Jan. 18, 1949. E. R. SHENK 2,459,462

TWO-TONE KEYER

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Fig. 1.

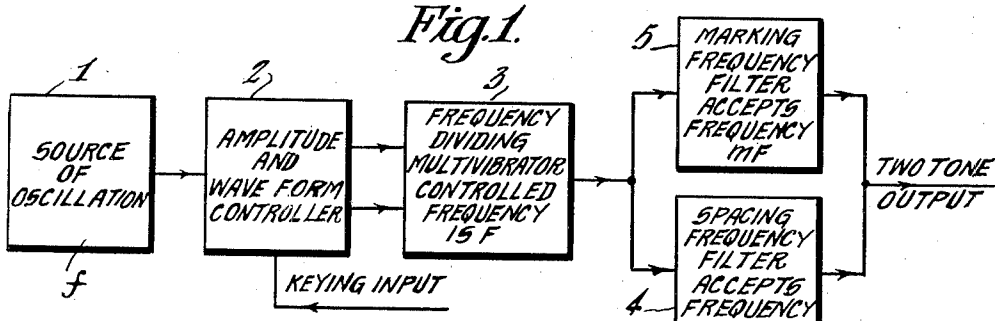


Fig. 2.

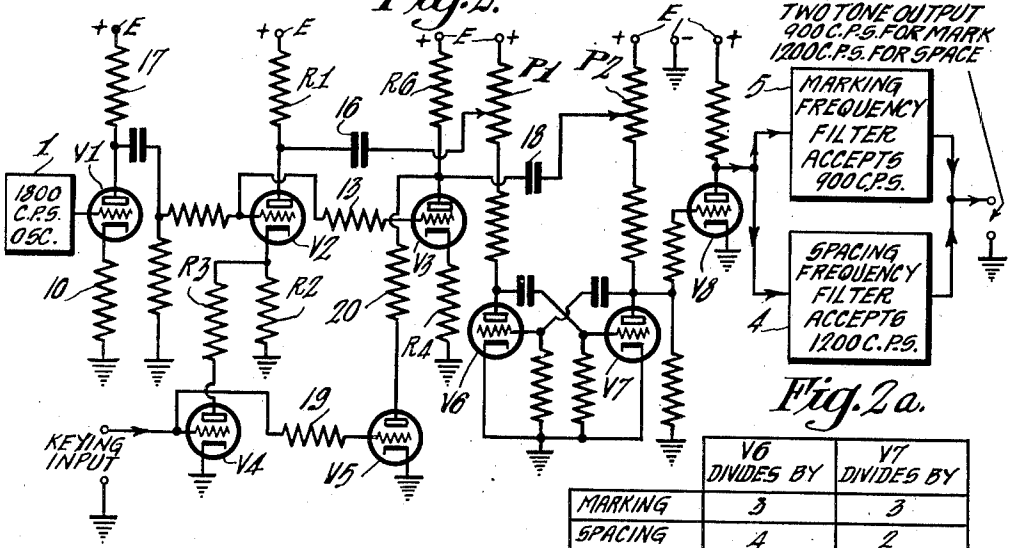
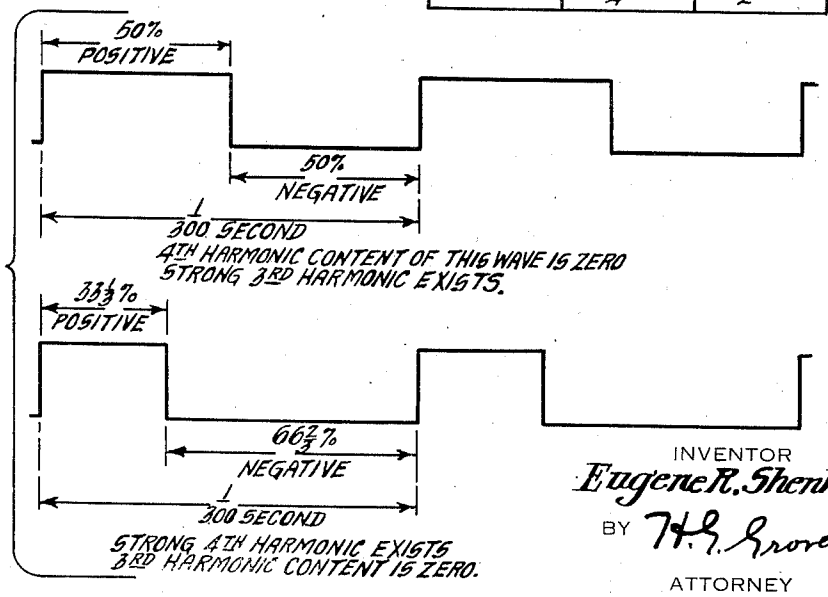


Fig. 2a.

	V6 DIVIDES BY	V7 DIVIDES BY
MARKING	3	3
SPACING	4	2

Fig. 3.



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TWO-TONE KEYER

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9 Claims. (Cl. 250—36)

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This application discloses a new and improved method of and means for generating oscillatory energies of two frequencies alternatively present and representing respectively mark and space condition as used in frequency shift to telegraphy or black and white (contrast) as used in facsimile and similar picture signalling systems. The telegraphy or facsimile receiver systems may be of the type described in Schock et al. application Serial #632,978, filed December 5, 1945, wherein is shown a receiver of such signals.

In many transmission systems where it is necessary to distinguish between two senses, for example, in frequency shift telegraphy signals or in black and white picture signals the two-tone or frequency shift method of signalling is becoming widely accepted as most desirable. This is in part because in the two-tone system energy is present in the receiver during spacing condition as well as during marking condition so that a more positive control of the recording apparatus is had.

Heretofore in two-tone keying systems, keying has in many cases been accomplished by providing continuously both tone frequencies and then by use of either a mechanical or electronic switch selectively choosing between the two tones in accordance with signal energies. A disadvantage of these known systems resides in the fact that as switching takes place from one tone to the other tone, parasitic oscillations and transients are generated in the circuits and then are transmitted with the signals unless elaborate filtering and damping means are used.

A general object of the present invention is to provide new and improved means of accomplishing two-tone keying of the nature described above.

A more specific object of the present invention is to provide an improved method of and means for generating oscillatory energies of different tone frequencies separated in the frequency spectrum the desired and rigidly fixed amount and for selectively translating said tone frequencies alternatively in accordance with signals for signalling purposes.

The above objects are attained in accordance with my invention by application of the well known fact that the harmonic frequency content of a rectangular wave is a function of the ratio of the positive portion of the wave to the total period of the wave. More specifically, in accordance with my invention the ratio of the positive to the negative portion of a rectangular alternating current wave is so selected as to render the amplitude of a given harmonic zero while maximizing another harmonic. The above ratio is then changed by signal keying so as to maximize the first harmonic and to minimize the said second harmonic. Suitable filtering circuits are then arranged to accept only the desired frequencies, one representing marking condition and the other representing spacing condition, or one representing black, the other representing white in a picture system. The terms "positive" and "negative" portions as applied to the waves are used broadly and include excursions in opposite directions irrespective of the sign of the voltage.

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In describing my invention in detail reference will be made to the detailed drawings wherein

Fig. 1 illustrates by block diagram and schematically the essential features of a two-tone keyer arranged in accordance with my invention.

Fig. 2 illustrates by circuit element including electron discharge devices, and circuit element connection, the essential features of a two-tone keyer arranged in accordance with my invention. In this embodiment the details of the selecting or filtering circuits are not shown since no claim to the same per se is being made herein.

Fig. 2*a* illustrates in a table form operation of the frequency divider used in the embodiment of Figs. 1 and 2; while

Fig. 3 illustrates by wave voltage diagram the manner in which the harmonics are generated and selected in the arrangement of Fig. 2.

In Fig. 1 rectangle **1** represents a source of oscillatory energy of any desired type which is of say sine wave form and of substantially constant frequency *f*. Rectangle **2** includes an amplifier and a current amplitude limiter and wave form controller which is excited by oscillatory energy from source **1** of the frequency *f*. The oscillations of frequency *f* are the synchronizing voltage, and are supplied to rectangle **3** wherein is included a frequency dividing multivibrator controlled, by oscillatory energy of the frequency *f*, to operate at a controlled frequency F. Rectangles **4** and **5** including filters for selecting harmonic energy of different frequencies representing different signalling condition and supplying the same to a two-tone output line from which the two tones may be impressed on a transmitting system. The two tones are separated by a fixed frequency band and since they are alternatively present they may be supplied over the common output circuit. The output of the multivibrators in **3** is supplied in parallel to the tone filters in **4** and **5**, one of which accepts a frequency, say *n*F, and the other of which accepts a frequency *m*F.

As will be seen from the description which fol-

lows, the arrangement is such that when marking voltage is supplied at the keying input terminals to control the amplitude of the wave form out of unit 2, the output wave form of the multivibrator in unit 3 is also controlled and is such that the frequency component nF is zero, but the component of frequency mF is considerable. Likewise, when the keying input to unit 2 is a voltage representing spacing condition, the amplitude of the synchronizing wave supplied to unit 3 is changed and the wave form of the multivibrator output is modified in such a manner that mF becomes zero and a large component of nF is present. It should be noted that the output tone frequencies are synchronous and are in the frequency ratio n/m. Furthermore, the frequency separation between the tones is an integral multiple of the fundamental frequency multivibrator in unit 3.

Details of the essential features of my system, except for the filters, has been shown in Fig. 2. In Fig. 2 the tubes V6 and V7 are in a multivibrator circuit which is, except as otherwise noted hereinafter, conventional. The control grids of the tubes are connected to the cathodes and ground by biasing resistors. The anodes and control grids are cross-coupled and the anodes are connected to the positive terminal of a source E of direct current potential through resistance including potentiometer resistors P1 and P2. The periodicity of the operation of the multivibrator including tubes V6 and V7 depends in part at least upon the magnitude of the anode potential. The output of the multivibrator is supplied to the control grid of a coupling tube V8 the anode of which is resistively coupled in parallel to the two filters 4 and 5. The source 1 may be any appropriate source of oscillations of substantially constant frequency and may be of sine wave form. The output of this source is supplied to an amplifier tube V1 which is biased by cathode resistor 10 and anode resistor 17 to operate as an amplifying current amplitude limiter. The output of this amplifier is fed to the grids of tubes V2 and V3 in parallel. A decoupling resistor 13 is included in the coupling to the grid of tube V3. The tubes V2 and V3 are similarly operated as current amplifiers and current amplitude limiters. Limiting takes place in the tubes V1, V2 and V3 by virtue of the fact that the control grids are driven beyond cutoff by the oscillatory energy on the negative halves of the cycles and are driven to saturation by the oscillatory energy on the positive halves of these cycles. The cathode circuit of tube V2 includes biasing resistor R2 of considerable value, while the anode circuit thereof includes anode load and voltage dropping resistor R1. The cathode circuit of tube V3 is similarly raised above ground by a biasing resistor R4 and its anode circuit includes an impedance and voltage dropping resistor R6. The anode of tube V2 is coupled to a point on potentiometer P1 by condenser 16 while the anode of tube V3 is coupled to a point on potentiometer P2 by condenser 18. The tube V2 then supplies synchronizing voltage to the plate circuit of tube V6 and the magnitude of this synchronizing voltage is adjustable by means of potentiometer P1. The tube V3 supplies synchronizing voltage to the anode circuit of tube V7 by way of condenser 18 and the magnitude of this voltage is adjustable by means of potentiometer P2.

The signal potential which in the example given may be considered to be zero voltage in the presence of marking condition or in the presence of black, and may be highly negative in the presence of spacing condition or when the picture is to be white, is applied in parallel to the control grids of two tubes V4 and V5. A decoupling resistor 19 is included in the coupling to the control grid of tube V5. The tube V4 is connected in shunt to the resistor R2 by the resistor R3. When tube V4 is non-conducting the anode current of tube V2 all flows through resistor R2 and considerable voltage is lost therein and the gain of this tube falls as does the magnitude of the synchronizing voltage fed to potentiometer P1. The tube V5 has its anode connected by resistor 20 to the anode of tube V3 so that this tube draws anode current through resistor R6, thereby sharing the current flow through this resistor R6 and the potential drop at the anode end thereof with the tube V3. Therefore, when tube V5 is non-conductive the gain of the tube V3 is greater than when the tube V5 is made conductive by the signals.

In the statement of operation which follows it is assumed that the source 1 supplies output of 1800 cycles per second. Other frequencies may be used. However, it is preferable that the frequency of the source 1 be a multiple of the frequency of operation of the multivibrator.

When zero voltage is applied to the input of tubes V5 and V4, potentiometers P1 and P2 are so adjusted that both tubes V6 and V7 divide by the same factor, in the example given by 3. This is shown in the chart of Fig. 2a. Thus the overall or total division of the multivibrator stage is 6. In this condition the output wave shape from the multivibrator is referred to as a 50:50 waveform, and it is positive for 50 per cent of the time and negative for the other 50 per cent of the time as illustrated in Fig. 3. A Fourier analysis of such a wave form reveals that the fourth harmonic component is zero amplitude. This fourth harmonic is 1200 cycles per second. The fundamental frequency of the multivibrator is 300 cycles per second, i. e., 1800 cycles divided by 6. Consequently, no output is obtained from the 1200 cycle per second filter in unit 4. The 50:50 waveform of Fig. 3, however, does contain a strong component of third harmonic frequency, which in this case is 3 times 300 or 900 cycles per second. Therefore, the 900 cycles per second or marking filter supplies 900 cycles per second frequency output to the two-tone line. Under these conditions it has been assumed that the tubes V4 and V5 have been conductive so that the bias on the cathode of tube V2 is reduced by the low impedance of tube V4 in shunt thereto and this tube is of relatively high gain while the potential at the anode of tube V3 has been reduced by current flow through R6 to supply tube V5 and this tube is of relatively small gain. Then the adjustment is made as stated above by means of potentiometers P1 and P2 so that both multivibrators have a factor of division of 3, or a total of 6, and the wave form is weighted 50:50.

The values of the component parts associated with tubes V4 and V5 are further selected so that when these tubes are rendered non-conductive by application to the control grids thereof, of a highly negative voltage representing say spacing condition in frequency shift signalling or white in picture signalling, the amplitude of the synchronizing voltage supplied by tube V2 over condenser 16 to potentiometer P1 and the anode of tube V6 falls sufficiently so that its order of division increases to 4. This amplification

falls by virtue of the fact that the tube V4 becomes non-conductive and the bias on the cathode of the tube V2 increases to lower the gain of this tube. In a somewhat like manner and simultaneously the potential on the anode of tube V3 increases so that the synchronizing voltage supplied by the tube V3 over condenser 18 to the potentiometer P2 in the anode circuit of V1 increases to an extent such as to cause the tube V1 to divide by 2. As a result the total order of division of the multivibrator remains unchanged, that is to say, the multivibrator as a whole divides by 6 and this output stays at a fundamental frequency of 300 cycles per second. However, the wave form is no longer of 50:50 weight. This weight is now 33⅓:66⅔. In other words, two parts of a total of six parts are positive, and four parts are negative.

Resorting again to the Fourier analysis it is found that the third harmonic component of such a wave form is zero but that a considerable component of fourth harmonic is present. Consequently, no output is obtained from the 900 cycles per second filter but the spacing tone or 1200 cycles per second filter does supply voltage to the output circuit or line.

While the keying input voltage in Fig. 2 has been identified as zero voltage in marking condition and a highly negative voltage in spacing condition, where the "marking" and "spacing" terminology has been arbitrarily carried over from the on and off type of telegraphy, it will be understood that zero voltage may represent spacing condition, etc. Furthermore, this keying input might equally well represent picture signals where, for example, the black portions might be represented by zero voltage and the white parts by negative voltage.

While only one numerical example and schematic circuit diagram have been shown to illustrate means for realizing the invention, it will be apparent to anyone skilled in the art that by proper design any set of tone frequencies can readily be obtained and that other detailed circuit configurations will accomplish the same result as does that of Fig. 2.

What is claimed is:

1. In a signalling system, a source of alternating voltage of substantially fixed frequency the durations of the alternations of which, above and below respectively a base value, are of a first ratio, a source of signalling potentials the magnitude of which changes, means coupled to said source of alternating voltage and controlled by said signal potentials for changing said ratio, and wave filters, arranged to select alternating voltages of different frequencies, coupled to said source of alternating voltage.

2. In a signalling system, a source of alternating voltage of substantially fixed fundamental frequency the durations of the alternations of which, above and below respectively a base value, are of a first ratio, said voltage being rich in components of a first harmonic frequency, a source of signalling potentials the magnitude of which changes, means coupled to said source of alternating voltage and controlled by said signal potentials for changing said ratio so that said voltage is rich in components of a second harmonic frequency, and two wave filters, one tuned to said first harmonic and the other to said second harmonic, coupled to said source of alternating voltage.

3. In a signalling system, a frequency divider including two tubes in an oscillation generating

circuit controlled by oscillating voltages to operate at a fundamental frequency, the frequency at which each tube of the divider tends to operate depending in part on the tube circuit constants and the magnitude of the controlling voltages, said divider operating to produce oscillatory energy of a wave form wherein the ratio of the duration of the excursions of the oscillations in one direction to the duration of the excursions of the oscillations in the other direction is of a first value, means for varying the magnitude of the voltages controlling the frequency divider in accordance with signals to change said ratio to a second value, and filters tuned to different harmonics of said fundamental frequency coupled to said frequency divider.

4. In a telegraphy or similar system, a frequency divider including two tubes in an oscillation generating circuit, a source of oscillating voltages of substantially fixed frequency coupled thereto to entrain the frequency divider for operation at its fundamental frequency, the frequency at which each tube of the divider tends to operate being dependent in part on the tube circuit constants and the magnitude of the applied controlling voltages, said divider as controlled operating to produce oscillatory energy of rectangular wave form wherein the ratio of the duration of the wave excursions in one direction to the duration of the wave excursions in the other direction is of a first value, a source of potentials of varying magnitude representing signals operating on said coupling between said first source and said divider to vary the magnitude of the applied controlling voltages to thereby vary said ratio, and filters tuned to different harmonics of said fundamental frequency, coupled to said divider.

5. In a telegraphy or similar system, a frequency divider including two tubes in an oscillation generating circuit, a source of oscillating voltages of substantially fixed frequency coupled thereto to entrain the frequency divider for operation at its fundamental frequency, the frequency at which each tube of the divider tends to operate being dependent in part on the tube circuit constants and the magnitude of the applied controlling voltages, said divider as controlled operating to produce oscillatory energy of rectangular wave form wherein the ratio of the duration of the wave excursions in one direction to the duration of the wave excursions in the other direction is of a first value, and wherein the oscillatory energy has large components of one harmonic of said fundamental and is deficient in components of another harmonic of said fundamental, a source of potentials of varying magnitude representing signals operating on said coupling between said first source and said divider to vary the magnitude of the applied controlling voltages to thereby vary said ratio, and two filters, one tuned to said one harmonic frequency and the other to said other harmonic frequency, coupled to said divider.

6. In a signalling system, a frequency divider comprising a pair of electron discharge tubes having electrodes interconnected by capacitors and connected to potential sources by resistors of such a value that the divider operates to generate oscillations of a fundamental frequency, a source of oscillations of a frequency which is a multiple of the frequency at which said divider operates, an amplifier tube in a first path coupling said source to a resistor in the circuit of said divider, a second amplifier tube in a second path coupling

said source to a resistor in the circuit of the divider, to entrain the same to operate at said fundamental frequency to generate oscillatory voltages the length of the excursions of which in one direction to the length of the excursions in the other direction is of a first ratio, a source of signal potentials, means for differentially modulating the gain of said amplifier tubes in accordance with said signals to generate oscillatory voltages in said divider the length of the excursions of which in said one direction to the length of the excursions in the other direction is of a second ratio, and frequency selective circuits coupled to said divider.

7. In a wave frequency reducing system, a source of oscillatory energy, a frequency divider coupled to said source and controlled thereby to generate a voltage of rectangular wave form of substantially fixed fundamental frequency which is a submultiple of the frequency of the oscillations of said source and which includes a strong component which is a harmonic of said fundamental, of one order, means coupled to said divider to select output energy of said one order harmonic frequency, a source of control potentials, means for modifying the magnitude of the first-mentioned oscillatory energy controlling said divider in accordance with said control potentials to change the relative lengths of the excursions about the axis of said wave of rectangular form so that the same includes a strong component which is a harmonic of said fundamental of another order, and means coupled to said divider to select energy of said other order harmonic frequency.

8. In a wave frequency reducing system, a source of oscillatory energy, a frequency divider coupled to said source and controlled thereby to generate a voltage of rectangular wave form of substantially fixed fundamental frequency which is a submultiple of the frequency of the oscillations of said source and which includes a strong component which is a harmonic of said fundamental, said voltage being deficient in components of another harmonic frequency, means coupled to said divider to select output energy of said one harmonic frequency, a source of control potentials, means for modifying the magnitude of the first mentioned oscillatory energy controlling said divider in accordance with said control potentials to change the relative lengths

of the excursions about the axis of said wave of rectangular form so that the same includes a strong component at said other harmonic of said fundamental frequency but is deficient in components of the frequency of said one harmonic frequency, and means coupled to said divider to select energy of said other harmonic frequency.

9. In a frequency shift telegraphy system, a multivibrator comprising a pair of electron discharge tubes having electrodes interconnected by capacitors and connected to potential sources by resistors of such a value that the multivibrator operates to generate oscillations of rectangular wave form, a source of oscillations of a frequency which is a multiple of the fundamental frequency at which said multivibrator operates, a current amplitude limiter tube having input electrodes coupled to said source of oscillations, a first amplifier tube in a first path coupling the output of said current amplitude limiter tube to a resistor in the circuit of one of said multivibrator tubes, a second amplifier tube in a second path coupling the output of said current limiter tube to a resistor in the circuit of the other multivibrator tube, to entrain the multivibrator to operate at said fundamental frequency, which is a submultiple of the frequency of said source, to generate oscillatory voltages the length of the excursions of which in one direction to the length of the excursions in the other direction is of a first ratio, a source of signal potentials, means for differentially modulating the conductivity of said amplifier tubes in accordance with signals to change said ratio, and two filters tuned to different harmonics of said fundamental frequency coupled to said multivibrator.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,159,596	Miller	May 23, 1939
2,338,395	Bartelink	Jan. 4, 1944
2,392,114	Bartelink	Jan. 1, 1946
2,413,932	Sziklai	Jan. 7, 1947
2,418,268	Lawson	Apr. 1, 1947