

March 1, 1949.

E. L. GINZTON

2,462,856

TRANSMITTER AND/OR RECEIVER CIRCUITS

Filed May 19, 1942

2 Sheets-Sheet 1

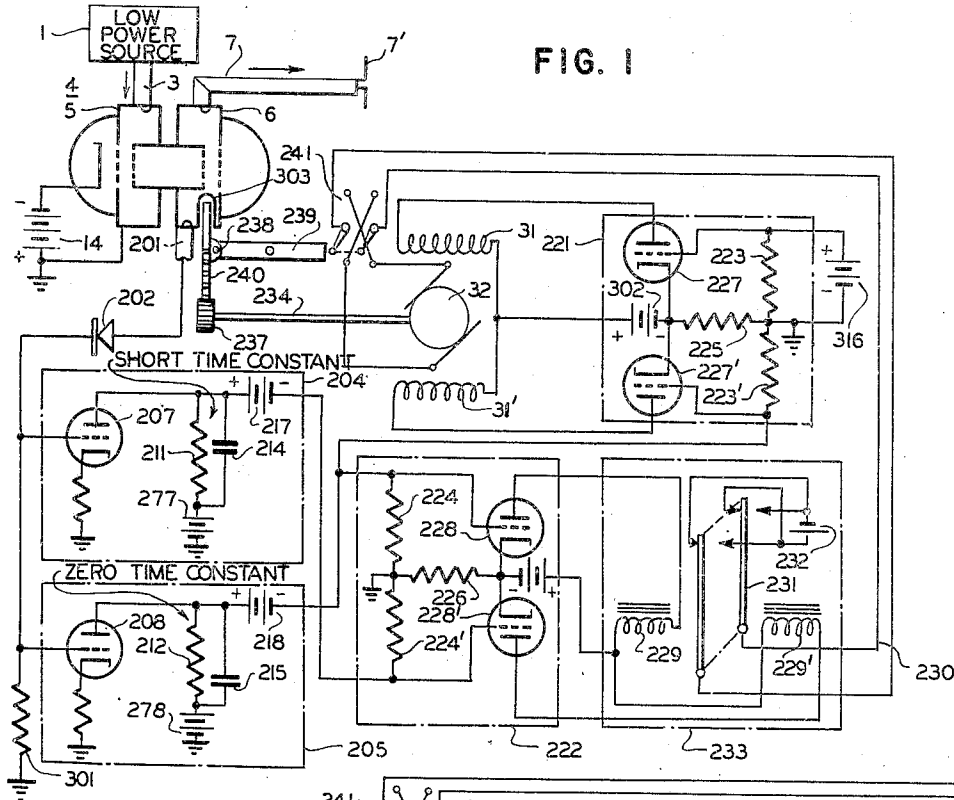
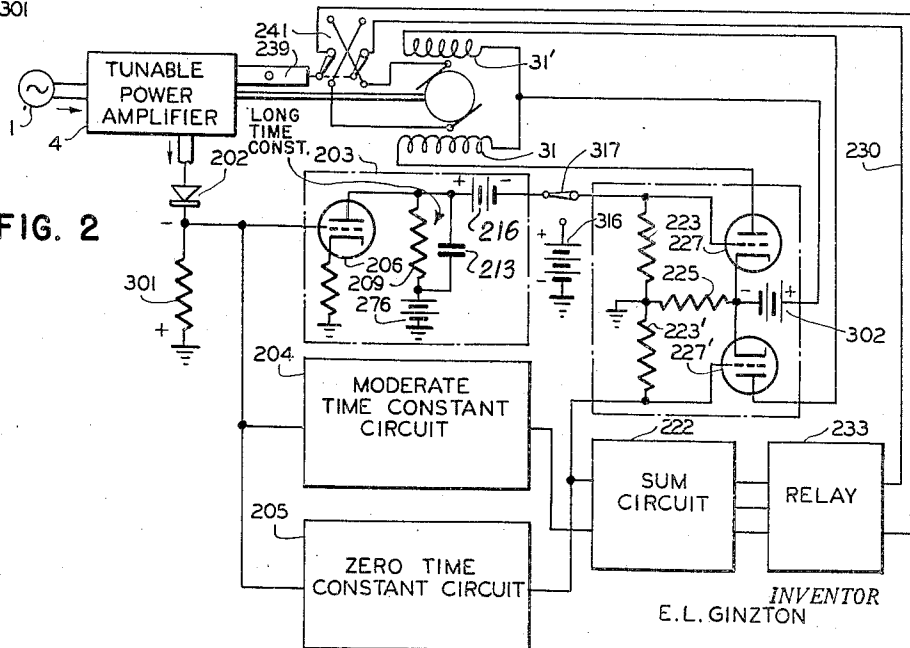


FIG. 2



INVENTOR
E. L. GINZTON

BY

Paul B. Hunter
ATTORNEY

March 1, 1949.

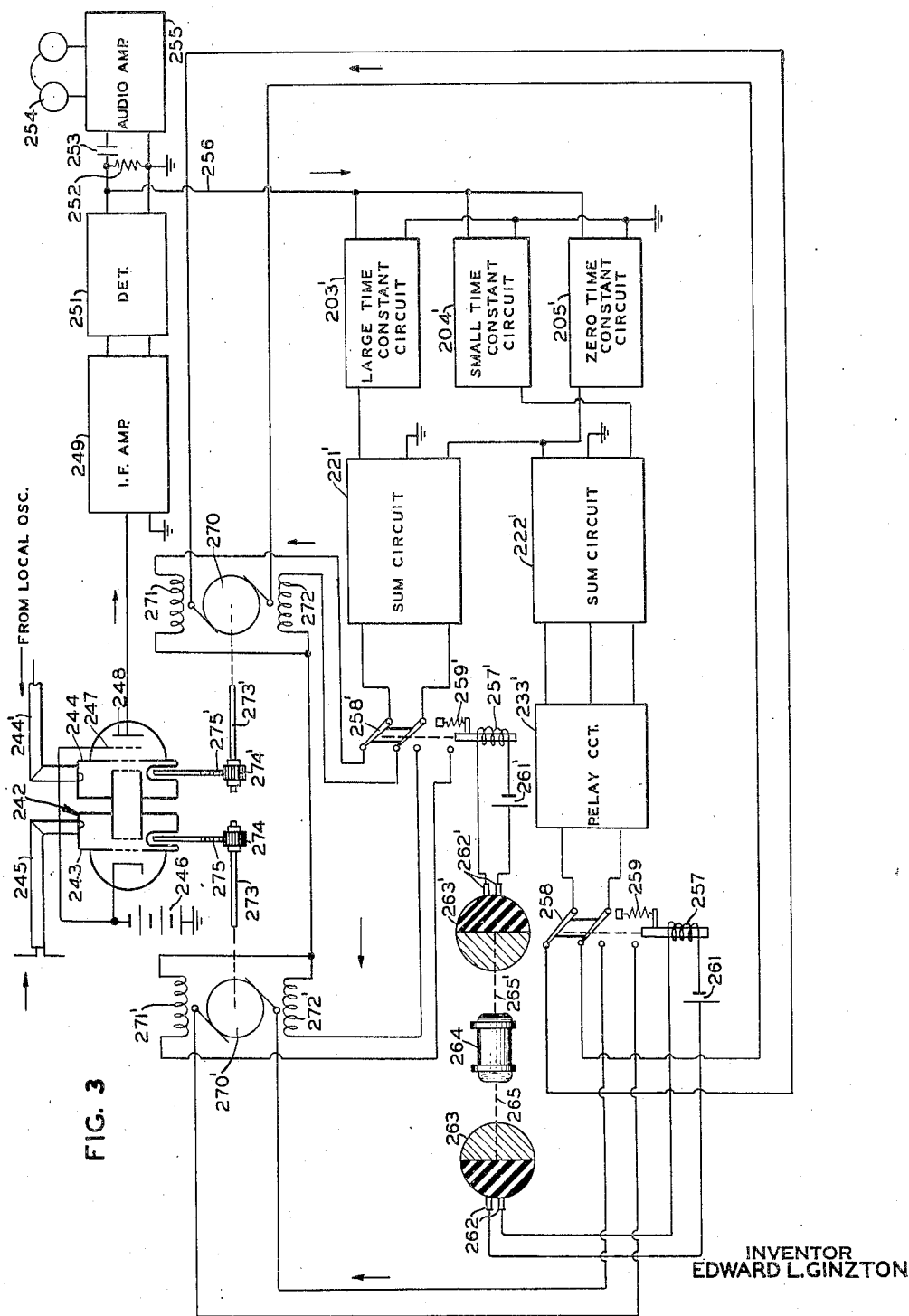
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2 Sheets-Sheet 2



INVENTOR
EDWARD L. GINZTON

Paul B. Hunter.
ATTORNEY

UNITED STATES PATENT OFFICE

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TRANSMITTER AND/OR RECEIVER
CIRCUITSEdward L. Ginzton, Wantagh, N. Y., assignor to
The Sperry Corporation, a corporation of Dela-
ware

Application May 19, 1942, Serial No. 443,604

24 Claims. (Cl. 250-17)

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This invention relates, generally, to transmitter and/or receiver circuits wherein means are provided for maintaining oscillators or amplifiers either at a fixed operating frequency or at an operating frequency determined by a master unit or by an incoming signal.

In the operation of transmitters and receivers, and specifically ultra high frequency transmitters and receivers, it is highly desirable that the transmitters be operated at as nearly fixed frequency as possible and that maximum output be maintained regardless of disturbing influences, such as changes in operating parameters, and that receivers be compelled to follow as closely as possible variations in the frequency of the incoming signal while operating at a maximum output. While the invention is disclosed in connection with ultra high frequency transmitter and receiver circuits it is understood that the same is not limited thereto but can be applied to other apparatus with equal facility, i. e., wherever tracking is desired or where maximum output is desired.

One object of the present invention is to provide means for causing the power amplifier of a transmitter to exactly track the oscillator used in conjunction therewith.

Another object of the present invention is to provide a maximizing device adapted for maintaining equipment at maximum output such, for example, as maintaining an oscillator at maximum output by use of memory circuits so designed that the system will search out the proper position of the control means to obtain a maximum output.

Other objects and advantages will become apparent from the specification, taken in connection with the accompanying drawings wherein the invention is embodied in concrete form.

In the drawings,

Fig. 1 is a schematic wiring diagram of a preferred embodiment of the invention applied to a transmitter power amplifier provided with memory circuits operating to maintain it at maximum output.

Fig. 2 is a schematic wiring diagram of another embodiment of the invention similar to Fig. 1.

Fig. 3 is a schematic wiring diagram of a further embodiment of the invention wherein the

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principles shown in Figs. 1 and 2 are applied to a receiver.

Similar characters of reference are used in all of the above figures to indicate corresponding parts.

Referring now to Fig. 1, the reference numeral 1 designates an oscillator illustrated as a low power source, preferably of the type disclosed in Patent No. 2,242,275, issued May 20, 1941, in the name of R. H. Varian, for Electrical translating system and method. The oscillator 1 may be used by itself or may be used as the upper end of a stabilized frequency multiplication chain such as a crystal controlled chain. Energy is supplied from the output or catcher resonator of source 1 through a concentric line 3 to the buncher resonator 5 of an amplifier 4 of the type disclosed in the above mentioned patent. Energy from the power amplifier 4 is supplied from catcher resonator 6 thereof through concentric line 7 and radiated as from a dipole antenna 7' attached thereto.

A maximum finding device useful for keeping apparatus at its maximum output is also shown in Fig. 1. In this figure the device is shown applied for keeping the catcher resonator 6 of the power amplifier 4 tuned to maximum output through concentric line 7 to the antenna 7'. The buncher resonator 5 is shown excited with ultra high frequency energy supplied from a concentric line 3 connected therewith, the said line being fed from low power oscillator 1. A concentric transmission line 204 coupled to catcher resonator 5 supplies a small amount of energy to a detector 202 of any suitable type, such as a crystal rectifier, the detected output of which appears as a voltage across its load resistor 301 and is fed into two time constant circuits 204 and 205, which circuits are respectively moderate or short- and zero-time-constant circuits. These circuits comprise triode tubes 207 and 208, respectively, whose grids are connected to the grounded (negative) terminal of resistor 301 and are thereby controlled from the output of detector 202. The tube 207 of the short-time-constant circuit 204 has a plate circuit including plate battery 277 and a resistance 211 which is bridged by a condenser 214 which is of moderate size so as to give this circuit a short-time-constant of preferably around one second or less.

Tube 208 of substantially zero-time-constant circuit 205 has a plate battery 278 in series with a resistance 212 in its plate circuit, which resistance 212 is bridged by a very small condenser 215 which gives this tube a very short or substantially zero time-constant, so that the current in this tube instantly responds to changes in its grid voltage. The cathode-biasing resistors of tubes 207 and 208 and their batteries 277 and 278 are selected to cause tubes 207 and 208 normally to pass current, and to make the potentials of their plates normally equal.

Two sum or combining circuits 221 and 222 are employed. The circuit 221 consists of the two tubes 227 and 227' whose plates are respectively connected through respective opposed field windings 31 and 31' of tuning motor 32 to a common plate battery 302 and thereby to their joined cathodes. The rotor of this motor 32 is connected to drive the shaft 234 carrying pinion 237 which operates rack 240 of a tuning plunger 233 which varies the resonant frequency of resonator 6. Motor 32 is of the type which is stationary when equal currents flow through its field windings 31, 31', and which rotates in one direction or the other according as the current in winding 31 exceeds or is less than that in winding 31'. The direction of rotation of motor 32 may also be reversed by reversing the polarity of the voltage applied to its armature.

The joined cathodes of tubes 227 and 227' are connected to ground through a common cathode-biasing resistor 225. The grids of these tubes are connected to ground through respective input resistors 223 and 223'. The grid of tube 227 is connected to the positive terminal of battery 316, whose other terminal is grounded. The grid of tube 227' is connected to the negative terminal of a battery 218 whose positive terminal is connected to the plate of zero-time-constant tube 208. The voltage of battery 218 is selected to oppose and to be substantially equal to the voltage between the plate of tube 208 and ground, when no voltage appears across detector load resistor 301; that is, when no oscillations exist in resonator 6, due to its resonant frequency being widely different from the frequency of the input from source 1. Hence, under this condition, no voltage appears across resistor 223'.

In the absence of potentials applied to the grids of these tubes 227, 227', equal currents are supplied to the two windings 31, 31' of motor 32, so this motor is stationary. If desired, tubes 227, 227' may be adjusted just to cut-off so that no current will be supplied to either winding 31 or 31' for zero grid voltages. Battery 316 serves to impress a voltage across resistor 223 making the potential on the grid of tube 227 more positive and causing tube 227 to pass more current and thereby drive motor 32 to actuate the tuning plunger 233 in a certain direction. This plunger 233 continues its motion until the end of travel thereof whereupon a trip lever 239 actuates a reversing switch 241 which reverses motor 32 so that this motor drives the plunger 233 in the reverse direction. In this way, the resonant frequency of resonator 6 is periodically varied or scanned across a frequency range until it coincides with the frequency of the energy supplied to input line 3.

Assuming that during the travel of the plunger 233 the amplifier 4 becomes tuned to the incoming signal from source 1, a negative potential derived from detector 202 is applied to the grid of tube 208, thereby decreasing the current

passed by tube 208, and making its plate more positive. This action is substantially instantaneous, since the time constant of resistor 212 and condenser 215 is almost zero. This action at once makes the grid of tube 227' more positive, and so that tube 227' passes more current to winding 31', which bucks winding 31 and hence reduces the speed of motor 32.

Preferably, the voltage of battery 316 is selected to be substantially equal to the maximum voltage produced across resistor 223' when resonator 6 is excited to maximum amplitude of oscillation; that is, when resonator 6 is tuned to resonance with the input supplied by line 3. This way, motor 32 will stop upon reaching proper tuning of resonator 6, since then the voltage across resistor 223' will be equal to the voltage of battery 316, producing equal excitation of windings 31, 31', which then neutralize one another to stop motor 32. If this condition of equality cannot be obtained, the battery voltage is selected to be as large as the maximum voltage across resistor 223' which is expected to occur during operation. Then motor 32 will run at least until the proper tuned condition is reached, although it may tend to run past this position. It is desirable that the battery voltage be not smaller than the resistor 223' voltage, since otherwise the motor will stop before true resonance is attained.

The second combining circuit 222 has two tubes 228, 228' with a common grounded cathode biasing resistor 226. The grids of these tubes are connected to ground through respective input resistors 224, 224', and are also connected respectively to the plates of tubes 207 and 208 through respective batteries 217 and 218, which oppose plate batteries 277 and 278. The voltages of batteries 217 and 218 preferably are substantially equal respectively to the voltages of batteries 277, 278 less the respective volt drops in resistors 211, 212 due to normal current therein (for zero grid voltage of tubes 207, 208), so that normally zero voltage is impressed across input resistors 224, 224'.

A relay 233 has two opposed coils 229, 229' connected respectively in the plate circuits of tubes 228, 228'. The armature 231 of relay 233 is normally in the position shown, and connects battery 232 to the armature of motor 32, by way of leads 230 and through reversing switch 241. If the output current of tube 228 is greater than that of tube 228', the action of coil 229 overcomes that of coil 229', and the relay armature 231 is kept pulled toward coil 229, as shown, to place the battery 232 across the leads 230 in one sense. If the current through coil 229' is greater than that in coil 229, the battery 232 is placed across leads 230 in the opposite sense, and motor 32 will run in the opposite direction. Thus, the direction in which motor 32 operates is determined by whether the potential of the grid of tube 228 is greater than that of tube 228' or vice versa.

In operation, assuming that amplifier 4 is operating far from its resonant frequency, the action of battery 316, circuit 221 and reversing switch 241 scans the operating frequency range until resonator 6 is tuned to a frequency near that of source 1. Then a voltage appears across resistor 301, and the current in both tubes 208 and 207 decreases. The current in tube 208 decreases faster than that in tube 207, due to the difference in the time constants of the plate circuits of those tubes. Thus, the potentials of the grids of tubes

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228 and 228' both become more positive, but that of tube 228 changes positively more quickly. The current in relay coil 229 therefore remains greater than that in coil 229', and relay armature 231 remains in the position shown. Motor 32 therefore continues to tune resonator 6 toward resonance with the input wave.

So long as exact resonance is approached, the voltage across resistor 301 continues to increase, and the current in coil 229 continues to exceed that in coil 229'. However, when the resonant condition is passed, the amplitude of oscillation of resonator 6 (and hence the voltage across resistor 301) decreases, instantaneously increasing the current in tube 208. The potential of the grid of tube 228 thus becomes more negative, decreasing the current in coil 229. The current in coil 229', however, does not change at once, due to the time constant of resistor 211 and condenser 214. Therefore, coil 229' attracts armature 231 and reverses motor 32, which then again returns resonator 6 to be resonant with the incoming wave from source 1. The resonant frequency of resonator 6 thus is caused to hover about the frequency of the input signal.

For the above operation to be maintained, it is necessary, of course, that the voltage of battery 316 be equal to or greater than the largest voltage produced across resistor 223' by virtue of the variation in voltage across resistor 301. It is desirable that battery 316 be equal to the voltage across resistor 223' when resonator 6 has its maximum amplitude of oscillation, since then, when the resonator is exactly tuned to the incoming signal supplied through line 3, the output of the zero time constant circuit 205 as supplied across resistor 223' exactly opposes the voltage of battery 316 as applied to resistor 223, so that the net field of motor 32 is zero, and hence this motor does not operate in either direction and resonator 6 is kept at resonance.

Now if it be assumed that, for some reason, amplifier 4 starts to operate at one side of its input frequency, then the output of tube 208 will at once fall off. Since the output of battery 316 is fixed, a differential field will be produced for motor 32 and this motor will start to operate to move plunger 240 in one direction. However, so far the direction of rotation of motor 32 has not been determined, and it merely operates in one direction or the other. If the rotation is in the correct direction, so that the resulting tuning brings the peak of the resonance curve of the amplifier back to the input frequency, then the difference between the outputs of channels 205 and 204 will be of positive polarity, indicating that the magnitude of oscillation in the amplifier 4 is building up, and the motor will continue to rotate in the same direction, since relay 231 will remain in its position shown in Fig. 1. The rotation continues until the output of amplifier 4 is a maximum, at which time the rotation will automatically stop since the volt-drops across 223 and 223' will then be equal. If the motor 32 actually started turning in the wrong direction, then the difference between the outputs of channels 205 and 204 will be negative, and this would reverse the direction of rotation of motor 32 due to the tripping of relay 231.

It will thus be seen that this device of Fig. 1 in a sense simulates manual tuning. In tuning any device to the maximum setting, one first observes what the output of the device should be, as provided here by battery 316. Then one

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arbitrarily moves the tuning knob and finds out whether or not the result is an improvement in the output, corresponding to the action of channels 204 and 205, which indicate whether the motor is turning in the proper sense.

An approximation to having the voltage of battery 316 equal to the voltage produced across resistor 223' at maximum oscillation of resonator 6, can be obtained by use of a long (substantially infinite) time constant circuit 203, shown in Fig. 2, in place of battery 316.

Circuit 203 is similar to circuits 204, 205, having a tube 206 with a long time constant circuit in its plate circuit, formed by resistors 209 and condensers 213. The grid of tube 206 is also connected to resistor 301. Suppose amplifier 4 is properly tuned. Circuit 203 then effectively "remembers" what the condition of amplifier 4 is, so that, should any deviation from the desired condition occur, circuits 204 and 205 will restore amplifier 4 to its previous condition as determined by circuit 203.

Thus, instead of an infinite time constant determining the operation of motor 32, i. e., that provided by battery 316, a somewhat shorter time constant is now substituted, namely that provided by circuit 203. It will be noted that channel 203 in operation effectively remembers what the output of detector 202 was when resonator 6 was perfectly tuned, channel 205 tells the motor 32 whether or not the detector output is more or less than it was a short time ago, and channel 204 determines whether or not the motor is turning in the right direction. That is, circuit 205 will cause motor 32 to retune amplifier 4 until balanced by circuit 203, the direction of rotation of motor 32 being determined by circuits 204 and 205 as before.

Fig. 1 is desirable when the apparatus is just starting up, for at that time the resonator 6 is completely detuned, the battery 316 then serving as a reference to determine what is expected of the amplifier 4. However, after accurate tuning is once effected, Fig. 2 is desirable, so that the long time constant circuit 203 will determine the voltage across resistor 223 and control the operation. It will be obvious that a simple switch, such as switch 317 of Fig. 2, may be used to transfer from the Fig. 1 system to the Fig. 2 system, after accurate tuning is accomplished by the Fig. 1 device.

If desired, two separate systems of the type of Fig. 1 or 2 may be used to separately tune resonators 5 and 6 or one such system may be caused to alternately tune these resonators by use of a commutator. The latter arrangement is illustrated in Fig. 3. In this figure the output of an entire receiver system is used to achieve proper tuning of the resonator rather than using the output of a crystal to maximize the output of the resonators, as in Figs. 1 and 2. In Fig. 3, the system of Fig. 2 is employed to maximize the output of a detector in the utilization channel of an ultra-high-frequency receiver of the superheterodyne type. The buncher resonator 243 of amplifier-detector 242 of Fig. 3 is shown receiving signal energy through line 245. Energy from a local oscillator is fed into the catcher resonator 244 by way of line 244'. The output from detecting-plate 243 is then an intermediate frequency wave modulated by the intelligence frequencies. This intermediate frequency wave is applied directly to the intermediate frequency amplifier 249, thence to detector 251 and audio amplifier 255, and thereby to the utilization de-

vice such as ear phones 254. The detected direct-current component of the output of detector 251 is applied as before to three channels, namely an infinite-large-time-constant circuit 203', a short-time-constant circuit 204' and a zero-time-constant circuit 205'. The outputs of these channels are applied as in Fig. 2 to sum circuits 221', 222'. The output of sum circuit 221', as before, may be applied directly to the field coils of a direct-current motor for retuning both resonators 243, 244 if desired, or for tuning the single resonator 244 as illustrated. The output of sum circuit 222' may be applied through reversing relay 233' to the armature of the same motor. In Fig. 3 the outputs of the two sum circuits 221', 222' are shown commutated by half-conductor, half-insulator commutators 263, 263' cooperating with relays 257, 257' and switches 258, 258'. The commutators 263, 263' are shown continuously driven by a motor 264. Thus, in operation the outputs of sum circuits 221', 222' are used alternately for controlling tuning motors 270, 270', each tuning operation being of a sufficient length of time to effect the required tuning. Obviously, by using additional commutators more than two tuning controls may be operated.

Although Figs. 1 to 3 have been shown as illustrated in connection with maximizing the output of a high frequency tube, these circuits are equally applicable for maximizing the output of any device where a voltage signal can be produced responsive to the output of the device and having a control member adapted to be driven by a motor and for adjusting the output of the device.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In apparatus of the character described, means for producing energy, and means for controlling said energy-producing means to maintain the latter at maximum output, said controlling means including means for supplying a potential responsive to the magnitude of the output of said energy producing means, a plurality of time-constant circuits connected for receiving said potential, the time constants of said circuits being different from one another, sum circuits supplied from said time-constant circuits, motive means connected for controlling the output of said energy producing means, said motive means being connected to be controlled from said sum circuits.

2. Apparatus as defined in claim 1 wherein said motive means comprises a plurality of separate motive devices, and wherein commutating devices are included in the connection between said motive devices and said sum circuits for effecting alternate operation of said motive devices.

3. In apparatus of the character described, a tunable device, a long-time-constant circuit, a short-time-constant circuit and a zero-time-constant circuit coupled to said device, a pair of sum circuits, the first of said sum circuits being connected to said long-time-constant and to said zero-time-constant circuit, and the second of said sum circuits being connected to said zero-time-constant circuit and to said short-time-con-

stant circuit, motive means for tuning said device, said first sum circuit being connected for starting and stopping said motive means, and said second sum circuit being connected for determining the direction of operation of said motive means.

4. In apparatus for maintaining maximum output amplitude from a device producing a potential responsive to said output amplitude, means controlling said device to vary the output amplitude thereof, and a plurality of control circuits responsive to said amplitude having different time constants and connected jointly to control jointly said controlling means, said circuits being responsive to said potential.

5. In the apparatus defined in claim 4, said controlling means comprising a motor, means connecting certain of said control circuits to said motor for effecting reversible actuation of said motor, and means connecting certain of said control circuits to said motor for selecting the proper direction of actuation of said motor.

6. In apparatus for automatically controlling the frequency of a variable frequency device, the combination comprising means for tuning said device including motor means, a plurality of control circuits having different time constants connected to the output of said device, means connecting certain of said control circuits to said motor means for effecting reversible actuation of said motor means, and means connecting certain of said control circuits to said motor means for selecting the proper actuation of said motor means.

7. In apparatus for automatically controlling the frequency of a variable frequency device, a detector connected to the output of said device, tuning means for said device, reversible motor means coupled to said tuning means, control circuits connected to the output of said detector for actuating the motor means, one of said control circuits serving to effectively remember the output of said detector when the device is properly tuned, another of said control circuits serving to effectively detect deviations of said detector output, and another of said control circuits for determining the direction of actuation of said motor means, and means connecting said control circuits to said motor means.

8. Apparatus for automatically controlling the frequency of a variable frequency device, a plurality of individual tuning means and motors for each tuning means, a plurality of control circuits having different time constants, integrating circuits connected to said control circuits, and commutator means alternately connecting said integrating circuits for controlling the respective motors.

9. In apparatus for controlling a variable frequency high frequency device, reversible motor-driven means for tuning said device, a plurality of control circuits having different time constants connected with the output of said device, three of said control circuits being substantially of zero, relatively small and large time-constants respectively, means including an integrating circuit connecting said large and zero-time-constant control circuits to said reversible motor-driven means, a relay circuit including a reversing switch connected to said motor-driven means, and a second integrating circuit connecting said small and zero-time-constant circuits to said relay circuit to determine the proper direction of rotation of the motor-driven means.

10. The apparatus defined in claim 9, wherein

said motor-driven means includes a plurality of tuning means for said device and a reversible motor for each tuning means, switching means for alternately connecting said first integrating circuit to said motors, a second switching means for alternately connecting said relay circuit to said motors, and commutator means controlling actuation of said switching means.

11. Apparatus for tuning a resonant circuit to resonance with an applied frequency, comprising means for tuning said circuit, means responsive to change in the amplitude of oscillation of said circuit for actuating said tuning means, and means responsive to the sense of said change in oscillation amplitude for controlling the direction of actuation of said tuning means.

12. Apparatus as in claim 11, wherein said actuating means comprises a long-time-constant circuit and a zero-time-constant circuit both responsive to said oscillation amplitude, and means differentially responsive to said time-constant circuits for actuating said tuning means.

13. Apparatus as in claim 11, wherein said sense-responsive means comprises a short-time-constant circuit and a substantially zero-time-constant circuit both energized by said oscillation amplitude, and means differentially responsive to said time-constant circuits for controlling the direction of actuation of said tuning means.

14. Apparatus for maximizing the output amplitude of a variable output device, comprising means responsive to a change in output amplitude of said device for adjusting said output amplitude in an arbitrary direction, and separate means responsive to the sense of said arbitrary adjustment for controlling said adjusting means to increase said output amplitude.

15. Apparatus as in claim 14, wherein said sense-responsive means comprises means for comparing the instantaneous output of said device with its output at a prior time and means for controlling said adjusting means in response to the polarity of the difference between said output values.

16. High frequency apparatus, comprising a mixer-detector having a pair of tuned circuits, means for supplying an input wave to be demodulated to one of said circuits, means for supplying a local oscillator wave to the other of said circuits, means for deriving an intermediate frequency wave from said mixer-detector, means for detecting said intermediate frequency wave, and means responsive to the output of said detecting means for controlling the tuning of said circuits into resonance with said input wave and said local oscillator wave, said last-named means comprising independent tuning means for said circuits and commutator means for actuating said tuning means alternately and successively in response to said detecting means output.

17. Apparatus as in claim 16, wherein said tuning controlling means comprises means responsive to a change in amplitude of said detecting means output for initiating operation of said tuning means, and means responsive to the sense of said amplitude change for controlling the direction of operation of said tuning means.

18. High frequency apparatus, comprising mixer means having a tuned circuit, means for supplying a received wave and a local oscillator wave to said mixer means, means for deriving an intermediate frequency wave from said mixer means, and means responsive to said intermediate frequency wave for controlling the tuning of said mixer, said tuning control means compris-

ing means for tuning said mixer, means responsive to a change in the amplitude of said intermediate frequency wave for initiating operation of said tuning means, and means separately responsive to the sense of said amplitude change for controlling the direction of operation of said tuning means.

19. High frequency power amplifier apparatus for amplifying a wave of predetermined frequency, comprising amplifying means having a tuned circuit, means for tuning said circuit, means responsive to a change in the amplitude of oscillation of said circuit for actuating said tuning means, and means responsive to the sense of said oscillation amplitude change for controlling the direction of actuation of said tuning means to retune said circuit into resonance with the frequency of said wave.

20. High frequency superheterodyne receiver apparatus, comprising an electron discharge device having a pair of cavity resonators tuned respectively to the received wave and the local oscillator frequency, and having means for projecting an electron beam successively through said resonators and for detecting variations in the velocity of said electrons, means for supplying a received wave to the resonator tuned thereto, means for supplying a local oscillator wave to the other of said resonators, means connected to said detecting means for deriving an intermediate frequency wave, and means for automatically maintaining said resonators tuned to said waves, said last means including means responsive to a change in amplitude of said intermediate frequency wave for tuning said resonators, and means responsive to the sense of said amplitude variation for controlling the direction of operation of said tuning means.

21. Ultra high frequency apparatus, comprising a source of received signal, a source of local oscillator frequency, a mixing device comprising a pair of spaced hollow resonators and means for passing an electron beam successively through said resonators, means for coupling each one of said sources to a different resonator, and detector means in the path of said beam beyond said resonators for producing an intermediate frequency from said device.

22. In apparatus for automatically maintaining maximum power output from a variable frequency device having its power output dependent upon its frequency, the combination comprising means for tuning said device, means for obtaining a signal corresponding to the amplitude of said power output, a plurality of control circuits having different time constants connected to said last-named means and all responsive to said signal, and means connecting all said control circuits to said tuning means to actuate said tuning means to maintain said device at optimum frequency for obtaining maximum power output therefrom.

23. Automatic control apparatus comprising a variable output device, means for adjusting the output of said device, means for deriving a signal corresponding to said output, means controlled jointly by said first signal and by a fixed signal for starting and stopping said adjusting means, and means controlled jointly by said first signal and a delayed version of said first signal for determining the direction of operation of said adjusting means.

24. Automatic control apparatus comprising a variable output device, means for adjusting the output of said device, means for deriving a first

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signal corresponding substantially instantaneously to said output, means for deriving a second signal corresponding to recently past values of said output, means for deriving a third signal corresponding to a desired condition of said output, means responsive to said first and third signals for actuating said adjusting means, and means responsive to said first and second signals for determining the direction of operation of said adjusting means.

EDWARD L. GINZTON.

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Certificate of Correction

Patent No. 2,462,856.

March 1, 1949.

EDWARD L. GINZTON

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 2, line 43, for the word "grounded" read *ungrounded*; column 6, line 15, for "condensers" read *condenser*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of October, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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