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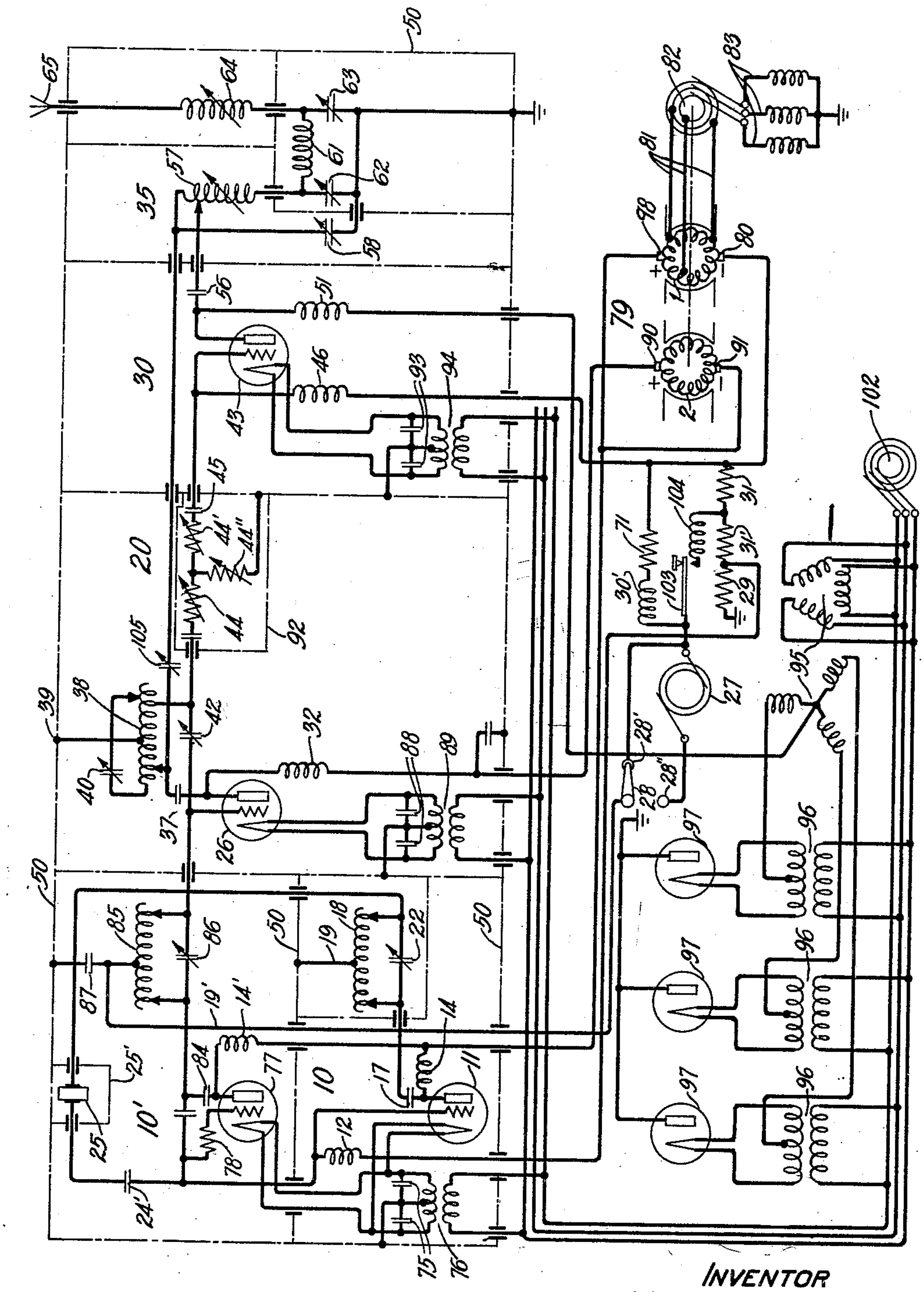

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CIRCUIT FOR ELECTRIC DISCHARGE DEVICES

Application filed October 28, 1927. Serial No. 229,450.

This invention relates to circuits for electric discharge devices and particularly to high frequency signal transmission systems.

An object of the invention is to simplify the circuit arrangement for supplying the required potentials to electric discharge devices.

In a specific embodiment, the invention is shown herein applied to a radio transmitter, which includes a crystal controlled electric discharge oscillator for generating a radio frequency wave and a multi-stage electric discharge power amplifier for amplifying the output of the oscillator. A single direct current generator is employed for supplying space current to the oscillator and grid biasing potential to the various stages of the amplifier, the grid of the last high power stage being connected directly to the negative terminal of the generator and the other stages being connected through a potentiometer network arrangement for obtaining the desired potentials. In order to employ a single source of potential for this purpose and still maintain the cathodes of all the discharge devices at ground potential, connections to the cathodes are made by the use of three slip rings connected to equi-distant points on the armature winding of the generator and grounded through a Y connected three phase coil.

The invention will be more readily understood by reference to the following detailed description of the radio telegraph transmitter shown in the drawing.

Referring to the drawing there is shown a radio telegraph transmitting system comprising a crystal controlled oscillator 10 coupled to a power amplifier comprising three tandem connected stages 10′, 20 and 30. The output circuit of the stage 30 is coupled to an antenna 65 by means of unit 35. The respective units 10, 10′, 20, 30 and 35 as well as the filter 61—62—63 are each included in a shielding compartment which completely encloses it except for suitable openings through which certain conductors pass. The shielding is shown by the broken lines 50.

The amplifier 10′ is interposed between the control oscillator 10 and the power amplifier 20 for the purpose of preventing reaction of the amplifier 20 upon the control oscillator 10.

The oscillator 10 includes the tube 11 having an input circuit connected to its control electrode and cathode. This circuit, for direct current, includes the high frequency choke coil 12 and the resistance 29 which has its remote terminal connected to ground and thence to the cathode of tube 11 by a path including shield conductor 50 and the secondary winding of transformer 76, which is connected to the filament of tube 11.

The feed-back circuit of tube 11 includes a blocking condenser 17 having one terminal connected to the anode, resonant circuit 18, 22, the piezo crystal control element 25, mounted in a separate shielding compartment 25′, and a second blocking condenser 24′. A mid-tap on inductance 18 of resonant circuit 18, 22 is connected by the lead 19 directly to the shield 50 and thereby to the filament of tube 11 through the condensers 75.

Element 18 of the resonant circuit is an adjustable inductance, and element 22 is an adjustable condenser. This circuit is preferably adjusted to the frequency at which oscillations are to be generated.

Piezo-electric element 25, which cooperates with resonant circuit 18, 22 in determining the frequency of oscillations, may be constructed in any well known manner and may consist of a quartz crystal of desired shape positioned between conductive plates. The manner of cutting and mounting such crystals is described in applications of W. A. Marrison, Serial No. 734,189, filed August 26, 1924 and Serial No. 730,165, filed August 5, 1924.

The amplifier 10′ comprises the space discharge tube 77 having its control electrode connected directly to the control electrode of tube 11 by a path including the resistance 78. This resistance reduces the coupling between the grids of tubes 11 and 77.

The anode of tube 77 is connected in parallel to the anode circuit of tube 11 by a path including the high frequency choke coil 14′. The space current paths for tubes 11 and 77 may be traced through the respective choke coils 14 and 14′ to the positive brush 98 of a double armature direct current generator 79, through the armature taps 81, slip rings 82 and associated brushes, and the star connected coils 83 to ground, and from ground through the conductor 50 to the cathodes of tubes 11 and 77 which are connected in parallel to the secondary winding of transformer 76.

A high frequency output circuit for tube 77 is connected to its anode and cathode and includes condenser 84 in series with resonant circuit 85, 86 and condenser 87, which has one terminal connected to ground through the shielding conductor 50.

The input circuit of tube 26, in amplifier 20, includes its control electrode and cathode. This circuit is coupled to the resonant circuit 85, 86, whereby amplified oscillations transmitted from control oscillator 10 through amplifier 77 are supplied to the input circuit of tube 26. This input circuit, for direct current, may be traced from the control electrode through inductance 85, lead 19′, switch 28, and either directly or via generator 27 to choke coil 30′, resistances 71, 31, 31′ and 29 in series, to ground and thence to the cathode of tube 26 by way of the shield conductor 50 and the secondary winding of transformer 89.

The space current circuit of tube 26 may be traced from its anode through high frequency choke coil 32 to the positive brush 90 on the second armature of generator 79 through the armature to the negative brush 91, positive brush 78 of the first armature through leads 81, slip rings 82, coils 83 to ground and thence to the cathode of the tube through conductor 50.

Tube 26 has a feed-back circuit, including in series condenser 37, resonant circuit 38, 40, and adjustable condenser 42, connected between its anode and control electrode. Resonant circuit 38, 40 is likewise tuned to the frequency of oscillations determined by the crystal 25.

A T arrangement of adjustable resistances 44, 44′ and 44″ is included between the output circuit of tube 26 and the input circuit of tube 43 in the amplifier stage 30. By means of these resistances, the voltage of waves supplied to the tube 43 may be adjusted to the desired value and at the same time, the impedance of the circuit may be matched to the respective output and input impedances of tubes 26 and 43.

A blocking condenser 45 is included between resistance 44′ and the control electrode of tube 43. Resistances 44, 44′, 44″ and the associated blocking condensers are enclosed in a separate shielded compartment 92.

The direct current input circuit of tube 43, connected between its control electrode and cathode, may be traced through the high frequency choke coil 46, to the negative brush 80 of generator 79, through leads 81, slip rings 82 and coils 83 to ground and thence by way of conductor 50 and the secondary winding of transformer 94 to the cathode of tube 43.

The space current circuit of tube 43 may be traced from its anode through high frequency choke coil 51 to the neutral point of the star connected secondary winding of three-phase transformer 95, from the respective outer terminals of this transformer winding to the mid-tap on the secondary windings of delta-connected, three-phase transformers 96, to the cathodes of space discharge rectifiers 97, to ground and thence to the cathode of tube 43.

The high frequency output circuit for tube 43 is connected to the anode and cathode and includes a condenser 56 in series with resonant circuit 57, 58, and a low pass filter 61, 62, 63 to ground at the shield conductor 50. The antenna 65 is also connected to ground by a path including adjustable inductance 64 and a variable condenser 63 in series. Condenser 63 is common to the output circuit of tube 43 and to the antenna circuit.

The filter 61, 62, 63 is designed to transmit a band of frequencies including the fundamental of the generated oscillations and to constitute a capacity reactance at the frequency of transmitted waves, and to correspond to the proper coupling capacity to be inserted between the output and antenna circuits. For harmonic frequencies the filter constitutes a high impedance path for excluding these frequencies from the antenna circuit.

A feed-back path for tube 43 connected between its anode and control electrode includes condenser 56, a small portion of inductance 57, adjustable condenser 105, resonant circuit 38, 40, resistances 44 and 44′ and condenser 45.

The filament current for tubes 26, 43 and 77 is supplied by the three-phase transformers 76, 89 and 94, delta-connected to an alternating current generator 102. The rectifiers 97 have their filaments heated by current from transformers 96 which are also delta-connected to generator 102. The current to be rectified is supplied through transformer 95 which has its primary delta-connected to the generator 102 and its secondary star connected to the rectifiers.

The key 103 is arranged to provide a low impedance path in shunt to resistance 31, thereby reducing the blocking potential applied to the control electrode of tube 26 so that this tube generates oscillations. These oscillations are applied to the input circuit of tube 43 which is thereby caused to generate oscillations.

In the operation of this system, oscillations are produced in the generator 10 by virtue of the feed-back coupling between the input and output circuits of tube 11. Since this feed-back circuit includes the piezo-electric device 25, the frequency of oscillations is determined by a natural frequency of the piezo-crystal in the manner set forth in the application of W. A. Marrison, Serial No. 730,165, filed August 5, 1924.

The amplifiers 20 and 30 are normally adjusted by means of condensers 42 and 105 to be in a condition upon the verge of instability such that when energy is supplied from the low power oscillator 10 to the input circuit of tube 26, oscillations are established in the amplifier 20 and when waves of the frequency of these oscillations are transmitted to the input circuit of tube 43, similar oscillations are established in its circuit.

The tubes 26 and 43 and associated circuits are so designed and adjusted that the frequency of the oscillations generated therein is controlled in accordance with the frequency of oscillations in the generator 10.

The control of the oscillations in amplifiers 20 and 30 by the waves from piezo oscillator 10 results from the tendency of two waves closely related as to frequency to pull into step or into synchronism when combined.

Since the piezo crystal 25 maintains the frequency of waves produced by generator 10 substantially constant, it follows that the oscillations generated in amplifiers 20 and 30, will fall into step with these waves and hence will likewise be held substantially constant as to frequency.

The oscillations produced in power amplifier 30 are transmitted through resonant circuit 57, 58 and through filters 61, 62, 63 to the antenna 65. The antenna circuit is preferably tuned by means of adjustable inductance 64 or condenser 63 or both to the frequency of the waves to be transmitted.

Signaling is accomplished by starting and stopping the oscillations in generators 20 and 30 under the control of key 103. The control electrode of tube 26 normally has a potential impressed upon it which is sufficient to block or at least reduce the flow of space current through it to such value that oscillations are not generated.

When oscillations are stopped in tube 26 they are also stopped in tube 43 which has its circuits normally adjusted a little below the oscillatory condition as already explained. When key 103 is closed, the potential applied to the control electrode of tube 26 is reduced as above described and oscillations are established in the amplifier. These oscillations produce similar oscillations in amplifier 30 and waves of corresponding frequency are radiated from antenna 65.

When key 103 is opened, the blocking potential is again applied to tube 26 and the oscillations in amplifiers 20 and 30 are stopped. This method of signaling constitutes continuous wave signaling.

If it is desired to signal by the modulated continuous wave method, switch 28 should be moved from contact 28′ to contact 28″. Generator 27 is thereby included in series in the input circuit of tube 26. The oscillations generated by amplifiers 20 and 30 are accordingly modulated in accordance with waves from generator 27 which are preferably within the audible range. Key 103 controls the production of oscillations in amplifiers 20 and 30 in the same manner as before so that high frequency oscillations modulated in accordance with low frequency waves are supplied to the antenna 65 under control of key 103.

The connection of leads 81 to the armature of generator 79 and the star connected coils 83 are provided to enable a divided potential to be obtained from this armature suitable for the space current source of tube 77 and for the polarized potential upon the control electrode of tube 43. The resistances 31, 31′ and 29 are supplied by current continuously by the connection to the negative brush of the armature 1 of generator 79.

The condensers 42 and 105 associated with tubes 26 and 43 respectively, are provided to compensate to a certain degree for the inherent capacity between the anode and control electrode of each tube. By adjusting these condensers, the amount of energy fed back may be controlled, so that the circuits may be adjusted to the desired point on the verge of instability. Resonant circuits 18, 22; 85, 86; 38, 40; and 57, 58 are all tuned to the same frequency at which all the amplifiers are designed to oscillate.

What is claimed is:

1. In a radio transmitting system, a plurality of space discharge tubes in tandem, each of said tubes being designed to operate at a different amount of power, and a source of power voltage for said tubes including a generator having an armature, and means for dividing the voltage generated in said armature including three phase coils star connected between said armature and ground.

2. In combination, a plurality of electric discharge devices each having an anode, a cathode and a control electrode, a direct current generator having an armature winding and multiphase slip rings connected to substantially equidistant points on said armature winding, an inductance device having a plurality of windings, connections including one of the windings of said inductance device for connecting each of said slip rings to ground, means for grounding the cathodes of said devices, and connections from the negative terminal of said generator to the control electrode of one of said devices and from the positive terminal of said generator to the anode of another of said devices.

In witness whereof, I hereunto subscribe my name this 27th day of October, A. D. 1927.

HUGH M. STOLLER.