

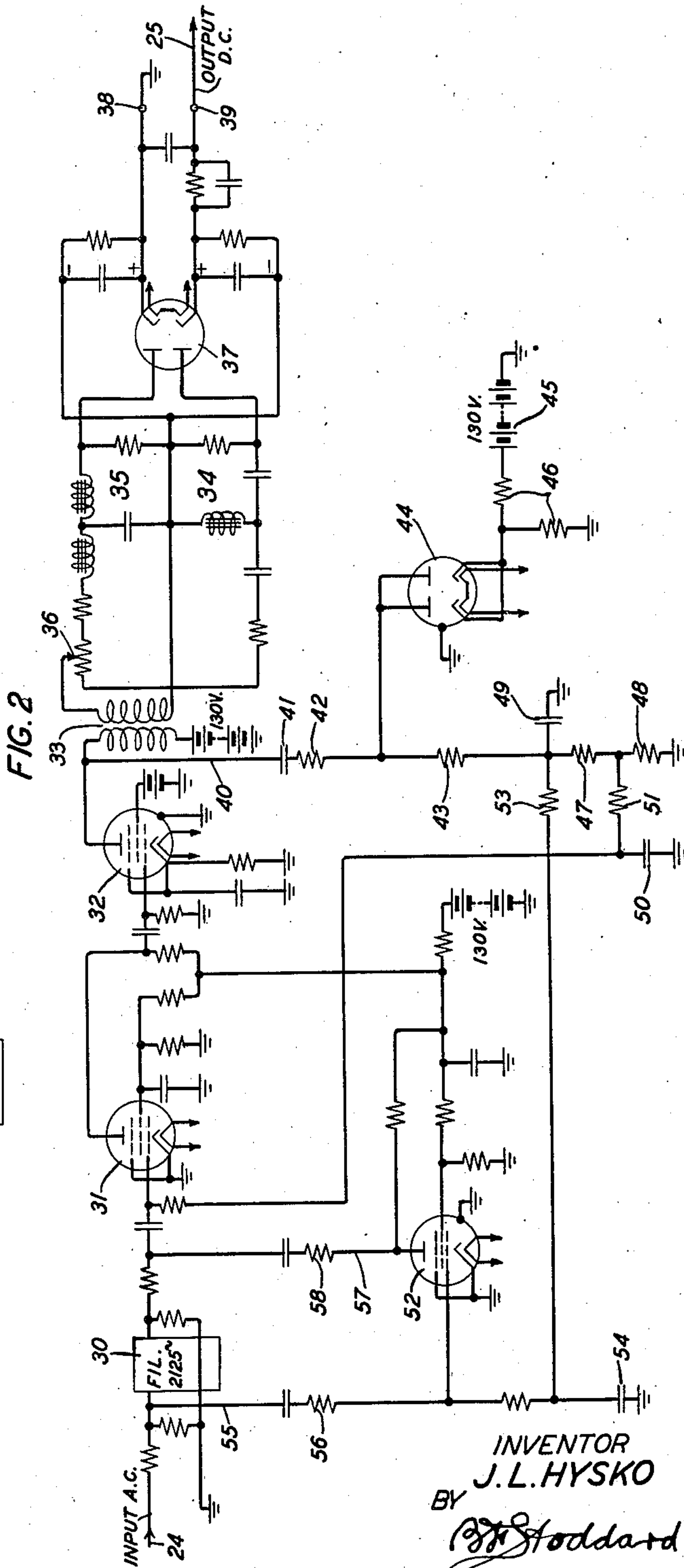
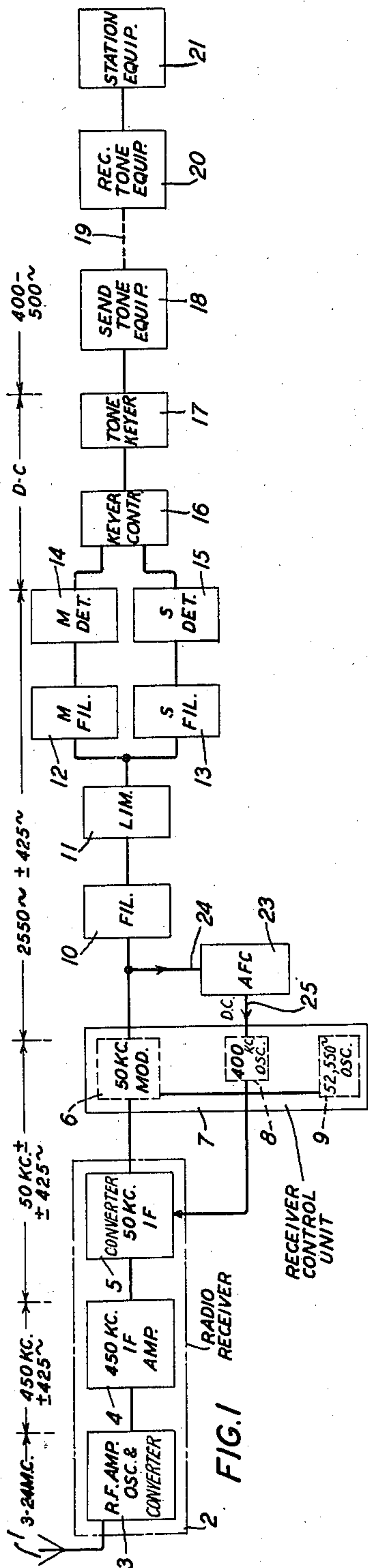
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RADIO RECEIVING SYSTEM

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RADIO RECEIVING SYSTEM

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This invention relates to radio receiving systems and, more particularly, to an improved automatic frequency control circuit for controlling the frequency of waves generated by a beating oscillator in a radio receiving system.

Heretofore, automatic frequency control circuits have been employed in radio receiving systems for controlling the frequency of waves generated by a beating oscillator having its output connected to a detector. In the case of radio transmission of telegraph signals employing waves of one frequency for one type of signal, such as a marking signal, and waves of a different frequency for another type of signal, such as a spacing signal, the receiving system usually employs band-pass filters for separating the two different frequencies. In some systems, this filtering is performed after the received radio-frequency waves have been detected and reduced to a lower frequency by combining them with waves generated by a beating oscillator. If the frequencies of the received waves depart from their assigned values, as they may due to various reasons, then it becomes necessary to employ an automatic frequency control circuit to vary the frequency of the beating oscillator by a corresponding amount so that the frequency of the detected waves will be approximately stable. However, in initiating communication with a radio receiving station, the heterodyned waves may, due to generation by the beating oscillator of waves of an incorrect frequency, be of frequencies which are outside the limits of the band-pass filters. When this happens, the output of the band-pass filters will be of nearly zero value and, consequently, will be insufficient to energize the automatic frequency control circuit.

Accordingly, it is an object of this invention to provide improved means for synchronizing a radio receiving station with a radio transmitting station.

It is also an object of this invention to provide a by-pass circuit across the input to an automatic frequency control circuit for use when the frequencies of the heterodyned waves in the radio receiving system are outside a preassigned range.

These and other objects of the invention are accomplished by connecting a monitoring electronic tube into a by-pass circuit shunting the band-pass input filter of an automatic frequency control circuit. When the frequencies of the heterodyned waves in the radio receiving system are within the limits of the input filter, they are passed through the filter and are amplified in

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the automatic frequency control circuit. A portion of the amplified energy is utilized to bias the grid of the monitoring tube for rendering this tube non-conductive. However, if the frequencies of the heterodyned waves are outside the limits of the band-pass filter, the biasing voltage will cease to exist thereby permitting the monitoring tube to become conductive. This, in effect, completes a path in shunt to the filter and allows the monitoring tube to relay the input waves to the amplifiers in the automatic frequency control circuit. The resulting amplified energy then produces control voltages in the automatic frequency control circuit which are employed for adjusting the frequency of the waves generated by the beating oscillator. These frequency adjusted waves are combined with the radio receiver input waves and the resulting waves will have frequencies within the limits of the band-pass filter and consequently will pass through the filter and will be amplified in the automatic frequency control circuit. A portion of this amplified energy will be utilized, as was mentioned above, to bias the grid of the monitoring tube to cut-off thereby restoring the circuit to its normal condition. Thus, by means of this by-pass circuit and its monitoring tube, the admittance band-width of the automatic frequency control circuit is, in effect, substantially increased.

These and other features of the invention are more fully described in connection with the following detailed description of the drawing in which:

Fig. 1 is a block diagram of a radio receiving system employing the improved automatic frequency control circuit; and

Fig. 2 is a circuit diagram of the improved automatic frequency control circuit.

In Fig. 1, radio signal waves, in the form of a radio-frequency carrier wave modulated by shifting its frequency either plus 425 cycles or minus 425 cycles in accordance with marking and spacing telegraph signals, are received by the antenna 1 which delivers them to a radio receiver 2 having a radio-frequency amplifier, oscillator, and converter 3 for converting the received signal waves into waves having a frequency of 450 kilocycles modulated to an extent of ± 425 cycles. These last-mentioned waves are amplified by an intermediate frequency amplifier 4 having its output connected to an intermediate frequency converter 5 for converting these waves into waves having a frequency of 50 kilocycles ± 425 cycles. The output of the converter 5 is supplied to a 50-kilocycle modulator 6 in a re-

ceiver control unit 7 which also comprises a 400-kilocycle oscillator 8 and a 52,550-cycle oscillator 9. The 52,500-cycle oscillator 9 has its output connected to the 50-kilocycle modulator 6 for modulating the signal waves having a frequency of 50 kilocycles ± 425 cycles which are thereby converted into waves of 2,550 cycles ± 425 cycles.

The output of the 50-kilocycle modulator 6 thus consists of waves having frequencies of either 2125 cycles, which is the marking frequency, or 2975 cycles, which is the spacing frequency. This frequency separation, or difference, of 850 cycles between the marking and spacing signals may be regarded as an invariant. These marking and spacing waves travel from the output of the 50-kilocycle modulator to a band-pass filter 10 having a pass band which is sufficiently broad to pass both the marking and spacing waves but which eliminates noise currents having frequencies outside this range. The output of filter 10 is connected to a limiter 11 in which the signal waves are amplified. The action of the limiter 11 is also such that it produces a substantially constant output for wide variations in the level of the input energy thereby compensating for variations due to radio fading.

The output of the limiter 11 is connected to the marking filter 12 and the spacing filter 13 in parallel. Filters 12 and 13 are designed to pass the marking waves and the spacing waves, respectively, and to exclude waves of other frequencies. Filter 12 has its output connected to the marking detector 14 and filter 13 has its output connected to the spacing detector 15. The detectors 14 and 15 amplify and rectify the signal waves and then supply the rectified signals to the keyer control circuit 16 which causes the tone keyer 17 to produce an audio frequency signal in response to the reception of marking energy and to produce no output in response to the reception of spacing energy.

These single-tone audio frequency signals produced by the tone keyer 17 are supplied to the send-tone equipment 18 from which they are transmitted as ordinary single-tone voice frequency signals over an intermediate link 19 which may be either a land line or a radio circuit. The signals transmitted over the intermediate link 19 are received by the receiving tone equipment 20 which, in turn, delivers them to the station equipment 21 for such utilization as may be desired. For example, the station equipment 21 may be provided with receiving teletypewriter equipment adapted to record the signals.

As was stated above, the limits of the band-pass filter 10 are such as to permit the marking and spacing waves of 2125 cycles and 2975 cycles, respectively, to pass. However, if the frequencies of the received radio frequency waves have departed from their assigned values for any reason, such as due to a shift in the frequency of the carrier wave, then the resulting audio frequency waves would be of frequencies which might be outside the limits of the filter 10. In this event, some or all of the audio frequency signal waves would be excluded by filter 10.

To avoid the occurrence of this undesired exclusion, the system employs an automatic frequency control circuit 23 having its input connected by a conductor 24 into the receiving system at a point between the output of the 50-kilocycle modulator 6 and the input of the filter 10, as is shown in Fig. 1. The automatic frequency control circuit 23 produces a direct current control voltage in a manner explained hereinafter

in connection with the description of the operation of its circuit shown in Fig. 2. This direct current control voltage is supplied over a conductor 25 to the oscillator 8 for controlling, or varying, the frequency of the waves generated by the oscillator 8 in a manner known to those skilled in the art. For example, the control voltage can be applied to a grid of a reactance tube having a variable amplification factor so that, as the grid becomes more positive, the gain of the tube is increased thereby increasing the effective capacitance in the tuning circuit and decreasing the frequency of oscillation. Negative potential on the grid will, correspondingly, effect an increase in the frequency of oscillation. When the frequency adjusted waves from oscillator 8 are now combined in the converter 5 with the waves from amplifier 4, the frequency of the resulting waves will be of the proper value so that, when they are combined in the modulator 6 with the waves from the oscillator 9, they will produce marking and spacing waves of 2125 and 2975 cycles respectively. Thus, the automatic frequency control circuit 23 serves to maintain the frequencies of the signal waves, supplied to the filter 10, at their proper preassigned values within plus or minus 50 cycles.

In Fig. 2, the marking and spacing waves from the modulator 6 of Fig. 1 are supplied to the automatic frequency control circuit over the conductor 24 as was described above. Since the 850-cycle frequency separation between the marking and spacing waves may be regarded as an invariant, as was also described above, the use of only one type of signal waves in the automatic frequency control circuit gives satisfactory operation. Since the marking wave is transmitted during idle periods, it is preferable to use this type of signal wave to operate the automatic frequency control circuit. Therefore, a band-pass filter 30 is employed to admit only the marking waves to the automatic frequency control circuit. The marking waves will thus pass through the filter 30, which may have limits of 1600 cycles and 2600 cycles, to the control grid of tube 31 where they are amplified. These amplified marking waves are then applied to the control grid of tube 32 where they are further amplified. The output of tube 32 has two branches one of which delivers a portion of this output energy to the primary of a transformer 33. The secondary of transformer 33 delivers this portion of the output energy to a high-pass filter 34 and a low-pass filter 35 which are connected in parallel and which act as a discriminator. Filters 34 and 35 are adjusted by means of the potentiometer 36 to have the same losses for waves having a frequency of 2125 cycles.

The outputs of filters 34 and 35 are rectified by the tube 37 which is a double diode connected to form two half-wave rectifiers. When the marking waves have a frequency of 2125 cycles, equal currents pass through the two diodes of tube 37 and no output voltage will be produced at the output terminals 38 and 39. If the frequency of the marking waves should be lower than 2125 cycles, this wave energy would pass freely through the low-pass filter 35 to the upper diode of tube 37 but little or none of it would pass through the lower diode of tube 37. When this condition exists, the upper output terminal 38 will have a positive potential with respect to the lower terminal 39. Since the upper terminal 38 is grounded, the lower terminal 39 will now be negative with respect to ground. Similarly, if the frequency of the marking waves should be higher

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than 2125 cycles, this wave energy would pass through the high-pass filter 34 to the lower diode of tube 37. Under this condition, the lower terminal 39 will be positive with respect to the upper terminal 38 and is, therefore, positive with respect to ground. In either event, the output of tube 37 is applied to the conductor 25.

As was stated above in connection with the description of the operation of the receiving system of Fig. 1, the control voltage from tube 37 is delivered by the conductor 25 to some control means, such as a reactance tube, in the oscillator 8 for varying the tuning of the intermediate frequency oscillator tube to maintain the output energy of the converter 5 at substantially the proper pre-assigned frequencies.

As was also stated above, the output of tube 32 has two branches, one of which has just been described above. In the other branch, a portion of the amplified waves travel along conductor 40 and pass through a small capacitance 41 of about 0.1 microfarad to a potentiometer, constituted by the resistances 42 and 43, which impresses one-half of the output voltage on the anodes of the double diode 44. The cathode of tube 44 is biased about plus 23 volts by means of the battery 45 acting through a potentiometer 46. If the peak voltage of the alternating current output of tube 32 is in excess of about 46 volts, for example, then pulses of current will pass to ground through tube 44 thereby increasing the charge of the capacitor 41. The resulting current in the resistors 43, 47, and 48 causes the condenser 49 to acquire a negative charge.

One-half of the negative voltage on the condenser 49 is applied to the control grid of tube 31. Since tube 31 is a variable gain tube, its gain is thereby reduced. A condenser 50 is provided to reduce the voltage ripple and also, together with the resistors 47, 48, and 51, to delay the response. Thus, tube 44 and its associated circuit act as an automatic volume control means to maintain the output of tube 32 substantially constant with a peak voltage a little greater than 46 volts so that the signal input into the discriminator constituted by the filters 34 and 35 will also be constant. With this input to the discriminator constant and invariable regardless of changes in the frequency of the signal waves, then the output of the discriminator will be unaffected by variations in the magnitude of the signal waves and will be proportional only to variations in the frequency of the signal waves.

Condenser 49 is also connected to the control grid of a monitoring tube 52 through a delay circuit including the resistance 53 of about 1.5 megohms and the condenser 54 of about 6 microfarads. When tube 32 produces its normal output in response to the passage of signal waves through the filter 30, the negative voltage on condenser 49 will be sufficient to bias tube 52 beyond cut-off.

In initiating communication, a marking signal is sent from the transmitting station and operates the automatic frequency control circuit as described above if the beating oscillator is initially operating at the correct frequency. However, if the beating oscillator is operating at an incorrect frequency, the heterodyned waves will be of frequencies outside the limits of the filter 30 and will be shunted around the filter 30 through the tube 52.

These waves travel to the control grid of the monitoring tube 52 by means of a by-pass circuit including the conductor 55 and a resistance 56 of

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about 4700 ohms. Because of the presence of the resistance 56, the level of the waves now applied to the control grid of tube 52 is only about one-sixth of the level applied to the input terminals of filter 30. Tube 52 will transmit this reduced wave energy over the remainder of the by-pass circuit, including the conductor 57 and the resistance 58 which is about 4700 ohms, to the control grid of tube 31. Due to the loss in the by-pass circuit, the level of the waves now supplied to tube 31 is lower than the level of the waves ordinarily supplied thereto by filter 30.

Tube 31 will amplify this wave energy and will supply it to tube 32 for further amplification. Due to the loss incurred in passing through the by-pass circuit, the output of tube 32 will be insufficient at this time to effect a biasing of tube 52 beyond cut-off. In addition, any bias voltage now applied to the control grid of tube 52 will reduce the gain of tube 52 and this in turn will reduce the value of the bias voltage.

The output of tube 32 is also applied to the discriminator constituted by the filters 34 and 35. Since, as was stated above, the output of the discriminator is proportional only to variations in the frequency of the heterodyned waves, it will now produce a control voltage at its output terminals 38 and 39. This control voltage will be applied by the conductor 25 to the controlled oscillator 8 in Fig. 1 for varying its frequency in the manner described above to bring the frequency of the output of the modulator 6 within the limits of filter 30. When this occurs, a sufficient charge will again be placed on condenser 49 which will bias tube 52 beyond cut-off, as was described above. This, in effect, opens the by-pass shunt circuit across the filter 30 thereby restoring the receiving system to its normal condition.

The operation of the automatic frequency control circuit during "busy" periods of the radio communication system of Fig. 1 is as described above. However, if a protracted spacing signal is transmitted for a period of about 10 seconds, the delay circuit, comprising the resistance 53 and the condenser 54, associated with the control grid of tube 52 will discharge to permit tube 52 to function in the manner described above. As a result, the tuning of the controlled oscillator 8 will be changed so that the frequency of the spacing waves produced by the modulator 6 will now be approximately 2125 cycles instead of their proper frequency of 2975 cycles. This condition can be corrected by transmitting a steady marking signal for a period of about 10 seconds to allow the correct tuning to be reestablished.

It is to be understood that this improved automatic frequency control circuit can be used in other types of communication systems than that shown in Fig. 1. For example, it can be used in a dual diversity receiving system having two diversity receiving circuits each of which is similar to the receiving circuit shown in Fig. 1. In this case, each of these diversity receiving circuits can be provided with its own automatic frequency control circuit. However, if desired, only one automatic frequency control circuit need be used and this can be accomplished by connecting its input into each of the diversity receiving circuits and by connecting its output to a beating oscillator which is common to both of the diversity receiving circuits.

What is claimed is:

1. In a radio receiving station having a beating oscillator for generating waves and a con-

verter for heterodyning received signal waves with waves generated by the beating oscillator, automatic frequency control means for regulating the frequency of the waves generated by the beating oscillator, filtering means for supplying the automatic frequency control means with a preassigned portion of the heterodyned received signal waves, by-pass means for supplying other portions of the heterodyned received signal waves to the automatic frequency control means, and control means for disabling the by-pass means in response to output energy produced by the filtering means.

2. A radio receiving system comprising in combination a beating oscillator for generating waves, a converter for heterodyning received waves with waves generated by the beating oscillator, automatic frequency control means for regulating the frequency of the waves generated by the beating oscillator, filtering means arranged to supply the automatic frequency control means with a portion of the heterodyned waves, by-pass means arranged to supply at least another portion of the heterodyned waves to the automatic frequency control means, first control means for disabling the by-pass means when the output of the filter is above a preassigned level, and second control means for rendering said by-pass means effective when the output of said filter falls below a preassigned level.

3. A radio receiving system comprising in combination a beating oscillator for generating waves, a converter for heterodyning received waves with waves generated by the beating oscillator, automatic frequency control means for regulating the frequency of the waves generated by the beating oscillator, filtering means arranged to supply the automatic frequency control means with a portion of the heterodyned waves, by-pass means arranged to supply at least another portion of the heterodyned waves to the automatic frequency control means, monitoring means adapted to disable the by-pass means when the output of the filter is above a preassigned level and for rendering the by-pass means effective when the output of said filter remains below a preassigned level for a preassigned period of time.

4. A radio receiving system comprising in combination receiving means for receiving radio frequency waves, converting means for converting the received waves into corresponding audio frequency waves, said converting means including a beating oscillator for generating waves, automatic frequency control means for varying the frequency of the waves generated by the beating oscillator, said automatic frequency control means including an input band-pass filter, at least one electronic amplifier connected to the output of said filter, a by-pass circuit connected between the input of the filter and the input of the electronic amplifier, and monitoring means adapted to close said by-pass circuit when the output of said electronic amplifier falls below a preassigned level and to open the by-pass circuit when the output of said electronic amplifier rises above said preassigned level.

5. A radio receiving system comprising in combination receiving means for receiving radio frequency waves, converting means for converting the received waves into corresponding audio frequency waves, said converting means including a beating oscillator for generating waves,

automatic frequency control means for varying the frequency of the waves generated by the beating oscillator, said automatic frequency control means including an input band-pass filter, at least one electronic amplifier connected to the output of said filter, a by-pass circuit connected between the input of the filter and the input of the electronic amplifier, a monitoring electronic tube connected in the by-pass circuit, a delay circuit having a condenser, charging means for applying at least a portion of the output energy from the electronic amplifier to the condenser for charging same, biasing means for utilizing said output energy to bias the monitoring electronic tube beyond cut-off for disabling the by-pass circuit, and energizing means for rendering said monitoring electronic tube conductive for rendering said by-pass circuit effective when said output energy falls below a preassigned level and said condenser discharges through the delay circuit.

6. A radio receiving system for receiving two types of signal waves of different frequencies, said system comprising in combination a beating oscillator for generating waves, modulating means for combining the received signal waves with the waves generated by the beating oscillator to produce signal waves of a first frequency and other signal waves of a second frequency, automatic frequency control means adapted for producing control voltages and for applying said control voltages to the beating oscillator for varying the frequency of its output in accordance with said control voltages, said automatic frequency control means having an input band-pass filter connected to the output of the modulating means, said filter having limits adapted to pass signal waves of only one of the frequencies produced by the modulating means, a by-pass shunt circuit adapted to be completed across the input band-pass filter, monitoring means adapted to complete the by-pass shunt circuit across the input filter, and activating means for activating the monitoring means to complete said by-pass shunt circuit during an absence of substantial output energy from said filter.

7. A radio receiving system for receiving at least two types of signal waves of different frequencies, said system comprising in combination a beating oscillator for generating waves, modulating means for combining the received signal waves with the waves generated by the beating oscillator to produce first signal waves having a preassigned frequency and second signal waves of a different preassigned frequency, a band-pass filter having its input connected to the output of the modulating means and having limits for passing only said first signal waves, control means connected to the output of said filter and adapted to produce control voltages when the frequency of said first signal waves departs from its preassigned value, means for applying said control voltages to the beating oscillator for varying the frequency of its output, a normally open by-pass circuit adapted to be connected around said filter, normally unoperated monitoring means adapted to close the by-pass circuit, and activating means for operating the monitoring means during the departure of said first signal waves from their preassigned frequency.

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