

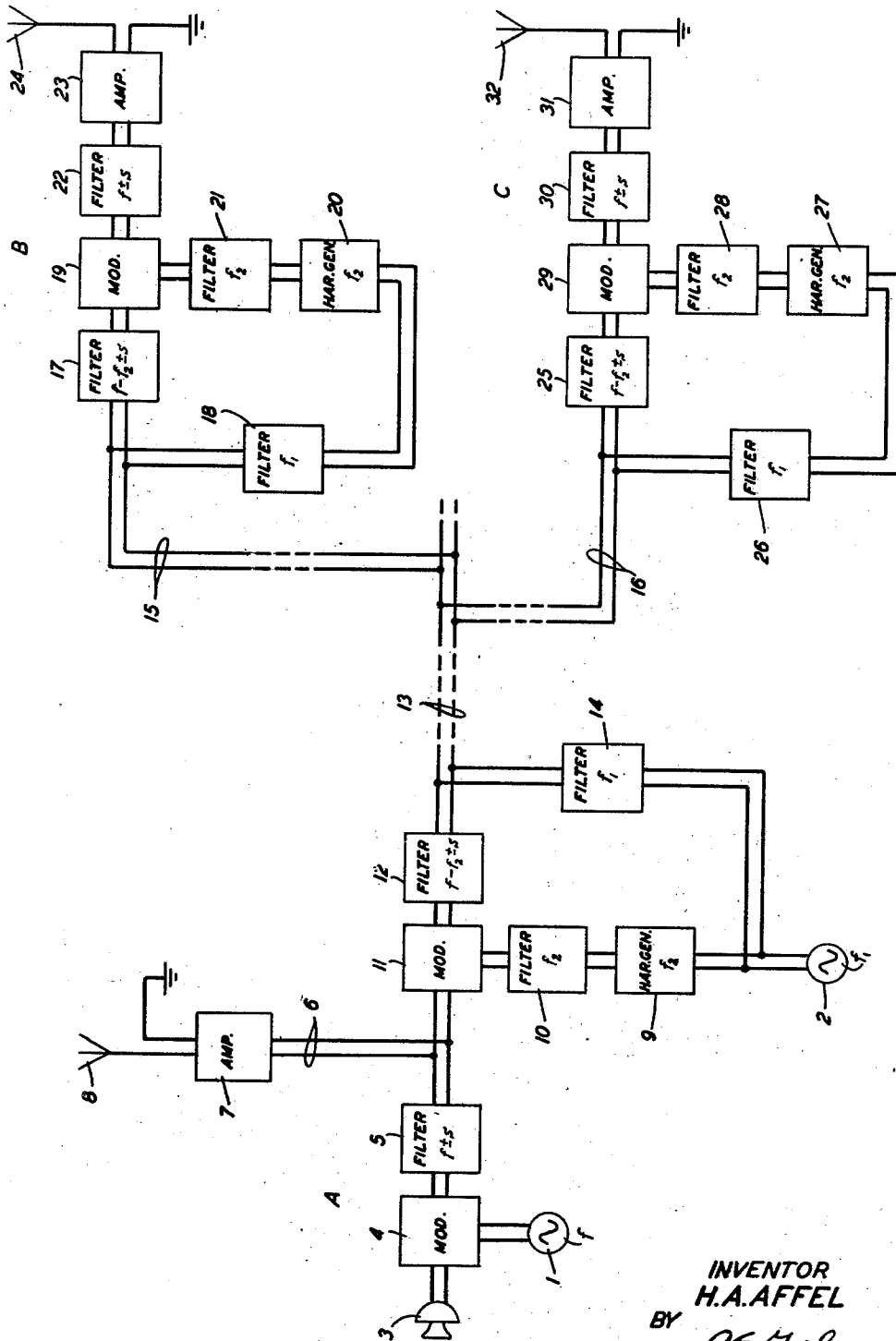
Sept. 28, 1937.

H. A. AFFEL

2,094,113

WAVE TRANSMISSION

Filed July 10, 1936



INVENTOR
H.A. AFFEL
BY *g2406*
ATTORNEY

UNITED STATES PATENT OFFICE

2,094,113

WAVE TRANSMISSION

Herman A. Affel, Ridgewood, N. J., assignor to
American Telephone and Telegraph Company,
a corporation of New York

Application July 10, 1936, Serial No. 89,967

2 Claims. (Cl. 250—17)

This invention relates to wave transmission and particularly to systems and methods for broadcasting a program from a plurality of stations simultaneously.

5 The objects of the invention are to secure a high degree of similarity in the character of the waves sent from a plurality of stations; to minimize the distortion incident to the transmission of speech or other program signals over metallic
10 lines to broadcasting stations; to utilize the signal currents sent to the broadcasting stations to maintain a common frequency for the transmitting current waves at all broadcasting stations; and to secure other improvements in the methods
15 of and in the means for broadcasting from a plurality of stations at a common frequency.

It has been proposed heretofore to utilize a common radio frequency in broadcasting a program simultaneously from a plurality of sending
20 stations. To this end the speech and other signal waves are transmitted over metallic circuits from a central point, such as a studio, to the several broadcasting stations, each of which is equipped with means for generating waves of the common
25 radio frequency. At each of these stations the incoming signal wave is utilized to modulate the radio frequency or carrier wave, and the modulated wave is then applied to the antenna for transmission. Since it is essential to good reception that the several sending stations maintain the common carrier frequency, some means is
30 necessary for holding the carrier frequency generators in synchronism. One known method of maintaining the common frequency is to send over a metallic circuit from the centralized point a synchronizing current of some suitable frequency and to utilize this current at the several
35 broadcasting stations to control a frequency converter, such as a harmonic generator, thereby obtaining waves of radio frequency with the frequency substantially uniform at all stations. A variation of this method is to provide automatic means for comparing the synchronizing frequency with the station frequencies, generated in
40 the usual way by independent oscillators, the comparing means automatically adjusting the station frequencies to a definite ratio to the synchronizing frequency. Another method is to modulate the program on the radio frequency carrier at only one point, and then to transmit the modulated radio frequency wave over wire lines to each of the stations where it is amplified and applied to the antennas. This last method has
50 particular advantages where it is desired to synchronize stations which are in close geographical

proximity, but has the disadvantage that the wire lines have a great attenuation for the relatively high frequency radio frequency wave. This method is described by Charles B. Aiken in a paper entitled "A Study of Reception from Synchronized Broadcast Stations," Proceedings of
5 the Institute of Radio Engineers, September, 1933.

According to a feature of the present invention, advantages are secured over these prior arrangements by means of a system in which the signal
10 wave is used to modulate a carrier wave generated at the master station to produce a modulated wave of the desired common frequency for broadcasting, which modulated wave is then radiated from the master station and also is beaten by a
15 wave derived from a second source of suitable frequency at the master station, and in which the beat wave thus produced and also a wave from said second source are sent over the wire lines to the other broadcasting stations. At each
20 broadcasting station the received wave from said second source is used to produce a wave of higher frequency, and this higher frequency wave is then modulated by the modulated intermediate frequency wave to produce a broadcasting wave of the desired common frequency. This arrangement enables the master station to broadcast the program as well as the other stations. It enables the program signals to be sent from the central point to the several broadcasting stations within
30 an intermediate frequency band best suited to the wire lines, thus minimizing distortion and attenuation. Moreover, since the frequencies of both waves received over the line at each broadcasting station depend on the same sources located at the master station, the broadcasting frequency derived from these two waves is the same at all stations, and a greater degree of similarity in the phase, shape and amount of modulation of the waves is secured.
40

Another feature of the invention is the novel method herein described of broadcasting the same signal simultaneously from a number of stations with a common carrier frequency, in which a representation of the signal is transmitted without distortion over wire lines from a central station to several broadcasting stations and in which the wave lengths transmitted from all broadcasting stations are maintained uniformly at the same value under the control of said central station.
50

These and other features of the invention will be described more in detail in the following specification and will also be particularly set forth in the appended claims.

The drawing, which forms a part of the specification, shows a diagrammatic view of the system of the invention.

cation, illustrates a broadcasting system comprising a plurality of interconnected transmitting stations together with a sufficient amount of the equipment to enable a clear understanding of the invention. Since the detailed construction of the various elements of the system is not essential to an understanding of the invention, these elements are represented in diagrammatic form.

A description will first be given of the equipment disclosed in the drawing. The system illustrated comprises a master or central transmitting station A and two associated broadcasting stations B and C; and it will be understood that any desired number of transmitting stations similar to stations B and C may be associated with the master station A as a part of the system. The master control station A is equipped with oscillation generators 1 and 2, which together furnish the intermediate and carrier frequency waves for the entire broadcasting system. The generator 1 generates a wave of frequency f which is utilized as the radio frequency or carrier frequency wave for broadcasting. The frequency f may be of any desired value, such as 1,000,000 cycles. The generator 2 produces a wave of relatively low frequency f_1 , such as 5,000 cycles. The carrier frequency generator 1 and the program microphone 3 are connected to a modulator 4, which may be of any suitable and well-known type. The output circuit of the modulator 4 is connected through a selective filter 5 to the input circuit 6 of a radio frequency amplifier 7. The output circuit of the amplifier 7 is connected to a radiating antenna 8. The filter 5 may be designed to pass any desired part of the output frequency band of the modulator 4. For the purpose of illustration it will be assumed that the filter 5 passes both side bands of frequencies $f \pm s$, where f is the carrier frequency of 1,000,000 cycles and s represents the band of program frequencies. The low frequency generator 2 is connected through a harmonic producer or generator 9 and a filter 10 to a second modulator 11. The harmonic generator 9 produces a wave of frequency f_2 , such as 980,000 cycles. The filter 10 is designed to selectively pass the wave of frequency f_2 and deliver it to the modulator 11. The modulator 11 is also connected to the output circuit of the filter 5 so that a portion of the modulated radio frequency wave f is also applied to said modulator. The modulator 11 serves to beat the modulated radio frequency waves $f \pm s$ with the wave f_2 to produce the usual sum and difference frequencies. A filter 12 serves to select the difference frequencies, namely $f \pm s - f_2$ (or $f - f_2 \pm s$). This band of frequencies, transmitted to the metallic transmission line 13, evidently consists of a carrier having a frequency $f - f_2$ and its two side bands representing modulation of this carrier by the program band of frequencies, s . For the example assumed, $f - f_2$ gives a frequency of 20,000 cycles; therefore, the output of the modulator 11 is a band of intermediate frequency waves including the frequencies 20,000 cycles plus the program frequencies s and 20,000 cycles minus s . Another filter 14 is designed to select a portion of the output of the low frequency generator 2 and to deliver it also directly to the transmission line 13.

The main transmission line 13 divides at convenient points and extends by way of branches 15 and 16 to the respective associated broadcasting stations B and C, which are exactly alike. At the station B the incoming metallic transmission line 15 is connected to filters 17 and 18. The

filter 17 is designed to select and pass the modulated waves of intermediate frequency. These waves are delivered by the filter 17 to a modulator 19. The other filter 18 is designed to selectively pass the low frequency component f_1 of the energy incoming over the metallic circuit 15. The low frequency wave f_1 is applied to a harmonic generator 20, which produces therefrom a wave of frequency f_2 , and this wave is selectively applied to the modulator 19 through the filter 21. The modulated intermediate frequency wave (20,000 $\pm s$) and the wave of frequency f_2 (980,000) are combined in the modulator 19 to produce the usual upper and lower bands of frequencies. In this case the lower band derived by the difference of the frequencies is removed by filter 22. The upper band, however, $f \pm s$ (1,000,000 $\pm s$), is selectively passed by the filter 22 to the radio frequency amplifier 23. The amplifier 23 is connected to the radiating antenna 24.

In a similar manner the energy incoming to station C over the metallic branch 16 is applied through filter 25 and by way of filter 26, generator 27 and filter 28, to the modulator 29; and the output energy from modulator 29 is applied by way of filter 30, amplifier 31, to the radiating antenna 32. And each of the other broadcasting stations not disclosed herein is provided with similar equipment.

In order to more clearly understand the functions of the different parts of the system above described, a brief statement of the operation will now be given. The program, which may be in any form, such as speech or music, is applied to the microphone 3 at the control station A. For simplicity of explanation it will be assumed that a program wave of a single frequency s is being transmitted at any given instant. The carrier frequency f is modulated with the signal frequency s in the modulator 4, and the two side frequencies $f \pm s$ are selected by the filter 5, are amplified by the radio frequency amplifier 7, and are then radiated by the antenna 8. At the same time a portion of the energy wave $f \pm s$ is applied to the modulator 11 together with a wave of frequency f_2 produced by the generator 2 and harmonic producer 9. The beat-note wave resulting from a combination of the waves $f \pm s$ and f_2 is selectively applied to the metallic transmission circuit 13 by the filter 12. Also, a portion of the low frequency wave energy from the generator 2 is selectively applied to the transmission line 13 by the filter 14. Thus the master broadcasting station A radiates a signal modulated wave, the radio frequency of which is controlled by the generator or oscillator 1, and also delivers to the transmission line a signal modulated intermediate frequency wave, the frequency of which depends directly upon the generator 1. At the broadcasting station B the signal modulated intermediate frequency wave $f - f_2 \pm s$, or 20,000 $\pm s$, is applied to the modulator 19 by way of the selective filter 17, and the low frequency wave f_1 is applied to the harmonic generator 20 by the selective filter 18. The generator 20 produces from the wave f_1 a harmonic wave of frequency f_2 (980,000 cycles), and this harmonic frequency f_2 is applied by the selective filter 21 to the modulator 19. The modulator 19 combines the frequencies 20,000 $\pm s$ and 980,000 to produce a wave having the frequency 1,000,000 $\pm s$. This resultant wave of radio frequency is amplified by the amplifier 23 and is then radiated by the antenna 24. The same operation occurs at broadcasting station C and at other broadcasting stations in the system.

As stated hereinbefore, this system enables the broadcasting of a single program on a single carrier frequency from a plurality of stations at the same time, including the central or control station, without the necessity of transmitting either the low frequency program waves or the high frequency carrier waves over the metallic circuits from one station to another. It also has the advantage that the frequency of the carrier waves radiated from all of the different broadcasting stations is controlled from the single oscillation generator at the central station. By obtaining the desired radio frequency wave directly from the source 1 at the master station, the master station serves as a broadcasting station as well as the remaining stations in the system; and, by combining a portion of the radio frequency energy from the source 1 with a wave produced from the low frequency source 2, a modulated intermediate frequency is obtained having a value most suitable for transmission over the metallic circuits to the other stations. And by combining at any one of the distant broadcasting stations the intermediate frequency wave, the frequency of which depends directly upon the frequency of sources 1 and 2 at the master station, with a wave produced from a portion of the energy from the source 2, a resulting modulated wave is obtained having exactly the same frequency as the modulated radio wave applied to the antenna at the control station A. If the frequency of the generator 1 varies, the same variation occurs in the radio frequency at the distant broadcasting station. Should the frequency of generator 2 vary, thereby increasing or decreasing the frequency of the intermediate frequency wave transmitted to the distant station, the variation is accurately compensated for at the distant station when the intermediate frequency wave is combined with the wave f_2 produced from the low frequency wave transmitted from the source 2. Thus the radio frequency wave at the distant station has a frequency which depends upon the source 1 at the central station and will vary according to the variations that may occur in the source 1.

Besides the advantages above mentioned, it is possible in this system to obtain a greater degree of approximation in some of the other characteristics of the radio waves, such as the shape, phase, and degree of modulation. This advantage is achieved in part by the method utilized wherein the carrier wave is modulated by the signal at the originating station and modulated intermediate frequencies derived therefrom and having frequency values most suitable for transmission over the metallic circuits to the other stations are utilized at the distant stations for obtaining the modulated radio frequency waves.

While the modulators, filters, generators, and

amplifiers are disclosed herein in schematic form, it will be understood that any suitable types of these equipments may be used. Also, it is assumed herein that both side bands of radio frequency waves are utilized. If desired, however, either one or both of the usual side bands may be transmitted.

What is claimed is:

1. In a broadcasting system, a plurality of stations arranged to broadcast the same program on a common carrier wave, one of said stations serving as a master station, wire lines interconnecting the master station and the other stations, a source of high frequency waves of the common carrier frequency at the master station, a signal source, means for modulating waves from said high frequency source directly by waves from said signal source and means for radiating the resulting modulated wave, an independent source of low frequency waves at said master station, harmonic producing means for producing a high frequency harmonic wave from said low frequency source, means for beating said harmonic wave with the modulated high frequency wave to produce a modulated wave of intermediate frequency, means for impressing the intermediate frequency wave together with a low frequency wave from said independent source upon said interconnecting lines, means at each of said other stations for selectively multiplying the frequency of the received low frequency wave to the same harmonic frequency as is utilized for beating at the master station, and means for beating the frequency multiplied wave with the received intermediate frequency wave to reproduce a modulated wave of the common carrier frequency.

2. The method of broadcasting a program at a common carrier frequency from a plurality of stations, one of which serves as a master station and all of which are interconnected by wire lines, which comprises generating a wave of the common carrier frequency at the master station, modulating the generated wave with a signal wave and radiating the modulated wave, separately generating at the master station an independent low frequency wave, producing a high frequency harmonic of said low frequency wave, beating said harmonic wave and said modulated wave to produce an intermediate frequency modulated wave, transmitting said intermediate frequency wave and said low frequency wave simultaneously to the other stations, producing at each of said other stations the same harmonic from said low frequency wave as is utilized for beating purposes at said master station and combining said harmonic wave with the received intermediate frequency wave to reproduce a modulated wave of the common carrier frequency.

HERMAN A. AFFEL.