Jan. 9, 1923.

O. B. BLACKWELL.

SIGNALING SYSTEM.

FILED JULY 7, 1920.

1,441,827.

3 SHEETS—SHEET 1.

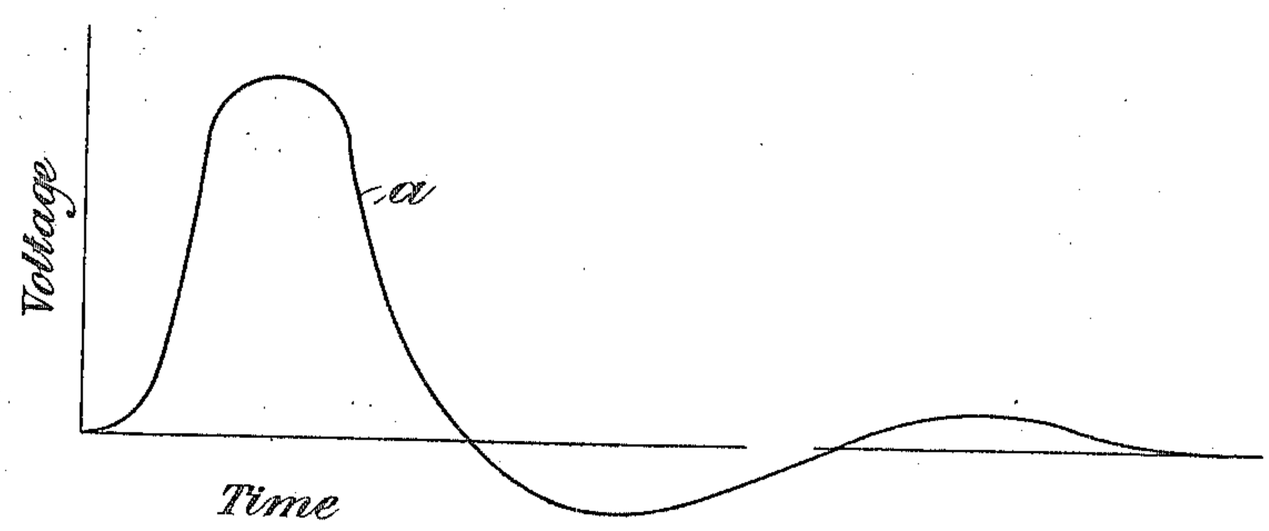

Fig. 1

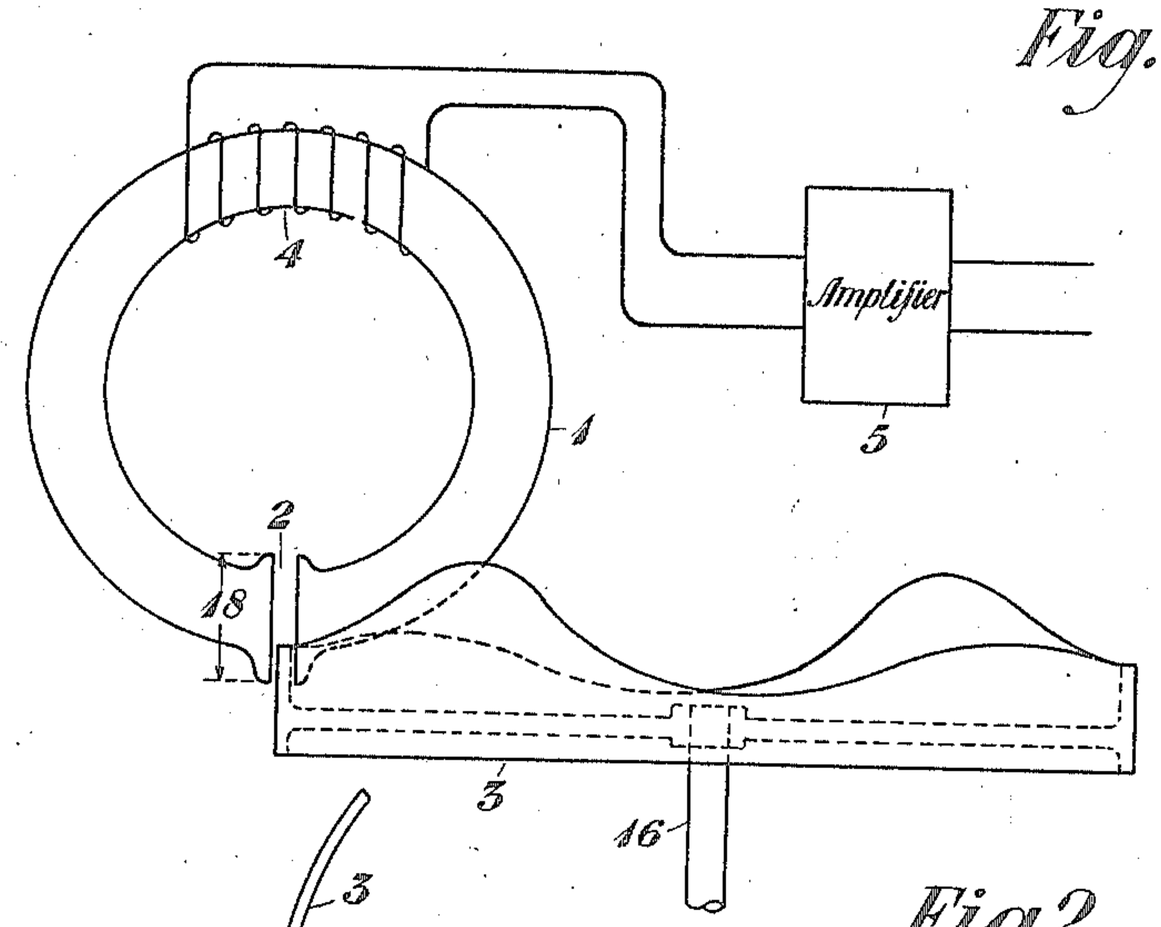

Fig. 2

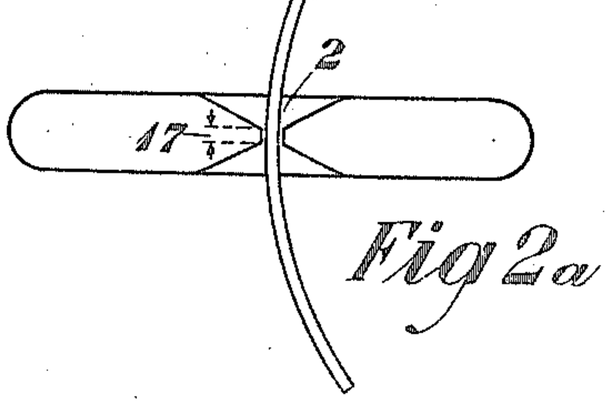

Fig 2a

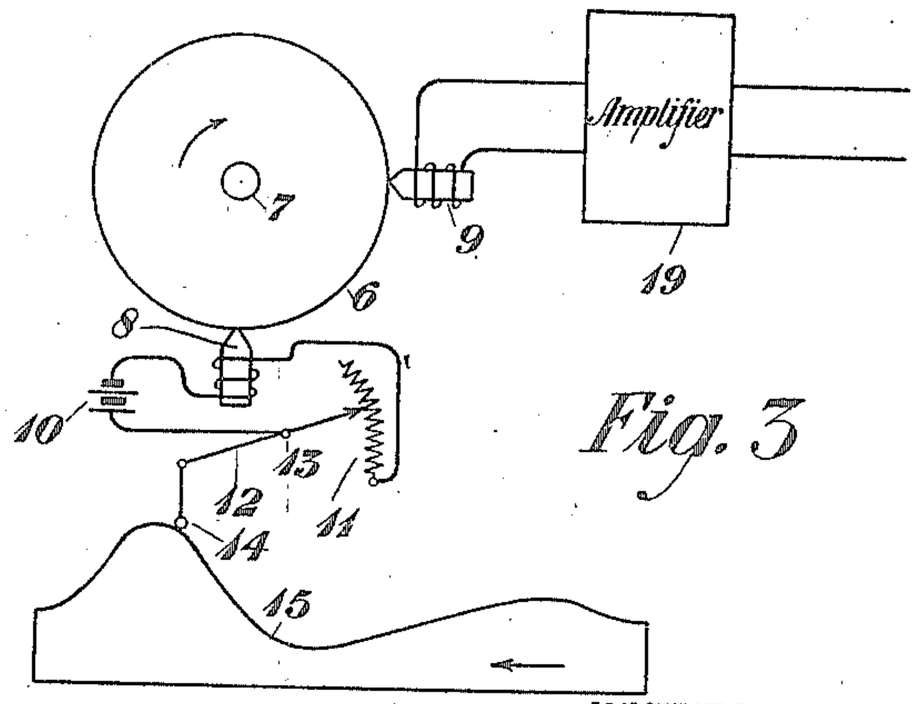

Fig. 3

INVENTOR

O. B. Blackwell

BY

John McClure

ATTORNEY

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3 SHEETS—SHEET 2.

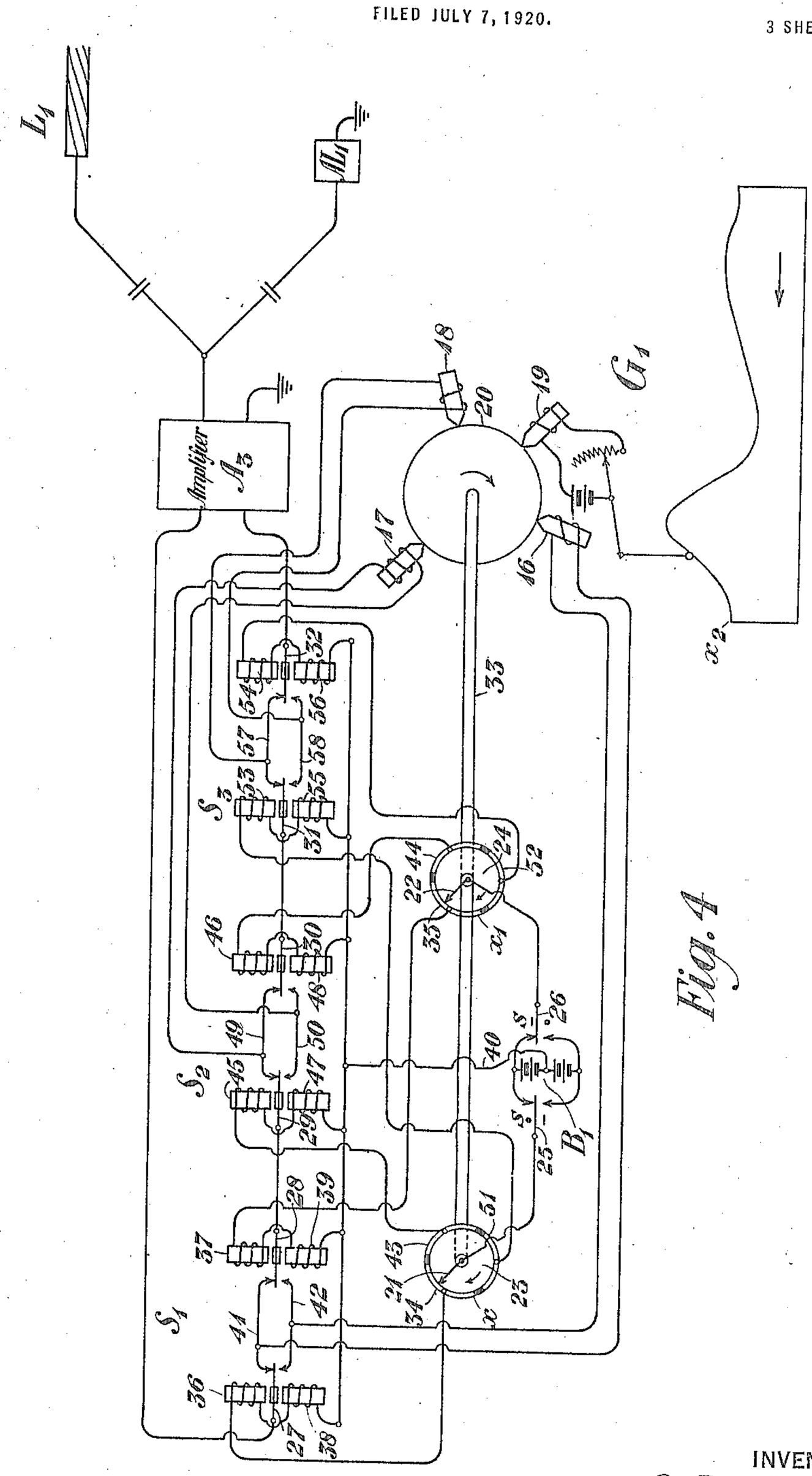

Fig. 4

INVENTOR

O. B. Blackwell

BY

John McClone

ATTORNEY

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3 SHEETS—SHEET 3.

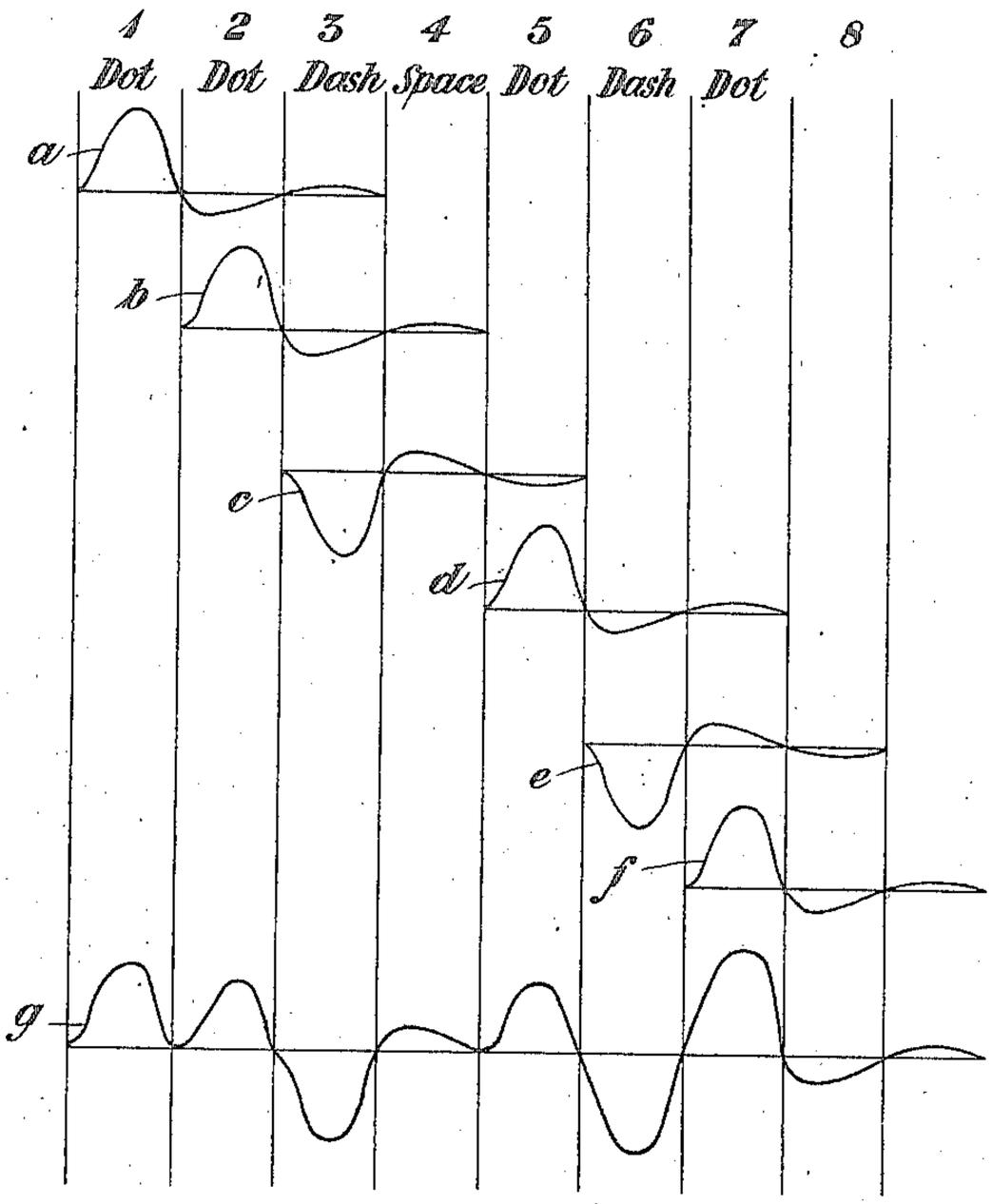

Fig. 5

INVENTOR
O. B. Blackwell
BY
John Mc Glone
ATTORNEY

Patented Jan. 9, 1923. 1,441,827

UNITED STATES PATENT OFFICE.

OTTO B. BLACKWELL, OF GARDEN CITY, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

SIGNALING SYSTEM.

Application filed July 7, 1920. Serial No. 394,574.

To all whom it may concern:

Be it known that I, OTTO B. BLACKWELL, residing at Garden City, in the county of Nassau 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 generating a voltage wave having the form best adapted for signaling over circuits characterized by great distortion and attenuation, such as submarine cables, and for applying such waves in the manner best adapted to obtain greater operating efficiency.

In the operation of submarine cables it is customary to use a code for transmitting signals in which an impulse in one direction represents a dot and an impulse in the other direction represents a dash. Heretofore, it has been customary to use a battery as the source of signaling energy, a dot being represented by an impulse of one polarity, and a dash by an impulse of opposite polarity. In order to prevent interference with the duplex balance, it has been customary to insert an impedance in the sending circuit so as to "round off" the waves. These impulses may also be obtained by means of a sine wave generator in which each half wave represents an impulse.

As is well known, after an impulse has been sent into a cable there persists for a varying period thereafter a charge in the cable which causes distortion of the subsequent signaling impulses. In order to correct this trouble it has been proposed to send out what are known as curbed signals in which at the end of each signaling impulse another impulse of lesser magnitude and in the opposite direction is sent into the cable, the function of which is to neutralize the residual effects of the prior signaling impulse. In all of the foregoing methods of signaling, the transmittal of each full impulse, whether curbed or not, must be entirely finished before the next signaling impulse is impressed upon the cable, which slows down the speed of transmission of signals.

One of the objects of the present invention is to overcome the attenuating and distorting effects which characterize the transmission of signals over submarine cables by providing means for the production of voltage wave which will have the form best adapted to give the desired arrival wave at the distant end and to cause the least interference in the duplex balance.

Another object of this invention is to provide a method and means for applying to a cable circuit signaling waves of the foregoing type without reducing the speed of transmission, which method is characterized by the continuance of the application of each signaling wave for a limited period after the beginning of the application of succeeding signaling wave or waves, which insures sending into the cable simultaneously with each signaling impulse another voltage wave which tends to overcome residual effects of prior signaling impulses.

This invention will be better understood from the following description when read in connection with the attached drawing of which Figure 1 represents a form of voltage wave which is typical of that class best adapted for submarine cable telegraphy; Figures 2 and 2ª represent one means for generating the desired voltage wave such as shown in Figure 1, and Figure 3 shows another means for generating such type of wave; Figure 4 shows an arrangement by means of which the wave set up by either of the foregoing generators may be applied to the submarine cable in the manner best adapted to overcome the residual effects of the cable upon successive signaling impulses; and Figure 5 shows graphically the type of transmitted wave resulting from the application of a plurality of signals to the cable.

The curve "*a*" shown in Figure 1 represents the form of a wave which is typical of a class best adapted to meet the requirements of submarine cable signaling. The form of such a wave may be determined by means of the equations set forth in the copending application of Carson, Serial Number 394,510, filed July 7, 1920. Although the wave shown in Figure 1 consists of three half-cycles, it is to be understood that the number may be increased or diminished without departing from the scope of this invention.

Experience has shown that it is difficult to design a generator which would be capable of producing a voltage wave the form of which is as shown in Figure 1, which wave would have sufficient energy to be used di-

rectly with the cable for transmitting signals. Such a wave may however be generated by means of the arrangements shown in Figures 2 and 3, in which a low energy wave of desired form is created by the generator and the waves are then amplified to the required degree in order that they may have the proper amount of energy for signaling. In Figure 2, 1 represents an electro-magnet the pole faces of which are brought close together so that the width of the slot 2 will be sufficient for the passage therethrough of the relatively narrow rotor which is a continuous strip of magnetic material. The pole faces are so designed that one of the dimensions 17 (Fig. 2ª) is very small as compared with the other dimension 18. The rotor 3, is so designed that it will, in the course of rotation about its axis 16, vary the reluctance of the magnetic circuit of the magnet 1 in accordance with a certain predetermined scheme which depends upon the desired form of the output waves. Thus it will be seen that the contour of that part of the periphery of the rotor 3, which moves between the upper and lower limits of the gap 2 (represented by the distance 18), varies in accordance with the form of the desired output voltage wave. Consequently the reluctance of the magnetic path is going to change with the variations in the cross section of the rotor as it moves through the gap. The variations in the flux in the magnet core 1 are proportional to the variations of the form of the rotor and consequently the voltage wave set up in the winding 4 will have the predetermined wave form. Such an output wave has substantially no energy and in order to render it available for signaling purposes it must be passed through a distortionless amplifier 5 such as, for example, the well known vacuum tube. Figure 2ª shows in detail a part of the generator of Figure 2 which makes clear the tapering of the pole faces in order to produce a narrow gap, 2, through which the rotor 3 moves at substantially uniform speed. It should be stated that the rotor shown in Figure 2 is adapted to produce two waves for each revolution. This, however, may be varied so as to produce a greater or less whole number of waves as particular conditions may require.

Figure 3 represents another form of arrangement to generate a wave of desired form and to give to such wave the necessary amount of energy. In the figure, 6 represents the disc of magnetic material which is adapted to be rotated around the axis 7. Arranged in close juxtaposition to the periphery of the disc are magnets, 8 and 9. The winding of the magnet 8 has in circuit therewith a battery 10 and a variable resistance 11. The movable arm 12 of the variable resistance which is pivoted at 13 is adapted to move up and down, in consequence of the movement of the roller 14 upon the cam 15. It will be seen that as the cam, which has the form simulating the form of the desired output wave, is moved in the direction shown by the arrow, the arm 12 will be moved up and down, thereby varying the resistance 11 in the circuit which embraces the magnet 8. The current flow through the winding of this magnet will be varied in accordance with the desired wave form and the resultant flux will magnetize the disc 6 which moves in synchronism with the cam 15. As the disc rotates it will induce in the coil of the magnet 9 a voltage wave having substantially the form represented by the cam 15. This wave will be passed through an amplifier 19 and after being amplified to the required degree will be impressed upon the outgoing circuit.

Figure 4 shows means for impressing the wave set up by the generating arrangement shown in the preceding figures, and especially by that shown in Figure 3, upon the submarine cable. It is the object of this arrangement to control the time of application of signaling waves to a submarine cable so that a wave such as is shown in Figure 1 will continue to be impressed upon the cable after the beginning of the application of subsequent signaling impulses. In the figure G_1 represents a generating device of the type shown in Figure 3 with the exception that four magnets are connected therewith instead of two as shown in the said figure. The magnets, numbered 16, 17 and 18, are designed to produce a voltage wave having the wave form corresponding to the magnetization of the moving disc 20 by means of the magnet 19. Connected with the same shaft which rotates the disc 20 are the arms 21 and 22 of the impulse distributors 23 and 24. Each of these distributors has three segments which are connected with the relays of the switching devices S_1, S_2 and S_3. The rotating arms 21 and 22 are connected with the armatures 25 and 26 of relays which may be controlled by any well known tape transmitting device. The switches S_1, S_2 and S_3 consist respectively of four relays connected in groups of two each, which are adapted to operate armatures 27 and 28, 29 and 30, 31 and 32. The armatures are normally connected in series with the input side of the amplifier A_3. The upper contacts of the armatures of the switches S_1, S_2 and S_3 are connected together and similarly the lower contacts. Bridged across the upper and lower contacts of each of the said switches are the circuits connected with the windings of the magnets 16, 17 and 18 respectively of the generating device

G_1. The output side of the amplifier A_3 is connected with the midpoint of the duplex balanced arms of the submarine cable network.

Having in mind the foregoing description of the parts of the apparatus and the functions of each, this invention will be better understood from the following description of its mode of operation. Let it be assumed that the disc 20 has been magnetized so as to be capable of reproducing a voltage wave of desired form, and that the magnet 19 is adapted to sustain this magnetization of the disc 20, since the cam moves in synchronism with the disc. The disc 20 is connected by means of the shaft 33 with the contact arms 21 and 22 of the distributors 23 and 24 and also with the tape transmitter (not shown) which controls the operation of the armatures 25 and 26 so that all of these elements will be synchronized. It will be seen that similarly located segments of the two distributors are connected with the relays of the same switching device, that is to say, the segments 34 and 35 of the distributors 23 and 24, respectively, are connected with the relays 36 and 37 of the switching device S_1. The relays of the switching devices S_1, S_2 and S_3 are polarized so that when their armatures are moved to any position they remain in that position until an impulse passes through the relay so as to move the armature to another position.

Let it be assumed that the direction of rotation of the arms 21 and 22 of the distributors is in the direction indicated by the arrow and that they have reached the points x and x_1 at which the said arms begin to make contact with the segments 34 and 35. Due to the synchronous operation of the parts, the disc 20 will be at this instant in such position as to begin inducing in the winding of the magnet 16 the beginning of the wave represented by x_2 on the cam of the generating device. Furthermore let it be assumed that when the tape transmitting device is positioned to transmit a dot, the corresponding positions of the armatures 25 and 26 is such that armature 25 closes its upper contact and armature 26 its lower contact. Accordingly a positive impulse will be transmitted from the battery B_1, over armature 25, contact of arm 21 and segment 34, and through the windings of relays 36 and 38 in series and conductor 40 to battery B_1. The direction of the current through the relays 36 and 38 will be such as to maintain the armature 27 in contact with its upper contact. Likewise a negative impulse will be transmitted from the battery B_1 over the lower contact of armature 26, contact of arm 22 with segment 35, through the windings of relays 37 and 39 in series and conductor 40 to battery B_1. The direction of current from the relays 37—39 will be such as to move the armature 28 to its lower contact. Accordingly the voltage wave which is set up in the winding of the magnet 16 will be impressed across the conductors 41 and 42, and eventually will be impressed across the input side of the amplifier A_3. The wave as amplified will be impressed upon the submarine cable L_1. Such a wave is shown by the curve "a" in Figure 5. The spaces 1, 2, 3, etc., represent the period of time required for the arms 21 or 22 to traverse corresponding segments of the distributors. As the arm 21 moves along the segment 34 the voltage will rise and fall as shown in column 1 of Figure 5. This part of the wave represents the transmission of a dot signal into the cable.

When the arms 21 and 22 move into contact with the succeeding segments 43 and 44 respectively of the distributors, the tape transmitter, which is synchronized with the distributors, will be positioned to send, for example, another dot signal into the cable. Accordingly, the armatures 25 and 26 will will remain in the same position they were heretofore. Consequently, there results the transmission of a positive impulse from the battery B_1, armature 25, the contact of arm 21 with segment 43, the windings of relays 45 and 47 in series and conductor 40 to battery which maintains the armature 29 upon its upper contact. Also the transmission of a negative implse from the battery B_1 through armature 26, the contact of arm 22 with segment 44, through the windings of relays 46 and 48 in series and conductor 40 to battery will cause the armature 30 of the relays to move to its lower contact. This will connect the circuit of the winding of magnet 17 across the conductors 49 and 50. Since the disc 20 is synchronized with respect to the arms 21 and 22, the said disc begins to set up the desired voltage wave in the winding of 17 when the arms 21 and 22 come into contact with the segments 43 and 44, and consequently a voltage wave such as is represented by "b" of Figure 5 will begin to be impressed across the input side of the amplifier A_3, and, as amplified, will be impressed upon the cable L_1. Since the relays of the switching devices S_1, S_2, and S_3 are polarized their armatures will remain in the position to which they were last moved. Accordingly the transmission of the wave "a" is not stopped by the beginning of the transmission of the wave "b" but continues to be impressed upon the cable as shown in column 2 of Figure 5.

As the arms 21 and 22 continue to rotate they will eventually be brought in contact with the segments 51 and 52 respectively, which control the operation of the relays of the switching device S_3. Let it be assumed

that the transmitter tape is designed to send a dash impulse, which means that armature 25 is moved to its lower contact and armature 26 to its upper contact. Accordingly a negative impulse is transmitted from battery B_1 over armature 25, the contact of arm 21 with segment 51, the relays 53 and 55 and conductor 40 to battery B_1, moving the armature 31 of the left hand relays of switch S_3 to its lower contact. The transmittal of a positive impulse from battery B_1, armature 26, the contact of arm 22 and segment 52, the windings of relays 54 and 56 and conductor 40 to battery will move the armature 32 of the right hand relays of switch S_3 to its upper contact. Accordingly the voltage wave which is beginning to be induced in the winding of the magnet 18 will be impressed across the conductors 57 and 58 in opposite direction from that in which the dot impulses were impressed. This wave will pass through the amplifier A_3 to the cable L_1 in the form shown by curve "*c*" of Figure 5. The form of the signal impulse, which is represented by the part of the curve embraced in column 3 will be modified by the parts of waves "*a*" and "*b*" which are being transmitted into the cable simultaneously with the transmission of the signaling impulse of curve "*c*".

Let it be assumed that the tape is punched so as to produce a space in the transmitted signals. Accordingly the armatures 25 and 26 will both be moved to their upper contacts and a positive impulse will be transmitted over the arms 21 and 22 and the segments 34 and 35 respectively to the corresponding groups of relays of the switching device S_1. As a result of this the armatures 27 and 28 are moved to their upper contacts and accordingly the potential set up in the winding of the magnet 16 cannot be impressed across the amplifier A_3 since one of the sides of the circuit is open. Therefore, no signaling impulse is transmitted into the cable during the period of time represented by the column 4, but during that time it will be seen that parts of the waves "*b*" and "*c*" continue to be transmitted into the cable.

The curves "*d*", "*e*", and "*f*" represent three more signaling waves which are applied to the cable as the result of the operation of the switches controlled by impulses from the tape transmitter in the manner just described. It should be understood, of course, that although these signaling impulses are applied as separate impulses, they become merged and the actual form of wave impressed on the cable is that represented by "*g*" which is the sum of the impulses from "*a*" to "*f*" inclusive.

It will be seen, therefore, that this invention provides means for generating a voltage wave having the form best suited for transmission over circuits characterized by great distortion and attenuation and to amplify those waves without distortion so as to give such energy as is necessary for purposes of transmission. It will further be seen that this invention also provides means for clearing out the residual charges resulting from the transmission of signaling impulses, thereby minimizing the distortion of subsequent signaling impulses that generally results from the presence of such residual charges.

Although this invention has been disclosed in certain specific form it is to be understood that it is not so limited, but is capable of embodiment in other and different forms within the scope of the appended claims.

What is claimed is:

1. In a signaling system the combination of a multiphase generator adapted to produce a voltage wave having a certain predetermined form, a line circuit, and switching means controlled by said generator adapted to apply the said wave to the said line circuit when said voltage reaches a predetermined value.

2. In a signaling system the combination of a multiphase generator adapted to produce a voltage wave having a certain predetermined form, a line circuit, means for amplifying said voltage wave and switching means controlled by said generator adapted to apply said wave to said line circuit when said voltage reaches a predetermined value.

3. In a signaling system the combination of a multiphase generator, a plurality of switches, and means for controlling the operation of the said switches, the said controlling means being operated in definite time relationship with said generator, whereby the period of application of the voltage waves may be automatically controlled.

4. In a signaling system the combination of a multiphase generator, a plurality of switches, and impulse transmitting means operated in definite time relationship by said generator whereby each of said switches may be operated at certain predetermined instants of time.

5. In a signaling system the combination of an alternating current generator, a plurality of relay operated switches, a tape controlled impulse sender, a plurality of segmental distributors connected with said generator adapted to control the operation of the said switches in predetermined order whereby the voltage wave of the said generator may be applied to a circuit at predetermined intervals.

6. In a signaling system, the combination of a low energy generator designed to produce a non-sinusoidal alternating voltage wave having the form of a damped wave for transmission over long cable circuits characterized by distortion and attenuation.

distortionless means to amplify to a predetermined degree the generated wave, and means to apply the said amplified wave to the said cable circuit when the wave reaches a predetermined instantaneous value.

7. In a signaling system comprising a generator of multiphase voltages, a line circuit, a plurality of distributors each having a rotatable contactor and at least as many segments as there are phases of voltages, a plurality of electro-magnetic switches individual to each phase of said generator, and a transmitter controlled in time of operation by said generator to apply an impulse to the contactor of one of said distributors whereby said impulse may be applied at the proper instant to one of said switches to cause the application of one of said voltage waves to said line circuit when the said wave is of predetermined magnitude.

8. In a signaling system, the combination with a generator adapted to produce a succession of trains of damped waves having definite form and a definite damping constant, a line circuit, an amplifier, a plurality of electro-magnetic switches each of which is adapted to connect one train of waves to said line circuit, a plurality of distributors operatively connected with said generator, a signal impulse sending device also operatively connected with said generator whereby the said switches may be controlled at definite times by said impulses to apply successive trains to said line circuit at time intervals equal to one-half of a wave length.

9. In a signaling system, the combination of a multiphase alternating current source adapted to produce damped waves of predetermined form and wave length, a line circuit over which said waves are to be transmitted, a signal impulse sending mechanism designed to operate on the principle that dots and dashes are represented by impulses of opposite polarity, a plurality of switches controlled by impulses from the said impulse sending mechanism to apply said waves to said line circuit, and distributing switches to control the time of application of the said impulses to the proper switches.

10. In a system characterized by the means set forth in claim 9, the method of transmitting telegraph signals with a minimum distortion, which consists in generating multiphase alternating currents having a definite damping constant, amplifying the said currents and impressing these currents upon a line circuit at intervals of one-half a wave length apart and controlling the polarity of the applied wave in accordance with the predetermined signal.

In testimony whereof, I have signed my name to this specification this 6th day of July, 1920.

OTTO B. BLACKWELL.