Sept. 22, 1925. 1,554,189

H. A. AFFEL

EQUALIZATION OF CARRIER TRANSMISSION

Filed May 27, 1920

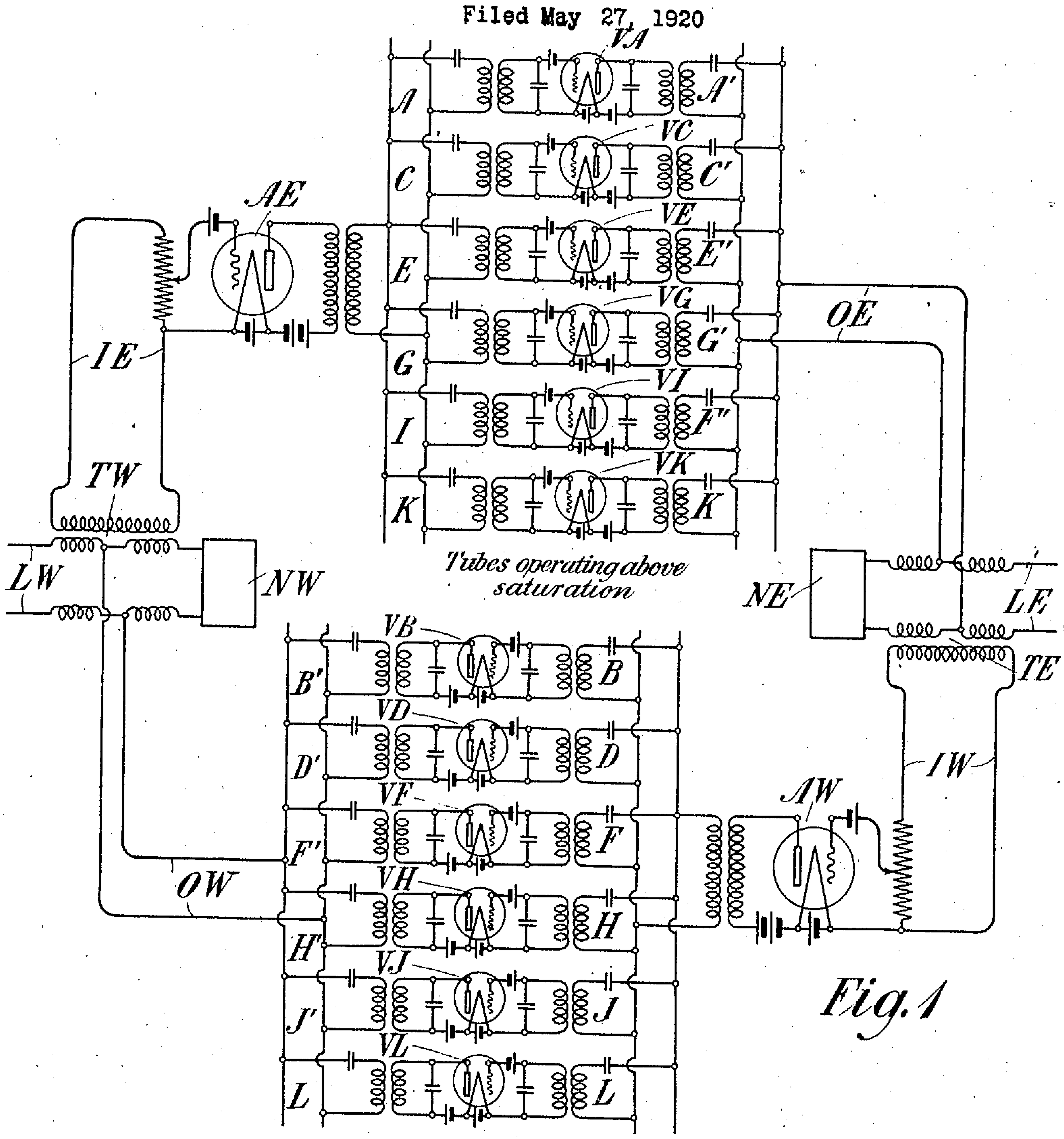

Fig. 1

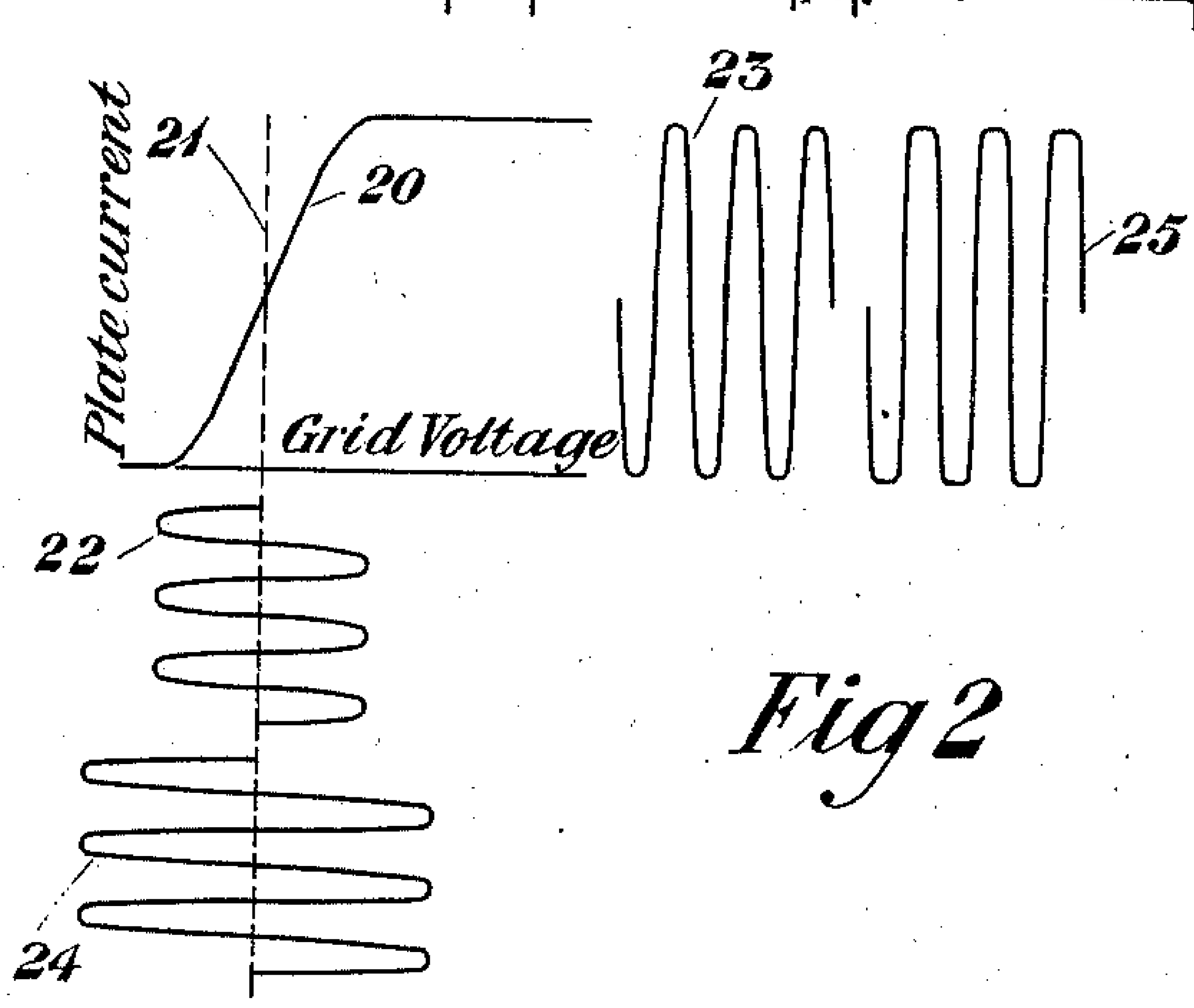

Fig 2

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BY

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Patented Sept. 22, 1925. **1,554,189**

UNITED STATES PATENT OFFICE.

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EQUALIZATION OF CARRIER TRANSMISSION.

Application filed May 27, 1920. Serial No. 384,775.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Equalization of Carrier Transmissions, of which the following is a specification.

This invention relates to systems of transmission in which carrier currents are employed for the transmission of signals, and more particularly to means and methods whereby the transmission efficiency of such systems may be maintained substantially constant.

Where a plurality of signals are simultaneously transmitted over the same conductive line or system by means of carrier currents of relatively high frequency, changes in attenuation occur from time to time which are due to a variety of causes. These attenuation changes arise mainly from the variations in the leakage condition of the open wire lines over which the carrier currents are normally transmitted, and these leakage conditions vary with weather conditions, the leakage being much greater during wet weather than during dry weather. This source of transmission variation is quite distinct from the principal cause of transmission variation in long cable circuits operated at ordinary telephone frequency where the resistance variation with temperature is a controlling factor.

Where a system comprises a long line having repeaters at various points along the line for the purpose of bringing the transmission up to a desired value under the worst conditions of operation, it is desirable that means be provided at each repeater point for reducing the currents leaving the repeater by an amount proportional to any change in transmission due to an improvement in the operating conditions.

One of the objects of this invention is to provide means and methods whereby the transmission efficiency of a system in which signals are transmitted by means of carrier currents may be maintained substantially constant. Another object of the invention is to provide means and methods whereby these results may be accomplished automatically, and preferably by electrical means rather than by adjusting mechanical devices.

These objects, together with other objects more fully apparent hereinafter, are realized in accordance with the present invention by transmitting the various carrier frequencies through devices such as vacuum tubes which are so arranged that under ordinary conditions the maximum voltage due to carrier currents impressed upon the grid circuits of the tubes will be greater than the saturating voltages of the tubes. Under these conditions, the output currents in the tube fluctuate between zero and saturation. If, due to wet weather conditions and the like, the attenuation is increased so that the maximum potentials impressed upon the tube due to the carrier frequencies are smaller than before, the output current in the tube will still fluctuate between zero and saturation, provided the reduced voltages are still greater than the saturation voltage. By thus arranging matters so that the tubes are always operated above saturation, the output fluctuations in current will be the same, regardless of the attenuation of the line over which the carrier frequencies have been transmitted.

The invention will now be more fully understood from the following description when read in connection with the accompanying drawing, Figure 1 of which is a simplified circuit diagram of an apparatus exemplifying the principles of the invention, and Fig. 2 is a curve illustrating the operation of the saturated vacuum tubes employed in connection with the invention.

Referring to Fig. 1, a repeating apparatus for two-way amplification of carrier currents is illustrated. While the arrangement disclosed is particularly adapted for carrier current telegraph systems, it is applicable to the transmission of other types of signals. The repeater apparatus illustrated interconnects two main line sections LE and LW over which carrier currents are transmitted in the manner well known in the art. Preferably the frequencies characteristic of the different carrier channels are alternated or "staggered" for transmission in opposite directions. That is, the frequencies used for transmission from west to east are interspersed between or alternated with the frequencies transmitted from east to west. By thus alternating or "staggering" the frequencies, it is possible to utilize frequency selectivity to prevent or assist in preventing singing in a repeater circuit. Singing may be further reduced or eliminated in the manner usual in ordinary repeater circuits, by balancing the transmission line sections. For this purpose, networks NE and NW are provided to simulate the line sections LE and LW respectively. The input circuit IE of the east-going amplifier and the output circuit OW of the west-going amplifier are associated with the transmission line circuit LW through the usual balanced transformer arrangement TW, while the similar circuits OE and IW are likewise associated with the line section LE through the transformer TE. Amplifiers AE and AW are provided for amplifying east-going and west-going transmission respectively. These amplifiers are intended to amplify by a common amplifier all of the frequencies used for transmission in any given direction, and are preferably amplifiers of the vacuum tube type, although other well known forms of amplifiers may be used.

The apparatus for maintaining the transmission efficiency substantially constant comprises a series of vacuum tubes, VA, VC, VE, VG, VI and VK, through which the several frequencies transmitted from west to east are individually passed, and a similar series of vacuum tubes, VB, VD, VF, VH, VJ and VL, through which frequencies transmitted in the opposite direction are separately passed. The tubes VA to VK inclusive, are associated with the input circuit IE through the resonant tuned circuits A, C, E, G, I and K respectively, and are also associated with the outgoing circuit OE through similar tuned circuits A′, C′, E′, G′, I′ and K′, tuned circuits B′, D′, F′, H′, J′ and L′ serving to connect the other set of tubes to the outgoing circuits OW, and said tubes being associated with the incoming circuit IW through the tuned circuits B, D, F, H, J and L. By this arrangement, each carrier frequency, after being amplified, will be selectively transmitted through an individual vacuum tube and by means of the tuned circuits associated with the output circuits of the individual tubes, the harmonics of the fundamental wave, caused by the distortion due to the tubes, may be suppressed.

In order to understand how the transmission efficiency of the system is maintained constant, reference will be had to the curve 20 shown in Fig. 2. This figure designates the characteristic curve of one of the vacuum tubes such as VA, the curve being plotted between the grid voltage and the plate current. As is well known, for a given filament temperature, the plate current increases as the grid voltage becomes less negative until a critical voltage is reached, known as the saturation voltage, after which the current remains substantially constant. As the voltage of the grid is lowered or made more negative, a voltage is finally reached at which no current flow in the output circuit takes place. This condition of affairs is indicated by the curve 20 of Fig. 2, in which the flat part of the curve at the right indicates the saturation condition while the flat part of the curve at the left indicates the corresponding no current condition. As is well known in the art, the grid may be biased by connecting a source of potential in the grid circuit. Preferably, this source will be so connected as to render the grid negative with respect to the filament. If the normal potential of the grid be adjusted so that the grid voltage is at the value indicated by the vertical dotted line 21 in Fig. 2, the superposition of an alternating voltage due to a carrier current will cause the current in the output circuit to fluctuate. If the superimposed voltage alternates between the values indicated by the curve 22 of Fig. 2, it will be seen that the output current will fluctuate between zero and the maximum saturating value as indicated by the curve 23. If, however, the voltage oscillations superimposed upon the grid circuit are of greater amplitude as indicated by the curve 24, the output current of the tube will still fluctuate between zero and the saturation value as indicated by the curve 25, although a graphic representation of the current fluctuations shows that the waves are flatted at both the top and the bottom. This flattening of the waves may be eliminated by passing the waves through a tuned circuit or other filter to remove the harmonics of the fundamental frequency.

If the tube is so adjusted that with the normal grid potential the output current flow will be about one-half of the saturation current, and if the saturation current be fixed at a value sufficiently low so that an alternating current of minimum amplitude such as would occur during abnormal line conditions will cause the output current to fluctuate between zero and the saturation value, it will be clear that no greater fluctuation in the output current will take place if the amplitude of the fluctuating input voltage be increased. Consequently, if the fluctuating voltage applied to the grid circuit of the tube under normal line conditions be of the increased amplitude indicated by the curve 24, the fluctuating output current will have a maximum amplitude determined by the saturation value to which the tube is set, and as the amplitude of the input voltage fluctuations decreases with wet weather or other abnormal conditions, the amplitude of the output current fluctuations will still be the same.

Referring to the diagram of Fig. 1, it will be apparent that each carrier frequency transmitted in a given direction will, after being amplified by the amplifier AE or AW as the case may be, be selected through the proper tuned circuit and impressed upon the corresponding vacuum tube, such as the vacuum tube VA, for example. If this vacuum tube is adjusted as above described, the high frequency output current will vary between zero and the saturation value, regardless of the changes due to wet weather or the like in the amplitude of the carrier frequencies transmitted over the line to the repeater. Consequently, within certain limits, the outgoing carrier currents from the repeater will have the same amplitude regardless of the variations in attenuation to which they are subjected under different weather conditions and the transmission efficiency of the circuit will, therefore, remain substantially constant.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. The method of maintaining substantially constant the transmission efficiency of a transmission circuit, which consists in so distorting alternating current waves of a given frequency after undergoing attenuation by transmission over the circuit, that the maximum amplitude of any of the individual waves under the condition of least attenuation will not exceed the amplitude of individual waves received under conditions of maximum attenuation during transmission, and selecting from the distorted wave the component corresponding to the original frequency before distortion, while substantially suppressing harmonics thereof.

2. The method of maintaining substantially constant the transmission efficiency of a transmission circuit, which consists in amplifying alternating current waves of a given frequency after undergoing attenuation by transmission over the circuit, distorting the amplified waves so that the maximum amplitude of any of the individual waves under the condition of least attenuation will not exceed the amplitude of individual waves under conditions of maximum attenuation during transmission, and selecting from the distorted wave the component corresponding to the original frequency before distortion, while substantially suppressing harmonics thereof.

3. The method of maintaining substantially constant the transmission efficiency of a transmission circuit, which consists in selecting the various transmitted frequencies after having undergone attenuation in being transmitted over the circuit, distorting the alternating current waves of each selected frequency so that the maximum amplitude of any selected wave under the condition of least attenuation will not exceed the amplitude of said wave under conditions of maximum attenuation during transmission, and selecting from the distorted waves of the various frequencies the components corresponding to the original frequencies before distortion, while substantially suppressing harmonics thereof.

4. The method of maintaining substantially constant the transmission efficiency of a transmission circuit, which consists in transmitting a plurality of alternating current waves of different frequencies over the circuit, amplifying the transmitted frequencies after having undergone attenuation in transmission over the circuit, selecting the amplified frequencies, distorting each selected frequency so that the maximum amplitude of any of the individual waves of that frequency under the condition of least attenuation will not exceed the amplitude of the individual waves of that frequency received under conditions of maximum attenuation during transmission, and selecting from the distorted waves of the various frequencies the components corresponding to the original frequencies before distortion, while substantially suppressing harmonics of said frequencies.

5. In a system for signaling, a transmitting medium which subjects transmitted frequencies to varying conditions of attenuation, and an arrangement for maintaining the transmission of the system substantially constant which comprises a vacuum tube arrangement upon which the transmitted frequencies are impressed after having undergone attenuation during transmission, said vacuum tube having its saturation point so set that the limiting voltage of the attenuated frequencies will be at least equal to the saturation voltage of the vacuum arrangement when said frequencies have been subjected to the most extreme condition of attenuation.

6. In a system for signaling, a transmitting medium which subjects transmitted frequencies to varying conditions of attenuation, and an arrangement for maintaining the transmission of the system substantially constant, which comprises an amplifying arrangement for amplifying the transmitted frequencies, after having undergone attenuation during transmission, and a vacuum tube arrangement upon which the amplified frequencies may be impressed, the saturation point of said vacuum tube arrangement being so set that the limiting voltage of the amplified frequencies will be at least equal to the saturation voltage of the tube when the frequencies have been subjected to the most extreme condition of attenuation.

7. In a system for signaling, a transmit-

ting medium which subjects transmitted frequencies to varying conditions of attenuation, and an arrangement for maintaining the transmission of the system substantially constant, which comprises a means for selecting the various frequencies, after having undergone attenuation during transmission, a vacuum tube upon which each selected frequency may be impressed, the saturation point of said vacuum tube being so set that the limiting voltage of the selected frequency applied thereto will be at least equal to the saturation voltage of the tube when said selected frequency has been subjected to the most extreme condition of attenuation.

8. In a system for signaling, a transmitting medium which subjects transmitted frequencies to varying conditions of attenuation, and an arrangement for maintaining the transmission of the system substantially constant which comprises an amplifying arrangement for amplifying the various frequencies, after having undergone attenuation during transmission, means for selecting the amplified frequencies, and a vacuum tube upon which each selected frequency is impressed, the saturation point of the vacuum tube being so set that the limiting voltage of the selected amplified frequency applied thereto is at least equal to the saturation voltage of the tube when said frequency has been subjected to the most extreme condition of attenuation.

9. In a system for signaling, a plurality of vacuum tubes upon each of which one of a number of signaling frequencies may be impressed, said tubes being so arranged as to distort frequencies impressed thereon, means for selecting to each tube one of said signaling frequencies to the exclusion of the others, and means associated with each tube for suppressing harmonics of the frequencies distorted by the tube while transmitting wave components corresponding to the original frequency impressed upon the tube.

10. In a system for signaling, a plurality of vacuum tubes upon each of which one of a number of signaling frequencies may be impressed, said tubes being so arranged as to distort frequencies impressed thereon, means for selecting to each tube one of said signaling frequencies to the exclusion of the others, and tuned circuits associated with the output of each tube for suppressing harmonics caused by distortion while transmitting wave components corresponding to the original frequency impressed upon the tube.

In testimony whereof, I have signed my name to this specification this 25th day of May 1920.

HERMAN A. AFFEL.