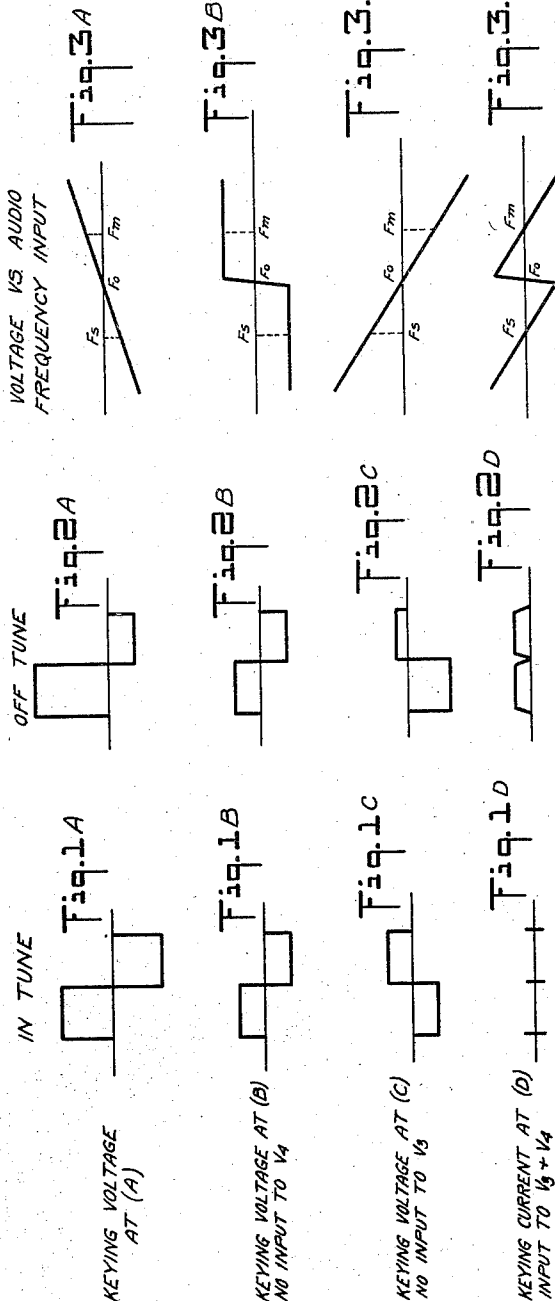


2,423,225

Filed Oct. 9, 1945



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2,423,225

FREQUENCY SHIFT TELEGRAPH RECEIVER
TUNING INDICATORReynold S. Chapin, Flushing, N. Y., assignor to
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Application October 9, 1945, Serial No. 621,262

9 Claims. (Cl. 178—88)

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This invention relates to wave signalling systems and more particularly to improvements in signalling systems of the frequency-shift category.

A principal object of the invention is to provide an improved tuning indicator arrangement for use in controlling the "in-tune" condition of frequency shift telegraph apparatus and the like.

A feature of the invention relates to a network having the components so arranged and interconnected to produce a frequency input versus amplitude output characteristic having a plurality of spaced parallel and linear sloped sections which symmetrically cross the zero amplitude axis or other minimum reference amplitude axis.

A further feature relates to a frequency discriminator and electron tube network for use with frequency shifted carrier, wherein any out-of-tune or undesired frequency-shift condition in the system, results in potential changes of substantially the same magnitude and sign at both ends of the shift range.

A further feature relates to a frequency discriminator and electron tube network for providing a saw tooth over-all relation between input frequency and output current.

A still further feature relates to the novel organization, arrangement and relative interconnection of parts which cooperate to provide an improved tuning control circuit for carrier frequency-shift receiving systems.

Other features and advantages not particularly enumerated will be apparent after a consideration of the following detailed descriptions and the appended claims.

In the drawing which represents one preferred embodiment,

Fig. 1 shows in schematic form a frequency-shift control and tuning indicator arrangement embodying the inventive features.

Figs. 1a to 1d are curves explanatory of the operation of Fig. 1 in the in-tune condition.

Figs. 2a to 2d are curves explanatory of the operation of Fig. 1 in the off-tune condition.

Figs. 3a to 3d are curves showing the relation between input frequency and output amplitude of the discriminator and electron tube network of Fig. 1.

When signalling is effected by frequency shifting of a radio carrier, the radiated wave, in the case of telegraph transmission, consists of a marking frequency and a spacing frequency. When such systems are provided with automatic frequency control or tuning indicators to keep the apparatus in the in-tune condition, separate con-

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trol channels usually regulated by respective potentiometers are required for the two conditions corresponding respectively to mark and space. This has been necessary because of the frequency versus voltage characteristic of the usual discriminators. The conventional discriminators have only a single crossover with the zero output axis, regardless of whether the system is in-tune or out-of-tune, and this crossover point corresponds to the mean frequency of the limits between which the carrier is shifted for mark and space. When the mean frequency of the carrier drifts, or when the receiving apparatus is not properly tuned to the mean frequency, these conditions are manifested by a change in detected output. With respect to the reference potential axis, the detected output will increase during one of the keying signals and decrease during the other keying signal for a condition of mistuning. The change in detected output for detuning is the same for both detected signals. The direction of detuning will determine whether both signals become more positive (less negative in the case of the detected signal which is negative) or both signals become more negative (less positive in the case of the detected signal which is positive). The potential difference between the mark and space detected signals remains constant for any condition of tuning over the linear position of the discriminator characteristic. Since the transmitted wave may rest in either mark or space condition for indefinite time intervals, any tuning indicator or automatic frequency control device must respond equally to either condition.

I have disclosed in my prior application Serial No. 615,838, filed September 12, 1945, a frequency discriminator and detector arrangement having the necessary equal change of output at the mark and space frequencies. My prior arrangement requires a special form of electronic or electromagnetic switch for controlling the required tuning indications to indicate the amount of off-tune of the receiving apparatus. The present invention is in the nature of an improvement on the system of my prior application. In accordance with the present invention, a discriminator and double rectifier arrangement is used in conjunction with a special combination of grid-controlled electron tubes for deriving a frequency input versus output amplitude characteristic which can be characterized as of general saw-tooth shape.

Referring to Fig. 1, the block 1 represents any well-known source of frequency-shifted carrier waves. For example, the carrier may have a mean frequency of F_c and it may be shifted in one di-

rection to a frequency F_m to represent a mark signal, and in the opposite direction to a frequency of F_s to represent a space signal. For a detailed description of a typical carrier frequency-shifting arrangement, reference may be had to application Serial No. 498,278, filed August 12, 1943. It will be understood that instead of having the carrier normally resting at a mean frequency of F_c and shifted equally in opposite direction to represent mark and space, the carrier may rest for example at the space frequency F_s and may be shifted to the opposite extreme of F_m to represent the mark frequency or vice versa. In any event, the receiving apparatus must be provided with a tuning control mechanism so as to tune it to the mean frequency between limits of the shifted carrier so as to produce equal signal voltages representing the mark and space signals.

The mark and space frequencies from the receiver 3 are impressed upon any well-known limiter device 4 so as to bring the two frequencies to substantially the same amplitude. The output of limiter 4 is coupled through an audio-frequency transformer 5 into a frequency discriminator which is of the linear differential type comprising for example inductances 6, 7, and their respective tuning condensers 8, 9. The resonant circuit 6—8 is tuned to a frequency approximately twice the deviation excursion from the mean frequency in the positive direction, i. e. above the mean frequency; likewise the tuned circuit 7—9 is tuned to a frequency approximately twice the deviation excursion from the mean frequency in the negative direction, i. e. below the mean frequency. The rectifiers 10, 11, and their respective load resistors 12, 13, and by-pass condensers 14, 15, are connected in balanced relation to inductances 6 and 7 in the well-known manner. The actual keyed signals from the discriminator may then be tapped off at point 16 and applied to a suitable audio-frequency amplifier 17 and thence to a signal reproducer or keyer 18.

In order to determine when the receiver 3 is in proper tuned condition with respect to the mean frequency of the shifted carrier, a potentiometer resistance 19 is connected across the output of the discriminator rectifiers and a pair of grid-controlled tubes 20, 21, are connected to the resistor 19. Also associated with the tubes 20 and 21 is any well-known form of indicating meter 22. In order to adjust the tuning indicator portion of the system initially, the cathode return circuits of the tubes 20 and 21 are each provided with a suitable switch 23, 24. When the system is in operation, switches 23 and 24 are closed.

As indicated, tube 20 is in the form of a dual triode, although it will be understood that two similar and separate triodes may be employed. The control grid 25 of one triode is connected directly to the point 16 so that it is excited directly by the keyed signals. The control grid 26 of the other dual triode is connected to ground. The control grid 27 of triode 21 is connected to the adjustable arm 28 of the potentiometer. It will be noted that the common positive terminal 29 of the plate power supply is connected through the moving coil of meter 22 and thence in parallel to the plate 30 of triode 21 and the plate 31 of the dual triode 20. Consequently, the current which flows through the meter 22 will be determined by the D. C. voltage conditions at the point B.

In order that the operation of the tuning control circuit may be understood, an explanation will be first given of the in-tune condition and then the off-tune condition. Referring to Figs.

1a to 1d, these figures represent respectively the signal voltages and currents at the corresponding points A, B, C and D, for certain conditions of the circuit. Fig. 1a represents the keying voltage at the point A corresponding to the in-tune condition from which it will be seen that it consists of a positive voltage representing the mark signal, and an equal negative voltage representing the space signal. It will be understood of course, that if desired these polarity relations may be reversed. When the keyed voltages of Fig. 1a are applied to the grid 25 and with the switch 23 closed, the tube 20 acts to limit the amplitude of the waves so that they never exceed a certain value as indicated by Fig. 1b. Fig. 1b therefore shows the limited waves of Fig. 1a when there is no plate current in triode 21, that is with the switch 24 open. It will be understood of course, that during the actual operation of the circuit, and after the system has been properly adjusted, the switch 24 is closed. However, during the initial adjustment of the system the switch 24 is open so that the keyed voltages at the point B are as represented in Fig. 1b. The tube 21 is connected so as to act as a phase inverter. In other words, when the switch 24 is closed and a keying voltage is applied to grid 27, this keying voltage is reversed substantially 180 degrees in phase as represented by Fig. 1c. Therefore, by proper adjustment of the level of the signal applied to grid 27 under control of potentiometer 28, cancellation of the keying voltage at point B may be obtained resulting in the wave shape represented by Fig. 1d. When the potentiometer arm 28 has been properly adjusted and with switches 23 and 24 both closed, if the receiving system is in tune, it will be indicated by half-scale deflection of the meter pointer 32. Preferably meter 32 is of the usual construction in which the pointer rests at the left hand extremity of the meter scale when no current is passing through the meter. The meter scale plate should be of the zero center scale type. The scale may then be calibrated in terms of positive and negative cycles of drift for any desired range of shift.

The operation of the system for the in-tune condition is as follows. The positive voltage at point A appears as a limited positive voltage of smaller amplitude at point D (in the absence of a signal input-to-grid 27 or when switch 24 is open). When grid 27 has applied thereto some of the voltage from point A through potentiometer 19, this voltage while not limited, is inverted in tube 21 and will appear as a linearly amplified negative voltage at point D. By proper adjustment of potentiometer arm 28, the positive voltage developed at the plate 31 may be fully cancelled by the negative voltage developed at the plate 30, resulting in zero amplified voltage at point D. The negative keying voltage at point A is likewise limited at plate 31 and appears at point D. The negative input voltage from point A appears at plate 30 as a positive voltage and opposes the negative voltage from plate 31. Consequently, as long as the receiver 3 is in-tune, the resultant signal voltage for both the mark and space signals at point D is zero. It follows that the resultant signal current passing through the meter 22 to the plate 31 is also zero. By proper selection of tubes, operating potentials and constants of the meter 22, the no-signal residual current flowing to plates 30 and 31 may be adjusted by means of resistors 33 and 34 to cause half scale deflection of the meter. Therefore, for the receiver in-tune condition and for the proper ad-

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justment of potentiometer arm 28 to secure balance of the two signal-voltages at point D, the resultant signal current is zero and the meter will be deflected to the half scale or central zero position by the residual tube currents. For off-tune receiving conditions, the meter will be deflected up scale equally on mark or space signals, or down scale equally on mark or space signals depending upon the direction of detuning.

The operation of the circuit for the off-tune condition is similar to that for the in-tune condition except that the resultant currents on mark and space do not balance to zero signal amplitude but to an equal positive or negative signal current amplitude, depending on the direction of detuning. However, the amplitude of the resultant current and the deflection of the pointer 32 is directly proportional to the degree of detuning.

The examination of the off-tune conditions as represented in Figs. 2a to 2d will show that for the particular off-tune condition illustrated thereby, the summation of the positive limited voltage developed at plate 31, and the larger negative voltage developed at plate 30 results in a negative voltage for the initial mark signal. The space or negative signal develops a negative voltage at plate 31, and a smaller positive voltage at plate 30. The combination of these two voltages at the common point B results in a negative voltage exactly equal to the negative voltage developed by the mark signal. Consequently, the deflection of the pointer 32 is equal on both the mark and space signals. However, the pointer 32 will not respond to the keying signals but will have a steady deflection during keying. This is so because of the fact that it is current practice in carrier-shift transmission to maintain the transmitted carrier while on the air at either the mark or space frequency.

Further insight into the operation of this circuit may be obtained by reference to the voltage versus audio frequency input waveshape diagrams of Figs. 3a-3d. In Fig. 3a is presented the waveshape resulting at point A, or the discriminator output when the input frequency to the limiter is varied. F_m is selected as the mark frequency and F_s as the space frequency. F_0 is the center frequency mid-way between mark and space. The output of 20 at point B is given in Fig. 3b. It is evident that the tube 20 has fully limited the signal of the discriminator at a voltage less than that corresponding to F_m and F_s in Fig. 3a.

Fig. 3c represents the output of 21, showing the signal of Fig. 3a amplified and phase inverted. Fig. 3d shows the combination of the signals of Figs. 3b and 3c effected in the common plate circuit at point D. The algebraic addition of the currents corresponding to these voltages takes place in the tuning meter 22.

By proper setting of potentiometer arm 28, the sloping sides of waveshape curve of Fig. 3d may be controlled to pass through the zero axis at any desired distance from F_0 . This means that the potentiometer 19 is a means of adjusting the circuit for correct operation of the tuning meter for various values of deviation. Potentiometer arm 28 may be supplied with a dial which is graduated and calibrated in terms of deviation.

In operation, the carrier shift signal is roughly tuned in on radio receiver 3 employing a beat frequency oscillator. The tuning meter pointer will experience deflections corresponding to the carrier shift keying characters. Potentiometer 19 which may be referred to as the deviation con-

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trol, is then adjusted until the meter pointer ceases to fluctuate with keying. Usually, the receiver is not exactly in tune, and it should now be tuned correctly by use of the tuning meter until the meter pointer rests at the mid-scale position or zero drift position. The value of deviation of the transmitted carrier shift signal may now be ascertained by reference to the previously calibrated dial of the deviation control.

For any single value of deviation, the scale of the tuning meter may be calibrated in terms of drift in cycles per second.

Application of this tuning meter circuit includes all situations where a frequency-shifted signal of any characteristic is to be monitored with reference to a particular frequency. In present day practice, this particular frequency is usually the mean frequency between the two frequency limits to which a signal is shifted. By use of suitable heterodyning equipment, this tuning indicator circuit may be used to monitor carrier shift transmissions. The tuning meter may be made sensitive enough to read transmitter drift of a few cycles per second and the calibrated dial of the deviation control 28 is a measure of the transmitter deviation.

In receiving applications, this tuning indicator may be used to monitor receiver tuning for the reception of any type of carrier shift radio signal; including all systems of telegraphic communication such as hand keying, automatic keying in systems of the coded impulse combination type. This indicator will function correctly for the reception of black and white facsimile carrier shift signals, as well as for telegraph signals.

What I claim is:

1. In combination, a frequency discriminator of the type having a frequency-versus-voltage characteristic with a single linear sloped portion between successive positive and negative peaks, and means connected to said discriminator to convert said single linear portion into a plurality of linear portions symmetrically spaced on opposite sides of a predetermined mean frequency, the last-mentioned means including a pair of grid-controlled electron tubes upon which the discriminator output is impressed, one of said tubes being a phase inverter and the other an amplitude limiter, and means to combine the inverted and amplitude-limited outputs of said tubes.

2. In combination, frequency discriminator and rectifier means to develop D. C. voltage characteristics such that the curve relating frequency input to D. C. output has a substantially continuous and linear sloped portion, and means to convert said portion into a substantial saw-toothed characteristic, the last-mentioned means including two paths for the D. C. voltages, a device for limiting the amplitude of the signals in one path and another device to invert the phase of the signals in the other path, and a common combining path including an indicator device for both the inverted and amplitude-limited voltages.

3. In combination, means to produce a voltage of a frequency representing a telegraph mark signal, means to produce a voltage of a different frequency representing a telegraph space signal, discriminator means upon which two said frequencies are impressed, means to rectify the mark and space frequencies in the output of said discriminator to produce corresponding D. C. signals, an amplitude limiter tube, a phase inverter tube, means to control the plate currents of both of said tubes by said D. C. signals, and a tuning

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indicator device connected in common to the plate circuits of said tubes.

4. In a system for receiving a frequency-shifted carrier having a frequency F_m representing a mark signal and a frequency F_s representing a space signal, a receiver having means to tune it to produce two frequencies corresponding respectively to said mark and space signals, a frequency discriminator connected to said receiver and having a frequency-versus-potential characteristic with a linear sloped portion joining successive positive and negative peaks, means to develop D. C. voltages under control of the signals from said discriminator, a first grid-controlled tube, a second grid-controlled tube, means to apply said D. C. voltages in separate paths to the grids of said tubes, means associated with one tube for limiting the amplitude of the signals therefrom without substantial phase inversion, the D. C. signals being applied to the other tube to effect phase inversion thereof, a tuning indicator device connected in common to the plate circuits of both said tubes, and means to adjust the D. C. potential applied to one of said tubes so that the resultant plate current of both tubes is at a predetermined value representing the in-tune condition of said receiver.

5. A system according to claim 4 in which said discriminator is of the balanced differential type.

6. In a system for receiving a frequency-shifted carrier having a frequency F_m representing a mark signal, and a frequency F_s representing a space signal, a receiver having means to tune it to produce two frequencies corresponding respectively to said mark and space signals, means to limit the amplitude of said two frequencies, frequency discriminator means and a rectifier network upon which the limited frequencies are impressed, a potentiometer resistance connected across the output of said network, a pair of grid-controlled triodes one triode having its control grid connected to said potentiometer and the other triode having its control grid connected to ground, the cathodes of said pair of triodes being connected to ground through a common resistor whereby the plate current of the other triode is amplitude limited but is in phase with the signals from said

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discriminator, a third triode having its control grid connected to said potentiometer whereby its plate current is phase inverted with respect to the signals from said discriminator, and a single tuning indicator device connected in common to the plate circuit of said other one of said first pair of triodes and to the plate circuit of said third triode.

7. The method of determining the in-tune condition of a receiver which responds to carrier frequency-shift signals which comprises, producing signals whose amplitudes correspond respectively to the frequency-shift limits and which are of substantially equal magnitude when the receiver is in-tune, deriving from said signals two voltages one of which is in phase with the said signals and the other of which is phase inverted, adjusting the relative levels of said two voltages so that when the receiver is in-tune the resultant is substantially zero, and when the receiver is out-of-tune the resultant is proportional to the amount of detuning and the sign of the resultant corresponds to the polarity of detuning.

8. The method according to claim 7 in which the characteristic curve which relates the frequency of the shifted signals to said resultant voltage is of saw-tooth shape.

9. The method of tuning indicator control in frequency-shift telegraph systems employing a frequency discriminator which comprises amplitude limiting in one path a portion of the signal voltage from the discriminator without substantial phase inversion, phase inverting in another path another portion of said signal voltage, and combining the amplitude limited and phase inverted voltages to produce an overall characteristic relating input frequency to resultant voltages which is of saw-tooth wave shape.

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REFERENCES CITED

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

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Number	Name	Date
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