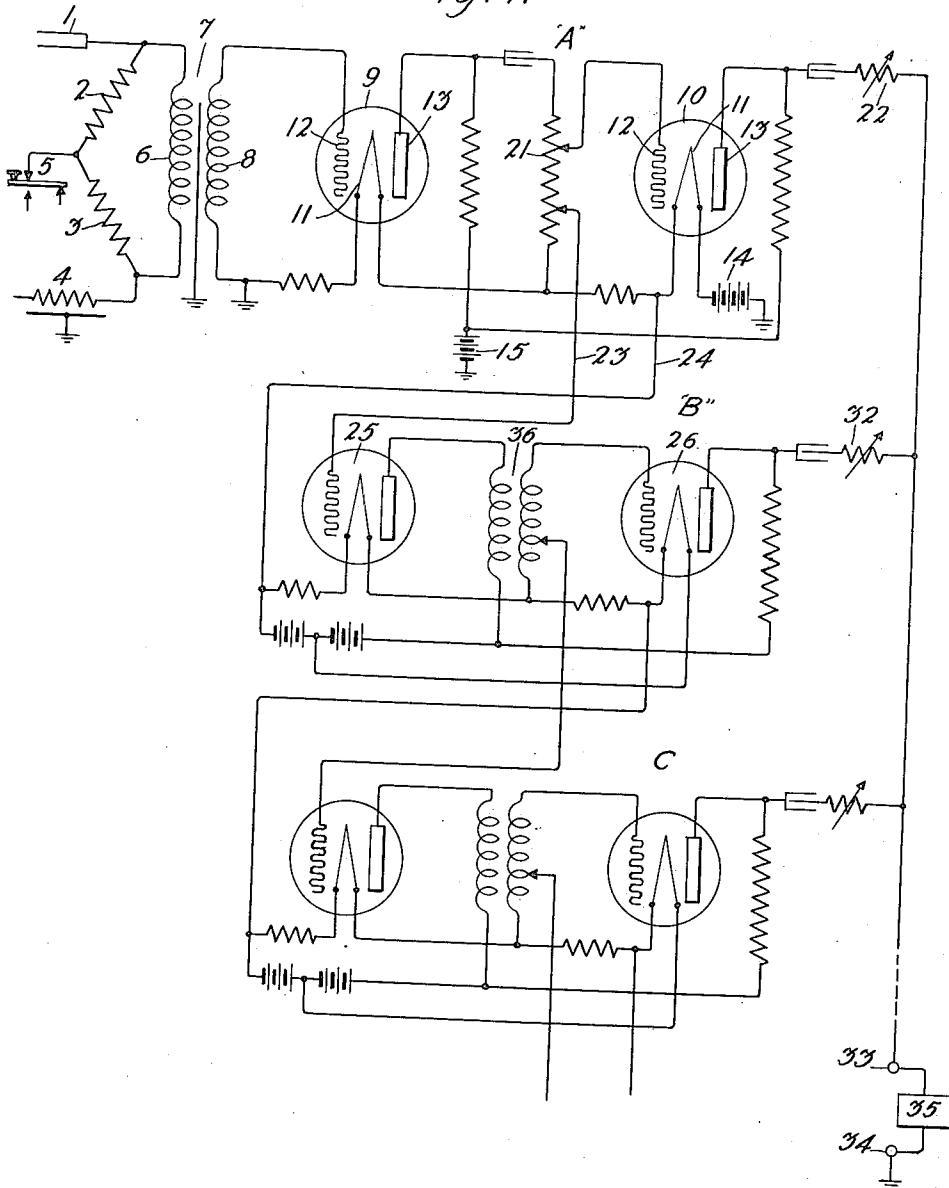


R. C. MATHES.
 AMPLIFYING AND CORRECTING SYSTEM.
 APPLICATION FILED AUG. 14, 1918.

1,311,283.

Patented July 29, 1919.
 3 SHEETS—SHEET 1.

Fig. 1.

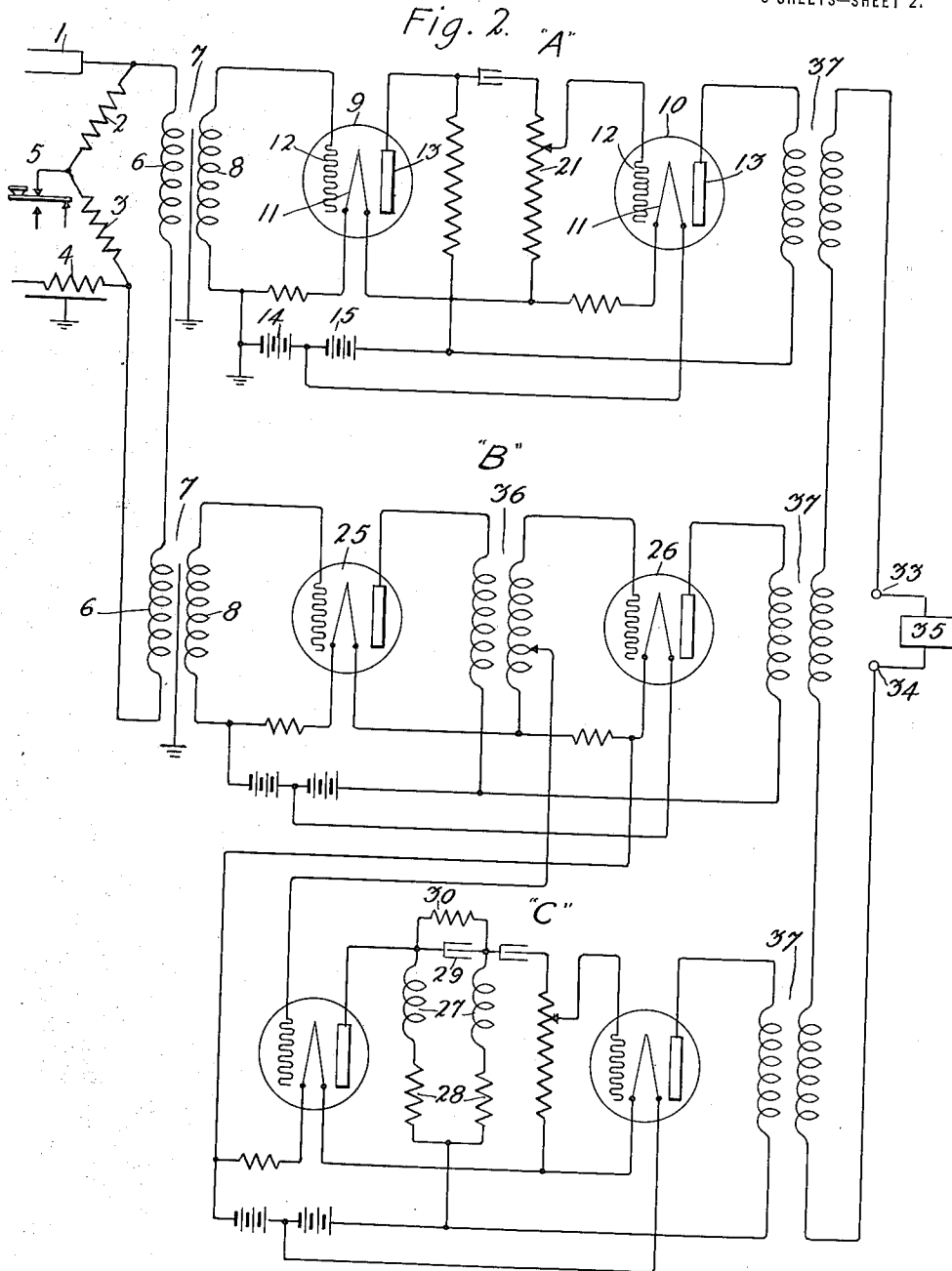


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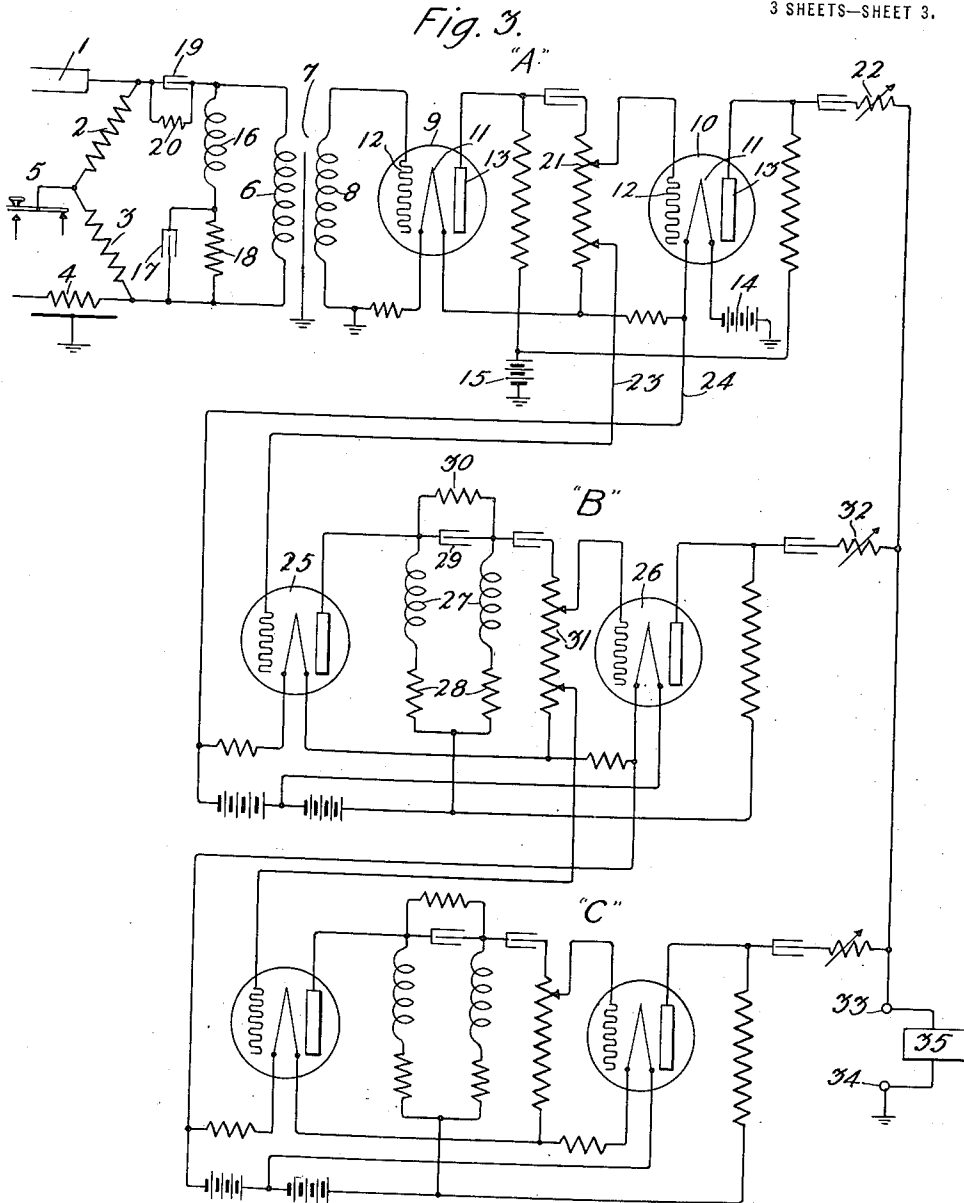
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3 SHEETS—SHEET 3.



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UNITED STATES PATENT OFFICE.

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AMPLIFYING AND CORRECTING SYSTEM.

1,311,283.

Specification of Letters Patent.

Patented July 29, 1919.

Application filed August 14, 1918. Serial No. 249,828.

To all whom it may concern:

Be it known that I, ROBERT C. MATHES, a citizen of the United States, residing at New York, in the county of Bronx, State of New York, have invented certain new and useful Improvements in Amplifying and Correcting Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to amplifying and correcting systems. It is particularly concerned with systems suitable for use in connection with telegraphic signaling over conductors of high capacity such as submarine cables.

It is well known that when signals are transmitted over high capacity conductors, the original wave form of the signals is destroyed, and the wave form of the received signal often bears very little resemblance to the original transmitted wave. In a co-pending application, Serial No. 240,792, filed June 19, 1918, I have shown how, by using correcting net-works at the receiving end of the cable, it is possible to differentiate the received wave, and to recombine the various derivatives; to make available for the actuation of the receiving instrument, a current having a wave form closely approximating that of the transmitted signal. In the said application it was also shown how amplifiers might be used to increase the power value of such corrected waves to the extent required for effective operation of the receiving instrument, or for retransmission to another telegraph conductor.

The present invention has for its object to facilitate the separation of the various derivatives and their recombination in proper proportions to give the desired synthetic curve. To this end the invention provides that instead of amplifying the arrival curve and the several derivative curves in one amplifying system, these various components are separated out and amplified to the desired degree, in separate and distinct amplifying systems, and are then combined, after amplification, in a common output or work circuit. The invention will be more clearly understood by reference to the accompanying drawings, in which Figure 1 gives a diagrammatic representation of a system arranged to amplify the main arrival curve and the derivatives thereof, each in a separate system; Fig. 2 shows a modi-

fication of the arrangement of Fig. 1 using a series combination of the output circuits and also a partial series connection of the input circuits of the various amplifier systems; and Fig. 3 shows a further modification wherein by the use of more complicated correcting net-works two or more of the component waves may be amplified together in a single system.

Referring to Fig. 1, 1 represents a telegraph conductor, in this case a submarine cable, terminating in a duplex net-work comprising the two ratio arms 2 and 3, and the artificial line 4. The apex of the net-work is connected to the usual transmitting key 5. Bridged across the net-work in the position of the usual receiving device is the primary winding 6 of the transformer 7. The secondary winding 8 of the transformer 7 is connected to an amplifier system A, here illustrated as a two-stage system employing thermionic amplifiers 9 and 10. These amplifiers have the usual filamentary cathodes 11, input or grid electrodes 12 and output electrodes 13. The filaments 11 are heated by current supplied from a battery 14. The output electrodes 13 are maintained positive with respect to the filaments 11, by means of a battery 15. The amplifier system A is here arranged and the transformer 7 is designed to transmit and to amplify the main arrival curve only, or a wave conforming very closely to it. Any transformer inserted in the circuit in this way has a differentiating action and produces in its secondary winding, a current whose form is that of a derivative of the primary current, so that normally the introduction of the transformer 7 in the position shown would pass on to the amplifier system A a current which was the derivative of the arrival curve, and the arrival curve itself would be to a large extent, if not entirely, lost. In order that the arrival curve may be retained and thus perform its function in keeping up the tail of the synthetic wave, the transformer 7 should have a relatively high time constant, and the shunt on the primary 6 comprising the ratio arms 2 and 3 should be relatively low in impedance. Thus by the proper selection of the transformer and shunting elements, the amplifier 9 may have applied to it a current wave which may be an approximate duplicate of the arrival curve. The output of the am-

plifier system A may be adjusted by means of the potentiometer 21 and the variable resistance 22. The resistance 22 has the further function of preventing the outputs of the other systems being fed back into the output circuit of the element 10, and thus varying its amplifying power from moment to moment. A portion of the output of the amplifier 9 is, however, applied by means of conductors 23 and 24 to the input circuit of an amplifier system B, composed, in this case, of two thermionic amplifiers 25 and 26. Located intermediate the amplifiers 25 and 26 is a transformer 36. This transformer will have a differentiating action upon the current applied to it and will produce across the input circuit of the amplifier 26, a voltage having a wave form corresponding to the first derivative of the voltage applied to the input circuit of amplifier 25. This first derivative current will be amplified in the amplifier 26 and the desired proportion of it to be added to the ultimate synthetic wave may be obtained by a proper adjustment of the amplifier or by the variable resistance 32 or by both.

Similarly, a further amplifying system C may be arranged to produce and to add a proper amount of a current wave having the form of a second derivative of the arrival curve, and the system may be further extended by adding other amplifying systems to produce as many more of the higher derivatives as are desired. It is thus seen that by the arrangement disclosed a wave form, approximating to any desired degree the form of the original transmitted wave, may be made available at the terminals 33 and 34 of a common output circuit, to actuate a recording device 35; or for retransmission over another telegraph conductor, which may be either a land line or submarine cable.

The alternative arrangement of Fig. 2 differs only slightly from that of Fig. 1 but illustrates how if desired the input circuits of the various amplifier systems, as well as their output circuits, may be connected in series rather than in parallel. Here the input circuits of both systems A and B are connected to the cable circuit through transformers 7, the primaries 6 of which are connected in series in the cable circuit. The output circuits of the amplifier systems A, B and C, are similarly connected through transformers 37, to a common output circuit, the secondary winding of said transformers being connected in series with the receiving device 35 as shown. It will be obvious that any series, parallel or series-parallel arrangement of the output and input circuits may be used without departing from the spirit and scope of the invention and that the particular arrangement to be employed will in general be

dictated by the specific service requirements to be met.

A further difference between the arrangements of Figs. 1 and 2 will be noted in the form of correcting net-work shown in system "C." This net-work is made up of inductances 27 and resistances 28 in series bridged across the line and a capacity 29 shunted by resistance 30 in series with the line. This net-work is of a form described in my copending application above referred to and need not be described in detail here. It is sufficient to note that such a net-work, while producing one or more derivatives of the voltage or current wave applied to it, also passes along a portion of the applied wave and thus delivers to its output circuit a combination wave composed of the impressed wave and one or more derivatives thereof the proportions of the different components being dependent upon the values of the different elements employed. In the case illustrated in Fig. 2 amplifier systems A and B would therefore (as in the arrangement of Fig. 1) produce in the common output circuit current waves having the forms of the arrival curve and its first derivative respectively, while amplifier system C, instead of producing a current corresponding to the second derivative alone will produce a complex wave in which the second derivative predominates or in which the second and third derivatives are present in any desired ratio depending upon the value of the inductances, resistances and capacity used. The use of such a correcting net-work is of advantage where it is desired to obtain a number of the higher derivatives without unduly multiplying the number of amplifying systems.

This idea is carried further in the system illustrated in Fig. 3. Here, for example, the primary 6 of transformer 7 is shunted by an inductance 16 and resistance 18 in series, while a condenser 19 shunted by resistance 20 is placed in series with the primary 6. This net-work has the effect of adding a first derivative to the arrival curve so that amplifier system A produces in its output circuit a combination of these two components. The condenser 17 shunting resistance 18 aids in maintaining the original form of the arrival curve and therefore helps to keep up the tail of the ultimate synthetic wave.

Similarly amplifier system B, by employing a net-work composed, for example, of inductances 27, resistances 28 and 30 and capacity 29, as shown, may be made to produce in the common output circuit a complex wave whose main component corresponds to a combination of the second and third derivatives of the arrival curve.

Amplifier system C may in a similar manner be made to produce a predominating component made up of a combination of the

fourth and fifth derivatives. Thus with only three amplifier systems it is possible to produce the first five derivatives of the arrival curve and to combine these six components in proper proportions in the common work circuit. It will be understood that the arrangement of Fig. 3 is somewhat less exact than that of Fig. 1, for example, and that is in the nature of a compromise between the latter arrangement and that disclosed in my copending application above referred to.

It will be noted that in passing through any vacuum tube element the polarity of the transmitted signal changes; that is, considering the element 9, if we apply a signal such that the polarity between the grid 12 and the filament 11 is changed from zero to positive, the potential between the plate 13 and the filament 11 will be changing so as to make the plate relatively more negative with respect to the filament. It will, therefore, be seen that the component corresponding to any one of the amplifier systems may be fed in either of two phases, according to the number of vacuum tube elements used in that system. Of course, where transformers are employed as in Figs. 1 or 2, the phases may also be reversed by interchanging the transformer connections. In Fig. 3, for instance, where such reversal of phase through the use of transformers is not possible, it will be noted that the component wave of channel B feeds into the output circuit in what may be considered reverse phase from channels A and C. It may equally well be fed into the output circuit in like phase by adding an additional vacuum tube element between element 26 and the common output circuit.

The same fundamental principle is, however, seen to be present in each of the three of the modifications here used as illustrative of the invention, namely—the use of a separate amplifying system for each of the dominating components which are intended to play their respective parts in determining the form of the ultimate synthetic wave to be used in the work circuit. Another feature present in the system and one which was also emphasized in the copending application above referred to is the arrangement whereby each correcting net-work or

transformer is separated from the preceding and succeeding one of the system by a device, in this case a thermionic amplifier, having unilateral conductivity. This makes it impossible for one net-work to react on the preceding one and makes possible the design of each net-work or transformer without reference to any other net-work in the system.

What is claimed is:

1. The method of combining with an electric wave of given form, other derived waves of different forms so as to produce a resultant wave of a desired form which consists in separating out the various component waves, amplifying them separately to the desired degree, and recombining the separately amplified waves to actuate a common receiving device.

2. The method of operating a signal responsive device which consists in deriving from the received current wave other currents each having a distinct wave form, amplifying each of said currents separately in a separate circuit and subjecting said responsive device to the conjoint action of said amplified currents.

3. In combination with a signaling conductor, means for producing from the currents arriving over said conductor, other currents differing therefrom and from each other in wave form, separate circuits on which the several currents are respectively impressed, means in each separate circuit for amplifying the currents therein, and a receiving device responsive to said amplified currents jointly.

4. The combination with a signaling conductor, a responsive device connected thereto for indicating the arrival of currents from said conductor, means intermediate said conductor and said device for amplifying said arrival current, means for deriving from said arrival current another current differing in wave form therefrom, separate means for amplifying said derived current, and means for combining said amplified arrival current and said amplified derived current to actuate said responsive device.

In witness whereof, I hereunto subscribe my name this 5th day of August, A. D. 1918.

ROBERT C. MATHES.