

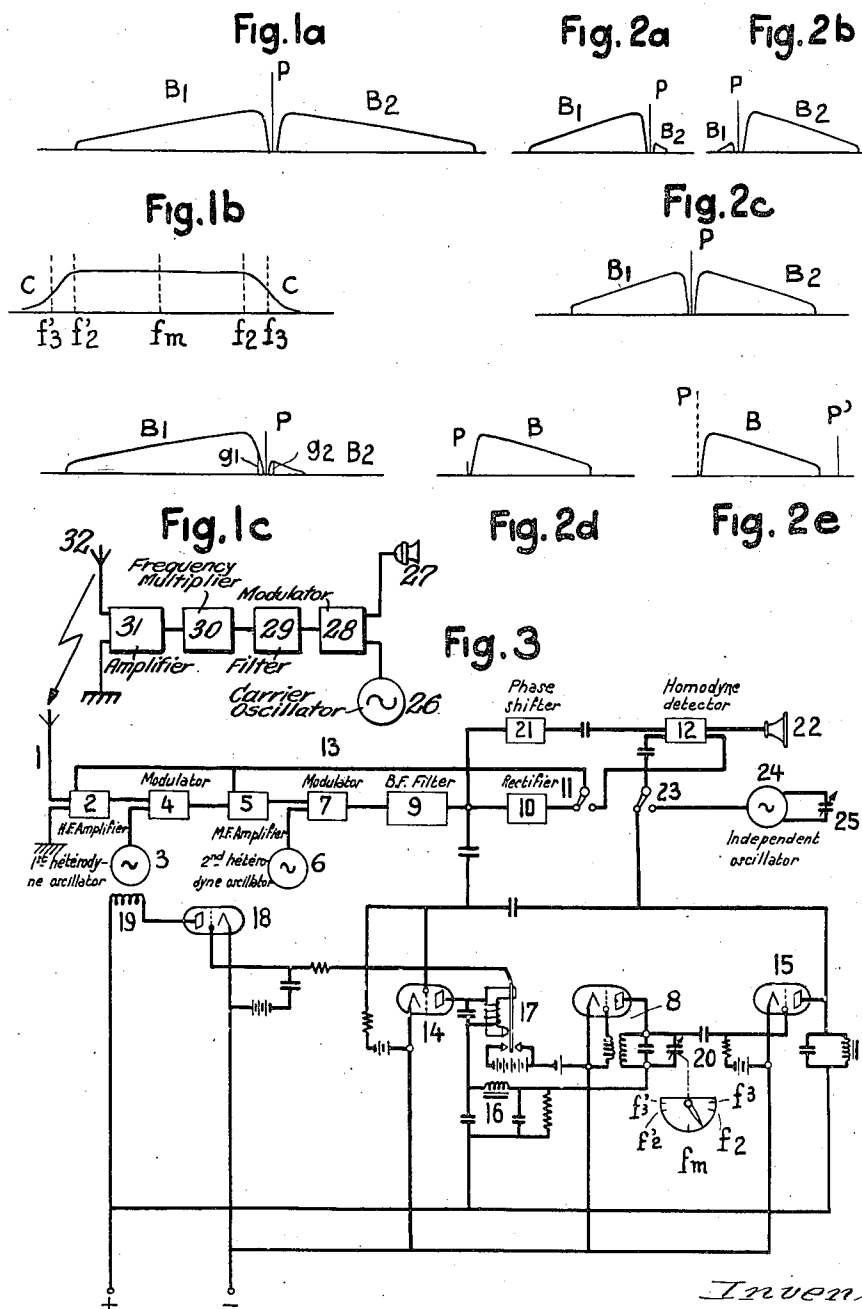
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H. J. J. M. DE REGNAULD DE BELLESCIZE

RADIOTELEPHONE SYSTEM

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Inventor

Henri Jean Joseph Marie de Regnauld de Bellescize,

By

John B. Brady
Attorney

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RADIOTELEPHONE SYSTEM

Henri Jean Joseph Marie de Regnauld de
Bellescize, Neuilly-sur-Seine, France

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The present invention is intended to overcome certain obstacles which have up to the present restricted to a great extent the use of single-band radiotelephony, although it is a signalling method with a great number of advantages. Thus, it will clear the ether from frequency bands which are not of vital necessity, increase the signal to noise ratio and attenuate the harmonic distortion due to selective fading. However, it is till now limited to speech transmission, since the transmission of music according to this method would require that for a difference of over 50 cycles with respect to the carrier all the lateral components be entirely maintained in one side-band and suppressed in the other; the required steep slopes of the characteristics of the corresponding filters, the passing band of which must on the other hand spread over a number of kilocycles, are obtainable only with difficulty. The present receivers for signals transmitted with only one side-band are further too highly specialised for permitting their use for general service: Some of them operate with the aid of a carrier, others are dependent upon the use of a pilot wave; both these types are usually improper for receiving usual signals comprising both side-bands, and this specialisation slows down considerably this branch of communication engineering which, for success, should first adapt itself to the conditions at present prevailing in this line.

The first object of the invention is to obtain practically all the advantages of single band signalling, without sacrificing the components of this single band which are closest to the carrier. This result is obtained by starting from the usual symmetrical two-band spectrum, and causing this spectrum to pass through a band-pass filter, the carrier frequency being arranged with respect to one or the other of the outer slopes of this filter so as to lie substantially at the point of said slope corresponding to an attenuation of 6 decibels. One of the two bands of the spectrum therefore coincides with that of the filter and is almost completely retained while the other is almost entirely suppressed. In the receiver the demodulation utilises an auxiliary oscillation in locked synchronism and in phase with the carrier. This signalling method maintains the respective values of the low and high notes, the audition of a low note resulting from the effect of two components, the amplitudes of which are attenuated, in the average, by one half by the filter slope, while the audition of the high notes is given by a single component of normal amplitude. The band-pass filter bringing about this transformation of the spectrum needs not be designed with abnormally steep cut-off slopes; it may be arranged either in the transmitter which will then radiate a substantially intact band and a residue of the other band, or in the receiver for supply-

ing the latter with only one band from a two-band signal. The local generator supplying the receiver with the auxiliary oscillation in phase with the carrier will preferably be synchronised by the method described in my Patent 1,976,877, granted October 16, 1934. This method ensures, indeed, a particularly effective selection of the synchronising current issuing from the carrier wave and this selection is precisely necessary for eliminating the lateral components very near to the carrier and unequally attenuated by the slope of the band-pass filter. If these components were not eliminated before arriving at the synchronising device, they would cause hunting due to the inequality of their amplitudes.

According to another object of the invention, the local generator synchronised with the carrier frequency serves not only for supplying the local oscillation necessary for demodulation, but also for controlling said carrier frequency after it has been lowered by the action of the heterodyne oscillators in the receiver. To this effect, the local generator is provided with a device, consisting for instance of a tuning condenser, permitting the adjustment of its natural frequency within a range of a few thousand cycles. This tuning device is calibrated in frequencies and is provided with marks corresponding to the middle and extreme frequencies respectively of the band-pass filter, and also to the two frequencies for which the received waves are attenuated by the filter by an amount of 6 decibels. It will therefore be sufficient to adjust the natural frequency of the synchronous generator according to these marks, in order to make certain that the carrier frequency is suitably arranged with respect to the passing band of the filter: For receiving a usual two-band signal, the local generator will be tuned so as to place the carrier frequency in points of the slopes giving the 6 decibel attenuation; for receiving a signal, the carrier of which has already been attenuated at the transmitter, said carrier will be set on one of the filter frontiers. This means of controlling the frequency of a received wave is remarkably simple and results from the following property, already protected by claim 16 of Reissue 20,821 to the inventor, of August 9, 1938: The natural frequency of a local generator in locked synchronism with a received wave will be held in exact coincidence with the average frequency of this wave when the synchronising uses the combined action of two frequency controls, one of which is applied to a first heterodyne oscillator in order to neutralise the drift.

The invention also permits receiving a signal transmitted on a single band accompanied by a pilot wave: The local generator of the receiver is then locked to this wave so as to control its frequency as indicated above. On the other hand,

the carrier is set up again locally by deriving it from a second generator, of similar construction to the first, also adjustable in frequency, but independent. Since these two local generators are similar and their natural frequencies are comparatively low, they will drift very little with respect to one another, so that after their frequency relation has once been adjusted, it will remain identical to the relation existing between the pilot and carrier frequencies of the signal.

The present invention thus describes on one hand a new type of telephone signal, the spectrum of which permits a true reproduction of the music while it is substantially no larger than those actually using a single band. On the other hand, the same receiver may, from now on, be used for receiving at will either signals of the above type or those transmitted strictly on one band only accompanied by a carrier or a pilot wave, or further the usual two-band signals, one of the bands being selected out by the filter provided in the receiver. The said excessive specialization, which up to the present constituted an obstacle to progress in this branch, has thus been eliminated. This result is achieved by simple means, comprising only one precise selection, viz. that of the current synchronising the local oscillator. Now, in Patent 1,976,877 it has already been explained that this selection may be obtained in a low-pass filter or even in a common aperiodic circuit. This simplicity of the means used permits the construction of cheaper receivers, and releases the makers from the obligation of resorting to highly intricate quartz filters as has heretofore been necessary due to the remarkable stability and steep cut-off slopes required for the latter.

Figures 1a-1c show the manner of producing the spectrum of a signal, the carrier of which is attenuated by 6 decibels, in order to maintain substantially unchanged one side-band while almost completely suppressing the other side-band.

Figures 2a-2e show various spectra of signals which it is possible to receive with a single receiver according to the invention, and

Figure 3 shows an embodiment of the system.

Figure 1a shows the spectrum of a normal telephone transmission comprising the two side-bands B1 and B2 on either side of the carrier P. The latter has been represented twice as high as the maximum ordinate of each side-band in order to indicate conventionally that its amplitude is at least equal to the resultant of the lateral oscillation together. The considered signal is passed through a band-pass filter, arranged at the transmitter and/or receiver and satisfying the following conditions, indicated in Figure 1b:

(a) The width of the passing band is substantially equal to that of either band B1 or B2 it is desired to keep, and

(b) The carrier frequency P coincides with a point of one of the slopes C, C, for which the attenuation is of the order of 6 db.

After passing through this filter, the signal spectrum is therefore changed to that shown in Figure 1c, viz. the amplitude of the carrier P is reduced by one half as compared to its initial value, one of the side-bands, here the left side-band B1, is maintained substantially unchanged, while the other band, B2, is almost entirely suppressed. In the band B1, the components corresponding to the high or medium notes have no longer any correspondent in the other side-band, B2, while the components $g1$, $g2$ contributing by pairs to give the low notes, are unequally at-

tenuated, this inequality becoming less and less marked as one approaches the carrier. It may therefore be stated as a first approximation that the very low notes are handled as in normal two-band telephony, while the high notes are treated like in single band transmission systems. The receiver must therefore be provided with the means necessary for restoring locally a very large amplitude carrier in phase with P. Assuming this condition to be fulfilled, the respective values of the low and high notes will be truly reproduced: Indeed, while the impression set up by a high note will result from a single component, the amplitude of which has been left unchanged by the filter, the impression set up by each low note will be the result of two components $g1$ and $g2$, attenuated by one half as an average and adding their effects since their phases remain substantially symmetrical with respect to that of the carrier P; this symmetry is a result of the fact that the phase shifts undergone by the various components of the spectrum in the filters remain practically proportional to the corresponding frequency shifts as long as only narrow regions of the spectrum are considered, as those where the amplitudes of $g1$ and $g2$ are sufficiently comparable to one another so that one of them may not be neglected with respect to the other.

A transmitter according to these principles will therefore comprise, as indicated in Figure 3, a source of carrier energy at 26, a source of modulation energy at 27, a modulator at 28, in which the spectrum of Figure 1a are produced, and the filter means at 29 necessary for attenuating the spectrum by substantially one half, in order to radiate one of the single-band spectra shown in Figures 2a or 2b. For obtaining this result, one may use the known method according to which the filtering according to Figure 1b is effected upon an auxiliary carrier frequency which is comparatively low, this frequency being thereafter raised to the required value by frequency changers 30, in the output of which a single beat frequency is retained, amplified at 31 and transmitted from antennae 32. The filters are in this case cheaper than those used for the complete suppression of one side-band, since the slopes C may be very much less steep. This steepness may be characterized by the range $f3-f2$ extending between the frontier $f2$ and the frequency $f3$ attenuated by the amount of 6 db.; the value which should be given to this range will be defined further. With ordinary receivers, the signals of Figures 2a and 2b are still intelligible although somewhat distorted.

The receiver shown in Figure 3 may receive at will either the signals with substantially single side-band of Figures 2a and 2b, or usual telephony, the spectrum of which is given by Figure 2c, or further signals according to Figure 2d, comprising a single band and a highly attenuated carrier P, or, lastly, single band (B) telephony with a pilot wave P', as shown in Figure 2e.

The said receiver comprises firstly the usual parts, viz. the aerial 1, the HF circuits 2, a first frequency changer consisting in the heterodyne oscillator 3 and modulator 4, the circuits 5 tuned to the intermediate frequency, eventually a second frequency changer 6, 7 lowering the carrier or pilot frequency to one of the final values imposed to it by the locked local oscillator 8. The receiver oscillations are then passed through the band-pass filter 9, the selection curve of which is similar to that of Figure 1b, the width of the

passing band, for instance 5,000 cycles, being chosen according to the fidelity required in the reproduction of the signal; f_m , f_2 , and f'_2 , f_3 and f'_3 indicate the medium and frontier frequencies, and those attenuated by 6 db., respectively. This filter supplies three branches, (a) the middle branch comprising the detector 10 controlling the antifading device when the switch 11 is placed on the left position, (b) the branch shown below, containing the oscillator 8 locked on the carrier or pilot wave in order to maintain the frequency of this wave in the required position with respect to the characteristic curve of filter 9, and (c) the upper branch supplying the detector 12 in which the signal is demodulated by means of the local oscillators 8 or 24. The antifading device controlling the amplification of the receiver through the lead 13 has no particular feature except that it depends on the detector 10 or detector 12 according to the position given to the switch 11; detector 10 is used preferably for the signals of Figures 2a, 2b and 2c and the control of the amplification then depends on all the components of the spectrum, the lateral components becoming predominant when the carrier fades out selectively. This feature stabilises the level of the audition. If, on the contrary, the transmitter radiates a strongly attenuated carrier, as indicated in Figure 2d, it is necessary to separate this carrier from the lateral oscillations for permitting it to control the antifading device; this selection is easily set up by a simple aperiodic circuit arranged in the output circuit of the homodyne detector 12, as already explained in my Patent 1,976,877. The device locking the oscillator 8 on the carrier or pilot wave may, in principle, be of any desired type, but the one described in the above patent is preferable owing to the simplicity thereby resulting for the selection means. It comprises essentially a rectifier 14 excited simultaneously by the received waves and by the much more powerful wave supplied by the oscillator 8 through the amplifier 15. The low-pass filter 16, eventually replaced by a simple aperiodic circuit, selects the synchronised current which controls electrically the oscillator frequency. The latter will lock on the carrier or pilot wave as soon as the frequency of this wave is brought by the heterodyne oscillators 3 or 6 near enough to the natural frequency of the oscillator 8. The two locked oscillations are further maintained in quadrature by a second frequency control 17, 18, 19 already described in my Reissue Patent No. 20,821. The latter control, which is electromechanical and effected more slowly than the first one, acts upon the heterodyne oscillator 3 so as to neutralise the drifts and consequently maintain permanently the equality between the natural frequency of oscillator 8 and the average value of the carrier or pilot frequency in the filter 9. It will therefore merely be necessary to modify the natural frequency of the oscillator for bringing and maintaining automatically the carrier or pilot frequency in any desired position with respect to the selection curve of Figure 1b. The tuning condenser 20 is provided to this effect with a number of marks corresponding particularly to the frequencies f'_3 , f'_2 , f_m , f_2 and f_3 . In the upper part of Figure 3, the filter 9 supplies a phase shifter 21 adjusted once for all in a manner that the oscillations supplied by the receiver to the detectors 12 and 14 be respectively in quadrature. Consequently, when the carrier is locked in quadrature in the detector 14 with the

local oscillation supplied by the generator 8, it will be in phase with this same oscillation in the detector 12, thereby ensuring homodyne reception of the signals corresponding to Figures 2a, 2b, 2c and 2d. These signals are ultimately received in the phones or loud speaker 22. The homodyne reception of the signals of Figure 2e, comprising one band and a pilot wave P' is obtained by throwing the switch 23 to the other position in order to subject the detector 12 to the action of the local oscillator 24, a condenser 25 of which permits to render the natural frequency of the oscillator identical to that of the carrier suppressed at the transmitter. In other words, this natural frequency is made, by means of the condenser 25, to differ from that of the oscillator 8, locked on the pilot wave P', by the amount by which the pilot frequency itself differs from the carrier. This frequency difference between the oscillators 8 and 24 may, if necessary, be checked by not represented automatic or acoustic means and will, moreover, vary only by small amounts if the oscillators are of similar construction.

From the above, it will be seen that the reception of the substantially single-band signals of Figures 2a and 2b is obtained by locking the oscillator 8 upon the carrier already attenuated at the transmission end and placing the condenser 20 in one of the positions for which the natural frequency of said oscillator, and therefore also the carrier frequency in the filter 9 will coincide substantially with one of the frontiers f_2 or f'_2 of this filter. The frontier f_2 will obviously be suited for the signals of Figure 2a, while the frontier f'_2 for those of Figure 2b. The switch 23 is placed so as to subject the detector 12 to the action of the oscillator 8. The signals of Figure 2c, comprising two bands and one carrier of normal amplitude, on which the oscillator 8 is locked, are received by adjusting the condenser 20 so as to give said oscillator, and therefore also the carrier frequency in filter 9, one of the values f'_3 , f_m or f_3 . The values f_3 or f'_3 will permit to receive at will one or the other band, while the other will be almost entirely eliminated and the carrier attenuated by one half. The value f_m is suited for the case when the signal is disturbed by interferences on both ends of its spectrum so that it is only possible to receive correctly the middle part of this spectrum. The signals of Figure 2d are received like those of Figures 2a or 2b, with the difference however that it may be preferable to energize the antifading device by the detector 12. The signals of Figure 2e are received by locking the oscillator 8 on the pilot wave P' and setting the condenser 20 in such a way that the totality of the spectrum be comprised in the passing band of filter 9, whereafter, the switch 23 being set so as to connect the detector 12 to the oscillator 24, the frequency of the latter is adjusted by the condenser 25 so as to restore the carrier wave.

The band width of the low-pass filter 16 and the slopes C of the filtering system arranged in the transmitter, in the receiver as at 9, or in both, are chosen according to the following principles: the slope C modifies the central part of the spectrum (Figure 1) in such a manner that to each component g_1 of the substantially retained side band B1 shall correspond in the substantially eliminated side-band B2 a symmetrical component g_2 which is more attenuated. Under these conditions, the selective fading could further set up some distortion on the lower notes

of the signal, this distortion being, however, less important than in usual communication systems, where all the lateral components have, two by two, respectively the same amplitude; the range of the slope C must therefore comprise as few lateral components as possible. The difference $f_3 - f_2$ will therefore be chosen of the order of 300 cycles as a maximum if it is intended to receive speech, and of 100 cycles for music. On the other hand, the band width of filter 16 must be small enough for preserving the synchronism of oscillator 8 from the influence of the pairs of components such as g_1, g_2 , which, on account of the slope C, would have received considerably unequal amplitudes; this inequality may, indeed, give the frequency of the locked oscillator a pendular movement. Therefore, the band width of filter 16 must be chosen between about 250 cycles for the reception of speech and about 50 cycles as a maximum for ensuring a practically perfect reception of music.

Various modifications may be brought to the system described. Thus, for instance, the filter 9 of the receiver could be inserted in the first intermediate frequency circuit, between the detectors 4 and 7; the low pass filter 16 could be replaced by a band pass filter inserted before the detector 14. The attenuation of the carrier by one half, necessary at the input of the homodyne detector 12, may be obtained partly at the transmitter and partly at the receiver, the carrier amplitude being then reduced each time to about 70% of its initial value. Due to the various sorts of transmissions which the receiver may have to receive, its tuning condenser 20 must preferably be continuously variable, the marks corresponding to the frequencies $f_3, f_2, f_m \dots$ serving as an indication for the operator of the attenuations set up in order to obtain the best acoustical quality.

What I claim is:

1. Telephone signalling method comprising the following operations: modulating a carrier wave in order to produce a spectrum, the components of which are distributed between the two side-bands symmetric with respect to said carrier, passing said oscillations through a band-pass filter, the band of which is of a width substantially equal to that of one of the spectrum bands, placing the carrier frequency in a point substantially midway of one of the filter slopes, for which the attenuation is about 6 decibels for a maximum difference in frequency of about 300 cycles per second, and demodulating said signal by means of a local oscillation of greater strength than the carrier wave and in phase with this wave for homodyne reception.

2. Receiver for telephone signals, the spectrum of which consists in side components and an auxiliary component, comprising a circuit for receiving said components, a heterodyne oscillator interfering with said components for altering their frequencies, a band-pass filter, the band of which is limited by two slopes while its width is substantially equal to that of one side-band, and a control device for placing and maintaining the altered auxiliary frequency in a suitable point with respect to the filter band; said control device comprising in combination a local generator, the natural frequency of which may be adjusted within a frequency range which is slightly broader than the passing-band of the filter, means for maintaining this local generator in synchronism with the altered auxiliary frequency,

and a drift corrector acting upon the heterodyne oscillator so as to maintain the permanent equality between the natural frequency of the synchronised local generator and the altered average frequency of the auxiliary component, whereby the adjustment of said local frequency forces said auxiliary frequency to lie in a point determined with respect to the filter band; and single side-band detection means for the signal passed by said filter.

3. Receiver for telephone signals, the spectrum of which consists in side components and a carrier component, comprising a circuit for receiving said components, a heterodyne oscillator interfering with said components for altering their frequencies, a band-pass filter, the band of which is limited by two slopes while its width is substantially equal to that of one side-band, and a control device for placing and maintaining the altered carrier frequency in a suitable point with respect to the filter band; said control device comprising in combination a local generator, the natural frequency of which may be adjusted within a frequency range which is slightly broader than the passing-band of the filter, means for maintaining this local generator in synchronism with the altered carrier frequency, and a drift corrector acting upon the heterodyne oscillator so as to maintain the permanent equality between the natural frequency of the synchronised local generator and the altered average frequency of the carrier component, whereby the adjustment of said local frequency forces said carrier frequency to lie in a point determined with respect to the filter band; and means for demodulating single side-band the signal passed by said filter by causing its components to interfere with an oscillation provided by the synchronised local generator.

4. Receiver according to claim 2, with said detection means comprising an independent local generator the natural frequency of which is adjustable, and a demodulator in which the signal components interfere with an oscillation provided by this independent local generator.

5. A signalling system comprising a transmitter for producing signals with one substantially intact side-band, the other substantially entirely suppressed and the carrier wave attenuated by one half; and a receiver comprising a band-pass filter, the band of which is of a width substantially equal to that of the signal band retained in the transmission, and an adjustable control device for placing and maintaining the carrier frequency in coincidence with one frontier of said filter.

6. Receiver for telephone signals, the spectrum of which comprises a single band of lateral components and a pilot wave, comprising a heterodyne oscillator for lowering the frequency of the received waves, a band-pass filter, a control device for placing and maintaining the pilot frequency in a suitable point of the filter band; this device comprising in combination a local generator of adjustable frequency, means for locking this local generator on the lowered frequency of the pilot wave, and a drift corrector applied to the heterodyne oscillator; a second local generator, the frequency of which is also adjustable, and a demodulator in which the components of the signal interfere with an oscillation supplied by this second local oscillator.

HENRI JEAN JOSEPH MARIE
DE REGNAULD DE BELLESCIZE.