

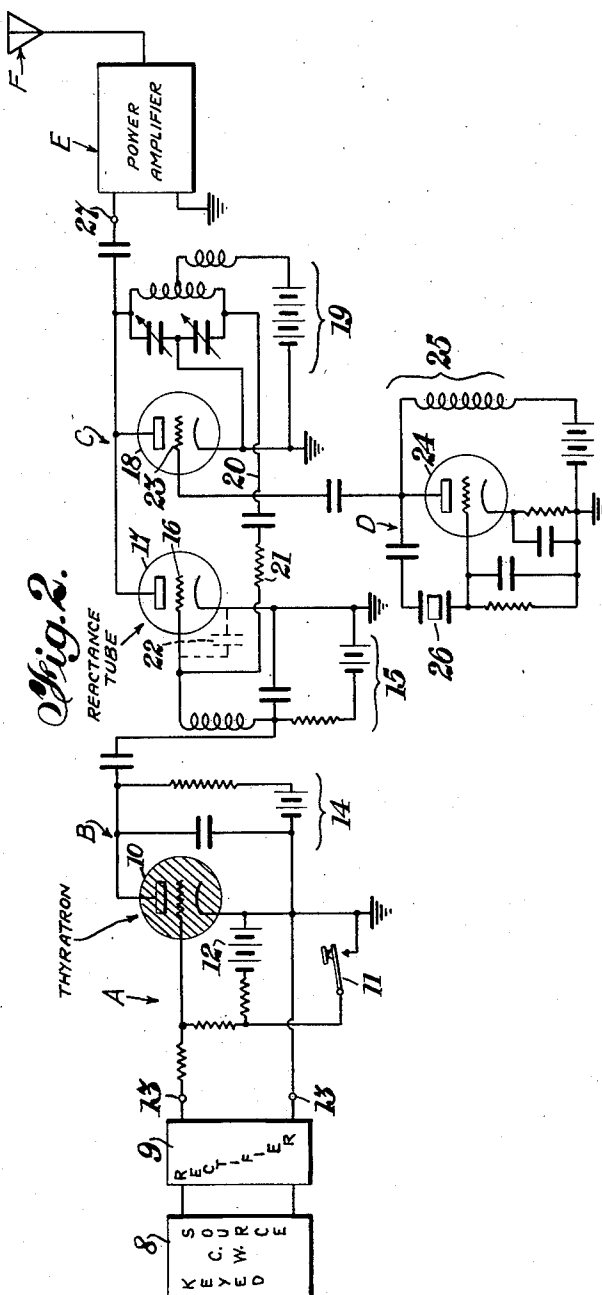
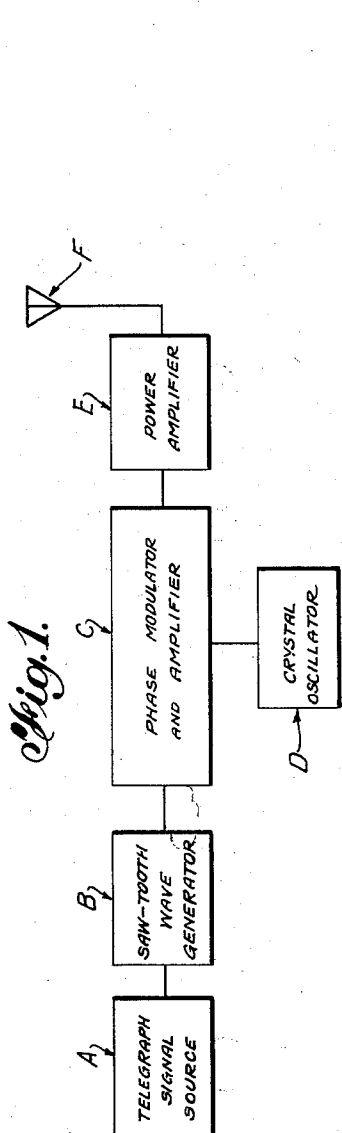
Aug. 7, 1945.

S. FRANKEL

2,380,959

FREQUENCY CHANGING SIGNAL GENERATING SYSTEM

Filed Oct. 21, 1943



INVENTOR.
SIDNEY FRANKEL

BY *Geo. J. Hyde*
ATTORNEY

UNITED STATES PATENT OFFICE

2,380,959

FREQUENCY CHANGING SIGNAL
GENERATING SYSTEM

Sidney Frankel, Forest Hills, N. Y., assignor to
Federal Telephone and Radio Corporation,
New York, N. Y., a corporation of Delaware

Application October 21, 1943, Serial No. 507,107

7 Claims. (Cl. 178—66)

This invention relates to electrical signal generating and transmission systems and particularly to systems for transmitting signals at different frequencies.

The invention is especially suitable for use in continuous wave telegraph systems in which successive components of the signal are sent at different frequencies. For instance, the signal elements such as dots and dashes, or "marking" signals, are transmitted on one frequency, while the intervening spaces, or "spacing" elements are sent out on another frequency. With this arrangement continuous transmission may be maintained, the signal components being identified by their frequencies. The required frequency shift can be obtained by changing the frequency of a wave-generating oscillator; but such an arrangement makes it difficult in practice to maintain the desired frequency stability, especially during spacing, and prevents the use of a stabilized oscillator.

A feature of the invention is the provision of a novel type of wave generating and transmitting system in which the frequency shift is produced without affecting the oscillator circuit, thereby permitting the use of a stable oscillator, and specifically a crystal-controlled oscillator. A further feature is the maintenance of uniform output when successive signal elements at different frequencies are continuously transmitted.

According to the invention both signal frequencies are obtained from a single stable oscillator, one being the normal oscillator frequency while the other is produced by a phase shifting arrangement in which a change in applied voltage produces a corresponding phase shift. The arrangement advantageously utilizes a reactance tube modulator in which said voltage is applied to the grid of the modulator tube. In utilizing an arrangement of this type it is not sufficient merely to apply the signal voltage to said grid, since the resulting fixed voltage change will result merely in a shift of the phase by a constant amount, which will not affect the frequency during the signal period following such an initial shift.

In order to obtain the desired frequency change it is necessary to provide a continuous and uniform change in the applied voltage, the resulting uniform phase shift being equivalent to a frequency change, the frequency produced being proportional to the rate of phase shift and therefore to the rate of change of the applied voltage. Since a voltage that is continuously changing at a uniform rate would soon reach an impractical

magnitude, the indicated method of changing frequency appears to be impractical.

A primary purpose of the invention is to provide a practical arrangement for producing the required voltage change and a resultant frequency change of satisfactory uniformity. This is in general accomplished by employing as a source of applied voltage a saw-tooth wave generator in which the voltage change during the main portion of each wave is substantially uniform, and the change or voltage return at the end of each wave is very rapid. With this arrangement the phase of the modulator output will be uniformly shifted during the period when the main portion of the voltage wave from the generator is applied to the modulator.

The frequencies produced by the very rapid voltage shift at the wave end and the correspondingly high rate of phase shift in the modulator will be so high that they are supersonic, avoiding the production of an undesirable tone quality, and can readily be filtered out without affecting the main frequency. Moreover, these high frequencies are of such short duration that they have a negligible overall effect on the signal waves, which are entirely satisfactory for continuous wave telegraphy.

Other objects and advantages of the invention will appear from the following description considered in connection with the accompanying drawing in which;

Fig. 1 is a block diagram of a system embodying the invention; and

Fig. 2 is a diagram of said system including the circuits of one form of the wave generating and modulating portions thereof.

In the system illustrated generally in Fig. 1, telegraph signals from a suitable source A are utilized to actuate a saw-tooth wave generator B, the operation of the signal source and wave generator being advantageously adjusted so that a plurality of saw-tooth voltage waves having uniform voltage increase and very abrupt voltage drop will be generated during the transmission of each signal element or marking period. The desired results may conveniently be obtained by employing a normally block generator tube, and unblocking the tube by applying the signal potential to the blocking grid.

The saw-tooth waves are applied to a modulator circuit C which also receives the output from a stabilized oscillator such as crystal oscillator D. The modulator C is of a type in which the phase of waves from the oscillator D is shifted by voltage waves from generator B during the trans-

mission of signal elements from said generator. This is advantageously accomplished by employing a reactance tube modulator in which the output from generator B is applied to the grid of the reactance tube, coupled to an amplifier tube which receives and amplifies the waves from oscillator D. The output of the combined modulator and amplifier C may be amplified as by power amplifier E and fed to antenna F for transmission where the arrangement is used in a radio transmitting system.

A circuit diagram of one embodiment of the system is shown in Fig. 2. The saw-tooth wave generator B comprises a gas-discharge tube or thyatron 10 which is normally blocked. The input circuit of said tube may be connected to a suitable keyer of standard type arranged to unblock the tube when the key is closed and to re-establish its blocked conditions when the key is open, and a special key-controlled local unblocking arrangement may likewise be provided. The local control includes key 11 connected to short-circuit the blocking battery 12 when the key is closed. The other includes input terminals 13 connected to any of the standard C. W. generator and keyer systems indicated generally at 8, in which continuous waves of suitable frequencies are keyed, said waves being rectified by rectifier 9 before application across terminals 13, the potential thus produced during signal or marking periods being suitable for unblocking tube 10. In Fig. 2 there is, therefore, shown a system in which two different keying controls are shown. In actual practice, the keyed source 8 may be situated at a point quite remote from the actual transmitter and it is often desirable to be able to key the signals directly at the transmitter, for testing or in case of line trouble between a remote keying point and the transmitter. The two keying arrangements shown in Fig. 2 in nowise interfere with one another. They can both be wired in so as simultaneously to be present, even though under normal operating conditions, only one of the keying controls will be utilized at any given instant. Therefore, these two keying arrangements do not constitute separate modifications of this invention.

Tube 10 is incorporated in a suitable saw-tooth wave generating circuit of known type, adapted to produce waves having a relatively uniform rate of voltage change throughout nearly the entire wave, and a very brief period of voltage return at one end of the wave. In the type of circuit illustrated, indicated generally at 14, the circuit components are designed to produce a steady substantially uniform voltage increase from the beginning of each wave to the point of tube discharge, which is as brief as is practicable.

The saw-tooth voltage wave from tube 10 is applied to a circuit provided with a source of oscillations and arranged to change the frequency of said oscillations in accordance with the variations in the applied voltage of the saw-tooth wave. This circuit is of a type which obtains the desired frequency change by means of a suitable phase shift, and advantageously is a reactance tube modulator circuit. A desirable embodiment is illustrated in which the saw-tooth waves from tube 10 are applied to grid 16 of reactance tube 17. The output of tube 17 is connected to the output of amplifier tube 18, whose output circuit 19 is connected to the grid 16 of tube 17 by a suitable feedback circuit 20 arranged to provide the necessary ninety degree phase shift. The feedback circuit disclosed is of an improved type in

which any tendency toward deviation from the required phase shift can be corrected by proper design or adjustment of the resistor 21. The circuit may utilize the grid-cathode internal capacity of tube 17, indicated at 22, or a corresponding external capacitor if the internal capacity is not of sufficiently high value.

The output of the oscillator D is applied to grid 23 of tube 18. The oscillator may be of conventional type, including a tube 24 connected to an oscillating circuit 25 including a piezo-electric frequency-controlling crystal 26. The output from tube 18 is conducted to terminal 27 which may be connected to the power amplifier E and antenna F.

The continuous uniform voltage shift applied to the grid 16 of tube 17 during the reception of the main portion of each saw-tooth wave will produce a corresponding uniform and continuous phase shift in the amplified waves from oscillator D in the output of tube 18, so that an output of a different frequency is supplied to the amplifier E; while the very high frequency shift similarly produced momentarily during the abrupt voltage drop at the end of each saw-tooth wave will be filtered out in the power amplifier E.

It has been found that by properly designing the saw-tooth wave generator circuit the voltage return period can be made so short that its effect on the output is negligible, the frequency produced by modulation being stable and continuous for all practical purposes and having a good tone that is not perceptibly affected by the effect of such voltage return. Voltage return periods of this type which have no appreciable effect on the output are for convenience referred to in the claims as of inconsiderable duration.

It is desirable to provide a discharge frequency for the saw-tooth wave generator B which will produce a plurality of saw-tooth waves during the transmission of each signal element, an arrangement that tends to improve the uniformity of operation of the system. A frequency shifting arrangement of the type disclosed will produce substantially uniform radiation from the antenna F, since the energy supplied to the antenna is not materially affected by the disclosed frequency changing system.

A brief resume of the operation of this transmitter is as follows: When neither one of the keying devices 8 or 11 acts to unblock the Thyatron 10, there are applied to the combined phase modulator and amplifier C, no currents of any character which will cause frequency changes therein. Accordingly, the fixed frequency current developed by oscillator D is applied, unchanged as to frequency, to amplifier 18, and the output of this amplifier excites power amplifier E, via coupling 27. There will then be radiated, or otherwise transmitted, a signal having a frequency correspondent to the frequency derived from oscillator D. When key 11 is depressed, or when an unblocking voltage is supplied by rectifier 9, Thyatron 10 will commence functioning, thus producing a saw-tooth voltage which is applied to the grid of reactance tube 17. The virtually continually changing voltage thus applied to the reactance tube causes a substantially uniform phase shift of the output derived from amplifier tube 18. As well known in the art, such phase shift gives rise to a change of frequency in the output of tube 18. As previously explained in detail, it is possible to neglect the effects occurring upon the return stroke of the saw-tooth oscillator since such return stroke is made to have

a duration of inconsiderable magnitude compared with the duration of the upward sloping portion of the saw-tooth wave. Therefore, the effective altered frequency derived from the action of the saw-tooth modulator may be considered substantially equivalent to that which would be obtained by the application to the phase modulator of a varying voltage, the rate of change of which voltage has substantially a constant slope. This brings it about that the altered frequency resulting from the saw-tooth modulator may be considered as substantially of a constant frequency having a value different from that of the frequency produced by oscillator D.

Receiving devices operating to distinguish between two or more different frequencies passing over a single channel of communication are well known in the art and, accordingly, a detailed description thereof is thought unnecessary. As one example of such receiver suitable for auditory reception, may be cited a heterodyne receiver in which the incoming signals are mixed with the output of the local oscillator so as to produce therewith a beat note lying within the range of audible frequencies. With an arrangement such as that just described, the two distinct incoming frequencies will produce two distinct beat notes, having different pitch from one another. It will be evident to one skilled in the art that any suitable type of frequency discriminatory receiver may be employed with the transmitter of this invention, and this invention is not limited to a heterodyne-type receiver.

While a preferred embodiment of the invention has been described and illustrated, it will be understood that this embodiment may be substantially varied without departing from the invention as set forth in the claims.

What is claimed is:

1. An electric wave frequency changing system comprising a source of waves of predetermined and substantially constant frequency, means for changing said frequency after the waves have left said source in accordance with an applied voltage and means for applying to the frequency changing means a frequency changing saw-tooth voltage wave having a voltage return period of inconsiderable duration, but keeping the output of said frequency changing means substantially constant, whereby the output of said system varies in frequency but is substantially constant in energy content.

2. An electric wave frequency changing system comprising a source of waves of predetermined and substantially constant frequency, means for changing said frequency after the waves have left said source by providing a substantially continu-

ous phase shift in accordance with the variation in an applied voltage, and means for applying to the frequency changing means a phase shifting saw-tooth voltage wave having a voltage return period of inconsiderable duration, but keeping the output of said frequency changing means substantially constant, whereby the output of said system varies in frequency but is substantially constant in energy content.

3. A frequency changing system as set forth in claim 2, in which said wave source includes means for stabilizing the frequency of said waves.

4. An electric wave frequency changing system comprising a source of waves of stabilized and substantially constant frequency, means for changing said frequency after the waves have left said source by providing a substantially continuous phase shift in accordance with variations in an applied voltage, said changing means including a reactance tube modulation circuit, and means for applying to the input of said circuit a saw-tooth voltage wave having a voltage return period of inconsiderable duration, but keeping the output of said frequency changing means substantially constant, whereby the output of said system varies in frequency but is substantially constant in energy content.

5. A frequency changing system as set forth in claim 4, in which the modulation circuit includes an amplifier tube, means for applying said waves to the input of the amplifier tube, a reactance tube coupled to the output of the amplifier tube, and means for applying the saw-tooth wave to the input of the reactance tube.

6. A continuous wave telegraph signal generator comprising a source of waves of predetermined and substantially constant frequency and means for periodically changing said frequency after the waves have left said source to form signal elements, comprising means for modulating the frequency of said waves in accordance with variations in an applied voltage, and key-controlled means for applying to said modulating means a frequency changing saw-tooth voltage wave having a voltage return period of inconsiderable duration, but keeping the output of said frequency changing means substantially constant, whereby the output of said system varies in frequency but is substantially constant in energy content.

7. A telegraph signal generator as set forth in claim 6, in which the saw-tooth wave applying means comprises a wave generating circuit including a normally blocked tube and key-controlled means for unblocking the tube.

SIDNEY FRANKEL.