

1,763,880

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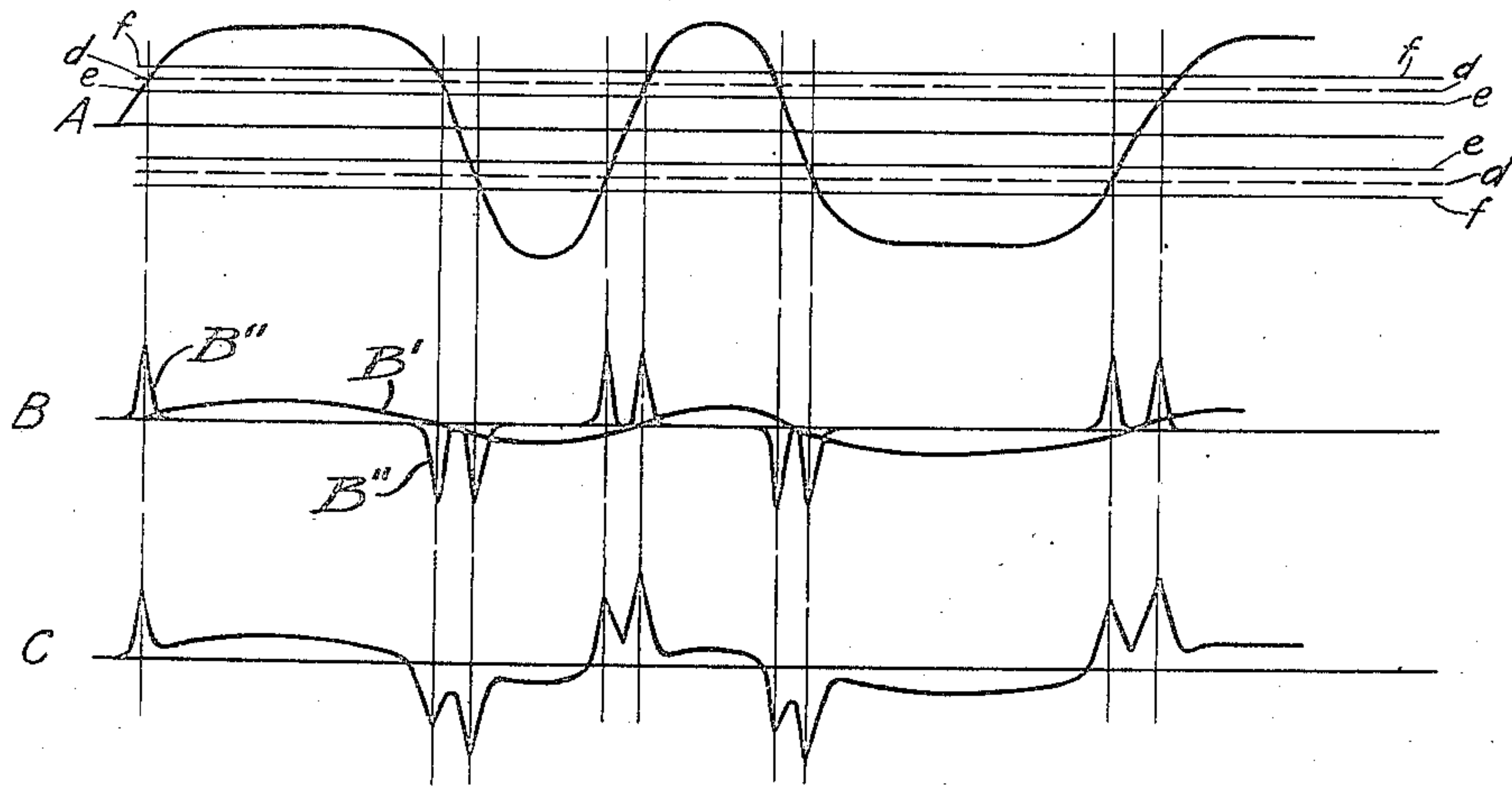


FIG. 2.

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SIGNALING SYSTEM

Application filed June 2, 1928. Serial No. 282,381.

This invention relates to signaling systems and more particularly to submarine telegraph systems adapted for high speed transmission.

5 An object of the invention is to improve the shaping of signal waves or impulses transmitted at high speeds.

It has heretofore been proposed to use auxiliary apparatus at the terminal of a submarine cable, designed to operate on the form of the signal waves and to shape their wave forms as to increase the legibility of the signal waves as recorded at the terminal. Combinations of apparatus for this particular purpose in connection with submarine cables are disclosed in Curtis Patent 1,624,396 issued April 12, 1927. These combinations are particularly useful in systems in which signals are transmitted at speeds varying from 30 to about 60 cycles per second, but in the arrangement of networks therein disclosed, especially those used at the transmitting end of the cable, the frequency components of the signal undergo different degrees of distortion in which cases the phase and the amplitude relations are changed and the amount of variation is increased proportionately with the speed of transmission.

According to the present invention satisfactory pre-shaping of signal waves is obtained at speeds ranging as high as 120 cycles per second or higher by operating on the high frequency and low frequency signal components separately in separate transformer circuits, and then combining the resultant waves in a low impedance vacuum tube amplifier. Networks for preshaping signals are included in the grid circuit of the amplifier and the plate circuit of the amplifier is therefore connected directly to the cable.

The characteristic features of this invention are the separation of the high and low frequency components of the signal pulses, the utilization of the high frequency components to produce properly timed short impulses and the recombination of the latter with the proper proportion of the low frequency components to produce a signal wave much better adapted for impressing upon a long loaded submarine cable than has been

possible by methods previously known in the art.

Other features of the present invention are a special transformer with biasing windings, which is employed to produce the properly timed short sharp impulses, a vacuum tube circuit wherein these impulses are combined with the transformed low frequency components, and the use of shaping networks located in the primary or secondary circuits, or both, of the low frequency transformer and in the secondary circuit of the high frequency transformers, which allow adjustment of phases and variations of relative amplitudes of various signaling components as well as permitting the suppression of undesired high frequency components which may exist in the secondary circuits of the high frequency transformers.

The high frequency or special transformers employed in the present invention, represent a specific case of a type of transformer which is disclosed and claimed in a copending application of E. T. Burton, Serial No. 280,709, filed May 26, 1928.

The invention will now be described in connection with the accompanying drawing in which,

Fig. 1 illustrates diagrammatically a circuit arrangement comprising one embodiment thereof; and

Fig. 2 shows current curves representing the operation thereof.

Referring to Fig. 1, transmitter 10 transmits current impulses through transformers 13, 14 and 15 to the grid circuit of vacuum tube amplifier 11. Transformer 13 is arranged to repeat only the low frequency components and apply them to the grid circuit of vacuum tube 11 at a comparatively low voltage without any substantial change in phase or amplitude. The high frequency components are repeated and applied to the grid circuit through transformers 14 and 15, each of which is equipped with a small, high permeability core having wound thereon, in the manner shown in the drawing, primary coils 17 and 18; secondary coils 19 and 20 and biasing coils 21 and 22. The entire signaling currents flow through the primary windings

of transformers 14 and 15. A small portion of the signal voltage is applied across the potentiometer 23, and part of this voltage is applied to the primary winding of the low frequency transformer 13 which has a high inductance. The series resistance 24 together with the shunt condenser 25 constitute a filter which prevents the high frequency signal components from entering the grid circuit of the amplifier 11 through transformer 13. To further this filtering action condenser 26 may be provided in the secondary of transformer 13 as shown.

The cores of transformers 14 and 15 (which for reasons of efficiency and desirability of operating characteristics may be composed of suitable high permeability material such as permalloy) become saturated at low amplitudes of currents flowing through their windings and therefore these transformers reach a stage of negligible mutual inductance when the signaling current in the primary windings 17 and 18 rises only slightly above zero value providing no biasing current is flowing in windings 21 and 22. When the signaling voltage is reversed a point in the current is reached during the cross-over when the core material becomes unsaturated and the permeability again rises to normal value while the current wave is passing through the low amplitude reached in changing polarity. As a result there is induced in the secondary windings 19 and 20 a short impulse, the amplitude and duration of which are determined by the coil constants and the time interval between the two points on the current wave which correspond to saturation of the core material.

In order to cause the impulses to occur at any desired point on the signal current rise and fall other than at zero, there are provided biasing coils 21 and 22 in which a continuous direct current is maintained, the current flowing through these coils in opposite directions. The biasing currents cause the saturated condition of the cores of coils 17 and 18 to be maintained until the signal current reaches a definite positive or negative amplitude, before it becomes effective in the secondary coil of either transformer. This definite amplitude may be described as that at which the sum of the magneto-motive forces produced by the signal current in the primary coils plus the magneto-motive force produced by the current in either biasing coil becomes zero. However, the time at which the signal current actually becomes effective to produce a secondary impulse, may extend over a range including the amplitudes slightly above and below this definite amplitude. The use of biasing current shifts the point of zero flux from the point of zero primary current to some selected point between zero and maximum signal amplitude. The effective range in which the secondary

impulses now occur will begin at a point where the biasing effect in either coil 21 or 22 is overcome by the signals in primary coils 17 and 18 and end at the newly established point of saturation. In other words, a secondary impulse occurs when the primary current is rising or falling between zero and maximum amplitude in either the positive or negative direction. As the signal current in coils 17 and 18 passes between zero and its maximum amplitude on either side of zero, an impulse occurs in the secondary coil 19 or 20, the direction of the impulse corresponding to the direction of the change in the signal amplitude, thereby producing a double secondary impulse every time the signal current in coils 17 and 18 crosses between maximum positive and maximum negative signal amplitude.

The secondary coils 19 and 20 are connected to the grid of amplifier 11 through networks 27, 28 and 29 wherein the secondary impulses may be adjusted in phase and relative amplitudes, and wherein any undesired high frequency voltages which may exist in the secondary coils 19 and 20 may be suppressed. The secondary circuits of transformers 13, 14 and 15 are connected in series to the grid so that the low and high frequency components are combined for amplification and transmission over line 12. In other words, the flow of high frequency current in potentiometer 29 causes a drop of potential therein and enough of this drop is included in the grid circuit, by adjustment of the movable contact, to secure the desired relation between the amplitudes of high and low frequency components. Low frequency potential variations induced in the secondary winding of transformer 13 are added in the series circuit of tube 11 to the varying drop in potentiometer 29 and impressed upon the grid.

Transmission line 12 is shown connected to the output circuit of amplifier 11 at a point between plate battery 30 and battery 31, the latter battery being connected in series with resistance 32 in a path to ground.

In order to better explain the operation of the circuit arrangement shown in Fig. 1 use is made of Fig. 2 wherein the curve A represents the signal wave in the primary coils 17, 18 and potentiometer 23. The relative amplitude of the biasing current in either of coils 21 or 22 is represented by line *d*, the point at which the signaling current in the primary windings 17 and 18 become effective to overcome the magnetic effect of the biasing current, is represented by line *e* and the point of saturation of the high permeability cores, which is established by the biasing current, is represented by line *f*. It is thus seen that when the signaling current in primary coils 17 and 18 rises in either positive or negative amplitude through the range *e* to *f*, a short

sharp impulse occurs in either of the secondary windings 19 or 20. Curve B shows the secondary voltages produced in transformers 13, 14 and 15 by curve A, the low frequency voltages indicated by curve B' as being superposed on, but shown as not combined as yet with, the high frequency voltages indicated by curve B''. Curve C illustrates how the combined voltages indicated by B' and B'' as shown in curve B, appear in the output circuit of vacuum tube 11 after the operation of vacuum tube 11 in recombining the secondary voltages produced by the low frequency and the high frequency components across the secondary winding of transformer 13 and potentiometer 29, into new impulses for transmission over line 12.

What is claimed is:

1. In a signaling system, the method of repeating signals for transmission, which consists in at least partially separating the high frequency components from the low frequency components of the signaling currents, reproducing the low frequency components substantially without change, operating upon the high frequency components by reshaping them to produce a plurality of impulses of opposite polarities for each incoming signal impulse, and combining the waves resulting from reshaping the high frequency components with the reproduced low frequency components to give a sharp discrete signal for transmission over a line.

2. In a signaling system, a method of repeating signals for transmission, which consists in at least partially separating the high frequency components from the low frequency components of the signaling currents, reproducing the low frequency components substantially without change, operating upon the high frequency components each time the signal wave rises and falls through a definite range of positive or negative amplitudes to reproduce short, sharp impulses of positive and negative polarities and of high amplitude, and combining said short, sharp impulses with said reproduced low frequency components to produce a signal capable of partly compensating for the attenuation of a transmission line.

3. In a signaling system, the method of repeating signals for transmission which consists in at least partially separating the high frequency components from the low frequency components of the signaling currents, reproducing the low frequency components substantially without change, operating upon the high frequency components to suppress the high and low amplitudes of positive and negative polarities and to produce short, sharp impulses of high amplitudes occurring when the signal is passing through the intermediate amplitudes, and combining the waves resulting from reshaping the high frequency components with the reproduced low

frequency components to produce a signal capable of withstanding the attenuation of a long transmission line.

4. A signaling system comprising a transmission line, means for producing signal waves comprising high and low frequency components, means for separating the high frequency components from the low frequency components of the signaling waves, means for inductively selecting the high frequency components and employing the change in voltage thereof within a definite range of amplitudes to produce a plurality of impulses of increased amplitude for each incoming signal impulse, and means for combining said low frequency components with said impulses to transmit to said transmission line new signal waves corresponding to those originally produced, but higher in amplitude.

5. A signaling system comprising a transmission line, signal impulse producing means, amplifying means connected to said line, a network connected intermediate said impulse producing and said amplifying means for separating the high frequency components from the low frequency components of the produced impulses, reproducing said low frequency components without any substantial change in phase and suppressing the current corresponding to said high frequency components of low and high amplitudes but employing the current of amplitudes between said low and said high amplitudes to reproduce short, sharp impulses, and means for combining said reproduced low frequency components and said short-sharp impulses in said amplifying means for transmitting to said line discrete signal impulses substantially in phase to those originally produced by said impulse producing means.

6. In a signal system comprising a transmission line, a transmitter for producing impulses, a vacuum tube amplifier connected to said line, a network connected to said transmitter for separating the high frequency components from the low frequency components of the transmitted impulses, a transformer for reproducing said low frequency components without any substantial change, transformers with high permeability cores for suppressing the current corresponding to said high frequency components of low and high amplitudes but employing the current of intermediate amplitudes to reproduce short, sharp impulses, circuit means interconnecting said transformers and said amplifier for combining said reproduced low frequency components and said short, sharp impulses to transmit signals capable of withstanding the attenuation of a transmission line.

7. A signaling system comprising a transmission line, a transmitter for producing signal impulses, a vacuum tube amplifier connected to said line, a network connected to said transmitter for separating the high fre-

quency components from the low frequency components of the transmitted impulse, a transformer for reproducing said low frequency components without any substantial change, transformers with high permeability cores for suppressing the high and low amplitudes of the high frequency components but allowing the intermediate amplitudes to produce new impulses in the form of short, sharp impulses, a shaping network connected in the secondary circuits of said transformers for allowing adjustments of phase and amplitudes of said transformed low frequency components and said short, sharp impulses, other means connected in said secondary circuits for suppressing the undesired high frequency voltages in said short, sharp impulses, and means for combining said reproduced low frequency components and the reshaped impulses on the grid of said amplifier to transmit signals capable of withstanding attenuation of said transmission line.

8. In a signaling system comprising a transmission line, a transmitter for producing impulses for transmission, a transformer for reproducing the low frequency components of said impulses without any substantial change, transformers with high permeability cores for suppressing the current corresponding to said high frequency components of low and high amplitudes but employing the current of intermediate amplitudes to produce short impulses, means for separately and independently controlling the secondary voltages of said transformers, and means for recombining impulses resulting from said secondary voltages for transmission over said line.

9. In a signaling system comprising a transmission line, a transmitter for producing impulses for transmission, a transformer for reproducing the low frequency components of said impulses without any substantial change, transformers with high permeability cores for suppressing the current corresponding to said high frequency components of low and high amplitudes but employing the current of intermediate amplitudes to produce short impulses, a potentiometer in the primary circuit of the first mentioned transformer and another potentiometer in the secondary circuit of the second mentioned transformers for separately and independently controlling the secondary voltages of said transformers, and a vacuum tube amplifier for recombining the impulses resulting from said secondary voltages for transmission over said line.

10. A telegraph impulse relaying system comprising a source of impulses, a line, two energy conveying channels connected between said source and said line, one of said channels including wave distorting means for producing a plurality of impulses of opposite

polarities and of increased amplitude for each incoming impulse, and means for recombining the waves transferred through said channels.

11. A telegraph impulse relaying system comprising a cable, a low impedance vacuum tube having its plate circuit connected directly to said cable, a transmitter for sending direct current signal impulses of positive and negative polarities to said cable, two energy conveying channels connected between said transmitter and said vacuum tube for separating the low and high frequency components of the incoming signal waves, one of said channels including means for producing a plurality of impulses of opposite polarities of increased amplitudes from each incoming wave, means on the input side of said vacuum tube for shaping the voltage impulses, and means for recombining the waves transferred through said channels in the grid circuit of said vacuum tube.

In witness whereof, I hereunto subscribe my name this 17th day of May, 1928.

EVERETT T. BURTON.

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