April 1, 1947. W. W. HANSEN 2,418,119

SECRET COMMUNICATION

Filed April 10, 1943 2 Sheets-Sheet 1

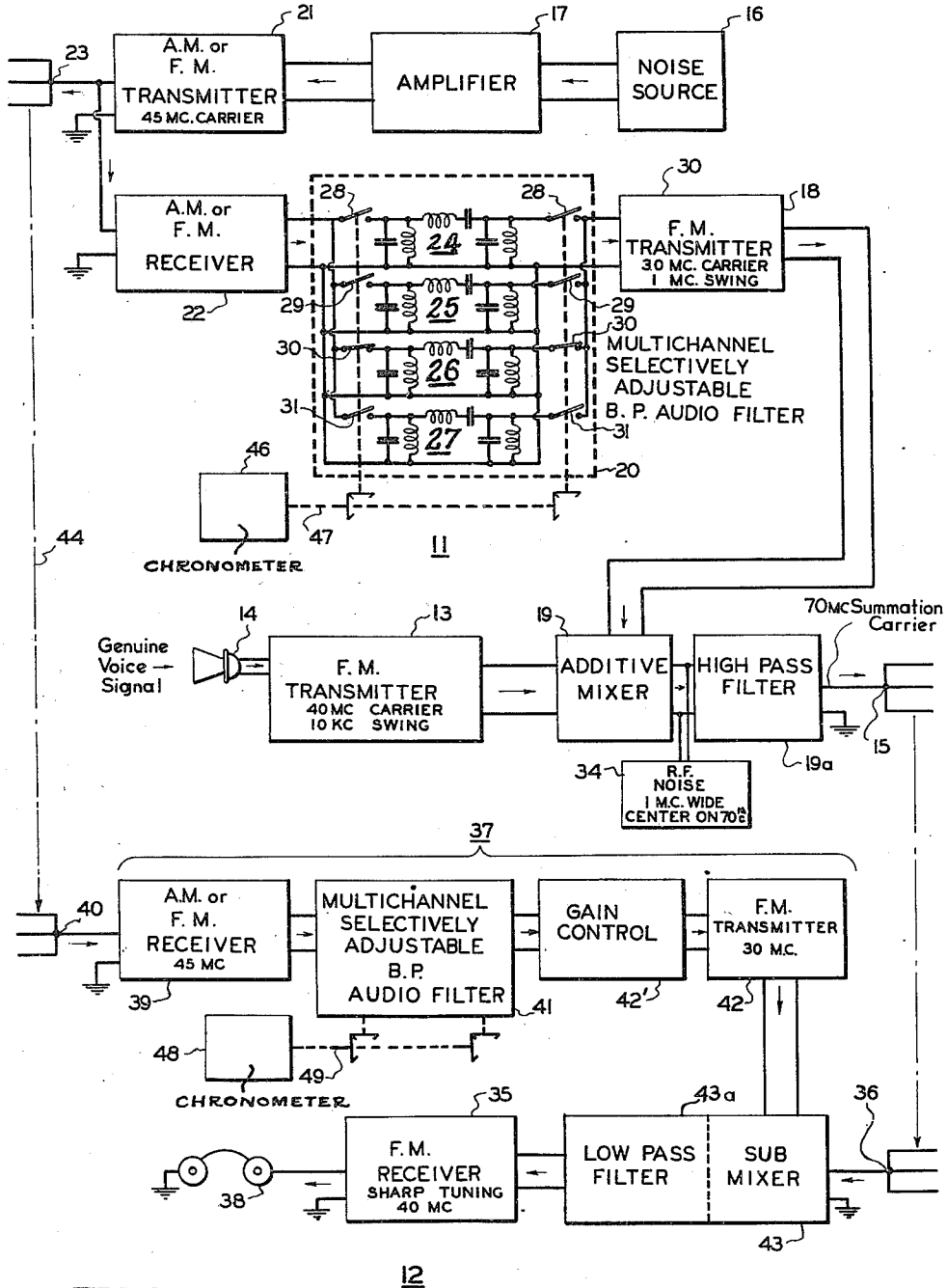


FIG. 1.

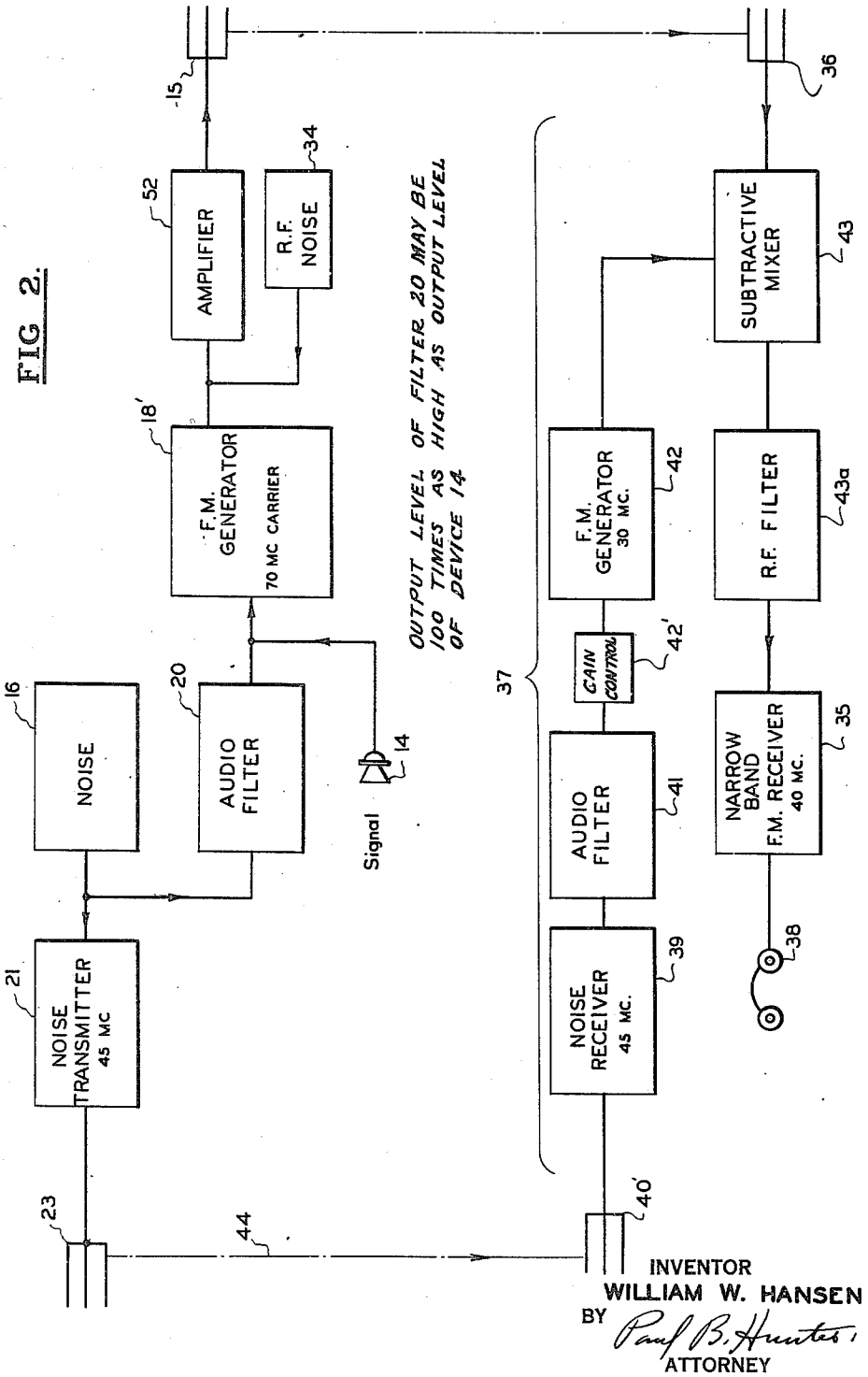
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FIG 2.



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SECRET COMMUNICATION

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5 Claims. (Cl. 250—6)

1

My invention relates to communication systems and concerns particularly methods and apparatus for conveniently carrying out secret radio telephone or telegraph communication.

It is an object of my invention to provide an improved secret communication system which is impossible to decipher by an unauthorized listener and the intelligence of which can be picked up by neither wide band nor narrow band receivers.

A further object of my invention is to provide a secret telephone communication system in which direct telephone communication may be carried out without delay for decoding.

Other and further objects and advantages will become apparent as the description proceeds.

In carrying out my invention in its preferred form, I utilize some form of frequency-modulation or phase-modulation radio carrier frequency transmission. For transmission of the desired or genuine signal, I utilize narrow swing modulation, and for masking or confusing the genuine signal and preventing unauthorized listeners from picking up the signals, I utilize wide swing modulation. The wide swing modulation comprises one or more, preferably a plurality of, different low frequencies carrying no useful information. In fact, usually an infinite number of frequencies or a continuum will be employed. The combination of wide and narrow swing modulation forms an unintelligible signal.

For the reception of the signals, I provide a frequency modulation receiver system arranged for selecting the narrow swing modulated carrier of the transmitting apparatus. To permit selecting the desired signal, I provide a device for locally producing low frequencies corresponding to the interference introduced at the transmitter with means for producing modulations corresponding thereto. Furthermore, I provide apparatus at the receiver for separating such locally produced interference modulations from the received signal. In this manner, an intelligible signal remains in the frequency modulation receiver of an authorized listener.

A better understanding of my invention will be afforded by the following detailed description considered in connection with the accompanying drawings, and those features of my invention which are believed to be novel and patentable will be pointed out in the claims appended hereto.

In the drawings,

Fig. 1 is a schematic or block diagram of a secret radio communication system constituting one embodiment of my invention, and

Fig. 2 is a block diagram of a modified system.

2

In the specific embodiment of my invention represented for the sake of illustration in Fig. 1, I provide transmitting apparatus collectively designated by the reference numeral 11 and receiving apparatus collectively designated by the reference numeral 12. The transmitting apparatus 11 comprises a relatively narrow-swing frequency modulation transmitter or generator 13, means for modulating the transmitter 13 in accordance with a genuine signal to be transmitted, for example, a microphone 14 arranged to be spoken into by the authorized communication officer, an antenna or radiator 15 for radiating a signal, and means for superimposing on the radiated signal wide swing modulations, in which the modulations convey no useful information. Such means for superimposing wide swing modulations or interference comprise a suitable source of noise 16, an amplifier 17 for building up audio frequency voltages corresponding to such noise sufficiently for modulation of a carrier, a wide swing frequency modulation transmitter or generator 18 made responsive to the output of the amplifier 17 and a mixer, for example, an additive mixer 19 for combining the narrow swing modulated signal of the transmtter 13 and the wide swing modulated interference signal of the transmitter 18 in the waves radiated from the antenna 15. It will be understood that the generators 13 and 18 need not have high power output as the power for transmission may be supplied by providing a final amplifier (not shown), coupled to the antenna 15 and excited by the output of the mixer 19.

For the purpose of making it more difficult, in fact, virtually impossible for unauthorized listeners to decipher the signals, I preferably interpose a multi-channel selectively adjustable band pass audio filter 20 between the output of the amplifier 17 and the input to the wide swing frequency modulation transmitter 18. For reasons which will become more apparent hereinafter, I also prefer to interpose between the amplifier 17 and the wide swing frequency modulation transmitter 18 another transmitter 21 for converting the noise output of the amplifier 17 into a modulated carrier and a modulation receiver 22 for reconverting the modulated radio frequency output of the transmitter 21 into audio frequency noise corresponding to the output of the source 16. The frequency transmitter 21 is provided with an antenna or radiator 23 for radiating the major portion of its energy to a receiving station, only a portion of the output of the transmitter 21 being fed to the receiver 22. The transmitter 21 and the re-

ceiver 22 are designed for the same type of modulation. They may be frequency-modulation devices, but not necessarily so. Amplitude modulation may also be employed.

The noise source 16 may be a suitable source of noise such as a resistor or a saturated diode producing thermal or shot effect noise which may be amplified by a suitable device such as the amplifier 17. Preferably the noise source includes frequencies in the genuine signal in order to make filtering out of noise impossible.

For the sake of illustration and more conveniently distinguishing between the elements of the apparatus, I have arbitrarily designated certain frequencies and modulation swings for various portions of the apparatus, but it will be understood that my invention is not limited to the specific values mentioned for the sake of illustration. The transmitters 21 and 18 are preferably adjusted for operation at frequencies sufficiently different not to cause interference if they are both of the frequency modulation type. For example, the transmitter 21 may have a 45 megacycle carrier and the transmitter 18 may have a 30 megacycle carrier. The transmitter 13 may be adjusted for another carrier frequency from the transmitter 18, for example, 40 megacycles. The swing of the transmitter 18 is made considerably greater than that of transmitter 13, for example, the swing of transmitter 18 may be 1 megacycle whereas that of transmitter 13 is only 10 kilocycles. The receiver 22 is of course tuned to the frequency of the transmitter 21. The transmitter 21 need not necessarily be arranged for either a wide swing or a narrow swing if it is designed for frequency modulation as either type of transmitter may satisfactorily be employed, as well as an amplitude modulated transmitter.

The multi-channel filter 20 may be of any suitable type providing a plurality of different audio frequency channels which may or may not overlap as preferred. It may take the form simply of an audio amplifier with base and treble tone control. For subjecting an unauthorized listener to the utmost difficulty, ten or twenty channels at least may be provided, and means may be provided for selecting several different channels for simultaneous use. Although more channels are preferably employed, in order to simplify the drawing, I have schematically represented four different audio frequency channels 24, 25, 26 and 27. For selectively connecting or disconnecting the channels, there are provided pairs of switches 28, 29, 30 and 31. As shown in the drawing, the switches 28, 29, and 31 are open and the switches 30 are closed so that only the channel 26 is in use. However, in the actual apparatus where a greater number of channels is preferably employed, I prefer to have the switches in the several, for example, four or five, channels closed simultaneously.

The mixer 19 may be of any suitable type and does not in itself constitute a part of my present invention but may, for example, be similar in principle of operation to the mixers utilized in superheterodyne radio receivers. One form of such mixers comprises a multi-grid vacuum tube having one signal supplied to one grid and the second signal supplied to another grid. If the mixer 19 is an additive mixer, it may be followed by a suitable device such as a high-pass filter 19a for cutting off the lower sidebands and the transmitter carriers and permitting only the upper sidebands, resulting from the combination of the

outputs of the transmitters 13 and 18 to be radiated from the antenna 15. For the transmitter frequencies assumed, the filter 19a would cut off the 30 and 40-megacycle carriers, and the approximated 10-megacycle lower sidebands, retaining only the sidebands centered on 70 megacycles, which may be called the radiated or summation carrier.

As an added precaution in preventing unauthorized listeners from attempting to receive the output of the narrow swing transmitter 13 with a wide band receiver, I prefer to provide a second noise source 34 which is arranged to combine radio-frequency noise with the output of the mixer 19. The noise source 34 is designed to produce a wide radio-frequency spectrum, e. g., one megacycle wide. It may be strong in comparison with the signal produced by the modulations of the signal source 14, if the swing of the F. M. generator 13 is small compared to the spectrum width of the generator 18 and of the noise source 34.

The receiver 12 is largely a counterpart of the transmitter 11. It includes a frequency modulation receiver 35 designed for sharp tuning or narrow band reception tuned to the output of the genuine-signal narrow-swing transmitter 13, a receiving antenna 36, and apparatus collectively designated by the reference numeral 37 for removing from the signal picked up by the antenna 36, the wide swing interference modulations superimposed upon the radiated signal by the wide swing frequency modulation transmitter 13. The receiver 35 includes headphones 38 or the like for converting the electrical signal into sound waves which carry the desired information to the receiving officer.

The apparatus 37 includes means for reproducing audio frequency interference identical with that passed by the filter 20 of the transmitter, converting such interference into radio frequency modulations and subtracting such modulations from the waves picked up by the receiving antenna 36. As illustrated in the drawings, the apparatus 37 comprises a receiver 39 with a receiving antenna 40 tuned and suitably arranged to receive the radiations from the general noise transmitting antenna 23, a multi-channel selectively adjustable bandpass audio filter 41, a frequency modulation transmitter or generator 42 and a subtractive mixer 43. For adjusting the swing of the F. M. transmitter 42 to that of the transmitter 18, a gain-control or variable attenuator 42′ is provided.

For providing a basis of reference in order to reproduce accurately the selected audio noise superimposed at the transmitter, the general noise before filtering is transmitted from the antenna 23 to the antenna 40 as represented by the dotted arrow 44. This noise is picked up by the receiver 39 converted into audio frequency noise, filtered by the filter 41, supplied to the transmitter 42 for reconversion into radio frequency modulations, and passed in to one side of the mixer 23. The receiving antenna 36 is also connected to the mixer 43 so that the output of the mixer 43, supplied through the conductors 45 represents the difference between the radiations received on the antenna 36 and the selectively produced noise modulations supplied by the transmitter 42.

It will be understood that the filter 41 corresponds to the filter 20 of the transmitter and that corresponding switches therein (not shown) are closed so that the same channels of audio

frequency noise are passed in the filter 20 and the filter 41.

The transmitter 42 corresponds to transmitter 18 in carrier frequency and possible range of swing.

If the mixer 13 is an additive mixer, the mixer 43 should be a subtractive mixer and vice versa. Thus, if the mixer 13 is additive and the lower sidebands have been cut off from the waves received by the antenna and transmitted to the receiver 35, the mixer 43 should be subtractive, and its transmission characteristic be such as to cut off the received carrier and upper sidebands retaining only the lower sidebands centered on 40 megacycles, in the case of the frequencies assumed in the transmitter. A filter 43a may be provided such that it cuts off above a predetermined frequency, in this case, above approximately 40 megacycles.

It will be apparent from a consideration of the characteristics of the apparatus that an unauthorized listener not having a duplicate of the receiving apparatus 12 will be unable to receive the genuine signals whether he uses a wide band or a narrow band receiver. A wide band receiver will pick up very strongly the unintelligible noise output of the transmitter 18 and will also pick up the noise output from the source 34 if such a source is provided. On the other hand, if the unauthorized listener utilizes a narrow band receiver in an attempt to tune in the signal and tune out the interference, the wide band modulations of the transmitter 18 will prevent proper operation of the receiver. Such wide swing modulations in effect tune the transmited wave outside the frequency band of the unauthorized listener's receiver for the greater portion of the time and thus make such a receiver inoperative.

The effect of the two noise sources 16 and 34 may be appreciated by considering hypothetical simplifications. It may be assumed first that the noise source 34 is disconnected and that the "noise" is actually a single frequency f_1 which produces a frequency swing $\pm f_2$ in the effective carrier or summation carrier radiated from the radiator 15, and indicated for the sake of illustration as having a frequency of 70 megacycles per second.

Then if there is no signal supplied from the source 14, the spectrum of the radiated carrier has components at frequencies $\pm nf_1$ away from the carrier, where n is any integer. The amplitudes fluctuate erratically with n until nf_1 approaches a magnitude of the order of f_2 after which they decrease rapidly. (This assumes that f_1 is small in comparison with f_2, and it will presently appear that this corresponds to correct operating conditions.) This spectrum could be measured with an amplitude modulated receiver provided its pass band is less than f_1. The process will be made difficult if f_1 is small. A frequency modulation receiver would simply have an output of f_1. With this assumed simplification, relatively little secrecy is obtained.

Let it be assumed now that a signal of a single frequency f_3 is introduced from the source 14. Then each sideband nf_1 is split by amounts mf_3, where m is any integer. This enormously complicates the spectrum and increases the difficulty of amplitude analysis. The problem can be made insoluble by replacing f_1 or f_3 by a continuous spectrum. Therefore, f_1 is made continuous, because f_3 must conform to the input signal. Thus, f_1 should be a "noise" voltage, preferably with some important components at frequencies f_3 and lower.

Under the foregoing conditions, a listener with a frequency modulation receiver would simply hear the frequencies f_1 and f_3. Plainly, f_1 can be filtered out, but the difficulty will be increased if f_1 is much stronger than f_3 and if it is close to f_3; that is, the frequency swing due to f_1, the "noise" should be large compared to f_3, the signal. Furthermore, f_1 and f_3 should be close together. This verifies the assumption above that f_1 is small in comparison with f_2; because the signal swing should be of the order of magnitude of f_3 to get good modulation, f_1 is of the order of f_3, and f_3 is small in comparison with f_2. Moreover, if f_1 is replaced by a voltage with a continuous spectrum, the receiver output will be noise plus signal with the noise more intense than the signal, in the ratio of f_2/f_3. If this is large and the "noise frequency" includes f_3, filtering in the receiver output will be impossible.

If, therefore, the noise has important components throughout the range of signal frequencies and if the swing due to the noise is large compared to that due to the signal, deciphering is impossible. This is true even without the noise added from the source 34.

The effect of the noise source 34 may now be considered.

If it is again assumed that f_1 is a single frequency and there is no signal from the source 14, then a spectrum of the radiated output from the antenna 15 is a super-position of a continuous spectrum and a line spectrum. This can theoretically be analyzed by an amplitude modulation receiver but only with considerably enhanced difficulty because its bands must be made narrower than f_1 to cut out noise. Moreover, a frequency modulation receiver, which in the first simplification gave simple results, will now give noise plus f_1, and if the noise is intense enough, there will be difficulty in finding f_1.

It may be concluded that if averaged over the band f_2, the noise is considerably larger than the signal; the relatively simple system with f_1 a single frequency can be solved by an unauthorized listener only with difficulty.

If f_1 is made continuous, the problem of intercepting transmitted information is greatly increased.

The noise supplied by the source 34 may be large compared with the signal of frequency f_2 of the source 14 without causing difficulty with the "authorized" receiver. This is true because the authorized receiver need only take in a band width f_3, whereas an unauthorized listener must take in the band f_2, and both will get the same signal energy. This shows again the desirability of making f_2 large in comparison with f_1 and f_3, for the ratio determines the permissible amount of additional noise which may be supplied by the source 34.

In order to minimize difficulty in the apparatus of Fig. 1 resulting from any possible distortion in the receivers 22 and 39, it is desirable that these receivers be identical in type and construction. Under these circumstances there is no need for the receivers to be distortionless because they will produce like effects in the energy supplied to the filters 20 and 41.

However, if the transmitter 21 and the receiver 39 are made substantially distortionless or are so constructed as to minimize possible difficulty from distortion, the system of Fig. 1 may be simplified by omitting the receiver 22.

In this case the noise output of the source 16 is supplied directly to the input side of the filter 20. In such a case the noise source 16 has parallel outputs to the noise transmitter 21 and the filter 20, as indicated schematically in Fig. 2.

Fig. 2 illustrates an even further simplification in the apparatus of Fig. 1 which may be employed if care is taken in the design and adjustment of the apparatus. In this case, two separate frequency modulation generators 13 and 18 are not required. Instead, a single frequency modulation generator 18' may be employed with parallel modulation sources from the filter 20 representing selected noise and the device 14 representing the genuine signal. If energy is to be radiated from the antenna 15 with a 70-megacycle effective carrier, the generator 18' is designed to produce a carrier of 70 megacycles.

The generator 18' is so constructed as to be capable of wide swing frequency modulation, and the output level of the filter 20 is maintained at a value such as to cause wide swing modulation of the generator 18', for example, a swing of about one megacycle, to correspond with the apparatus of Fig. 1. The signal source 14, on the other hand, is so designed as to produce a normal modulation level such as to produce narrow swing modulation of the generator 18', for example, a 10-kilocycle swing corresponding to the apparatus of Fig. 1. In this case, the antenna 15 will radiate the carrier modulated with noise over a wide swing and with the desired signal over a narrow swing, as in the case of the apparatus of Fig. 1.

It will be understood that in the apparatus of Figs. 1 or 2 an amplifier 52 may be interposed in the connections to the antenna 15. If the additional noise source 34 of Fig. 1 is employed in the apparatus of Fig. 2, it may be connected to supply noise in parallel with the output of the generator 18' to the input side of the amplifier 52, as indicated schematically.

For the modified embodiment of Fig. 2, the same receiving system 37 as shown in Fig. 1 may be employed. Since the wide swing noise supplied by the filter 20 to the frequency modulation generator 18' may be removed from the radiated carrier by the frequency modulation generator to the receiver, the apparatus of Fig. 2 will operate in the manner described in connection with Fig. 1. It will be understood that more careful design and adjustments of the apparatus are required than in the case of the apparatus of Fig. 1 because, to a considerable extent, the use of identical units in the transmitting and receiving station of Fig. 1 causes distortions introduced in the transmitting station to be removed again in the receiving station.

The apparatus illustrated is particularly useful for communication between ships of a fleet, for example, where orders and information must be transmitted and understood immediately for proper carrying out of maneuvers and no time can be allowed for decoding messages sent in code sufficiently complicated to avoid prompt decoding by unauthorized or undesired listeners. With such use of the apparatus, it will be understood that the particular channels of the filters 20 and 41 which are to be used will be designated in previously given orders, or the channels may be changed for different times of the day. With as many as twenty different channels to choose from, it will be apparent that a tremendous number of permutations and combinations is possible, so that in effect each of these different combinations serves as a different automatically operating coding and decoding system for secret communication.

It is impossible for an unauthorized listener to decipher the code because unlike other types of codes, the system cannot be deciphered by working on one unknown element at a time until after with infinite patience, if necessary, all elements have been deciphered. In this case, the code can be deciphered only by simultaneously knowing every factor of the code even if the unauthorized listener should have succeeded in obtaining a duplicate of the receiving apparatus 12.

However, if desired to make it still more difficult for an unauthorized listener to receive the signals, synchronized interchanging switches may be provided for the filters 20 and 41 for progressively changing the connections of the switches 28 to 31, for example, in the transmitter and corresponding switches in the receiver. For example, a ship's chronometer 46 may be connected through suitable linkage represented by dotted line 47 to operate the selection switches 28 to 31 in accordance with a sequence or progression fixed by cams (not shown) and a ship's chronometer 48 at the receiving station may be arranged to drive corresponding linkage 49 for operating similar changeover switches (not shown) in the filter 41.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A system of secret radio communication, comprising transmitting and receiving apparatus, said transmitting apparatus comprising a relatively narrow swing frequency modulation transmitter, means for modulating said transmitter with a genuine signal to be received by an authorized listener, a wide swing frequency modulation transmitter, a source of audio frequency noise, a filter for selecting predetermined components of said noise source and connections between said filter and said wide swing frequency modulation transmitter for modulating the latter transmitter with such selected audio frequency noise components, a noise transmitter operating on a different frequency with input connections from said noise source, an output antenna for transmitting a radio frequency wave modulated in accordance with such noise, a second output antenna, and means for combining the outputs of the first and second transmitters in the radiation from said second antenna, said receiving apparatus comprising a noise receiving antenna and a frequency receiver tuned to said noise transmitter, a third frequency modulation transmitter and a filter interposed between said receiver and said third transmitter for passing the same noise components as said first filter, a signal receiving frequency modulation receiver tuned to the signal producing narrow-swing transmitter of the transmitting apparatus, a second receiving antenna responsive to the radiation from said second transmitting antenna, and means for subtracting the output of said third frequency modulation transmitter from the energy received by said second receiving antenna for supplying the difference to said signal-receiving receiver.

2. A system of secret radio communication comprising the elements set forth in claim 1 to-

gether with a second noise source arranged for combining its output with the signal inputs supplied to the second antenna.

3. A communication system comprising a radio transmitter and a radio receiver; said transmitter comprising means for generating a radio frequency carrier, and means coupled to said transmitter for frequency modulating said carrier in accordance with a combination of a desired intelligence signal and an interference signal; and said receiver comprising a local oscillator, a mixer coupled to said local oscillator and arranged to receive said frequency modulated carrier and to produce a heterodyne output signal of frequency varying in accordance with a combination of the frequencies of said frequency modulated carrier and said local oscillator, and means for frequency modulating said local oscillator in accordance with said interference signal, whereby the frequency of said heterodyne output signal varies in accordance with said desired intelligence signal.

4. Apparatus for receiving a carrier frequency modulated in accordance with the sum of a first modulation component and a second modulation component, comprising a receiver local oscillator, a mixer coupled to said local oscillator and adapted to receive said frequency modulated carrier and to produce a heterodyne output signal of a frequency varying jointly in accordance with the frequency of said carrier and the frequency of the output of said local oscillator, means for frequency modulating said local oscillator in accordance with a wave of the frequency and amplitude of said first modulation component, and frequency discriminator means receiving said heterodyne output signal for producing an output voltage varying in accordance with said second modulation component.

5. A communication system comprising means for generating a first radio frequency carrier, means for modulating said first radio frequency carrier in accordance with a first signal voltage, means for generating a second radio frequency carrier, means coupled thereto for frequency modulating said second carrier in accordance with a combination of said first signal voltage and a second signal voltage, a first receiver tuned to said first radio frequency carrier and adapted to reproduce a detected version of said first signal voltage, a superheterodyne frequency modulation receiver tuned to receive said second radio frequency carrier, said superheterodyne receiver including a local oscillator, and means coupled to said local oscillator and to said first receiver for frequency modulating said local oscillator in accordance with said detected version of said first signal voltage.

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