

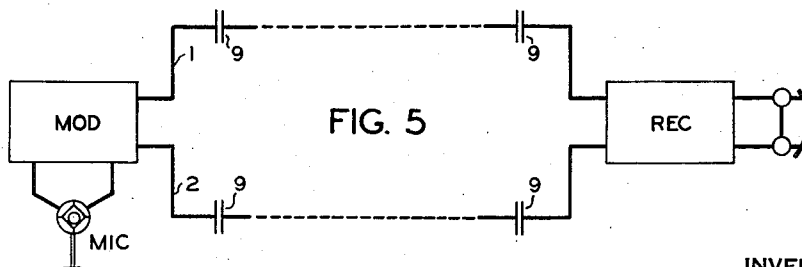
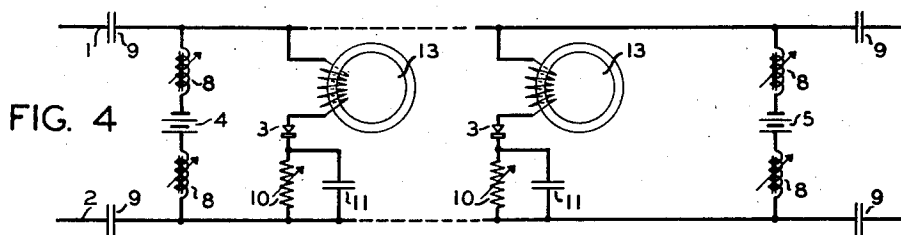
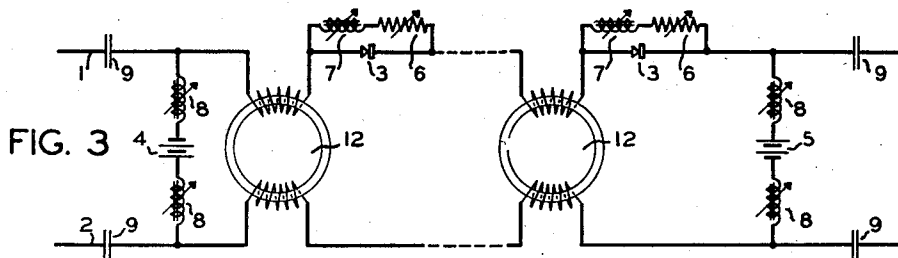
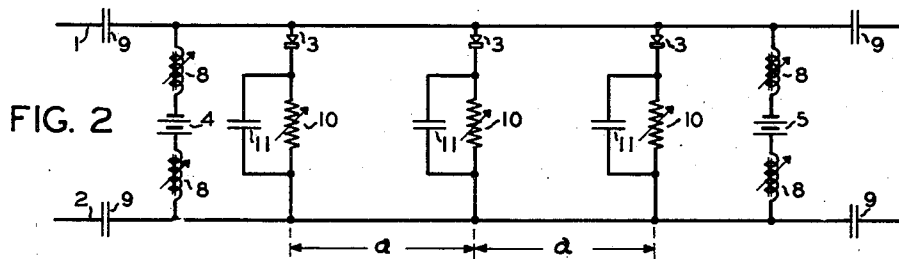
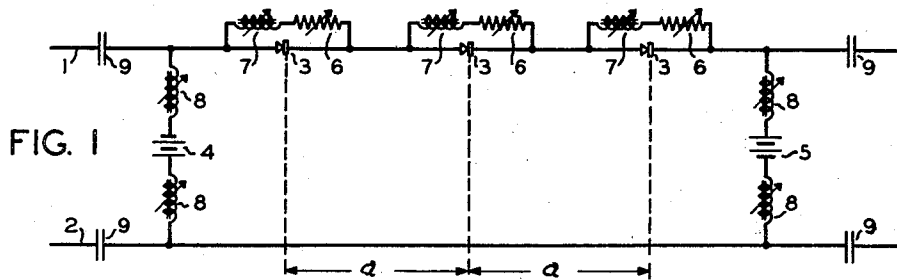
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ALTERNATING CURRENT SIGNALING SYSTEM

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ALTERNATING CURRENT SIGNALING
SYSTEM

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20 Claims. (Cl. 178—45)

This invention relates to alternating current signaling systems, and particularly such systems when the signaling is conducted over subterranean or submarine cables.

5 In such systems attenuation losses are reduced by pupinizing the conductors, that is, by loading them either at intervals with loading coils, or continuously. The loading coils are usually arranged in series in one of the conductors in order
10 to transmit a wide frequency band. They may, however, be connected in shunt between the two conductors if it is desired to transmit only a narrow frequency band.

One difficulty which must be overcome in alternating current signaling systems is power losses in the line. These power losses increase with increase of the signaling frequency, due to the skin effect and dielectric losses in the insulation. The power losses cannot be avoided by pupinizing the
20 line.

This invention provides means for avoiding these power losses completely, and is applicable to both low frequency and high frequency systems. Negative resistances, which may consist
25 of galena or zincite crystals, are introduced into the line. These may be placed in series in one of the conductors or in parallel across the two conductors of the line. Steel pins may be used to make contact with the crystals. The nature and characteristics of such crystals, as well as the range of operation and functioning thereof as negative resistances, are well known, as is evident from a detailed description pertaining thereto by O. V. Lossev in an article entitled "Oscillating
35 Crystals" appearing at page 1167 of the January 1925 issue of "Radio News". An article on "The Discovery of the Oscillating Crystal" by Dr. Greenleaf W. Pickard, appearing at page 1166 of the same issue, makes it evident that the nature, characteristics, etc. of such crystals have been
40 known for many years. The crystals are fed with direct current which supplies the energy to compensate for the alternating current power losses. The direct current supplied to the crystals is conducted by the line which carries the alternating
45 current signals, so the cable or conductor forms a unit with the crystals. The direct current may be supplied at the ends of the line so the power losses may be compensated at intervals without any other special apparatus at the places where
50 the crystals are inserted in the line, and without any local servicing. Such a system is, therefore, admirably adapted for subterranean or submarine cables.

55 In order for the system to operate to best ad-

vantage, it is necessary to supply each crystal with equal amounts of current regardless of voltage and energy losses in the cable. The invention provides means for accomplishing this result.

This invention is applicable to pupinized lines as well as to lines which are not pupinized. In the case of pupinized lines, the crystals are inserted in series with the loading coils.

In the case of pupinized lines the crystals may easily be arranged to cause the line to oscillate at a base frequency and its harmonics. Such a line may be used for carrier telephony, or telegraphy, by simply modulating the oscillations of the line with the signals and providing a corresponding demodulating device at the other end. In this manner, therefore, the necessity for an oscillation generator is obviated and a considerably improved result is achieved.

In the drawing:

Fig. 1 is a circuit diagram of a two conductor line with crystals arranged in series in one conductor;

Fig. 2 is a circuit diagram of a two conductor line in which the crystals are arranged in shunt
25 between the two conductors;

Fig. 3 is the same as Fig. 1 except that the line is pupinized;

Fig. 4 is the same as Fig. 2 except that the line is pupinized; and

Fig. 5 shows any of the circuits of Figs. 1 to 4, inclusive, with modulating and demodulating means shown at the ends of the line for carrier telephony or telegraphy.

In Fig. 1 a line consisting of two conductors 1, 2, is provided with crystals 3 in series in conductor 1. Batteries 4 and 5 supply sufficient potential to the crystals to bias them to the point of negative resistance. Conductor 2 may also be provided with crystals in series if desired, but this is not necessary. Resistances 6, which may be variable if desired, are provided in shunt with the crystals 3. These resistances are adjusted so that the same amount of current passes through each crystal regardless of the voltage losses in the line, and the spacing of the crystals. Choking coils 7 are connected in series with the resistances 6 across the crystals 3 to protect the resistances from alternating current in the conductors. Choking coils 8 are also connected in series with the batteries 4 and 5 across the conductors 1 and 2 to protect these batteries against the alternating current in the line.

Condensers 9 are connected in the conductors 1 and 2 to limit the flow of direct current to the

section of the line supplied by batteries 4 and 5.

In Fig. 2 the crystals 3 are connected in parallel across the conductors 1 and 2. In this case the resistances 10 are connected in series with the crystals 3 and are shunted by condensers 11 to by-pass the alternating currents.

The crystals may be spaced on the line at any desired intervals and improved transmission characteristics will result. However, the best results will be obtained when the crystals are equally spaced. It is possible to eliminate power losses completely by determining the spacing in accordance with the well known formula which represents the departure of the transmission characteristics of lumped lines from smooth lines.

Figs. 3 and 4 show how my invention may be applied to pupinized lines. When so applied all the advantages of the pupinized line are retained and the advantages of my invention are also obtained. When the line is not loaded, the crystals are inserted at more frequent intervals than loading coils are inserted in the case of a loaded line. If my invention is applied to loaded lines, however, the crystals and the loading coils should be mounted together.

Fig. 3 is identical with Fig. 1 except for the insertion of loading coils 12, as shown.

Fig. 4 is identical with Fig. 2 except for the insertion of loading coils 13, as shown.

In Fig. 5 signals originating in a microphone Mic are modulated in a modulator Mod with the natural oscillations of the line. At the other end of the line the signals are detected in a rectifier, and received on a telephone or any other suitable receiving device. The apparatus shown in Fig. 5 may be applied to the lines shown in any of the preceding figures.

What is claimed is:

1. An alternating current signaling system comprising a line consisting of a pair of conductors in a cable, crystals connected directly in one of said conductors to compensate for watt losses of signal energy in said conductors, means remote from the crystals and external to the cable for biasing the crystals to a point of negative resistance, a resistance shunting each crystal for regulating the biasing current supplied thereto, and a choke coil in series with each resistance to reduce the flow of alternating current through the resistance.

2. Means for reducing the loss of signal energy in alternating current signaling systems, comprising conductors, crystal contacts to reinforce alternating currents in said conductors, a choke coil and a resistance element shunting each crystal contact, and remote means for supplying direct current to said crystal contacts thereby to bias the crystal contacts to a point of negative resistance.

3. Means for reducing the watt losses of signal energy in signaling systems, comprising a line consisting of conductors, crystal contacts connected in said line to reinforce the signaling currents traversing said conductors, a choke coil and resistance element shunting each crystal contact, means to supply direct current over said conductors to each crystal contact to bias said crystal contacts to a point of negative resistance, and an impedance to signaling currents interposed between said conductors and said supply means.

4. Means for reducing the watt losses of signal energy in signaling systems, comprising conductors, crystal contacts connected in said conductors to reinforce the signaling current therein, a choke coil and resistance shunting each crystal

contact, means at the ends of said conductors to supply direct current to each crystal contact, and impedances connected between the terminals of said means and said conductors.

5. Means for reducing the watt losses of signal energy in alternating current cable signaling systems, comprising conductors, crystal contacts to reinforce the current in said conductors, a choke coil and a resistance shunting each crystal contact, means at the ends of said conductors for supplying direct current to the crystal contacts, and means for protecting said supply means against alternating currents.

6. Conductors in underground- and submarine cables for alternating current systems shunted by crystal contacts to reduce the watt-losses of the signals in the conductors.

7. Conductors in signaling systems shunted by crystal contacts at regular intervals to reduce the watt-losses of the signals in the conductors.

8. Pupinized conductors in underground- and submarine cables for alternating current systems shunted by crystal contacts to reduce the watt-losses of the signals in the conductors.

9. Two conductors in underground- and submarine cables for alternating current systems shunted by crystal contacts and a resistance in series with each crystal contact.

10. Two conductors in underground- and submarine cables for alternating current systems shunted by crystal contacts and a resistance shunted by a condenser, in series with each crystal contact.

11. Two conductors in underground- and submarine cables for alternating current system shunted by crystal contacts and a resistance shunted by a condenser, in series with each crystal contact and means to connect direct current sources to the conductors for supplying the crystal contacts that they act as negative resistances.

12. Two conductors in underground- and submarine cables for alternating current system shunted by crystal contacts and a resistance shunted by a condenser in series with each crystal contact and direct current sources connected through choking coils with the conductors and condensers between two sections of conductors and crystal contacts.

13. Means to reduce the loss of signal strength in conductors in alternating current signaling systems, comprising a line consisting of a pair of conductors, a plurality of negative resistances connected in said line, and means to modulate the natural oscillations of said conductors.

14. In combination, two conductors in a cable for alternating current signaling, self-induction coils connected to the conductors to compensate for signal attenuation due to capacity effects between the conductors, crystal contacts uniformly spaced along the length of and contained within the cable and connected in series with the self-induction coils to reduce the watt losses of the signals traversing the conductors, and means at the ends of the cable to connect direct current sources to the conductors for supplying thereover to the crystal contacts such biasing current that they act as negative resistances.

15. In combination, two conductors in a cable for alternating current signaling, crystal contacts uniformly spaced along the length of and contained within the cable and connected directly in series in one of the conductors to reduce the watt losses of the signals traversing the conductors, and means at the ends of the cable to connect direct current sources to the conductors

for supplying thereover to the crystal contacts such biasing current that they act as negative resistances.

16. In an alternating current signaling system having a pair of conductors in a cable, means for reducing the watt loss in signal energy transmitted over the conductors comprising a plurality of crystal contacts spaced along and contained within the cable and directly connected in the conductors to reinforce the signal current in the conductors, and means external to the cable at the ends of the conductors for supplying thereover to said crystal contacts biasing direct current to cause the crystal contacts to act as negative resistances.

17. In an alternating current signaling system having a pair of conductors in a cable, means for reducing the watt loss of signal energy transmitted over the conductors comprising a plurality of crystal contacts spaced along and contained within the cable to reinforce the signal current in the conductors, means including a direct current source external to the cable at the ends of the conductors for supplying over the conductors to said crystal contacts biasing current to cause the crystal contacts to act as negative resistances, a resistance element for each crystal contact to regulate the biasing current supplied thereto, and an impedance element for each crystal contact so connected thereto and to the resistance element individual thereto that the alternating current signals are caused to pass readily through the crystal contacts and not through the resistances.

18. In combination, two conductors in a cable for alternating current signaling, self-induction coils connected to the conductors to compensate for signal attenuation due to capacity effects between the conductors, crystal contacts uniformly spaced along the length of and contained within the cable and connected in series with the self-induction coils, the coils being more closely spaced than the crystal contacts whereby

said coils and contacts co-operate to reduce the watt losses of the signals traversing the conductors, and means at the ends of the cable to connect direct current sources to the conductors for supplying thereover to the crystal contacts such biasing current that they act as negative resistances.

19. In an alternating current signaling system having a pair of conductors in a cable, means for reducing the watt loss of signal energy transmitted over the conductors comprising a plurality of crystal contacts uniformly spaced along and contained within the cable and directly connected to the conductors to reinforce the signal current in the conductors, the distance between successive crystal contacts of known negative resistance being such that $Z \sin \alpha a > Z' \sinh \beta a$, where Z is the real and Z' the imaginary impedance of the cable conductors; a is the spacing of the crystal contacts; α is the velocity of the signal currents; and β is the damping efficiency, and means including the source of direct current external to the cable at the ends of the conductors thereof for supplying over the conductors to said crystal contacts biasing direct current to cause the crystal contacts to act as negative resistances.

20. In an alternating current signaling system having a pair of conductors in a cable, means for reducing the watt losses of signal energy transmitted over the conductors comprising a plurality of crystal contacts uniformly spaced along and contained within the cable and directly connected to the conductors to reinforce the signal current therein, the distance between successive crystal contacts being shorter than the shortest wavelength of said signaling currents, and means including sources of direct current external to the cable at the ends of the conductors for supplying over the conductors to said crystal contacts biasing direct current to cause the crystal contacts to act as negative resistances.

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