Dec. 7, 1937. M. BAESECKE ET AL 2,101,699

ALTERNATING CURRENT SIGNALING SYSTEM

Filed May 26, 1934

Fig. 1

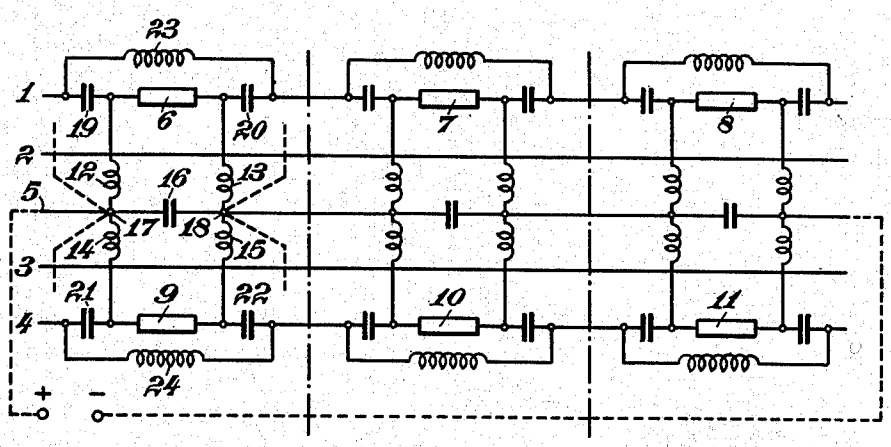
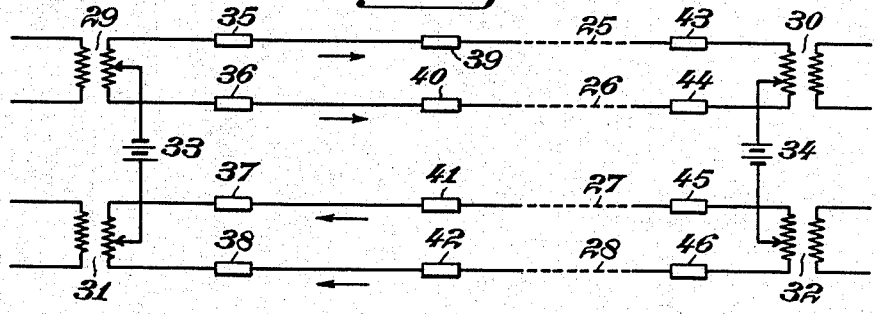


Fig. 2



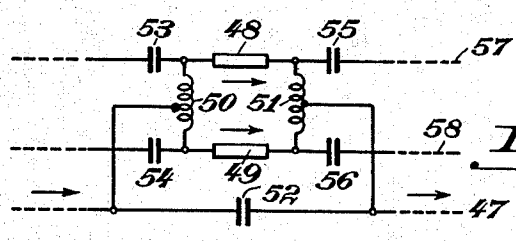
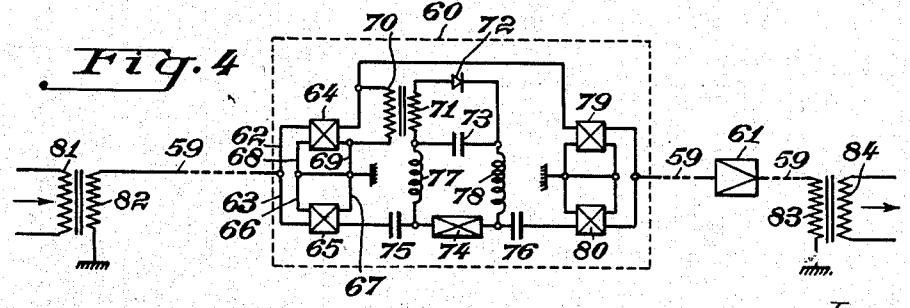


Fig. 3

Fig. 4



Inventors:
Martin Baesecke
and Hans Mayer
by Lotte & Kehlenbeck
Attorneys

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ALTERNATING CURRENT SIGNALING SYSTEM

Martin Baesecke, Berlin-Siemensstadt, and Hans Mayer, Berlin-Charlottenburg, Germany, assignors to Siemens & Halske, Aktiengesellschaft, Siemensstadt, near Berlin, Germany, a corporation of Germany

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14 Claims. (Cl. 178—45)

This invention relates to signaling systems in which negative resistances are employed to reduce the energy losses of signal currents. More particularly this invention relates to alternating current signaling systems, such as telephone or telegraph circuits, especially when the signal currents are transmitted over long distances, for instance over underground or submarine cables. In particular, this invention affords advantages when crystals, powder resistances, suitable metal alloys and so on are used as negative resistances.

One difficulty which must be overcome in signaling systems with negative resistances is the supply and control of the current biasing the negative resistances to a suitable point of their characteristic. This current is be transmitted over the whole signal system which contains widely different resistances, and must have a relatively high input voltage.

According to the present invention special circuits are provided to supply the biasing current to the several negative resistances along the lines. This supply circuit is so dimensioned that a very good insulation exists between the individual supply conductors with respect to the relatively high voltage at the ends of the supply circuit.

A generic feature of the several specific embodiments which we have disclosed in this application, is found in the fact that the voltage required for the production of the biasing current is not applied between the two conductors of a telephone circuit.

According to a further feature of our invention a separate line is provided to supply the biasing current to a plurality of signal lines, especially for cable purposes.

Another feature of the invention consists in employing parts of the signal lines or special circuits cooperating with the signal lines, for supplying bias current to the negative resistances.

Another feature of this invention consists in superposing alternating current channels in the signal current circuits to conduct the alternating current to the points at which negative resistances are located and in rectifying this current to obtain a direct current for biasing purposes. This method affords the advantage that the biasing current can be conducted over direct current blocking devices, such as for instance transformers. Besides separate lines for biasing current are not necessary.

Still another feature of this invention consists in the use of means for controlling the biasing current and adjusting the negative resistances from the ends or section points of the lines. In particular, according to our invention the biasing current itself may be employed for transmitting control impulses over long distances to the several negative resistances or to their control devices.

Further particularities of the invention will be described hereinafter with reference to the examples shown in the accompanying drawing. It is to be understood that the invention is not limited to the precise conditions or proportions herein set forth, as they may be readily varied by those skilled in the art.

Fig. 1 illustrates diagrammatically a system for supplying biasing current to a plurality of signal lines by a single separate line.

Fig. 2 represents a system for supplying a biasing current only by signal lines without disturbing the signal transmission.

Fig. 3 shows the supply of biasing current from a separate line to a two-wire circuit with parallel negative resistances.

Fig. 4 shows the superposition of an alternating current for biasing purposes in a signal line.

In Fig. 1 we have illustrated a section of a plurality of lines parallel to each other which are provided for signal purposes, for instance this figure may represent a portion of a telephone cable. For the sake of simplicity we have shown only two double wire circuits 1, 2 and 3, 4 respectively. The portion illustrated is subdivided, as indicated by the vertical dash-dotted lines, into three subsections in which negative resistances of well-known character, and particularly bodies of suitable substances are arranged in the conductors 1 and 4, as indicated at 6, 7, 8 and 9, 10, 11 respectively. Both terminals of the negative resistances are connected over chokes (designated by 12, 13 and 14, 15 respectively in the left-hand subsection) to the conductor 5 which serves as supply source for biasing the negative resistances. As indicated the conductor 5 extends parallel to the signal lines and is connected to a direct current source which may be located at one end of the cable. The ends of the chokes connected to the conductor 5 are also connected to each other by a capacity, indicated at 16.

The latter as well as the chokes are provided to block the supply conductor 5 and the circuits with respect to one another against voice currents flowing through a negative resistance. Energy losses and crosstalk are thus prevented. Instead of simple chokes, networks may be provided, preferably with a short-circuit on the side of the supply conductor. The middle and the right portions of Fig. 1 show the same arrangement for each of the subsections as the one at the

extreme left. At the points 17, 18 we have indicated by the dotted lines that two further wire circuits may be connected to the supply conductor in the same number. For the return of the biasing direct current we may use a separate conductor or ground connections.

Particularly when using cables, the cable sheathing or the sea water may serve as the return conductor.

As shown in Fig. 1, the negative resistances of one conductor are connected in series with respect to the biasing current, that is, the two ends of the negative resistances are connected to the same conductor of the supply circuit. According to our invention, it may be preferred in some cases to connect the negative resistances belonging to one circuit, alternately or in any other desired order to one or the other conductor of the supply circuit, in which case a separate conductor would be provided for each direction of the supplying current. The negative resistances may be also connected in parallel to the supply conductor with respect to the same points of view as above described, to block the supply circuit against the signaling currents. The adjustment of the working points of the negative resistances may be effected by series or parallel connection of separate resistances or by suitable dimensioning of filters, or even when the same relations exist in all circuits, by connecting resistances in the supply circuit or by suitable dimensioning of the supply circuit. When using the invention for long distance lines, particularly in the case of parallel lines as in a cable, a preferable arrangement might be to provide several supply circuits or to arrange a main supply circuit and branch off at predetermined intervals, sub-supply circuits supplying biasing current to the corresponding sections. A supply circuit with a separate source may also be provided for several sections of a line or of a bunch of circuits.

To prevent a flow of the biasing current through the signal conductors from the two sides of the negative resistances, according to Fig. 1 the sections of these conductors between the negative resistances are blocked against the biasing current by capacities, such as indicated at 19, 20 and 21, 22 respectively, having only a low resistance to the passage of the signal currents. To enable a flow of direct current or of low frequency alternating currents for signal purposes through the conductors 1 and 4, suitable by-pass connections are provided. In Fig. 1 simple chokes 23, 24 are indicated for this purpose. These must be dimensioned to offer a high resistance to currents of higher frequencies such as, for instance, voice currents.

According to a further feature of our invention the two wires of a supply circuit are strung or arranged in such a manner that they will be separated from one another by insulation adequate with respect to the direct current voltage. Particularly in the case of cables, the two wires of the supply circuits are arranged in different parts of the cable, for instance in different wire-groups which are very well insulated from each other.

In those cases where the mutual influence of the circuits traversed by the signal currents, for instance the cross talk in cables, is to be reduced to a minimum, a symmetrical distribution of the negative resistances over the two conductors of a circuit is a preferable arrangement. It has been found that the mutual influence of the circuits can be diminished still more if the direction of the biasing current in the two conductors is chosen properly. According to our invention it is preferable to make the biasing current flow through the two conductors of a cable or open line circuits with negative resistances in the same direction in each of the conductors. This method affords special advantages with lines having Pupin coils for damping attenuation, in addition to including negative resistances, because the Pupin coils are biased magnetically in case the biasing current flows through the two conductors in different directions, that is, with respect to the signal current. The biased Pupin coils would diminish their attenuating effect and magnify the cross talk. Preferably, the biasing current is supplied to the two-wire circuit at symmetrical points, for instance over the midpoint taps of transformers, chokes or other cross resistances, and is again taken off at such points.

Examples of such arrangements are illustrated by Figs. 2 and 3.

In Fig. 2 two double-wire circuits, for instance those of a telephone cable having conductors 25, 26 for transmission in one direction and conductors 27, 28 for transmission in the other direction, are shown as connected with the line terminals by transformers 29, 30 and 31, 32 respectively. The midpoints of the transformer windings connected to the line are at the one end of the line connected to a battery 33, and at the other end of the line to a battery 34 supplying the biasing current to the negative resistances 35 . . . 46 connected in the line. The conductors 25, 26 and 27, 28 respectively are traversed, substantially as in a phantom circuit, by the biasing current which flows in the same direction in both conductors of the same pair, whereby the symmetry is magnified considerably. The line section extending from the one or the other end of the whole line to the next pair of negative resistances 35, 36 and 37, 38 or 43, 44 and 45, 46 respectively is suitably equalized to one half of the length of the other line sections for instance 35, 39 . . . 36, 40. In this manner an easy connection of lines may be effected.

Fig. 3 represents an arrangement for supplying the biasing current by a separate conductor. To the terminals of the negative resistances 48, 49 arranged symmetrically in the two conductors 57, 58 of a two-wire circuit, are connected the chokes 50, 51 which connect the said two conductors to one another. From a third conductor 47 the biasing current is supplied to the negative resistances through the said chokes. The capacities 53—56 serve to prevent a flow of direct current through the conductors 57, 58. On the other hand, a capacity 52 is arranged to provide a short circuit for any signal currents which may flow through the chokes 50, 51.

Instead of a separate line such as described above, a phantom circuit may be employed as a common supply circuit for a plurality of lines. In all cases it is preferable to employ side circuits at a considerable distance from one another in the bunch, in view of using a high input voltage. To cause the biasing current to flow through the conductor in the same direction, it is also possible to shunt all conductors with respect to the biasing current by cross resistances or equivalent elements and to employ a common return conductor. The latter may be a separate conductor, or the cable sheathing, or the earth, or sea-water.

In many cases it is not possible to conduct a direct current as a biasing current along the lines

on account of interference from foreign sources, such as power currents. In such cases it is preferable to block the line or sections of the line by transformers. For other reasons as well, for instance when using amplifiers or capacitive couplings in the line, a direct current flow can be prevented.

According to one feature or embodiment of our invention, an alternating current is conducted to the points at which there are negative resistances or over those parts of the line which do not permit a flow of direct current, and is rectified before being supplied to the negative resistances. The alternating current source may be located at the end of the line or of the subsection of the line, or connected to separate conductors provided for supplying the biasing current. Preferably, the rectification is effected by contact devices, for instance dry rectifiers or in any other well-known or approved manner. For this purpose we may use negative resistances of the same character as those provided for reducing the attenuation of the line. Fig. 4 shows an example of such an arrangement.

At 59 we have indicated a long distance line, for instance a submarine cable having only one conductor, the return conductor being replaced by sea-water. At 81, 82 and 83, 84 respectively, we have indicated the terminal transformers to the primary windings of which standard or approved apparatus, for instance any well-known telegraphy apparatus, are connected. The line 59 is subdivided into several sections, each having a repeater station formed by connections with negative resistances such as the one indicated at 74. Let us assume that the telegraph current has a frequency at the lower limit of audio-frequency, and that for biasing the negative resistances there is superposed on the line 59 an alternating current which has a frequency below the audio-frequency band. In the station 60 the telegraph current flows through the filter 65, capacity 75, negative resistance 74, capacity 76 and filter 80 back to the line section between 60 and 61. The filter 64 does not permit passage of the telegraph current but of the superposed biasing current, so that the latter flows through the primary winding 70 of a transformer, the secondary winding of which is connected to a rectifier 72. The rectified alternating current is supplied over the chokes 77, 78 to the negative resistance 74 and acts as a biasing current. The capacity 73 serves as a short circuit for audio-frequency currents coming over 77, 78. In a parallel branch, the alternating current from the filter 64 flows through the filter 79 and furthermore to the line 59. The filters 64 and 79 do not permit the passage of audio-frequency currents and are earthed by the conductors 66, 68. The superposed current for biasing purposes might also be in the range of upper-audio-frequencies.

According to a further feature of our invention, in lines containing negative resistances for reducing the energy losses, means are provided by which the negative resistances can be controlled or switched in or out. This arrangement is particularly advisable in the case of long lines. These means can be adjusted manually or automatically and located at the terminals of the lines or in subsections of the lines. In the latter case a remote control is desirable.

In the simplest embodiment of our invention, the biasing current flowing through the line is controlled for all negative resistances at the terminals of the line or at any other point of the line. This permits a common variation of the attenuation to be effected for the whole line. Regulation may be effected by varying the voltage of the biasing current or by varying the resistance of a branch of the biasing circuit, not traversed by the signal current. For instance, as indicated in Fig. 2, the connection of the batteries 33 and 34 with the coils of the respective transformers may be adjustable, the arrows being the conventional representation of controllers or slides which can be moved to different points of the said coils. When the line is subdivided into several sections and a separate biasing source is provided for every section, the same arrangements can be made. Another possibility consists in apportioning or attaching to every negative resistance the value of which is to be controlled, or to a group of such resistances, a special operating device, for instance a selective switch, by which it is possible to effect a variation of the resistance values, for example a switching in or out of the resistances. By such an operating device parallel resistances can be switched in or out, in steps, for instance the biasing current or the signal current may be conducted over this parallel circuit. The variation of the negative resistances can be also effected in a continuous manner, for instance by influencing continuously changeable positive resistances connected to the negative resistances.

The said regulating devices can be controlled in any well-known manner from the terminals of the line, or from supervisory stations at other points of the line, or in dependence upon the attenuation of the line. According to a further feature of our invention, we may employ the biasing current itself for the remote control of the regulating device, by transmitting impulses for a short time by means of this current, whereby for instance a selective switch is controlled. Using alternating current as the biasing current for the negative resistances rectified at the points where negative resistances are located, switching apparatus can be controlled selectively by varying the frequency of the alternating current in a well-known manner. It is also within the scope of our invention to employ for the remote control, separate lines or channels over which the control of the regulating devices is effected by alternating or direct current.

What we claim is:

1. A signaling system comprising lines for signal transmission, said lines extending from a transmitting station to a receiving station, negative resistances connected in these lines at different distances from the ends of the lines, for reducing the loss of signal energy, and a special line extending lengthwise of the signaling system and connected with a plurality of said signal lines for supplying currents to bias the negative resistances.

2. A cable circuit comprising lines for signal transmission, said lines extending from a transmitting station to a receiving station, negative resistances connected in these lines at different distances from the ends of the lines, for reducing the loss of signal energy, a source of bias current, a separate conductor for supplying said bias current to said negative resistances, and separate means for the return of the bias current to its source.

3. A cable circuit comprising lines for signal transmission, said lines extending from a transmitting station to a receiving station, negative

resistances connected in these lines at different distances from the ends of the lines, for reducing the loss of signal energy, a source of bias current, and a two-wire circuit for supplying said bias current to said negative resistances, the two wires of said circuit within the cable being well separated from each other electrically.

4. A signaling system comprising a signal line extending from a transmitting station to a receiving station, negative resistances connected in said line at different distances from its ends, for reducing the loss of signal energy, a separate line for supplying biasing current to said negative resistances, filters interposed between the said biasing current line and the signal line to block the signal currents, and devices located in the signal line on either side of each negative resistance, to block the biasing current.

5. A signaling system comprising a signal line extending from a transmitting station to a receiving station, negative resistances connected in said line at different distances from its ends, for reducing the loss of signal energy, and a separate line for supplying biasing current to said negative resistances, each side of a negative resistance being connected with the same conductor of said separate line.

6. A signaling system comprising two signal lines each composed of two conductors, negative resistances connected in said conductors, and a separate current supply circuit for biasing the said negative resistances, the two conductors of one signal line being connected in parallel for leading the biasing current in the one direction, and the two conductors of the other signal line being connected in parallel for leading the biasing current in the other direction.

7. A signaling system comprising a cable containing two signal lines each composed of two conductors and well separated electrically from the other line, the two conductors of the same line being connected in parallel, negative resistances connected in said lines, and means for supplying biasing currents to said negative resistances, said biasing means being connected to each of said four conductors.

8. A signaling system comprising a signal line composed of two conductors, negative resistances connected in said conductors at corresponding points thereof, cross-connections between said conductors to connect them in parallel at the two terminals of said negative resistances, and a separate line, connected with said cross-connections, for supplying biasing current to said negative resistances.

9. A signaling system comprising a signal line, negative resistances in said line, a source of current for biasing said negative resistances, and a single controller, connected in series with a plurality of said resistances for varying the voltage of said biasing current in such plurality of resistances.

10. A signaling system comprising a signal line, negative resistances in said line, a source of current in circuit with said negative resistances for biasing the latter, and a single controller, connected in series with all the resistances in said circuit, for varying the resistance of the circuit through which said biasing current flows through all of said resistances.

11. A signaling system comprising a plurality of independent electrical circuits for signal transmission, each circuit having conductors extending from a transmitting station to a receiving station, negative resistances connected in these conductors for reducing the loss of signal energy, and means for supplying currents to bias the negative resistances, said means including auxiliary conducting means connected between said conductors and connected to a source of current to form an electrical circuit through said resistances and substantially coextensive with said system.

12. A signaling system comprising a plurality of independent electrical circuits for signal transmission, each circuit having conductors extending from a transmitting station to a receiving station, negative resistances connected in these conductors for reducing the loss of signal energy, and means for supplying currents to bias the negative resistances, said means including current supply means, auxiliary current conducting means for connecting a terminal of said current supply means to said conductors, and to form an electrical circuit through said resistances and substantially coextensive with said system.

13. A signaling system comprising a plurality of independent electrical circuits for signal transmission, each circuit having conductors extending from a transmitting station to a receiving station, negative resistances connected in these conductors for reducing the loss of signal energy, and means for supplying currents to bias the negative resistances, said means including unidirectional current supply means connected to said conductors for passing the biasing current at least through parts of said conductors and to form electrical circuits through said resistances and substantially coextensive with said system.

14. A signaling system comprising a plurality of independent electrical circuits for transmitting separate signals between stations, each circuit having a conductor with negative resistances connected therein to reduce the loss of signal energy, and means to supply current to bias said resistances, said means comprising a source of bias current and means connecting said source with each of said independent circuits.

MARTIN BAESECKE.
HANS MAYER.