July 1, 1947. M. G. CROSBY 2,423,229

AUTOMATIC TUNING CONTROL AND INDICATION FOR FREQUENCY SHIFT SYSTEMS

Filed July 21, 1945 2 Sheets-Sheet 1

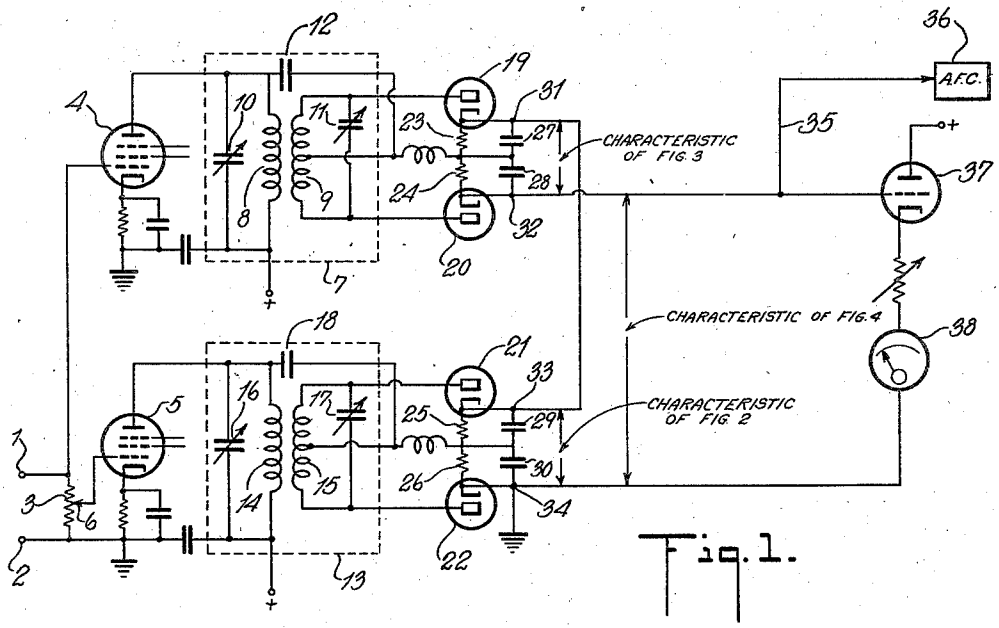


Fig. 1.

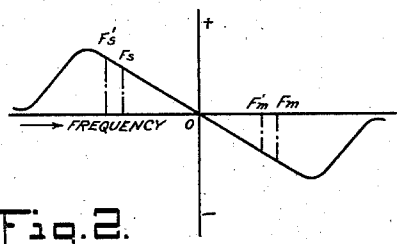


Fig. 2.

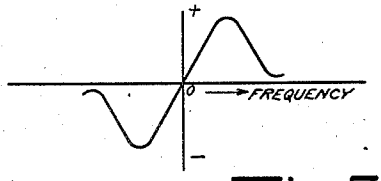


Fig. 3.

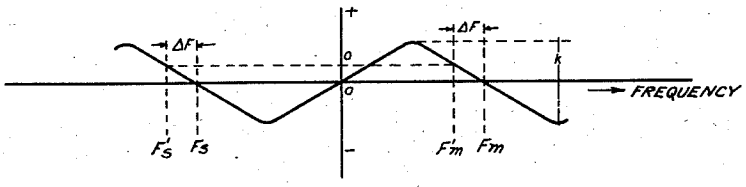


Fig. 4.

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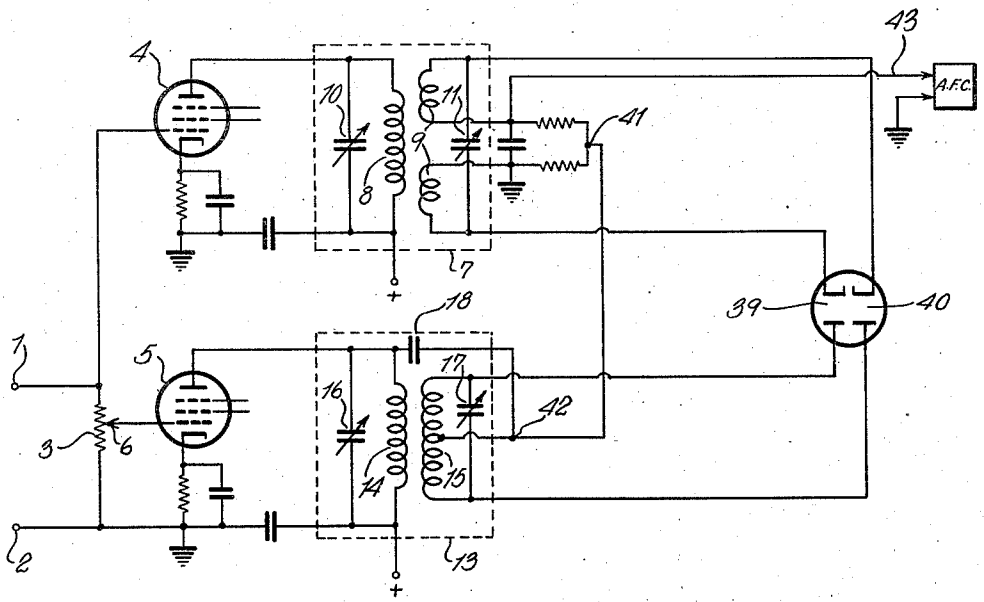


Fig. 5.

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AUTOMATIC TUNING CONTROL AND INDICATION FOR FREQUENCY SHIFT SYSTEMS

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10 Claims. (Cl. 250—8)

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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 relates to improved discriminator and detector arrangements for use in frequency shift telegraph systems and the like.

Another object is to provide an improved automatic frequency control arrangement for use in controlling the "in-tune" condition of frequency shift telegraph apparatus.

Another object is to provide an improved tuning indicator control arrangement for indicating the in-tune or out-of-tune condition of frequency shift apparatus.

A feature of the invention relates to a frequency discriminator network having the components so correlated and designed as to provide a plurality of crossover points of zero potential corresponding to mark and space signal conditions.

Another feature relates to a frequency discriminator network having an over-all frequency versus output potential characteristic, which exhibits three crossover points with the zero output axis.

A further feature relates to a frequency discriminator 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 at both ends of the frequency shift range.

A further feature relates to a frequency discriminator network composed of a plurality of separate discriminator units, each of which has a frequency versus output characteristic with only a single crossover point with the zero axis, the networks being combined so that the over-all characteristic has a plurality of zero crossover points corresponding respectively to the mean of the frequency shifted spectrum, and also to the limits of the said spectrum, which limits represent for example, mark and space signals.

A still further feature relates to the novel organization, arrangement and relative interconnection of parts which cooperate to provide an improved frequency discriminator particularly useful in frequency shift signalling apparatus.

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

In the drawing:

Fig. 1 shows in diagrammatic form a frequency shift control and tuning indicator system embodying features of the invention.

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Figs. 2, 3 and 4 are curve diagrams explanatory of the invention.

Fig. 5 is a modification of Fig. 1.

Within recent years, the so-called frequency shift method of transmitting telegraph mark and space signals has come into comparatively wide use. In the case of radio carrier shift transmission, the radiated wave consists of a mark frequency and a space frequency. When such systems are provided with automatic frequency control or tuning indicators to keep the apparatus in the "in-tune" state, separate control channels usually regulated by respective potentiometers are required for the two conditions corresponding respectively to mark and space. This has been necessary heretofore, because of the frequency versus voltage characteristic of the usual discriminators. Such discriminators have only a single crossover point 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 frequency of the carrier drifts, this is manifested by opposite polarity conditions at the limits of the frequency shift spectrum and the change in detected output is greater at one end than at the other. Since the transmitted wave may rest on either the mark or space condition for indefinite time intervals, any tuning indicator or automatic frequency control device must respond equally to either condition. The present invention provides a discriminator and a detector arrangement having the necessary equal change output at the mark and space frequencies regardless of the amount of frequency drift or out-of-tune condition. In accordance with the invention, the discriminator network employs two discriminators to obtain an over-all characteristic in which there are two points of zero potential corresponding to the mark and space conditions, and which provide output potentials varying by the same amount for a given change in drift in the mark and space frequencies.

Referring to Fig. 2, there is shown a typical characteristic curve of frequency versus output, using a conventional frequency discriminator. Frequencies F_s and F_m represent the "in-tune" condition, wherein the crossover point with the zero output axis is symmetrically located between the mark frequency F_m and the space frequency F_s. Frequencies F_s' and F_m' represent an out-of-tune or frequency drift condition, from which it will be seen that the change in the mark output is an increase in the negative direction, while the

change in the space output is a decrease in the positive direction, and these two outputs are of different amplitude.

I have found that if a discriminator having a relatively broad band characteristic such as that of Fig. 2 is suitably combined with a similar "narrow band" discriminator having a characteristic such as shown in Fig. 3 for example, there results an overall characteristic such as shown in Fig. 4. In Fig. 4, F_s and F_m represent respectively the space and mark frequencies for the "in-tune" condition. For the out-of-tune condition caused by a drift in frequency equal to ΔF, the mark and space frequencies have drifted to the points F'_m and F'_s. It should be observed that when the mark and space frequencies drift by the amount ΔF, the detected output changes from 0 to 0—a. This change in detected output is the same both for the mark and space condition. Such a characteristic is different from the usual discriminator characteristic such as shown in Fig. 2 or Fig. 3 in which a single frequency is applied to obtain a positive and negative detected voltage as the frequency changes.

In order to obtain the resultant characteristic of Fig. 4, it is necessary to combine the discriminators represented by the characteristics of Figs. 2 and 3 in such a way that the broad characteristic of Fig. 2 is subtracted from the sharp characteristic of Fig. 3. The circuit arrangement for achieving this necessary combination of the two characteristics is shown in Fig. 1. In this figure, the frequency shifted signals are applied at terminals 1, 2 from any well-known source of frequency shifted carrier. For example, this carrier may have a mean frequency of F_0 and it may be shifted in the positive direction to frequency F_m to represent a mark signal and in the negative direction to frequency F_s to represent a space signal. The frequency shifted carrier is applied across potentiometer resistance 3 which is connected respectively to the control grids of two grid-controlled amplifier tubes 4, 5 of any well-known type. The control of tube 4 may be connected directly to the high potential end of resistance 3, while the control grid of tube 5 is connected to the resistance 3 by means of a sliding potentiometer contact 6. Amplifier tube 4 feeds a frequency discriminator 7 comprising the coupled inductances 8, 9, tuning condensers 10, 11, and the coupling condenser 12. Likewise the amplifier tube 5 feeds a discriminator 13 comprising coupled inductances 14, 15, respective tuning condensers 16, 17, and coupling condenser 18. The discriminators 7 and 13 are preferably of the well-known phase shift type in which the usual opposite-slope characteristics are presented to the respective diodes 19—20 and 21—22. The tuned circuits 8—10, 9—11, and 14—16, 15—17 provide a phase change with frequency which results in an amplitude change applied to the respective sets of diodes. This phase shift action is explained in Terman's "Radio Engineering Handbook," page 586. The rectified output of the two diodes is taken off symmetrically from the respective diode load resistors 23—24 and 25—26 and their respective by-pass condensers 27—28 and 29—30. The various elements of the discriminator 7 are adjusted so that the characteristic curve of frequency versus voltage at the points 31, 32 corresponds to that of Fig. 3, while the characteristic curve of frequency versus voltage at the points 33, 34 is represented by Fig. 2. As shown in Fig. 1, the detected outputs of the two discriminators 7 and 13 are connected in series opposing, so that the ordinates of the characteristic of Fig. 2 are subtracted from the corresponding ordinates of Fig. 3. This result is achieved by the series connection of the D. C. outputs of the diode detectors as shown in Fig. 1, so that there results a simple arithmetic subtraction.

The resulting combined output of the two discriminators may be applied over conductor 35 to any well-known automatic frequency control device 36 which controls the frequency of the frequency shift transmitter or the frequency shift receiver whose "in-tune" condition is to be controlled. At the same time, this resultant combined output may be applied to a grid-controlled tube 37 whose plate current circuit is connected to a suitable meter 38 which produces an indication proportional to the out-of-tune condition or frequency drift ΔF.

By means of potentiometer contact 6, the relative magnitudes of the broad and sharp discriminator levels can be adjusted. Adjustment of the contact 6 will vary the slope of the various parts of the characteristic of Fig. 4 and will thereby furnish a means for varying the separation between the points F_s and F_m. Normally contact 6 is adjusted so that the distance k (Fig. 4) is equal to distance l.

Referring to Fig. 5, there is shown an alternative method of combining the characteristics of the broad and sharp discriminators. Parts of Fig. 5 corresponding to those of Fig. 1 are designated alike. In general, the arrangement of Fig. 5 is the same as that of Fig. 1, with the exception that a single pair of diodes 39 and 40 are used, and the broad and sharp characteristics of the two discriminators 7 and 13 are combined before detection. For this purpose the voltage from the primary coil 14 in discriminator 13 is fed through a single condenser 18 to the connected center tap points 41 and 42 of the two discriminators. This can be done because all that is required for discriminator 13 is a co-action between the unretarded voltage directly from the plate of tube 5, and the retarded voltage from the secondary 15. The sharp selectivity retarded component for the characteristic of Fig. 3 is obtained from discriminator 7, while the broad selectivity component is obtained from discriminator 13. These two components are combined with the unretarded component applied through condenser 18 to give the resultant characteristic shown in Fig. 4. The resulting automatic frequency control voltage can be tapped off via conductor 43 which then corresponds to conductor 35 of Fig. 1, and this tapped-off voltage may be used to control any suitable automatic frequency control device for the frequency shift apparatus or it may produce a visual indication in a suitable meter such as the meter 38 in Fig. 1.

While certain specific embodiments have been disclosed herein, various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A frequency discriminator arrangement comprising a plurality of networks each of which has a different response characteristic relating input frequency to output voltage, and means to combine said networks to provide an overall response characteristic which is different from that of each network individually and has a plurality of cross-over points with the zero voltage axis.

2. A frequency discriminator arrangement comprising a plurality of networks one of which

has a broad band response characteristic relating input frequency to output voltage, the other having a narrower band response characteristic, and means to combine said networks to provide an overall response characteristic which has at least three cross-over points with the zero voltage axis.

3. A frequency discriminator arrangement comprising a plurality of networks one of which has a susbtantially linear characteristic portion relating output voltage to input frequency between two predetermined frequencies F1, F2, the other network having a substantially linear characteristic portion relating output voltage to input frequency only over a section of said band F1—F2, and means to combine said networks to provide an overall characteristic which represents the arithmetic resultant of said two characteristics.

4. A frequency discriminator arrangement according to claim 3 in which said combined means provides an overall resultant characteristic which is the difference between the said characteristics of the networks.

5. A frequency discriminator arrangement comprising a broad band frequency discriminator network, a narrow band frequency discriminator network, and means to combine said networks so that their outputs are in series opposing relation.

6. A frequency discriminator arrangement comprising a broad band frequency discriminator network, a narrow band frequency discriminator network, means to apply different frequency signals in parallel to the inputs of said networks, means to combine the outputs of said networks in series opposing relation, and a utilization device connected to said combined output.

7. A frequency discriminator arrangement comprising a wide band discriminator having a characteristic with a linear section passing through the zero voltage point at a frequency which is the mean between two selected frequencies F1—F2, a narrow band frequency discriminator having a characteristic with a linear section passing through said zero voltage point but of different slope from the first-mentioned linear section, and means combining said networks to provide a resultant characteristic having a linear section also passing through said zero voltage point, said resultant section having at its opposite ends reversed slope linear sections which intersect the zero voltage axis symmetrically on opposite sides of said zero voltage point.

8. In a signalling system of the carrier-shift type wherein one carrier frequency represents one signal and another carrier frequency represents a different signal and the carrier shift is symmetrical about a mean carrier frequency, means to derive a tuning control signal corresponding to the in-tune or out-of-tune condition of the system, the last-mentioned means comprising a pair of frequency discriminators having characteristics with linear sections of different slopes, means to impress said frequencies of both said discriminators simultaneously, means to rectify and combine the outputs of said discriminators in series opposing, and a single indicator device connected to said combined output for indicating the tuned or intuned condition of the system.

9. A system according to claim 8 in which each of said discriminators is of the phase-responsive type.

10. A system according to claim 8 in which the outputs of the discriminators are applied to a combining circuit prior to rectification by said rectifying means.

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