Feb. 12, 1924. 1,483,172

D. K. GANNETT

SIGNALING SYSTEM

Filed April 19, 1920 2 Sheets-Sheet 1

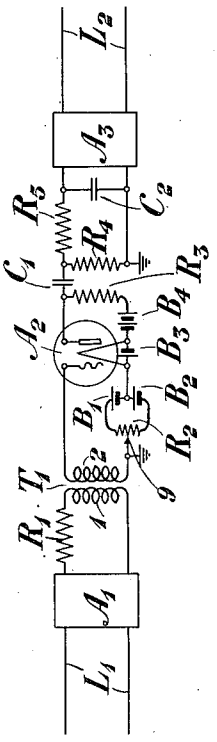


Fig. 1

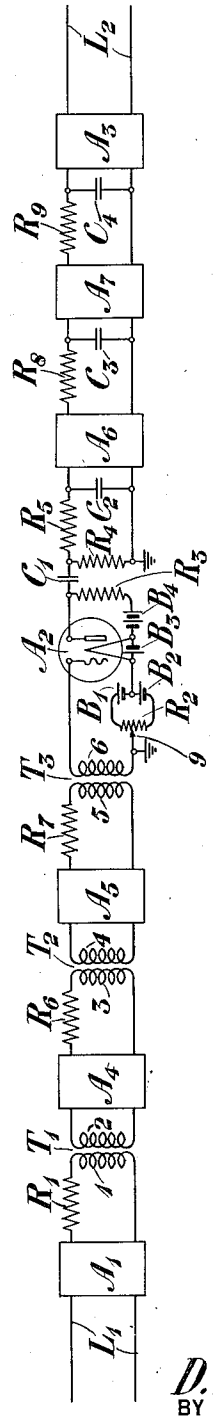


Fig. 2

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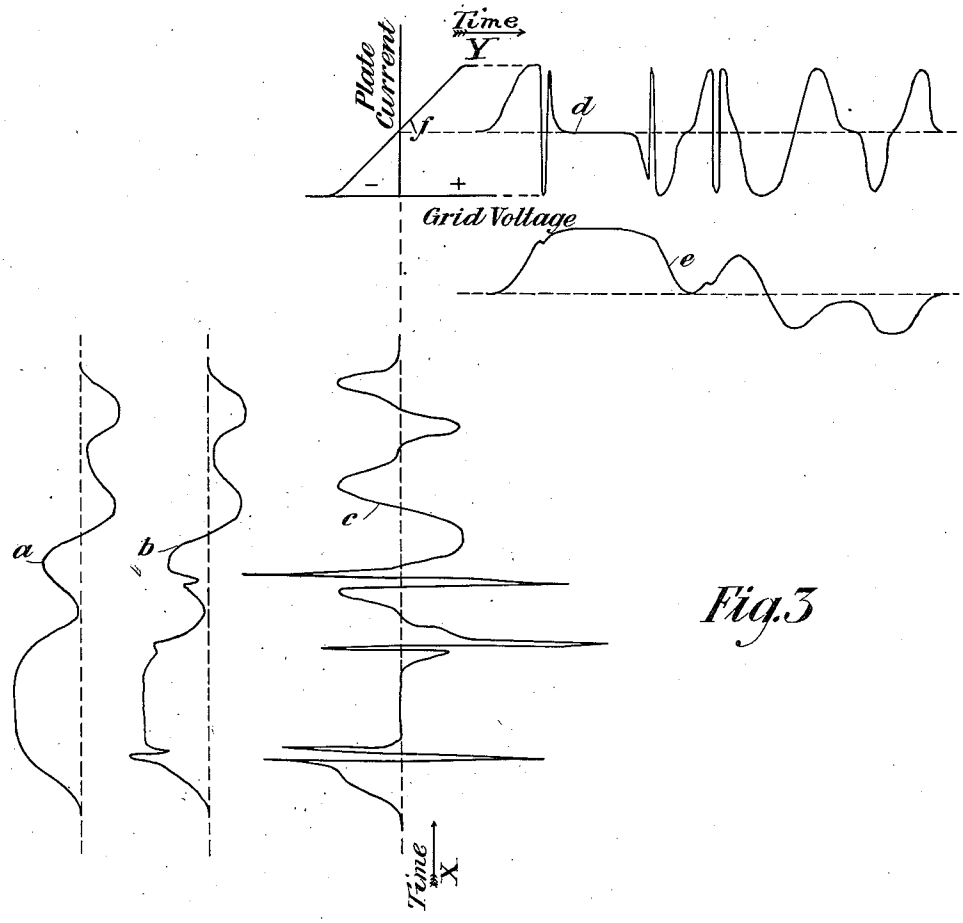


Fig.3

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UNITED STATES PATENT OFFICE.

DANFORTH K. GANNETT, OF ARVERNE, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

SIGNALING SYSTEM.

Application filed April 19, 1920. Serial No. 375,077.

To all whom it may concern:

Be it known that I, DANFORTH K. GANNETT, residing at Arverne, Far Rockaway, in the county of Queens and State of New York, have invented certain Improvements in Signaling Systems, of which the following is a specification.

This invention relates to signaling systems, and especially to means for eliminating the interference effects upon signaling currents by currents induced in submarine cables by extraneous causes.

In the operation of submarine cables, the received signaling waves are frequently distorted by potentials induced in the cables by various causes, usually extraneous to the cables themselves. Such interfering currents, upon their arrival at the receiving station, may be of sufficient magnitude as to modify the shape of the signaling wave so as to render difficult the deciphering of the transmitted signal. Means have been proposed heretofore to eliminate the effects of such interfering currents upon the transmitted signaling currents, which means embrace the use of resonant circuits operated as filters to transmit therethrough the signaling frequency and to attenuate, and thereby exclude, the interfering frequency.

It is the object of the present invention to eliminate interference by utilizing the transmitting properties of devices which have a saturation characteristic such that the amplitude of the wave transmitted therethrough may be limited. By such an arrangement an interfering impulse which is characterized by a steeper wave front than the signaling impulses, will be reduced in amplitude, and consequently its resultant effect upon the signaling wave will be greatly diminished.

This invention will be better understood from the following description when read in connection with the attached drawing, of which Figure 1 shows a simple form of the interference eliminating arrangement; Figure 2 shows a similar arrangement embodying a plurality of elements; and Figure 3 shows graphically the manner in which the arrangements in Figures 1 and 2 perform their operations.

In Figure 1, L_1 represents a transmission circuit such as a submarine cable which is adapted to have impressed thereon at its opposite end, a signaling impulse for transmission thereover, and is also exposed to interference from extraneous causes. The circuit L_1 is connected with the input side of the amplifier A_1, which may be of any well known type. The output side of the said amplifier includes a resistance R_1 and primary winding 1 of the transformer T_1, the function of which is to differentiate the received wave thereby accentuating the magnitude of the interference impulses relative to the signaling wave and to impress said modified wave upon the input circuit of a power-limiting device, such as a vacuum tube. The secondary winding 2 of the transformer T_1 is connected with the input circuit of the vacuum tube device A_2 which is designed to function as a power-limiting device. Connected with the grid circuit of the device A_2 are the resistance R_2, the batteries B_1 and B_2 and the contact 9, by means of which the grid potential may be adjusted so as to operate at the center of the characteristic curve between the grid voltage and the plate current of the vacuum tube device. B_3 is a filament heating battery and B_4 serves to maintain the potential of the plate positive with respect to the filament. A condenser C_1 is inserted in the output circuit of the device A_2 in order to prevent the battery B_4 from affecting the potential of the grid of the subsequent amplifier A_3. R_3, R_4 and R_5 are resistances of relatively large magnitudes, the resistance R_3 being, for example, of approximately one-fourth of a megohn and R_4 and R_5 of two megohms each. Bridged across the circuit is a condenser C_2 of large capacity, that is, of about four microfarads, which operates to integrate any wave impressed across its terminals so that the resultant wave is substantially the integral of the impressed wave. The integrated wave is amplified by the amplifier A_3 and passes over the line L_2 to the recording apparatus.

Figure 2 is similar to Figure 1, except that a greater number of differentiating and integrating units have been provided and unilateral devices, such as vacuum tube amplifiers, have been inserted between the adjacent networks in order to prevent undesirable reaction between the respective elements. Thus in Figure 2, the amplified wave is impressed across a circuit embracing

three differentiating networks in series, which networks are represented by the resistances and transformers R_1 and T_1, R_6 and T_2, and R_7 and T_3, respectively. The adjacent networks are separated by the vacuum tube devices A_4 and A_5. The power-limiting device A_2 and its immediate circuits are similar to those shown in Figure 1, and need no further description. The output side of the device A_2 comprises the same number of integrating networks as there were differentiating networks in the input side. Thus the resistances and condensers, R_5 and C_2, R_8 and C_3, and R_9 and C_4 represent integrating networks which are separated by the unilateral devices A_6 and A_7. The output side of the last network is connected with the amplifier A_3 which in turn is connected with the line L_2, with which the receiving apparatus is connected.

Figure 3 shows graphically the manner in which the arrangement shown in the previous figures effect the desired result. In this figure, "*a*" represents a signaling wave such as may be transmitted over a submarine cable in which an impulse in one direction represents a dot and in the other direction a dash. The curve "*a*" represents the word "sat" comprising three dots, a dot and dash, and a dash. The curve "*b*" represents the effect upon the signaling wave of impulses set up within the cable by causes usually foreign to the cable itself. Such impulses are usually in the nature of a transient having a steep wave front and which is generally quickly damped. The curve "*c*" represents the form of the wave "*b*" after it has passed through a differentiating network. The wave "*c*" is impressed across the grid circuit of the power-limiting device which has a characteristic curve represented by "*f*". It will be noticed that the curve "*f*" is symmetrical with respect to the *y* axis which effect is obtained by the proper adjustment of the contact 9 along the resistance R_2 in the grid circuit of the device A_2 in Figures 1 and 2. The curve "*d*" represents the output current of the device A_2. This device is so operated that the difference between the values of grid voltage corresponding to the saturation limits of the device is substantially equal to the difference between the upper and lower limits of that part of the curve "*c*", produced by the signaling wave and not by the interfering wave. With the device A_2 so adjusted, the signaling wave will be transmitted therethrough without diminution in amplitude, but the peaks of the curve "*c*", which represent the differentiation of the interfering component of the wave will be eliminated, which means a reduction in the amount of interfering energy. The curve "*e*" represents the output of the integrating network which shows the manner in which the signaling wave has been restored to approximately its original form, and the interfering wave has been substantially eliminated, being represented by the slight variations which occur in the curve "*e*" at approximately the same point at which the interference occurs on the curve "*b*." In curves *a*, *b* and *c*, time is represented by the arrow X and in curves *d* and *e* by the arrow Y. It will accordingly be seen that the lower end of the curve *c* (when the drawing is held vertically) corresponds in point of time to the left-hand end of the curve *d*. Thus, the fluctuations of curve *d* from left to right corresponds with the fluctuations of the curve *c* upward in the direction of the arrow X.

Having in mind the foregoing description of the various parts which are represented in the different figures and of the functions or purposes of each of the parts, this invention will be more clearly understood from the following description of its mode of operation.

If there be transmitted over the line L_1 as shown in Figure 1, a wave such as is shown by "*b*" in Figure 3, the amplitude of the impressed wave will be amplified by the amplifier A_1 to such an extent that the distance between the maximum positive and negative values will be substantially equal to the grid potential corresponding to the distance between the *x* axis and the upper saturation limit of the characteristic curve of the device A_2. The amplified wave is then impressed across the primary winding of the transformer T_1 which induces in the secondary winding 2 a curve which is substantially the form represented by "*c*" in Figure 3. This curve "*c*" will produce variations in the grid potential corresponding to variations of the impressed wave and there will result in consequence variations in the plate current within the limits represented by the distance between the *x* axis and the upper saturation limit of the characteristic curve. In view of the nature of a device which has a saturation point in its operating characteristic, the output wave form corresponds to the input wave form only within the saturation limits. Since the device will not pass current proportional to the peak values of the curve "*c*", much of the energy represented by the interfering impulses will be eliminated by the power-limiting device A_2. If the wave "*d*", which issues from the output of the device A_2, is impressed across the network represented by the resistance R_5 and the capacity C_2, the form of the wave will be changed thereby, and the resulting wave "*e*" will be the integral of the impressed wave *d*. The wave *e*, which is substantially the signal wave "*a*", most of the effects of the interfer-

ing impulses being eliminated, will be impressed across the amplifier A_3 and the amplified resultant wave will in turn be impressed across the line L_2 with which the recording apparatus is connected.

From the foregoing, it will be seen that if a signal wave which is distorted by interfering currents be differentiated and the differentiated wave passed through suitable current-limiting devices, and the output wave of that device be then integrated, we will obtain the original signaling wave substantially free from the effects of the interfering impulses.

It sometimes happens that the slope of the interfering wave is substantially the same as that of the signaling wave, that is to say, that the rate of change of the current is substantially the same. Since the voltage across the inductance is proportional to the rate of change of the current, if the rate of change of the two impressed curves be substantially the same, there will not be sufficient difference between the maximum values of the differentiated wave to enable the current-limiting device A_2 to properly eliminate the effect produced by the interfering wave. Since, however, the frequency of the interfering wave impulse is usually greater than that of the signaling impulse, we may effect the desired separation by differentiating the impressed wave several times, which tends to increase the amplitude of the interfering wave more than the other wave. Such an arrangement is shown in Figure 2, and by integrating the wave the same number of times as it was differentiated, we may obtain the signaling wave freed substantially from the effects of the interference.

Although this invention has been disclosed in a certain form, it is capable of embodiment in other and different forms without departing from the scope of the appended claims.

What is claimed is:

1. In a signaling system the combination with a signal transmission line exposed to interference from extraneous sources of a network comprising bridged inductance across which the waves transmitted over the said line are impressed and adapted to produce the first derivative of the said waves, a translating device whose characteristic curve has a saturation point upon which the said derivative wave may be impressed whereby the amplitude of the wave may be limited and a second network comprising bridged capacity across which the output wave of the said translating device may be impressed whereby the integral of the impressed wave may be obtained.

2. In a signaling system, exposed to interference from extraneous sources, the combination with a signal transmission line exposed to interference from extraneous sources of a plurality of networks comprising bridged inductance, the respective networks being separated from each other by unilateral devices, a translating device designed to limit the amplitude of the wave transmitted therethrough and a plurality of networks comprising bridged capacity separated from each other by unilateral devices whereby the interference component of the signaling waves may be substantially eliminated.

3. In a signaling system, the combination with signal transmission means exposed to interference from extraneous sources of a network designed to effect electrically the differential of the wave impressed thereon, a translating device having a saturation characteristic, the upper and lower limits being symmetrically related to the Y axis which may be operated so as to cut off all values of the impressed differential waves above the maximum value of the differentiated signaling component and a second network connected with the output side of the said translating device designed to effect the integration of the wave impressed thereon whereby the effects of extraneous interference upon the signaling waves may be minimized.

4. In a signaling system, the method for substantially eliminating the effect on signaling waves of interference from extraneous sources, which consists in differentiating the signaling wave as distorted by interference, limiting the differentiated wave in magnitude to the maximum value of the signaling component thereof, and integrating the said differentiated wave as thus limited.

5. In a signaling system, the combination with a signal transmission circuit exposed to interference from extraneous sources of a network across which the waves transmitted over the said circuit are impressed and adapted to produce the first derivative of the said waves, a translating device whose characteristic curve has a saturation point upon which the said derivative wave may be impressed whereby the amplitude of the wave may be limited, and a second network across which the output wave of the said translating device may be impressed whereby the integral of the said derivative wave may be obtained.

6. In a signaling system, the combination with a signal transmission circuit exposed to interference from extraneous sources of a network across which the waves transmitted over the said circuit are impressed, and adapted to produce the nth derivative of the said waves, a translating device whose characteristic curve has a saturation point upon which the said derivative wave may be impressed, whereby the amplitude of the wave may be limited, and a second network across which the output wave of the said translat-

ing device may be impressed whereby the nth integral of the derivative wave may be obtained.

7. In a signaling system, the method for substantially eliminating the effect on signaling waves of interference from extraneous sources, which consists in the successive differentiation to the nth degree of the distorted wave, limiting the magnitude of the differentiated wave to a predetermined maximum value, and successively integrating to the nth degree the said differentiated wave as thus limited.

In testimony whereof, I have signed my name to this specification this 16th day of April 1920.

DANFORTH K. GANNETT.