

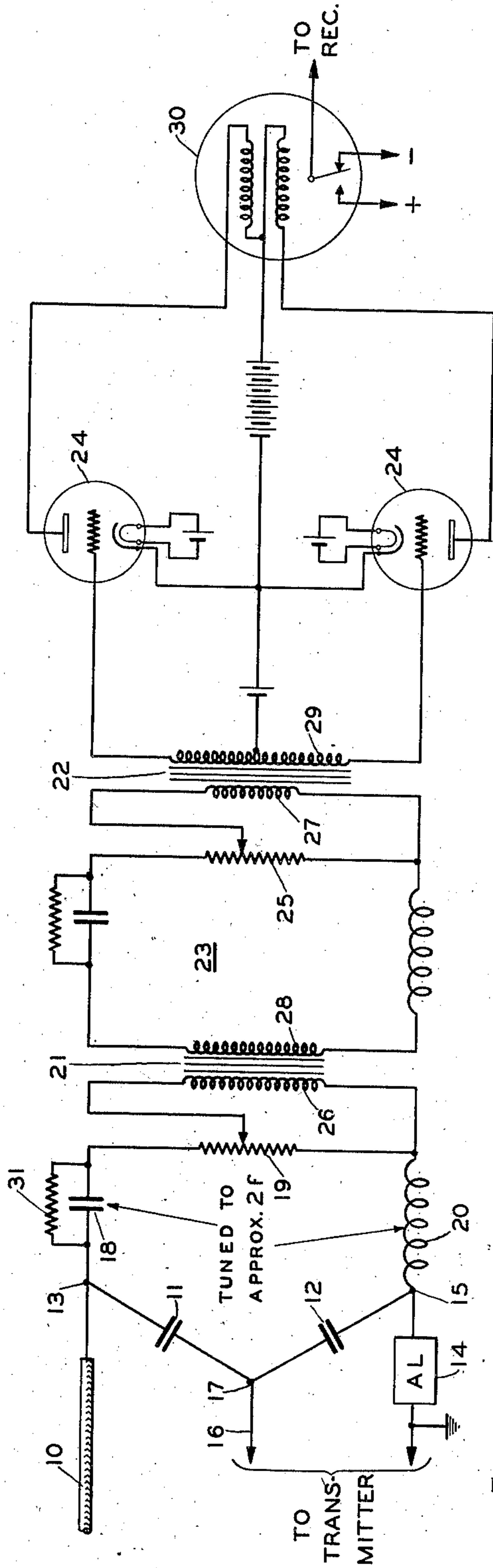
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SUBMARINE CABLE RECEIVING SYSTEM

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SUBMARINE CABLE RECEIVING SYSTEM

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This invention relates to signal transmission systems and especially to telegraph systems wherein the signals are distorted by the characteristics of the transmission line, which is the case when long ocean cables are operated at relatively high signalling speeds.

It is the major object of this invention to increase the efficiency of such systems by improving the quality of the received signals.

Another object of the invention is to provide a shaping network whereby the magnitude of all components comprising the received signal up to a predetermined frequency are restored substantially to their original relative proportions

Still another object of the invention is to correct, by means of a receiving network, for the relative phase displacement of the signal frequency components caused by the characteristics of the cable.

A further object of the invention is to suppress all inherent and extraneous frequency components of the received signal above a predetermined frequency.

It is generally recognized that the signals received at the terminal of a long ocean cable not only are very weak but also are greatly distorted, and that while a weak signal may be amplified, it still will be so distorted as to be unintelligible. In general, the code signals which are impressed upon the sending end of the cable are permutations of impulses of unit time duration of either positive or negative polarity. In the following description the most rapid alternations of positive and negative potential will be designated as f , the fundamental signalling frequency. These signalling impulses, as sent, have wave forms that are substantially rectangular and thus may be considered as comprising frequency components ranging from zero to infinity.

It is well known that the characteristic distortion of such a signal, in its propagation in the cable, is caused by the greater attenuation of the higher frequency components and by the greater transmission time lag of the lower frequency components. Hence, a receiving network which will produce attenuation and phase shifting effects varying with frequency substantially inversely proportional to those produced by the cable will be instrumental in restoring the signal substantially to its original shape. The amplitude of the reshaped signal, of course, will be that of the frequency component most attenuated by the cable. However, it has been found that the frequency components above about $2f$ may be eliminated without affecting proper reception, and

even with improved results on account of the reduction in interference. In accordance with the invention, the shaping of the signals is effected by a network tuned to approximately $2f$.

For a better understanding of this invention together with other and more specific objects thereof, reference will be had to the following description taken in connection with the accompanying drawing, the single figure of which illustrates a preferred embodiment of the invention.

There is illustrated the termination of a cable in the familiar bridge arrangement used for duplex operation wherein the condensers 11 and 12 form two of the bridge arms. The cable conductor is connected to the extremity of one arm at the point 13, the artificial line 14 is connected to the extremity of the other arm at the point 15, and the transmitter is connected by the conductor 16 to the junction point 17 of the two bridge arms. It will be understood that duplex operation may be derived by any other of the well known means of terminating the cable.

In the form of the invention shown, the points 13 and 15 are connected through a single section of the signal shaping network which comprises a capacity 18, a resistance 19 and an inductance 20 arranged in series connection and having a natural period of resonance at a frequency substantially equal to $2f$. It is obvious that, when a signal is impressed between the points 13 and 15, the frequency component thereof approximately equal to $2f$ will appear across the resistance element 19 as a voltage which is unchanged both in amplitude and in phase. Similarly, voltages for all other frequency components of the signal will appear across the resistance 19 decreased from their received amplitudes substantially in the proportion that their respective frequencies deviate from the resonant frequency ($2f$), and shifted in phase, leading or lagging that in which they were received substantially proportional to their respective deviations under or over the resonant frequency of the shaping network.

In other words, in accordance with the present invention, a frequency component of the received signal, in this case equal to approximately $2f$, twice the fundamental signalling frequency, is not affected by the shaping network and all lower frequency components are attenuated and displaced in phase to an extent depending upon their departure from the frequency $2f$ in order to compensate for the distortion produced by the cable. The fact that the shaping network produces, on frequency components higher than twice the fun-

damental signalling frequency, lagging phase effects which are cumulative with those produced by the cable is not detrimental since these components are so attenuated as to be unimportant. Being of relatively small amplitude as received, they are thus effectively suppressed and add little or nothing to the definition of the reshaped signal, which is in accordance with one of the aforementioned objects of this invention. Furthermore it will be appreciated that the frequency components of any extraneous voltages, commonly termed interferences, which may be present in the received signal, above the arbitrarily selected maximum frequency necessary for adequate signal definition, are also suppressed with the attendant diminution of that form of distortion. Hence the resultant signal has a wave form which is sufficiently well defined to be entirely legible to an efficient translating device, but which has an amplitude of the order of that of the frequency component which is substantially equal to $2f$, twice the fundamental signalling frequency. The resonant characteristics of the tuned circuit 18, 19, 20 may be varied somewhat but the best results are obtained if the network is resonant at or less than $2f$ but not less than f .

A plurality of these resonant networks may be connected in cascade and, in practice, it frequently is found advantageous to employ such an arrangement. Attention should be directed to the fact that, when using a network comprising a plurality of sections, while the combined network will be resonant at substantially twice the fundamental signalling frequency, the resonant frequency for each individual section may be somewhat different, but in any case at a point between the frequencies f and $2f$. Also, where a cable is operated duplex, it is desirable that the amplifier be electrically separated from the receiving bridge circuit so as to prevent the introduction into the received signals of any disturbing influences created by the operation of the transmitter of outgoing signals. For this purpose one or more transformers may be included in the receiving system between the bridge circuit and the amplifier.

The drawing illustrates one such transformer 21 interposed between two cascaded sections of shaping networks and another transformer 22 between the second network 23 and the conventional vacuum-tube amplifier 24. It will be understood, of course, that either or both of these transformers may be omitted from the circuit or one may be interposed between the receiving bridge circuit and the first section of the shaping network. Also an amplifier may be included between individual sections of the shaping network. The particular arrangement of any of these interconnecting devices will be determined by the conditions under which the system is to be operated.

It should be noted that while the output potentials of the network are normally derived from the voltage drops across the resistances 19 and 25, improved results may often be obtained by utilizing only a portion of these voltage drops to energize the primary windings 26 and 27, respectively, of the transformers 21 and 22. Such a procedure will obviate another type of distortion which may be introduced into the signal by adverse time constants of the primary circuits of the transformers 21 and 22. As illustrated in this form of the invention the secondary winding 28 of the transformer 21 is connected to the input circuit of the second section 23 of the shaping

network, and the secondary winding 29 of the transformer 22 is connected to the input circuit of an amplifier 24 comprising, in this instance, a pair of thermionic vacuum tubes connected in push-pull relation. The output circuit of the amplifier 24 is connected to the control circuit of the translating relay 30, the local circuit of which is employed to operate a recorder.

In this type of network it is apparent that there is an asymptotic increase of attenuation with a decrease in frequency below a certain point. Since one type of disturbance to which a cable signal is subjected is the so-called "earth currents" which are relatively of very low frequencies, they will be effectively deleted from the signal by virtue of this aforementioned characteristic of the network. However, certain low frequency components of the original signal, which are necessary to the proper definition of the reshaped signal, will be correspondingly suppressed. Hence, it is necessary to suitably control the admittance of the network so as to pass a maximum of low frequency signal components with a minimum of extraneous low frequencies. To this end, the capacity element 18, for instance, is shunted with a relatively high resistance 31.

Since it is possible to operate a translating device by signals which are sufficiently defined by the frequency components up to twice the fundamental signalling frequency, it should be apparent from the foregoing description that a receiving system in accordance with this invention used in conjunction with a submarine cable will provide for the substantially uniform attenuation of all frequencies included in a predetermined signal spectrum with the attendant suppression of all other frequencies; and in addition will provide for the reception of these selected frequencies by a translating device substantially in their original relative phase relationship.

The circuit elements comprising the present network are few in comparison with previously existing types for accomplishing the same result. Accordingly, the necessary adjustments are correspondingly fewer and less critical. Hence marked economies may be effected both in original cost and also in the cost of operation.

As indicated hereinbefore, this invention is susceptible to many minor changes and modifications without departing from the spirit thereof. Hence, it is desired to define the scope of the invention accordingly by the following claims.

What is claimed is:

1. In a system for receiving signals from a conductor having phase and attenuation distortion, a correcting network of capacity, resistance and inductance elements arranged to form a tuned series circuit resonant at approximately twice the fundamental signalling frequency, means for impressing said signals upon the terminals of said network, an output circuit for said network including at least a portion of said resistance element and excluding any other element of the network, a translating device, and means for interconnecting said output circuit with said translating device.

2. In a system for receiving signals from a submarine telegraph cable, a wave shaping network comprising in series a capacity, a resistance and an inductance forming a tuned circuit resonant at a point between the fundamental signalling frequency and the second harmonic thereof, means for impressing said signals upon the ter-

minals of said network, a translating device, and means for impressing the voltages developed across said resistance element upon said translating device.

5 3. A system for receiving signals from a conductor having phase and attenuation distortion including a wave shaping network comprising a capacity, a resistance and an inductance in series connection forming a tuned circuit resonant at
10 a point between the fundamental signalling frequency and the second harmonic thereof, means for impressing said signals upon the terminals of said network, an output circuit for said network including at least a portion of said resistance element and excluding any other element
15 of the network, a translating device, and means to interconnect said output circuit with said translating device.

20 4. A system for receiving signals from a transmission line having phase and attenuation distortion, including a shaping network comprising a capacity, a resistance and an inductance arranged in series, an input circuit therefor derived from the terminals of said network and connected
25 to said transmission line, an amplifier, a translating device, an output circuit for said network including at least a portion of said resistance ele-

ment, excluding any other element of the network and connected to the input circuit of said amplifier having an output circuit connected to said translating device, and means for impressing
5 upon said amplifier input circuit signal waves having components lower in frequency than substantially twice the fundamental signalling frequency.

5. A system for receiving signals from a submarine telegraph cable, including a correcting
10 network comprising a series arrangement of a capacity, a resistance and an inductance, an input circuit therefor derived from the terminals of said network, an output circuit for said network including at least a portion of said resistance ele-
15 ment and excluding any other element of the network, means for connecting said input circuit to said cable, a second of said networks having input and output circuits, means to connect the output circuit of said first mentioned network
20 to the input circuit of said second network, an amplifier, means for connecting the output circuit of said second network to said amplifier, and means operable by said amplifier to translate and
25 record said signals.

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