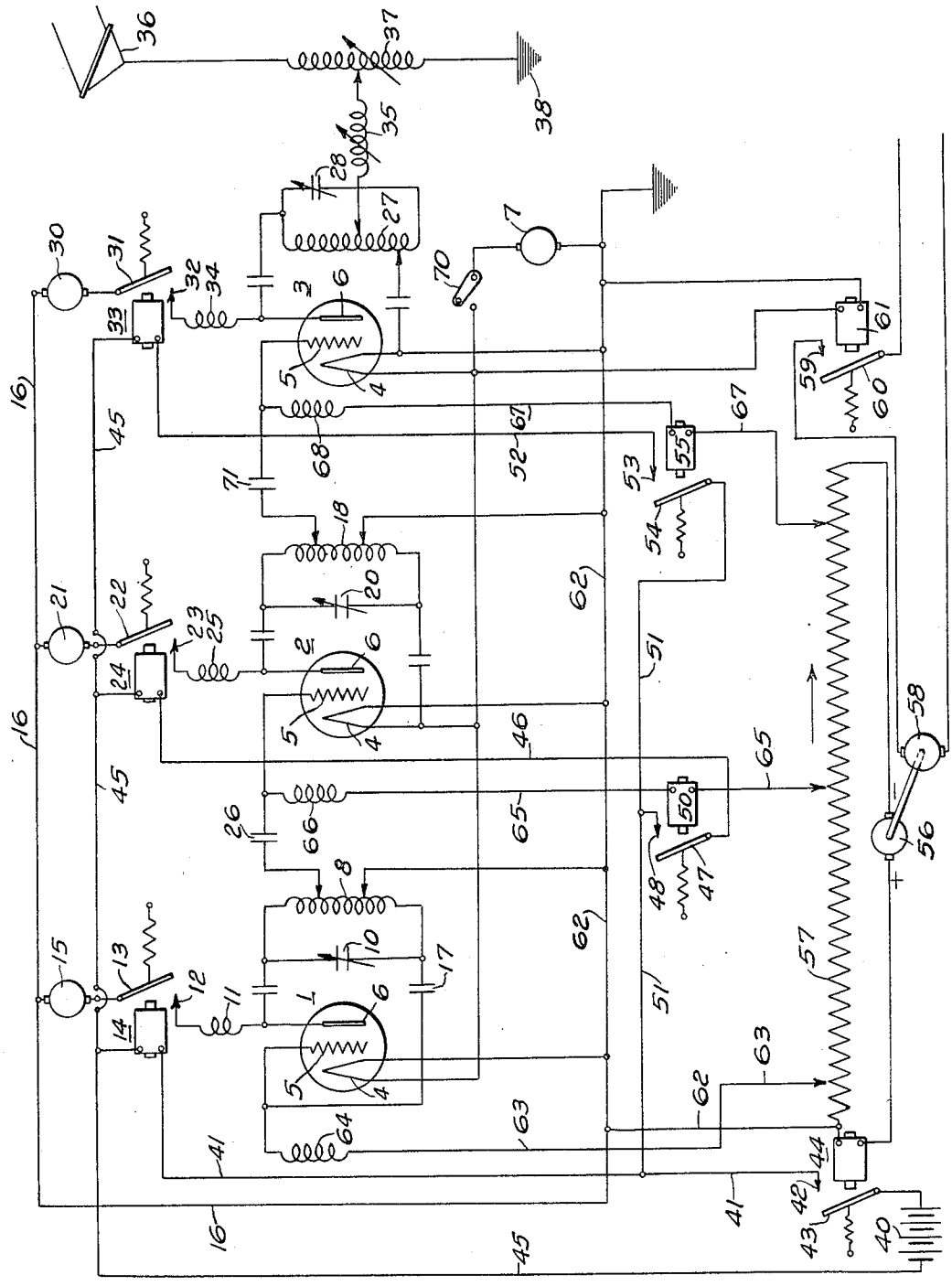
Nov. 7, 1933. R. L. DAVIS 1,934,525

WAVE TRANSMISSION SYSTEM

Filed Nov. 7, 1927



INVENTOR
Robert L. Davis.
BY
Wesley G. Carr
ATTORNEY

Patented Nov. 7, 1933 1,934,525

# UNITED STATES PATENT OFFICE

1,934,525

## WAVE TRANSMISSION SYSTEM

Robert L. Davis, Pittsburgh, Pa., assignor to Westinghouse Electric & Manufacturing Company, a corporation of Pennsylvania

Application November 7, 1927. Serial No. 231,521

7 Claims. (Cl. 250—27)

My invention relates broadly to wave-transmission systems, and it has particular relation to safety devices used therein for preventing abnormal circuit conditions from causing damage.

Within the past few years, the power output of radio transmission systems has steadily increased. It is not at all uncommon, at the present time, to radiate, in the form of high-frequency oscillatory energy, as much as 50 to 100 kilowatts from a single station. The amplifier, modulator, and oscillator tubes employed in high-power stations all handle large amounts of power and are easily damaged by excessive overloads. Such tubes are relatively expensive, and it is highly desirable that they shall be protected against damage by a plurality of safety devices.

In the patent to Ryan, 1,565,505, means are shown whereby a plurality of abnormal conditions are each instrumental in causing the removal of power from the thermionic devices. Among such conditions may be mentioned (1) decrease in the flow of cooling water, (2) too high temperature of the cooling water, (3) overloading of the power amplifier tubes, (4) abnormal current in the power transformer and, (5) exposure of energized apparatus to accidental contact by the operator. Insofar as I am aware, however, previous workers in the art have not fully appreciated the necessity of providing means for preventing the application of plate potential to power tubes in the event that the grids thereof are not biased to the proper negative potential, and have overlooked the possibilities of tube-damage caused by the resulting heavy plate current.

It is accordingly an object of my invention to provide, in wave transmission systems of the type comprising high-power tubes, instrumentalities that function to prevent the application of plate potential to such tubes in the event that the grids thereof are not properly biased.

It is a further object of my invention to provide, in systems of the type referred to, instrumentalities which will function to deprive any given tube of plate potential in the event of failure of the grid-bias-potential supply thereto.

Another object of my invention is to provide instrumentalities whereby each of a plurality of power-tubes connected in cascade shall be supplied with plate-potential in proper sequence, upon the actuation of a single control-device.

Another and more specific object of my invention is to provide, in wave transmission systems of the type in which are utilized a master oscillator and a plurality of power amplifiers, instrumentalities which will function to deprive the power amplifiers of plate potential in the event that the grid-bias-potential supply to the master oscillator is interrupted.

In one commercial embodiment of my invention, I attain the above referred-to objects by interposing relay devices in the conductors supplying grid-bias potential to each of the power-tubes, and interpose additional relay devices in the plate circuits of the individual tubes, so arranging the second-mentioned relay devices that they are controlled by the first-mentioned relay-devices.

Among the novel features of my invention are those particularly set forth in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with further objects and advantages thereof, will best be understood from a consideration of the following description of a specific embodiment taken in connection with the accompanying drawing.

The single figure of the drawing is a diagrammatic view of a radio-transmission system in which is incorporated a preferred form of my invention.

The apparatus illustrated in the drawing comprises a thermionic oscillator 1 coupled in cascade to a thermionic amplifier 2, which, in turn, is coupled to a second thermionic amplifier 3, preferably of higher power.

Each of the thermionic devices comprises a filament 4, a grid 5 and a plate 6, and is supplied with filament power from a source 7, which source may be either a battery or a generator, as shown.

The plate or output circuit of the thermionic oscillator may be considered as comprising two distinct portions, (1) a tuned loop consisting of an inductor 8, shunted by a tuning condenser 10, in which loop flows the high-frequency component of the plate current and, (2) a direct-current path comprising a radio-frequency choke 11, the fixed contact 12 and movable armature 13 of a relay 14, a source 15 of high potential and a conductor 16 connecting the negative pole of the source 15 to the filament. The oscillation generator is not provided with a distinct and separate input circuit, grid excitation therefor being obtained through a condenser 17 which couples the grid 5 to the oscillatory output circuit.

The thermionic amplifier device 2 is provided with an output circuit comprising an inductor 18 shunted by a tuning condenser 20, and high potential for the plate of the device is supplied from

a generator 21 through a circuit which includes the movable armature 22 and fixed contact 23 of a relay 24, and a radio-frequency choke coil 25. The grid of the thermionic amplifier 2 is coupled to the output circuit of the preceding oscillator through a condenser 26.

The second thermionic amplifier 3 is provided with an output or tank circuit comprising an inductor 27 shunted by a tuning condenser 28, and plate potential for the amplifier is supplied from a generator 30 over a circuit which includes a movable armature 31 and fixed contact 32 of a relay 33, and a radio-frequency choke coil 34.

The output circuit 27—28 is coupled, by means of a variable reactor 35, to a radiation structure which preferably includes an antenna 36, a variable inductor 37 and a ground connection 38, or a counterpoise.

The winding of the relay 14, associated with the high-potential supply circuit for the thermionic oscillator 1, is arranged to be energized from a battery 40, the energizing circuit comprising a conductor 45, a conductor 41 and the fixed contact 42 and movable armature 43 of a relay 44.

The winding of the relay 24, associated with the plate-potential supply for the first amplifier tube 2, is supplied with current from the battery 40 over a circuit including the conductor 45, a conductor 46, the movable armature 47 and the fixed contact 48 of a relay 50 and a conductor 51 which is connected to the conductor 41.

The winding of the relay 33, associated with the plate-potential supply circuit of the second amplifier device 3, is supplied with current from the battery 40 over a circuit including the conductor 45, a conductor 52, the fixed contact 53 and the movable armature 54 of a relay 55 and the conductor 51.

In order to supply grid-biasing potential for the several thermionic devices, I provide a generator 56 having a resistor 57 and the winding of the relay 44 connected in shunt thereto. The generator 56 is preferably actuated by a driving motor 58 which is supplied with power from any convenient commercial source, the supply circuit including the fixed contact 59 and the movable contact 60 of a relay 61.

The filaments of the thermionic devices 1, 2 and 3 are connected to the positive end of the resistor 57, adjacent to the relay 44, through a conductor 62, thus maintaining the filaments at a positive potential with respect to all points on the resistor as long as current is passing through the resistor from the generator 56.

The grid of the thermionic oscillator 1 is connected to a point on the resistor 56 near the positive end thereof, by means of a conductor 63, the connection including a radio-frequency choke coil 64. The grid of the first amplifier device is connected to a more negative point on the resistor 57 by means of a conductor 65, the connection including a radio-frequency choke coil 66 and the winding of the relay 50. The grid of the second thermionic amplifier is connected to a still more negative point on the resistor by means of a conductor 67, the connection including a radio-frequency choke coil 68 and the winding of the relay 55.

A starting switch 70, which may be of any well known type, is included in the filament supply circuit connected to the generator 7, and the generators 15, 21, 30 and 57 are provided with suitable driving motors (not shown). The generators 15, 21, 30 and 56 may be replaced by storage batteries, if desired, or suitable rectifiers may be substituted therefor.

In order to explain the operation of a wave-transmission system arranged according to my invention, it should first be assumed that potential has been supplied to the motors driving the generators 15, 21, 30 and 7. The starting switch 70 is then closed, completing the filament supply circuit for the thermionic devices, and energizing the winding of the relay 61. As soon as the relay 61 is energized, the armature 60 is drawn against the fixed contact 59, closing the circuit which supplies potential to the motor 58 which drives the bias-potential generator 56. A current then flows in the resistor 57, in the direction indicated by the arrow, and through the winding of the relay 44, causing the armature 43 thereof to be attracted toward, and make contact with, the fixed contact 42. A circuit is accordingly completed through the conductors 45 and 41 which permits the battery 40 to energize the winding of the relay 14 associated with the plate-potential supply circuit of the oscillator device 1. Upon energization of the relay 14, the armature 13 is drawn against the fixed contact 12, and plate-potential is accordingly applied to the oscillator 1, permitting the generation of oscillations thereby.

As soon as oscillatory currents appear in the output circuit of the oscillator tube, they are applied across the input circuit of the first amplifier tube through the coupling condenser 26 and the conductor 62. During positive half-cycles, electrons are attracted to the grid of the amplifier tube, and a grid current accordingly flows through a circuit which may be traced from the grid through the choke coil 66, the winding of the relay 50, the resistor 57 and over the conductor 62 which is connected to the filaments of all of the tubes. The relay 50, being accordingly energized, pulls up the armature 47 and completes a circuit which permits the application of potential from the battery 44 to the winding of the relay 24 associated with the plate supply circuit of the first amplifier tube.

The energizing circuit for the relay 24 may be traced from the positive pole of the battery 40 over the conductor 45, through the winding of the relay, the movable contact 47 of the relay 50, the fixed contact 48 of the same relay, the conductor 51, the fixed contact 42 of the relay 44, the armature 43 of the same relay and back to the negative pole of the battery. The armature 22 of the relay 24 is accordingly caused to move against the fixed contact 23 associated therewith, and potential is applied from the generator 21 to the plate of the amplifier tube.

The oscillations generated by the oscillation-generator tube will accordingly be amplified and repeated in the output circuit of the amplifier tube, which circuit comprises the inductor 18 and the tuning condenser 20. A portion of the potential drop across the output inductor is applied to the input circuit of the second amplifier tube 3 by means of a coupling condenser 71 and the conductor 62.

The sequence of operations above described in connection with the application of plate potential to the first amplifier tube is now repeated in connection with a second amplifier tube. The relay 55 being energized by the rectified grid current in the amplifier tube 3, permits the energization of the relay 33 to apply potential to the plate of the second amplifier tube. As soon as plate potential is applied, in the manner just described, the tube begins to function as an ampli-

fier, and the resulting oscillations in the output circuit thereof may be supplied to the radiating structure by means of a coupling device of any appropriate type.

After the system has reached a stable state, the connections of the several grids to the resistor may be so readjusted, if desirable, that each thermionic device receives the proper grid-biasing potential. Obviously, if the points of connection of the conductors 63, 65 and 67 are moved toward the negative end of the resistor, the bias potentials on the respective grids will become more negative with respect to the common filament connection 62, and vice versa.

If, for any reason, the bias potential generator 56 fails, the relay 44 will be deenergized, and holding current will be removed from the relays 14, 24 and 33 associated with the high-potential supply circuits for the several tubes. Should the oscillator tube cease to function, input excitation for the first amplifier stage would also cease and, consequently, the relay 50 would be deenergized by reason of the cessation of grid current through the winding thereof. The deenergization of this relay would in turn deenergize the relay 24 associated with the plate supply circuit for the first amplifier tube and that tube would cease delivering input excitation to the second amplifier tube. Inasmuch as the relay 55 would, accordingly, be deprived of holding current, the relay 33 associated with the high-potential supply circuit of the second amplifier tube would be deenergized, permitting the said circuit to be broken.

If, for any reason, the grid-leak circuit of either the oscillator tube or the first amplifier tube becomes broken, the same sequence of operations just described will take place and the tubes will be depriced of plate potential.

I have accordingly provided a system that is very effective in preventing damage to high-power tubes upon failure of grid-bias potential supply thereto. In addition, when my invention is incorporated in a wave-transmission system, the proper sequential operation of the successive tubes connected in cascade is assured. The load is not thrown abruptly on the system, but is applied gradually, inasmuch as the several tubes go progressively into operation.

Although I have shown the relays 14, 24 and 33 as connected in circuit between the high-potential generators 15, 21 and 30 and the individual thermionic devices supplied with plate potential thereby, these relays may quite advantageously be inserted in the circuits which supply potential to the motors driving the several generators. The switch 70 may also be included in the circuit supplying energy to the motor (not shown) which drives the generator 7, in which event the entire transmission system can be set into operation in proper sequence by the mere closing of the said switch.

In addition, my invention prevents the application of plate potential to any tube which is not properly biased, and a destructive plate current therein is accordingly obviated.

Although I have shown and described only a single embodiment of my invention, numerous modifications will be apparent to those skilled in the art. My invention, therefore, is not to be limited except insofar as is necessitated by the prior art or by the spirit of the appended claims.

I claim as my invention:

1. In a wave-transmission system, a plurality of thermionic devices, means for supplying plate-potential thereto, means for supplying grid-biasing potential to said devices, and means individual to each device for disconnecting the plate-potential supply therefrom upon failure of the grid-biasing potential supply.

2. In a wave-transmission system, a plurality of thermionic devices, means for supplying plate-potential thereto, common means for supplying all of said devices with grid-biasing potential, and means individual to certain of said devices for preventing the application of plate-potential thereto in the absence of grid-biasing potential.

3. In combination, a plurality of thermionic amplifiers, a thermionic oscillation generator coupled thereto, means for supplying all of said devices with plate potential, means for supplying said devices with grid-biasing potential, and means whereby a failure of grid-biasing potential supply to said oscillation generator causes an interruption to the plate potential supplied to said amplifiers.

4. In combination, a plurality of thermionic amplifiers, a thermionic oscillation generator coupled thereto, means for supplying all of said devices with plate potential, means for supplying said devices with grid-biasing potential, and means whereby a failure of grid-biasing potential supply to said oscillation generator causes an interruption to the plate potential supplied to all of said thermionic devices.

5. In a wave-transmission system, a thermionic oscillation generator, a thermionic amplifier coupled thereto, means for providing plate potential for said devices, and means responsive to electrical conditions in the output circuit of said oscillation generator for controlling the application of plate potential to said thermionic amplifier.

6. In a wave-transmission system comprising at least two thermionic devices connected in cascade, means for providing plate potential for said devices, and means responsive to electrical conditions in the output circuit of the earlier device in the series for controlling the application of plate potential to the later device.

7. In combination, a thermionic device having an output circuit and an input circuit, a grid-condenser and grid-leak associated with said input circuit, means for applying electrical potential variations across said input circuit whereby said device functions as a rectifier to permit current to flow in said grid leak, a plate-potential source, and means responsive to said grid-leak current for controlling the connection of said source in said output circuit.

ROBERT L. DAVIS.