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RADIO TRANSMITTING SYSTEM

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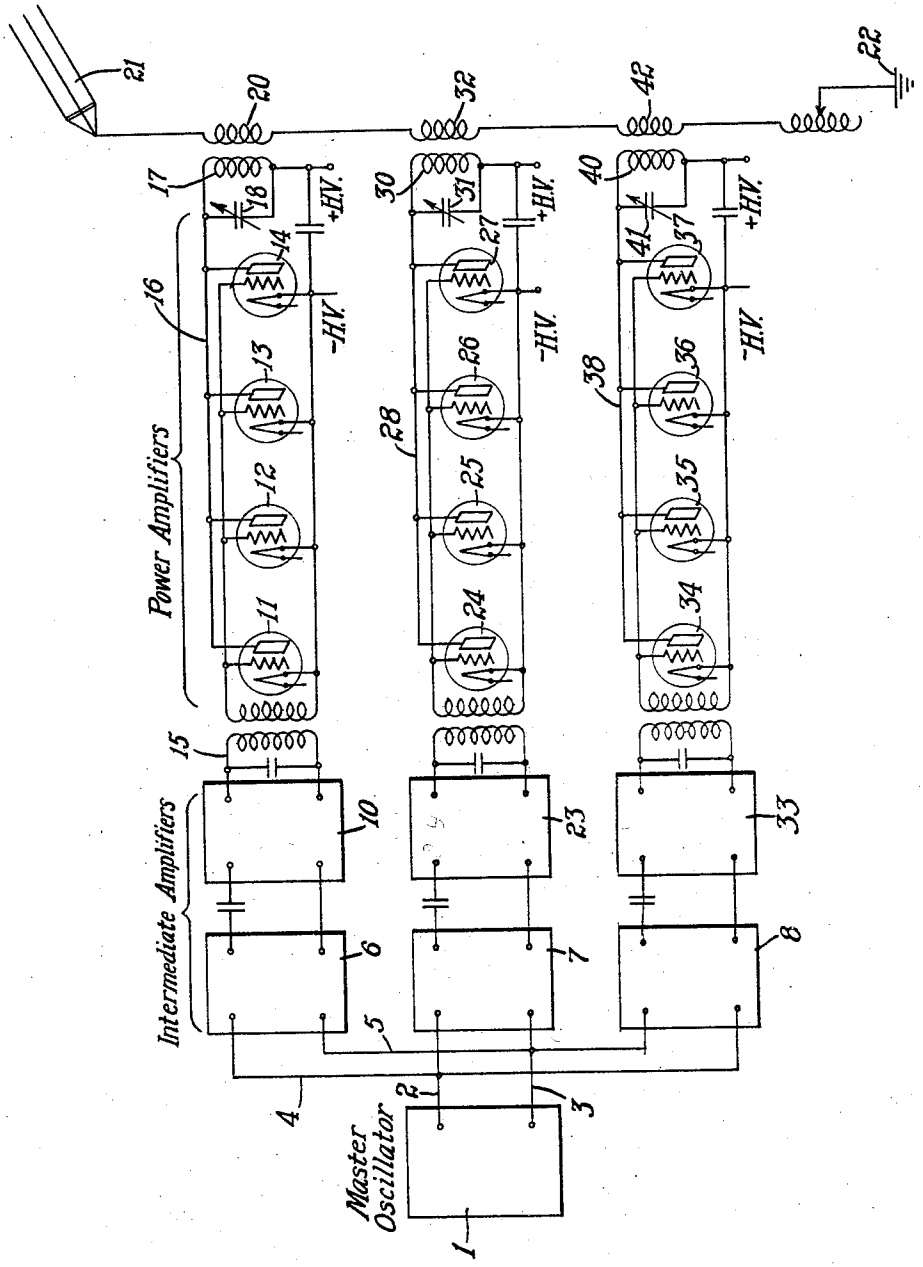

INVENTOR

Donald G. Little

BY

Wesley S. Barr

ATTORNEY

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UNITED STATES PATENT OFFICE

DONALD G. LITTLE, OF EDGEWOOD, PENNSYLVANIA, ASSIGNOR TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA

RADIO TRANSMITTING SYSTEM

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My invention relates to radio transmitting systems, and it has particular relation to systems in which transmission is effected by utilizing carrier-currents of extremely high frequencies of the order of 3,000 kilocycles or higher.

It has been quite definitely established that less energy is required for communication over long distances if high frequencies are used, than is required for low frequencies. It is not feasible, however, in the case of commercial transmitting stations, to reduce the power to the point where fading, static, etc., tend to interfere with the messages being sent, and all of such stations must of necessity make use of a plurality of high-power, water-cooled tubes in order that an adequate amount of energy shall be radiated.

By reason of the large size of the electrodes in high-power, water-cooled amplifying tubes, their inter-electrode capacity is high, and when a plurality of them are connected in parallel, as is customary if large power-output is imperative, the total capacitance is so great that it is substantially impossible to tune the output circuit associated therewith to wave-lengths below 100 meters. The amount of energy radiated at high frequencies therefore, has been limited by the number of power-tubes that could be connected in parallel without de-tuning the output circuit from the desired transmission frequency, the most powerful short-wave transmitter with which I was acquainted previous to the present invention being capable of radiating only 15 kilowatts at 20 meters, and having an effective commercial range of only 500 miles.

It is accordingly an object of my invention to provide a radio transmitting system that is capable of radiating a larger amount of power at high frequencies than similar systems known to the prior art.

Another object of my invention is to provide a short-wave transmitting system in which high-power, water-cooled tubes may be successfully utilized.

Another object of my invention is to provide a novel circuit network for a radio transmitting system, whereby the effect of the inter-electrode capacity of the requisite number of high-power water-cooled amplifying tubes is minimized.

I attain the aforementioned objects by subdividing into a plurality of groups the power amplifying tubes necessary to provide the requisite amount of radiated power, and by so limiting the number of tubes in each parallel-connected group that the total inter-electrode capacity thereof is less than the capacity necessary to tune the output circuit to the desired frequency. Each group of power-amplifying tubes has its output circuit coupled to a radiating structure in series-aiding relation, and is energized from a master-oscillator common to all the groups, through an individual intermediate amplifier. I have also found it feasible to utilize a single intermediate amplifier for two or more groups of power amplifiers, and to control all of the intermediate amplifiers from another amplifier of lower power which is directly energized from the master oscillator.

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 transmitting system arranged according to a preferred embodiment of my invention, certain elements, such as voltage sources, modulating devices, switches, etc., that have no bearing on the invention, being omitted for sake of clarity.

Referring specifically to the drawing, a master oscillator 1, which may comprise a piezo-electric crystal-controlled thermionic device or other appropriate oscillation generator, is connected in parallel by conductors 2, 3, 4 and 5 to a plurality of intermediate amplifiers 6, 7 and 8. Each of the intermediate amplifiers may comprise a plurality of low-power thermionic devices coupled together in cascade, either by transformers,

resistor-condenser networks or impedances untuned or tuned to the frequency generated by the master oscillator.

The intermediate amplifier 6 is connected to a second intermediate amplifier 10, the output of which is applied to the input circuit of a plurality of high-power water-cooled thermionic devices 11, 12, 13 and 14 connected in parallel. A radio frequency transformer 15 may be utilized for coupling the second intermediate amplifier 10 to the power amplifier stage as illustrated, or an impedance coupling device of any well known type may be used if desirable. For examples of coupling devices, reference may be made to the patent to Curtis, 1,648,811.

The anodes of the power amplifier thermionic devices 11, 12, 13 and 14 are connected in parallel by a conductor 16 to a tunable output or tank-circuit comprising an inductor 17 and a variable condenser 18. The inductor 17 is coupled to an inductor 20 included in a radiating structure which may comprise an antenna 21 and ground connection 22, or the ground connection may be replaced by a counterpoise. In the latter case, the inductor 20 in the antenna circuit need not be in inductive relation to the output inductor 17, a single lead conductively connected therebetween sufficing to transfer energy from the output circuit to the antenna.

The anodes of the power amplifier thermionic devices are supplied from a source of high voltage (not shown), and the cathodes thereof may be supplied from the same source (not shown) that supplies the cathodes of the thermionic devices comprised in the intermediate amplifiers and the master oscillator.

The intermediate amplifier 7 is coupled to an intermediate amplifier 23 which may comprise a plurality of thermionic devices of slightly higher power, though not of the water-cooled type, and the output circuit of the intermediate amplifier 23 is coupled to the common input circuit of a plurality of high-power water-cooled thermionic devices 24, 25, 26 and 27 connected in parallel. The anodes of the thermionic devices 24, 25, 26 and 27 are connected in parallel by a conductor 28 to a tunable output circuit comprising an inductor 30 shunted by a variable condenser 31. The inductor 30 is coupled to a second inductor 32 serially comprised in the radiating structure. The anodes of the devices 24, 25, 26 and 27, are supplied from the same high-potential source that supplies the anodes for the first described group of power amplifiers.

The intermediate amplifier 8 is coupled to an amplifier 33 of slightly higher power, having an output circuit which in turn is coupled to the common input circuit of a plurality of high-power water-cooled tubes 34, 35, 36 and 37, the corresponding elements of which are connected in parallel. The power tubes 34, 35, 36 and 37 are connected by a conductor 38 to an individual output circuit comprising an inductor 40 shunted by a tuning condenser 41, and the inductor is coupled to an inductor 42 comprised in the radiating structure. The third group of power tubes is supplied with anode potential from the common source which supplies the first and second mentioned groups.

In addition to the elements thus far described, a complete radio transmitting station would comprise modulating devices, additional potential sources, various switching and control devices, and numerous other circuit connections which have been omitted from the drawing in order that applicant's invention shall not be needlessly obscured. The omission of these elements detracts in no way from the completeness of the present disclosure.

In the operation of a radio system arranged according to my invention, the intermediate frequency amplifiers which control the several groups of power amplifiers are energized exactly in phase by the master oscillator, which is so arranged that the frequency supplied therefrom is the same frequency to which the output circuits of the several groups are tuned. Accordingly, the power amplifiers transmit energy to the radiating structure at a definite predetermined frequency and exactly in phase.

The number of power amplifier tubes included in each group is governed by the plate-filament capacity of the individual tubes. The plate-filament paths of the several tubes in each group are connected in shunt to the output-circuit tuning condenser and the total capacity thereof must not be greater than the total capacity required to tune the output circuit to the predetermined frequency. Such capacity is largely determined by the inductance necessary in order that the coupling between the output circuit and the antenna shall be sufficient to insure an efficient transfer of energy therebetween. In other words, it is not feasible to reduce the inductance of the output inductor below a certain definite value for each and every transmission frequency, and consequently, the maximum value of the tuning condenser associated therewith is rather sharply determined.

Assuming, for example, in the system illustrated, that it is desired to transmit on a wave length of 100 meters, corresponding to a frequency of 3,000 kilocycles, and that a power output of 50 kilowatts is necessary to satisfactorily cover the desired transmission range, it may be determined by calculations familiar to those skilled in the art, that a certain definite number of high-power water-cooled tubes is necessary. The number chosen for purposes of illustration, namely 12, is merely an arbitrary number and bears no relation to the actual number required in the

hypothetical case. If these 12 tubes were connected in parallel to a single output circuit having the required amount of inductance, the total plate-filament capacity would be so much greater than the capacity necessary to tune such output circuit that it would be impossible to transmit on the frequency desired, namely 100 meters. By distributing the power tubes in groups as shown, however, the total capacity of any one group may be made much less than the required tuning capacity and each output or tank circuit may accordingly be accurately tuned by the variable condensers shown.

The total amount of power transferred from the several groups of amplifiers to the radiating structure is substantially the same when the system is arranged according to my invention as when all of the tubes are connected in parallel to a single output circuit, the losses in the two additional tuning condensers, in the output inductors and the losses in the connecting wiring being substantially negligible.

It is also feasible to further sub-divide the power-amplifiers, if desirable, and to energize two or more of the groups from a single intermediate amplifier. In such event, all of the intermediate amplifiers may in turn be energized in parallel from a single intermediate amplifier coupled directly to a master oscillator.

Various other systems of sub-dividing the apparatus between the power amplifier groups and the master oscillator may be employed, all falling within the scope of my invention, which is mainly directed to the subdivision of the power-amplifiers proper, into separate groups of parallel-connected devices, in order that the total inter-electrode capacity of the devices in any one group shall not prevent proper tuning of an output circuit energized thereby.

My invention is particularly advantageous when it is desired to radiate a relatively large amount of power at frequencies above 3,000 kilocycles. I have established, by experiment, that when the power amplifiers are sub-divided properly, a transmitting system can be provided which will radiate many times more power than systems known to the prior art, wherein all of the power amplifier tubes were connected in parallel.

Although described in connection with space-radio, my invention is not to be restricted thereto, but is equally applicable to carrier-current transmission over wires whenever the transmission frequency is so high that tube capacity must be taken into account in the tuning of the output circuit, or in other situations where large power-output at high frequency is necessary.

Although I have shown and described a single specific embodiment of my invention, numerous modifications thereof 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 and by the spirit of the appended claims.

I claim as my invention:

1. In combination, a master oscillator, a plurality of intermediate amplifiers coupled thereto, and energized in synchronism and in phase therefrom, a plurality of groups of parallel-connected power-amplifying thermionic devices coupled to said intermediate amplifiers, an output circuit for each group, and a work circuit coupled to said output-circuits.

2. In a radio transmitting system of the short-wave type wherein it is desired to transmit a larger power output at higher radio frequency than is normally feasible with all the power amplifying devices in parallel connection to a single output circuit, a plurality of groups of power-amplifying thermionic devices connected in parallel, means for applying varying potentials in phase across the input-circuits of the groups, a tuned output circuit for each group, the said output circuits being coupled to a single work circuit, the total inter-electrode capacity of the thermionic devices in each group being of such value as to permit the output circuit individual thereto to be tuned to high frequencies of the order of three thousand kilocycles.

In testimony whereof, I have hereunto subscribed my name this 3rd day of August, 1927.

DONALD G. LITTLE.