March 22, 1938. C. W. HANSELL 2,111,665

SIGNALING SYSTEM

Original Filed March 26, 1931 3 Sheets-Sheet 1

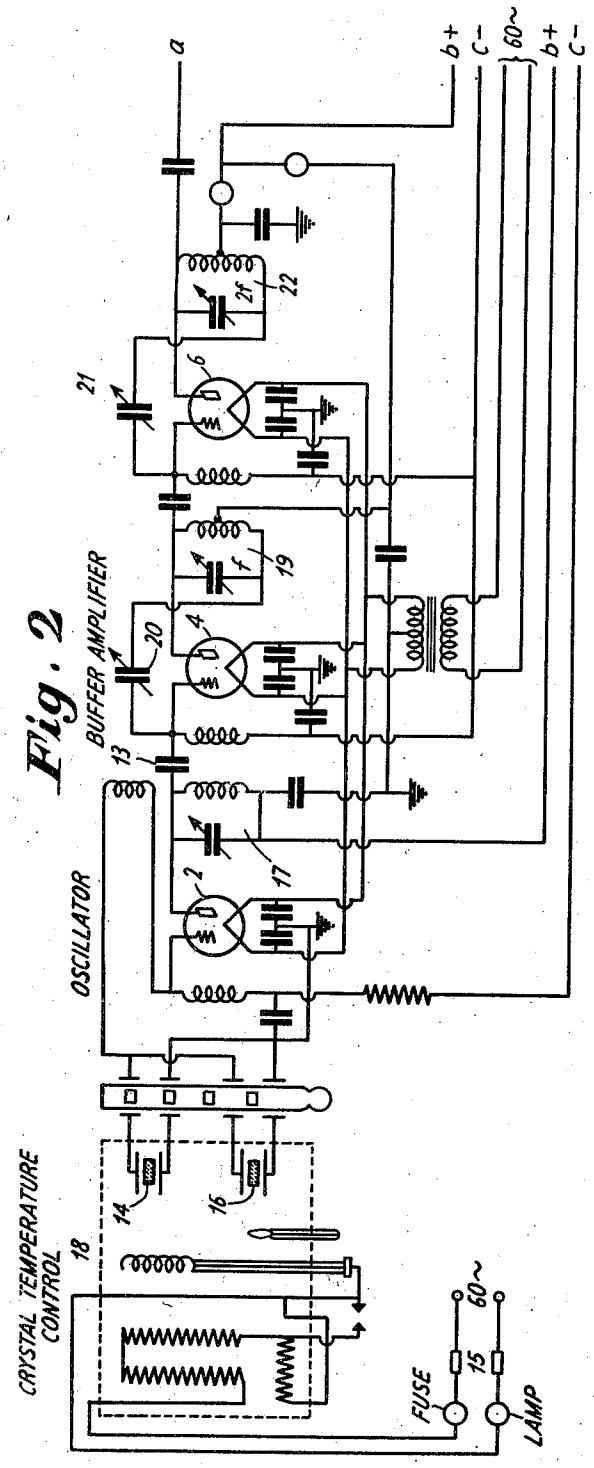


Fig. 2

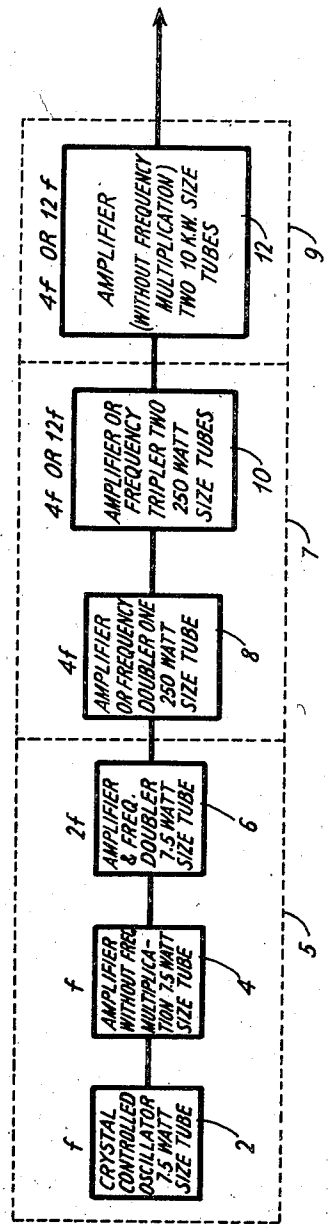


Fig. 1

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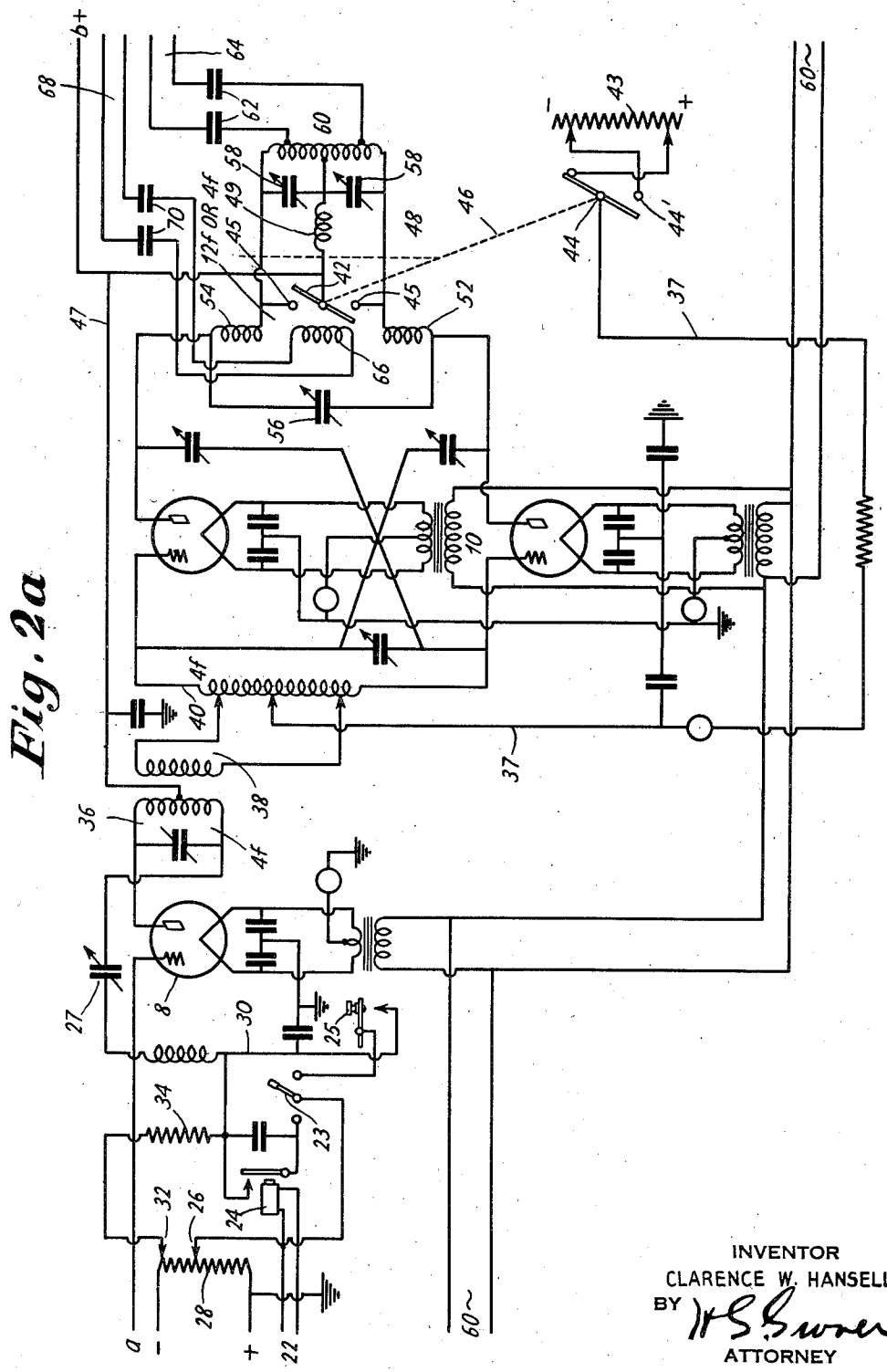


Fig. 2a

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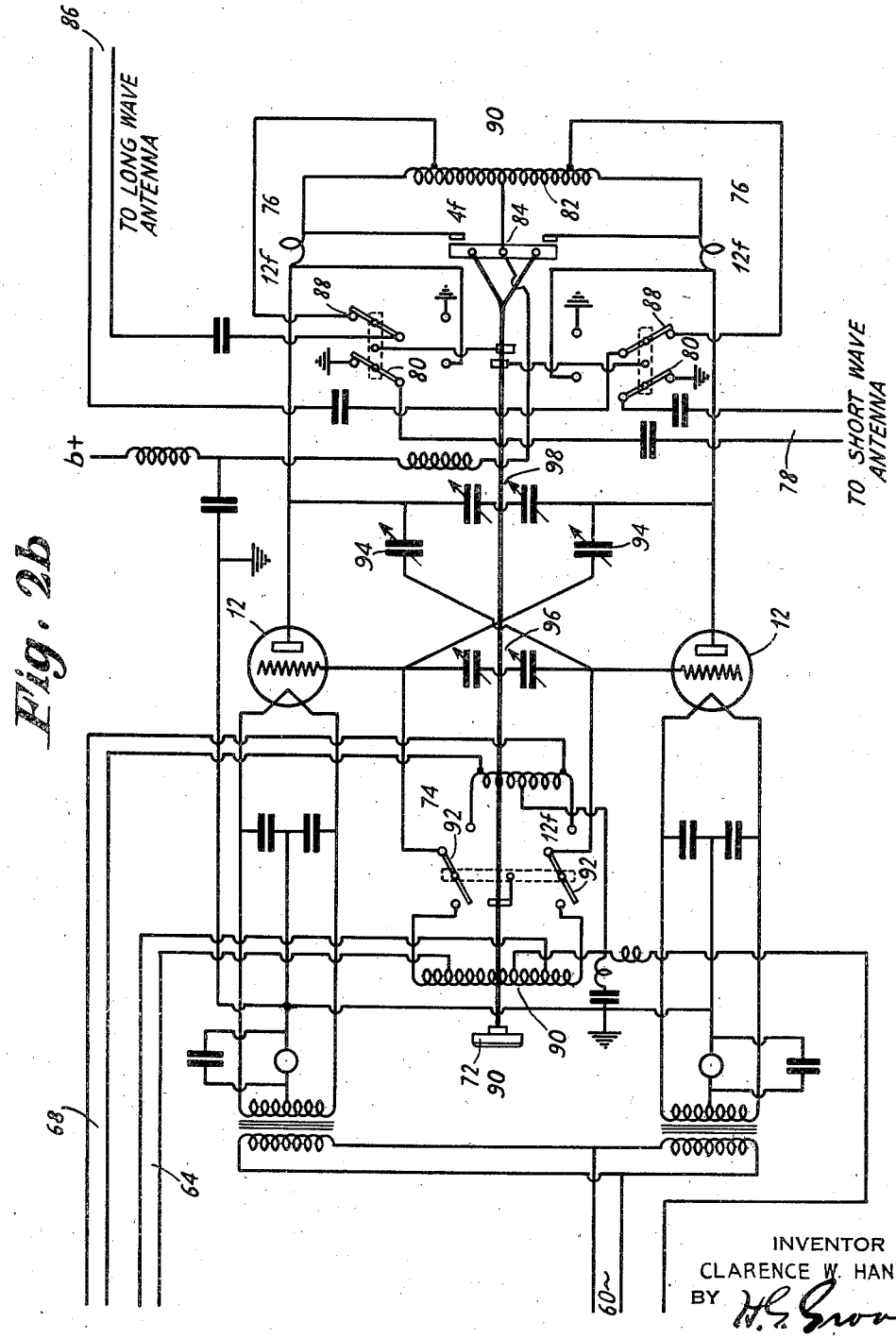


Fig. 2b

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Patented Mar. 22, 1938 2,111,665

UNITED STATES PATENT OFFICE

2,111,665

SIGNALING SYSTEM

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Original application March 26, 1931, Serial No. 525,419. Divided and this application January 29, 1936, Serial No. 61,268

19 Claims. (Cl. 250—17)

It has been common practice prior to my present invention to control the frequency of radio frequency transmitters by means of relatively low power, lightly loaded master oscillations, the outputs of which were amplified through a chain of radio frequency amplifiers to the power desired for transmission. In this previously developed system the conditions for holding the frequency of the master oscillators constant could be obtained more easily and economically than would be the case if the oscillations were developed directly in the vacuum tubes which produce the power to be radiated from antennae. A system of the latter kind has been developed for high frequencies by the British Marconi Company and is known as the "British beam system."

In the United States, a method for maintaining master oscillators much more constant in frequency than had been possible previously was invented by W. G. Cady and is disclosed in his United States Patent 1,472,583. This method of Cady's employs a piezo-electric crystal and results in a great improvement in frequency control. However, it is subject to limitations in that its constancy is diminished at the higher frequencies and the amount of power obtainable from the crystal oscillator is small.

The first limitation is removed by operating the crystal oscillator at relatively low frequency and increasing this frequency by vacuum tube frequency multipliers. A method for doing this is disclosed in U. S. Pat. #1,771,375 of I. F. Byrnes. At the beginning of the development of high frequency transmitters the method described by Byrnes was extended to the use of several similar stages of vacuum tubes each operating as a frequency multiplier and resulting in a final output at one of the higher harmonics of the crystal frequency. This resulted in a great improvement in frequency stability through the use of a relatively low frequency crystal even though the output frequency of the transmitter was much higher than any previously used for high power, long distance, communication.

In this type of transmitter, the frequency multipliers were all low power tubes of the same size and types so that there was no increase of power in the successive frequency multiplier stages. The output from the last frequency multiplier was amplified by a chain of vacuum tube amplifiers, all operating at the same frequency, to the final power level required for the antenna. In this case the amplifying system followed the previously established practice used in master oscillator-amplifier transmitters of the type used in the British beam system. The main difference was that the conventional master oscillator was replaced by the combined crystal oscillator and frequency multipliers.

Although this method of constructing and operating a transmitter was an improvement over any previously used methods, yet, at high frequencies, the circulating currents through the dielectric capacities of the tubes caused losses which reduced the amplification and troubles were experienced from undesired spurious oscillations. These spurious or parasitic oscillations were caused by energy feedback from output to input circuits of amplifier stages and from high power stages to lower power stages. The adjustments required to eliminate these undesired oscillations were critical at high frequencies and difficult to maintain over long periods.

In accordance with my invention disclosed and claimed in my copending appln. Ser. No. 525,419, filed March 26, 1931, Patent #2,032,208 dated February 25, 1936, I eliminate most of the low power frequency multiplying stages and by the use of a new system in which the successive intermediate stages of amplification work at successively higher power levels, and, most important, the amplifier stages act as frequency multipliers. Thus in said application, I combine amplification and frequency multiplication in the successive stages of an amplifier system.

After this is done the earlier stages of the amplifier work at lower frequencies where they are more efficient. Also, in the system disclosed in said application, the input and output circuits of each intermediate amplifier stage are tuned to different frequencies so that the feedback from output to input circuits causes little current in the input circuit because of its lack of tuning to the frequency of the energy fed back. Likewise, the feedback of radio frequency energy from any stage of amplifier to previous stages is very greatly reduced because of the wide differences in frequencies to which the amplifier circuits are tuned. Consequently, there is a marked freedom from parasitic oscillations and an ease of control and operation borne out in transmitters actually built incorporating the said invention never before approached in an amplifier system for high radio frequencies.

In the said system of frequency multiplication at increasing power and also in the system of frequency multiplication at substantially constant power, I have obtained a still further improvement in operation by the use of capacity neutralization and harmonic regeneration as

previously described in my U. S. appln. Ser. No. 177,505, filed March 23, 1927 Patent #1,878,308 dated September 20, 1932.

As set forth in detail in said U. S. appln. Ser. No. 525,419 Patent #2,032,208 dated February 25, 1936, of which the present application is a division, I have shown that tubes with more than three electrodes may be used in frequency multiplier-amplifiers to excellent advantage. Transmitters are now in use employing tubes with two grids in which one grid serves to shield the control grid from the anode and, the addition of the screen grid, which may be kept substantially at zero radio frequency potential, together with appropriate circuit shielding, serves some of the purposes of the capacity neutralization in my appln. Ser. No. 177,505, Patent #1,878,308, dated September 20, 1932, with the advantage that no neutralizing adjustment need be made by an operator and the probability of inefficiency due to human error is greatly reduced.

In the system of appln. Ser. No. 525,419, Patent #2,032,208 dated February 25, 1936, it is possible to use any or all stages of an amplifier as frequency multipliers but where expediency in design makes it desirable, some stages may be used as amplifiers without change of frequency. Preferably, the last stage is an ordinary amplifier since the last stage amplifier determines the final transmitter output so that it is important to obtain as much power as possible from it. This is desirable because the power efficiency of the last stage is a large factor in determining the overall efficiency of the transmitter, and, if the last stage were used as a frequency multiplier it would be necessary to make some sacrifice in power output and efficiency. In said system I employ screen grid tubes in the last stage or three-electrode tubes with capacity neutralization together with other features essential to good electrical and mechanical construction. Under certain conditions one or more of the earlier stages may act as amplifiers without frequency multiplication. For example, I may use an ordinary amplifier immediately after the crystal because by doing so the load on the crystal circuit is reduced insuring greater constancy of frequency.

In the system disclosed in appln. Ser. No. 525,419, Patent #2,032,208 dated February 25, 1936, I improve the stability of operation of vacuum tube amplifier and frequency multiplier systems to make them less subject to the effects of power supply voltage variations and at the same time I protect the vacuum tubes from destructive currents. This is accomplished by employing the combination, for electron discharge devices, of a fixed biasing potential and a potential obtained by passing rectified grid current through a grid leak resistance.

It is characteristic of vacuum tube frequency multipliers and high efficiency amplifiers that the relative values of grid bias and radio frequency excitation potential must be rather critically adjusted. If an operator, while making adjustments, or the power supply voltage causes a variation above or below normal in radio frequency output from any stage, then the excitation and the efficiency and output of the next succeeding stage is adversely affected. In the system disclosed in said copending application, I may make the biasing potential increase and decrease in accordance with the excitation in a manner to hold relatively constant output and efficiency by employing grid leak bias.

However, when this is done, if for any reason the master oscillator, or any intermediate stage fails to function, so that there is no excitation on any stages, their grid bias falls to zero. In this case the tubes are subject to excessively high and destructive anode currents and losses which endanger the lives of the tubes. Overload protection on the power supply will not entirely remove this danger because the input currents, controlling overload protective devices, under this condition may not exceed the normal input while the energy dissipation in the tubes is greatly increased due to loss of output. In cases where the input currents would be sufficiently higher than normal to trip out overload circuit breakers there is still danger of tube failure because the overload, although of shorter duration, is increased in severity.

To remove this danger of tube failure while still retaining most of the advantages of grid leak bias, was a further object of the system disclosed in appln. Ser. No. Patent #2,032,208 dated February 25, 1936, and to fulfill it I employ sufficient fixed bias to protect the tubes in case their excitation fails and obtain the remainder of the required biasing potential from grid leak resistances in series with the fixed bias.

In practice, it is desirable that provision be made whereby a stage or several stages may operate either as an amplifier or a frequency multiplier or as amplifiers or frequency multipliers. This permits signaling at different powers and different frequencies with the same number of stages and same apparatus.

In accordance with the invention set forth in my U. S. Appln. Ser. No. 649,470, filed Dec. 30, 1932, I provide switching and tuning means in the output circuits of certain stages to make them operate as amplifiers or frequency multipliers. When they operate as amplifiers, the switching means is set at such a point that the output circuit of the stage is tuned to the frequency of the input circuit. The stage now acts as an amplifier of the impressed oscillations.

When it is desired that the stage act as a frequency multiplier, the switching means is set at such a position that the output circuit of the particular stage is tuned to a harmonic (odd or even) of the frequency to which the input circuit of the stage is tuned. The stage now acts as a frequency multiplier.

The biasing potential under which a stage operates efficiently as an amplifier may be less than the biasing potential under which a stage operates efficiently as a frequency multiplier.

In my novel transmitter of the said application, I provide means for increasing the bias applied to the control electrodes of the stage when the stage operates as a frequency multiplier, and for decreasing said bias if the stage is to be changed back to a straight amplifier or relay.

In my novel transmitter of the present invention, I provide a final stage having input circuits and output circuits of different resonant character which may be put in or out of connection with a pair of discharge devices by means of a single switch. The circuits are balanced in all positions of the switch.

The resonant character of each set of input and output circuits is such that the final stage may be tuned to one of several frequencies harmonically related to a basic frequency used in the initial stages of the transmitter as disclosed herein and in the parent appln. Ser. No. 525,419, filed March 26, 1931 Patent #2,032,208 dated

February 25, 1936. The selected output circuit is connected by the same switch movement to an appropriate radiating system. An additional feature is means cooperating with the same switch for grounding that or those radiating systems not in use.

Transmitters including the novel features of the present invention have been in commercial service for some time. A transmitter including the switching and tuning means as disclosed briefly above has been disclosed in my United States appln. Ser. No. 189,162, filed May 5, 1927, Patent No. 2,063,248, dated December 8, 1936.

In accordance with United States Patent Office procedure my invention is defined in the appended claims. However, it may best be understood, both as to its structural organization and mode of operation by referring to the accompanying drawings, wherein:

Fig. 1 is a block diagram of a commercial transmitter built in accordance with my present invention; while

Figs. 2, 2*a* and 2*b* schematically illustrate a circuit arrangement used in the apparatus shown in Fig. 1.

Fig. 1 illustrates diagrammatically a transmitter especially adapted for long distance communication work. Fig. 1 is a block diagram of the transmitter which is illustrated in detail in Figs. 2, 2*a* and 2*b* which are wiring diagrams of the more important elements of the transmitter shown schematically in Fig. 1.

As shown in Fig. 1, the transmitter comprises a crystal controlled oscillator **2** followed by buffer or shock absorbing amplifier **4**, two frequency multiplier stages **6**, **8** the latter also being used as a modulator and both multipliers being used preferably as frequency doublers. Another stage **10** adapted to be used as a simple amplifier or, as indicated, as a frequency tripler, and, a final amplifier stage **12** are provided. As indicated, the crystal controlled oscillator **2**, buffer amplifier **4**, and first frequency multiplier **6**, may be placed safely within a single shielding compartment **5** without fear of parasitic oscillation generation, and similarly the stages **8** and **10** may be placed in another separate shielding compartment **7**. The final amplifier stage **12** should, of course, be placed with an individual shielded compartment **9**. Inasmuch as shielding is well known in the art, a further description of it is unnecessary here.

The tube sizes indicated in Fig. 1 are given merely by way of example and as set forth more in detail in my appln. Ser. No. 525,419 Patent #2,032,208 dated February 25, 1936, may be varied widely in practice. Attention is directed in particular to the second frequency multiplier and amplifier **8**, which is of much larger size and rating than frequency multiplier and amplifier **6**, or, amplifier **4**. As a result of this construction, a considerable amount of amplification of the energy is produced in the frequency multiplier, which eliminates many of the amplifiers which would be necessary if, in accordance with prior practice, the frequency multipliers are all made of the same size and rating, such as that of stage **6** for example. And similarly, the frequency multiplier stage **10** is made considerably larger in size and rating than the prior stage **8** so that within the frequency multiplier **10** a considerable amount of amplification ensues along with frequency multiplication. By the use of amplification within the stages **8** and **10**, as already indicated, a long chain of amplifiers, subject to parasitic oscillation and costly maintenance, for building up the energy to a value sufficient to operate power amplifier **12** is eliminated.

The arrangement shown in Fig. 1 is illustrated in greater detail in Figs. 2, 2*a* and 2*b*. The regeneratively coupled electron discharge device oscillator **2** is frequency controlled by either crystal **14** or **16** by suitable actuation of coupling or switching arrangement **11** which couples either crystal capacitively to the input electrodes of oscillator **2**. The purpose of using two crystals is, of course, to provide a spare crystal or to vary the final output of the transmitter.

The crystals preferably are temperature controlled by any suitable temperature controlling apparatus diagrammatically indicated within rectangle **18** energized with heating energy from a suitable source **15**.

The output circuit **17** of the oscillator **2** is tuned substantially to the fundamental frequency of the crystal placed in circuit with oscillator **2**, by the capacity and inductance of said circuit and, energy in said circuit is fed through a blocking condenser **13** to the buffer amplifier **4** having a tunable output circuit **19** tuned also to substantially the fundamental frequency. To prevent parasitic oscillation generation or self oscillation, the buffer oscillator may be neutralized by the use of a suitable neutralizing condenser **20** as indicated, or, as illustrated in my appln. Ser. No. 525,419, Patent #2,032,208 dated February 25, 1936, the transmitter tubes may be made of the screen grid type so that external neutralizing circuits are unnecessary. Similarly, for better control the crystal oscillator tube **2** may be of the screen grid type or of any multi-electrode type. The buffer amplifier, of course, acts to maintain constant load on the crystal oscillator preventing variations in load from making themselves felt upon the electrodes of the oscillator **2**.

Output energy appearing in tunable circuit **19** is fed to the input terminals of the first frequency multiplier, here indicated as a frequency doubler and amplifier **6**, having a tunable output circuit **22** tuned to the second harmonic ($2f$) of the fundamental frequency f. As described in my copending application, Serial No. 177,505, filed March 23, 1927, Patent #1,878,308 dated September 20, 1932, frequency multiplier and amplifier **6** may be regeneratively coupled by means of a condenser **21** for energy of harmonic frequencies, but degeneratively coupled for energy of the fundamental frequency so that presence of energy of the fundamental frequency in the output circuit of tube **6** is effectively eliminated or reduced to a negligible value.

Heating current for the electron emission elements of the tubes **2**, **4** and **6** may be supplied from a 60 cycle source as shown. Positive potential for the anodes of tubes **2**, **4** and **6** may be supplied by wave of leads *b*, while biasing potentials for the control grids of tubes **2**, **4** and **6** may be supplied by way of leads *c* from any source.

Output energy from the frequency doubler **6** and amplifier **6** is fed through conductor *a* to the frequency multiplier-amplifier modulator **8** shown in Fig. 2*a*. The output circuit of tube **8** is tuned substantially to the fourth harmonic of the fundamental and as illustrated is regeneratively connected by capacity **27** for energy of the harmonic frequency $4f$.

Keyed energy appearing in line **22** may be used to remotely control the electromechanical relay **24** to alter the bias on the grid of tube **8** so that when the relay armature is in its contacting

position it will shift the grid voltage on tube 8 to such a value as to pass peaks of input current into the output circuit of tube 8 such that it is shock excited at the harmonic frequency $4f$ as described more fully in my copending application just referred to. That is, in the closed position of relay 24, a less negative potential is supplied by way of conductor 26 coupled to a suitable point on potentiometer 28, and key 23 closed in the left hand position to the grid of tube 8, through connections 30. When the relay armature is in the open position, negative tapping point 32 biases the grid of tube 8 through resistance 34 to such an extent that no high frequency energy appears in the output circuit 36 of tube 8. In addition to the relay for controlling the transmitter there is provided means by which the control may be transferred from relay 24 to the local telegraph key 25 for the use of the transmitter attendant. To do so, switch 23 is closed in the right-hand position.

Fourth harmonic signal modulated high frequency energy is fed inductively, as indicated, through lines 38 to the input electrodes of a pushpull connected frequency amplifier or frequency multiplier and amplifier 10 for the complete action of which reference is again made to my copending application Serial No. 177,505, Patent #1,878,308, dated September 20, 1932. As shown, the stage 10 acts simply as an amplifier, but, this stage may be used as a frequency multiplier to produce energy of a frequency three times the frequency of the energy appearing in the input circuit 40. The energy thus produced is of a frequency $12f$.

With the switches 42 and 44 in the position shown the tuned resonant output circuit connected with the stage 10 includes the inductances 52, 54 and 60 and the variable capacities 56 and 58 which tunes said circuit to the frequency of the input circuit 40, that is, to a frequency $4f$. The tubes now act as simple amplifiers.

When switches 42, 44 are moved to their other position by uni-control means 46, 44 closes contact 44' so that a higher negative bias is applied to the grids of the pushpull connected tubes 10 by way of lead 37 from the potentiometer 43 connected with any source. The same movement of control means 46 closes contacts 45 so that the portion of the output circuit 48 to the right of the dotted line 50, is cut out of circuit entirely, or is short-circuited away from the output electrodes of tubes 10. In this latter position of switch, the output circuit includes inductances 52, 54 and condenser 56, and these elements tune said circuit to the twelfth harmonic of the fundamental $4f$ as indicated.

In both positions of the switches, the circuits of the pushpull stage are symmetrical as shown. In both positions of the switches potential is supplied to the anodes of the tubes in stage 10 by way of a lead 47 to the electrical center of the resonant output circuit. When the stage acts as an amplifier the inductance 49 is included in this connection.

When acting as a simple amplifier, output energy from the output circuit of tubes 10 is fed through blocking condensers 62 and lines 64 to the input side of the power amplifier 12. When acting as a frequency tripler or multiplier as indicated, output energy from tubes 10 is fed inductively by secondary coil 66, to the lines 68 though blocking condensers 70 and to the input side of the power amplifier 12.

As described in my Patent No. 1,751,996, it is preferable that the output ends of the transmission lines 38, 64 and 68 are coupled to the respective input circuits such that the lines face a portion of the input circuit equivalent in value to the surge impedance of the line so that standing waves are not set up thereon.

The stage 12 or the tubes therein are almost always used, in order to obtain best overall efficiency for the entire transmitter, as a simple amplifier, provision being made to readily adjust the tuning of the amplifier to either one of the frequencies which it is desired to amplify. Thus, a uni-control switching means 72 is provided which places low frequency coils 90 and 82 in the input and output circuits respectively of tubes 12, when stage 10 is used as an amplifier for energy of the lower frequency $4f$. Under such circumstances also, the transmission line 78 to the short wave or high frequency antenna is grounded by switches 80 as indicated. The long wave antenna 86 is connected by switches 88, as shown, to the long wave output circuit including 82.

A reverse movement of controlling member 72 will act to short-circuit the long wave coil 82 out of circuit by switch 84, to connect the low wave length antenna transmission line in circuit at switch 80 and, the relatively longer wave antenna transmission line 86 will be grounded by the other position of switches 88. In the input circuit, the longer wave coil 90 will be removed from circuit, and, the shorter wave coil 74 will be placed in the circuit, all of which takes place on the reverse setting of switch 72.

This uni-control arrangement for rapid changeover in amplifier frequency is broadly similar to that described and claimed in my copending application Serial No. 189,162, filed May 5, 1927, Patent No. 2,063,248 dated December 8, 1936.

To prevent parasitic oscillation generation, the power amplifier tubes 12 are neutralized by condensers 94 cross-connecting the terminals of the input and output tuning condensers 96, 98 respectively.

As indicated, the cathodes of the various tubes may be energized by alternating currents. Unidirectional potentials for the potentiometers 28 and 43 and the various unidirectional supply leads b and c shown in Figs. 2, 2a and 2b may be obtained from separate rectifiers as found necessary, but, in accordance with the present invention it is preferred that the separate rectifiers be energized from a single alternating current source whereby there is less tendency for changes in amplification with changes in supplied alternating voltages as would be the case where various rectifiers are supplied from different alternating sources.

What is claimed is:

1. In a high frequency transmitting system employing electron discharge tubes each having input and output electrodes, a plurality of input circuits having a common portion adapted to be connected with said input electrodes for impressing on the input electrodes of said tubes a characteristic control frequency, a symmetrical compound output circuit connected between the anodes of said tubes, said compound circuit including a common portion and a plurality of reactive portions connected to said common portion, switching means connected with said output circuit for short-circuiting one of said portions to change the resonance frequency of said circuit, switching means connected with said in-

put circuits for connecting a selected one of said input circuits to the input electrodes of said tubes, means cooperating with said input circuits and said output circuit for maintaining symmetry of said circuits in all positions of said switching means, and a common control for said switching means.

2. In a relaying circuit, a pair of electron discharge tubes, each having a control grid, an anode and a cathode electrode, a plurality of tuned circuits, means for connecting one of said tuned circuits between the control grids of said tubes, a pair of signal resonant circuits comprising series inductances and parallel capacities one of which circuits includes the other, connected between the anodes of said tubes, a separate antenna system appropriate to each of said signal resonant circuits, switching means including a switch for short-circuiting a portion of said signal resonant circuits, and for coupling one of said antennas to said resonant circuits, and means cooperating with said switching means for grounding the antenna system not connected to said resonant circuits.

3. Relaying means comprising, a pair of electron discharge tubes, each having a control grid, an anode and a cathode, a plurality of signal resonant circuits adapted to be connected with the control grids of said tubes, an output circuit including a plurality of lumped reactances in series and other reactances shunting at least one of said first named lumped reactances, connected with the anodes of said tubes, a switch in parallel with at least one of said lumped reactances, said switch in the open position permitting said output circuit to resonate at one frequency and in the closed position at a different frequency, a switch cooperating with said first named plurality of signal resonant circuits for connecting a selected one thereof to the grids of said tubes, a plurality of antenna systems adapted to be coupled to said output circuit, and a switch for selectively coupling one of said antenna systems to said output circuit and for grounding the remaining antenna systems.

4. A relaying means as recited in claim 3 wherein said switches are unicontrolled.

5. Signaling means comprising, a pair of electron discharge tubes, each having a control grid, an anode and a cathode, means for operating said tubes at several different frequencies comprising, a plurality of input circuits having a common portion for applying waves of different frequency to the control grids of said tubes, a plurality of output circuits having a common portion connected to the anodes of said tubes, a plurality of antenna systems, and switching means for connecting a selected one of said input circuits to the control grids and cathodes of said tubes and a selected one of said output circuits to the anodes and cathodes of said tubes, and one of said antenna systems to the selected output circuit.

6. Signaling means as recited in claim 5 in which means cooperate with said switching means to maintain said input and output circuits symmetrical in all positions of said switch.

7. Signaling means as recited in claim 5 in which switching means cooperate with said antenna systems for grounding the ones not connected to said output circuit.

8. A signaling system as recited in claim 5 wherein said switching means is connected with a common control.

9. Signaling means comprising, an electron discharge tube having a control grid, an anode and a cathode, means for operating said tube at different frequencies comprising, a plurality of circuits having a common portion for applying waves of different frequency to the control grid of said tube, a plurality of output circuits having a common portion adapted to be connected to the anode of said tube, a plurality of antenna systems adapted to be connected to said output circuits, and switching means for connecting a selected one of said input circuits to the control grid and cathode of said tube, and a selected one of said output circuits to the anode and cathode of said tube, and a selected one of said antenna circuits to said selected output circuit.

10. Signaling means as recited in claim 9 in which means cooperate with said switching means to maintain said input and output circuits symmetrical in all positions of said switch.

11. Signaling means as recited in claim 9 in which switching means cooperate with said antenna systems for grounding the ones not connected to said selected output circuit.

12. A signaling system as recited in claim 9 wherein said switching means are connected to a common control.

13. In a relay circuit, a pair of electron discharge tubes each having a control grid, an anode, and a cathode electrode, a plurality of tuned input circuits, and means for connecting a selected input circuit between the control grids of said tubes, a circuit comprising series inductances and a parallel capacity connected between the anodes of said tubes, a plurality of antenna systems adapted to operate at different frequencies, switching means including a switch for short-circuiting a portion of said circuit comprising series inductances and a parallel capacity to change the natural resonant frequency thereof, and for coupling one of said antennas to said last named circuit, and means cooperating with said switching means for grounding the antenna systems not connected to said last named circuit.

14. Wave energy relaying means comprising a pair of electron discharge tubes each having a control grid, an anode, and a cathode, a plurality of signal resonant circuits each having a common portion adapted to be connected with the control grids of said tubes, an output circuit including a plurality of reactances in series and another reactance shunting at least one of said first named reactances connected with the anodes of said tubes, a switch connected with at least one of said reactances, said switch in the open position permitting said output circuit to resonate at one frequency and in the closed position at a different frequency, a switch connected with said first named plurality of signal resonant circuits for connecting a selected one thereof by way of said common portion to the grids of said tubes, a plurality of antenna systems adapted to be coupled to said output circuit, and a switch for selectively coupling one of said antenna systems to said output circuit and for grounding the remaining antenna systems.

15. In a signaling system, a pair of electron discharge tubes each having a control grid, an anode, and a cathode, means for operating said tubes at several different frequencies comprising, a plurality of input circuits having a common portion for applying waves of different frequency to the control grids of said tubes, a plurality of output circuits having a common portion connected to the anodes of said tubes, a plurality of antenna systems, and switching means for connecting a

selected one of said input circuits to the control grids and cathodes of said tubes and a selected one of said output circuits to the anodes and cathodes of said tubes and one of said antenna systems to the selected output circuit.

16. Signaling means comprising, an electron discharge tube having a control grid, an anode, and a cathode, means for operating said tube at different frequencies comprising, a plurality of circuits having a common portion for applying waves of different frequency to the control grid of said tube, a plurality of output circuits having a common portion adapted to be connected to the anode of said tube, a plurality of antenna systems adapted to be connected to said output circuits, and switching means for connecting a selected one of said input circuits to the control grid and cathode of said tube and a selected one of said output circuits to the anode and cathode of said tube and a selected one of said antenna circuits to said selected output circuit.

17. A relay device comprising, a thermionic tube having anode, cathode and control grid electrodes, a plurality of input circuits resonant at different frequencies, a switch for connecting a selected one of said input circuits to the control grid electrode of said tube, a compound output circuit connected with the anode of said tube, said output circuit including several reactances, one or more of which may be short-circuited by a second switch so that said output circuit may resonate at different frequencies corresponding to the frequencies of said input circuits, a plurality of load circuits, a third switch for connecting a selected one of said load circuits to the anode electrode of said tube, said last named switch including means for grounding the load circuits not connected to the anode electrode of said tube, and a common control means for all of said switches.

18. A relay device comprising, a pair of thermionic tubes, each having anode, cathode and control grid electrodes, a plurality of input circuits resonant at different frequencies, switching means for connecting a selected one of said input circuits to the control grid electrodes of said tubes, a compound output circuit including several reactances, one or more of which may be short-circuited by other switching means so that said output circuit may resonate at different frequencies corresponding to the frequencies of said input circuits, a plurality of load circuits, additional switching means for connecting a selected one of said load circuits to the output electrodes of said tubes, and a common control means for all of said switching means.

19. A relay device comprising, a pair of thermionic tubes, each having anode, cathode and control grid electrodes, a plurality of input circuits resonant at different frequencies, a first switching means for connecting a selected one of said input circuits between the control grid electrodes of said tubes, a compound output circuit including several reactances, one or more of which may be short-circuited by a second switching means so that said output circuit may resonate at different frequencies corresponding to the frequencies of said input circuits, a plurality of load circuits, a third switching means for connecting a selected one of said load circuits to the output electrodes of said tubes, said last named switching means including means for grounding the load circuits not connected to the output electrodes of said tubes, and a common control means for all of said switching means.

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