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SHAPING ARRANGEMENT FOR METALLIC TELEGRAPH CIRCUITS

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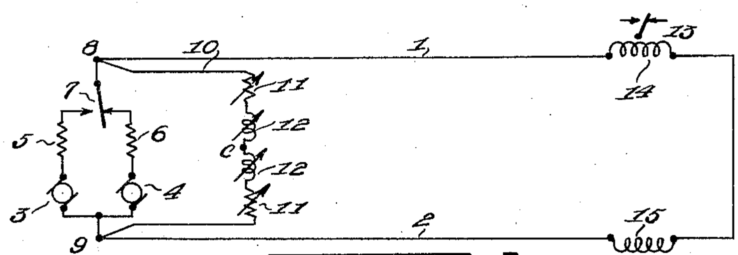

Fig. 1

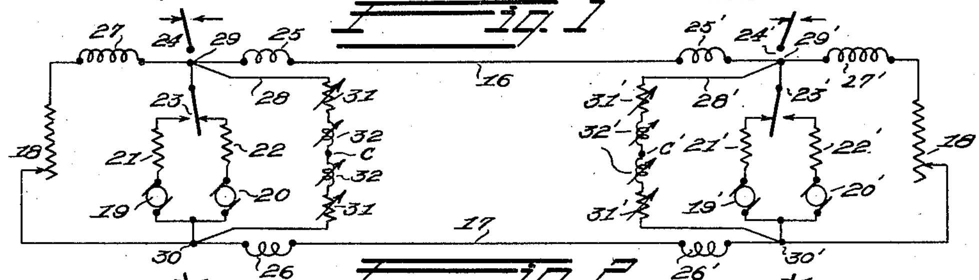

Fig. 2

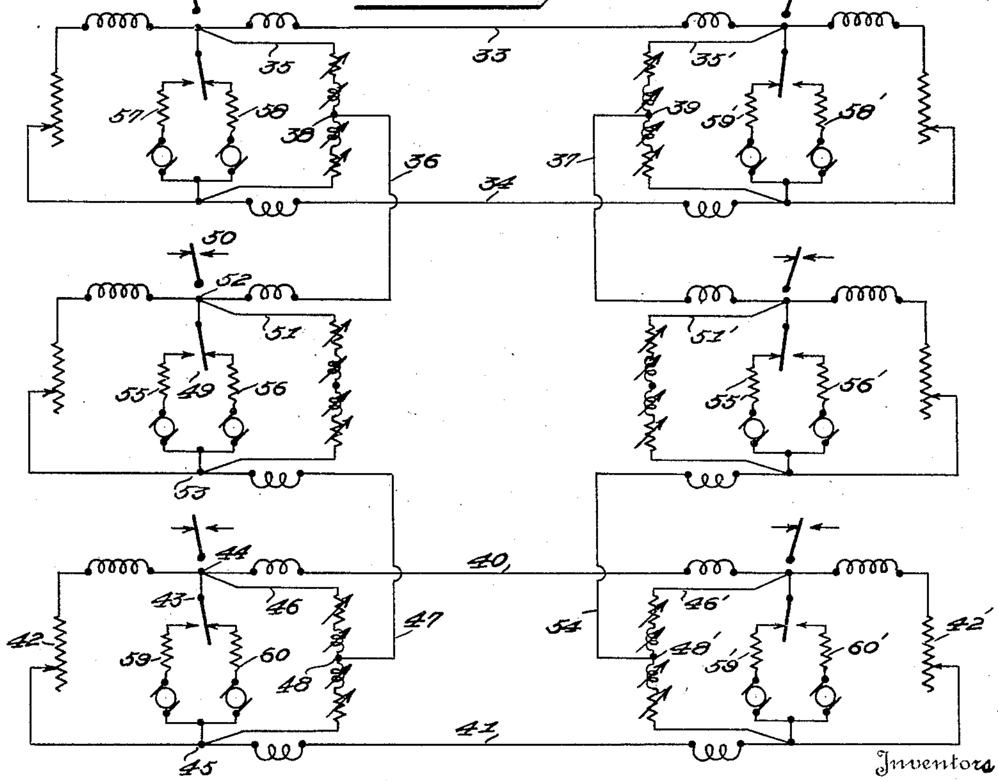

Fig. 3

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UNITED STATES PATENT OFFICE

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SHAPING ARRANGEMENT FOR METALLIC TELEGRAPH CIRCUITS

Application filed July 9, 1930. Serial No. 466,790.

This invention relates to telegraph circuits, and in particular to shaping networks for metallic telegraph circuits.

The object of the invention is to control the distortion at the receiving end of the telegraph circuit by means of a properly adjusted shunt containing resistance and inductance in combination with a series resistance in the battery leads at the transmitting or distant end of the circuit.

A further object of the invention is to utilize for this purpose the inductive resistance shunt in a superposed system which is used to provide a means for superposing the phantom circuit on the two side circuits.

Broadly, the object of the invention is to so compensate for line distortion that the speed of signal transmission can be materially increased.

The factor which limits the speed at which telegraph signals may be transmitted over a long metallic circuit has been found to be signal distortion. As the speed of operation is increased this distortion becomes evident as a shortening of certain signals and lengthening of others. In general the tendency is to shorten the pulses of single dot frequency following a long pulse of opposite polarity. This is a result of the current of the single pulse not having time to attain its final or steady state value in the receiving relay.

The metallic circuit attenuates the signals in proportion to their frequency. When the difference between the attenuation to the direct current, or zero frequency, signal component and to the highest dot frequency transmitted becomes too large, the telegraph circuit becomes unworkable on account of distortion. The difference between the attenuation of the entire circuit to the highest dot frequency of transmission and the attenuation to the lowest dot frequency of transmission can be considered as a measure of the circuit distortion.

The permissible difference in the attenuation to the highest dot frequency and the attenuation to the lowest dot frequency will vary somewhat with the character of the receiving apparatus. Experience has shown that even with modern telegraph relays a circuit begins to fail due to distortion when the speed is reached where the attenuation to the highest dot frequency is twice the attenuation to the lowest frequency. On electrically long metallic circuits the speed at which this ratio obtains is quite low. It is therefore necessary to provide some means for compensating for distortion if long metallic circuits are to be utilized economically for telegraph service.

There are several methods of compensating for this distortion. The method disclosed hereinafter is convenient and effective and is of particular advantage in connection with superposed systems such as disclosed in R. V. Morgenstern Patent No. 1,758,900, dated May 13, 1930, entitled Superimposed telegraph circuits. In that application an inductive shunt about the transmitting generator or signal source is used to provide a means for conductively connecting the phantom circuit to the two side circuits. Because of its selective action this same inductive shunt can, by proper adjustment, serve as the signal shaping means compensating for line distortion. As the line circuit attenuates the high frequencies to a greater extent than the low frequencies, a means for attenuating the transmitted signal in such a way as to compensate for the circuit attenuation would serve to correct signal distortion.

Figures 1, 2 and 3 illustrate telegraph circuits with inductive shunts adapted to correct for signal distortion.

Figure 1 shows a circuit designed for one-way metallic transmission only.

Figure 2 shows a circuit duplexed for two-way metallic transmission.

Figure 3 shows a superposed system in which both the side circuits and the phantom circuit are duplexed for two-way transmission. In this figure the inductive shunt and shaping network is applied to all three circuits of the superposed system.

In Figure 1 the line conductors 1, 2 extend between transmitting apparatus at one terminal and receiving apparatus at the other. The transmitting apparatus comprises metallic generators 3 and 4 having a common terminal connected to one line conductor 2 with their opposite terminals connected through resistances 5 and 6 to the tongue and contacts of a transmitter 7, thence to the other line conductor 1. The line terminals to which the transmitting apparatus is connected are indicated at 8 and 9. In shunt to the line, at the terminal 8 and 9, is connected a shunt circuit 10 comprising resistances 11, 11 and inductances 12, 12. As illustrated, the resistance and inductance is split to provide a center point C, but this is not essential if the shunt does not also serve as a means for conductively connecting a superposed circuit to the metallic side circuit. The inductances and resistance may be variable.

At the distant end of line conductors 1, 2 is a receiving relay 13 comprising coils 14 and 15. The tongue and contacts of the receiving relay are indicated diagrammatically.

It will be noted that shunt 10 is in parallel with the line circuit. Whatever current flows through this shunt passes through the common battery tap resistance 5 or 6, and therefore lowers the potential applied to the line circuit at terminals 8, 9, since the potential applied to the line circuit is the transmitting battery potential minus the drop through the battery tap resistance.

The shunt circuit consisting of inductance and resistance will pass current in inverse proportion to the frequency. Consequently the potential applied to the line circuit will vary with the signal frequency. It will be highest for the high frequencies and lowest for the steady state, or zero frequency, condition. This variation in potential applied to the line circuit can be made to compensate for the unequal attenuation in the circuit. When the shunt circuit has been properly adjusted, the over-all effect as viewed from the receiving end is that all frequencies in the signal range are more uniformly attenuated.

In Figure 2 the line 16, 17 is balanced for duplex operation by means of an artificial line 18 at each terminal. As in Figure 1, metallic generators 19, 20 are connected to line through resistances 21 and 22, and the tongue and contacts of transmitter 23. The receiving relay 24 comprises coils 25, 26 and an additional coil 27 connected in series with the artificial line in the usual manner to make the receiving relay 24 non-responsive to signals originating at the transmitter of the same station. The tongue and contacts of the receiving relay are diagrammatically represented at 24.

As in Figure 1 a shunt circuit 28 is connected across the terminals 29 and 30 of the line. This shunt comprises resistances 31 which may be variable and inductances 32 which may also be variable. The shunt 28, when suitably adjusted, serves as a shaping shunt for signal impulses originating at the transmitter 23. The electrical midpoint of the shunt, at which a phantom circuit may be connected, is indicated at C.

At the distant station similar apparatus is provided the elements of which are indicated by the same numerals with the prime added. Thus the shunt 28′ at the distant station is connected to terminals 29′, 30′, and acts as a shaping network composed of resistance and inductance for signal impulses originating at transmitter 23′.

In Figure 3 the apparatus described is duplicated for the two side circuits, and similar apparatus is used at the phantom circuit terminals. The line conductors 33, 34 are arranged for duplex operation, and the shunt circuits 35 and 35′ serve at opposite terminal stations to correct for line distortion. In addition these shunt circuits act as means for conductively connecting the phantom circuit conductors 36 and 37 to the side circuit. The connection of conductor 36 to shunt 35 is made at its electric midpoint 38, and the connection of conductor 37 is made to the electrical mid-point 39 of shunt 35′. A second side circuit comprising line conductors 40—41 is adapted for duplex operation by means of artificial lines 42 and 42′. A transmitter 43 is connected to terminals 44 and 45 of line conductors 40—41, and to the same terminals is connected the shunt circuit 46 comprising resistance and inductance. The phantom circuit conductor 47 is connected at the mid-point 48 of shunt 46. The phantom circuit apparatus is represented diagrammatically as comprising a transmitter 49 and receiving relay 50. An inductive resistance shunt 51 is connected across terminals 52, 53 of the transmitter 49 and serves to shape the signal impulses from transmitter 49 to correct for line distortion on the phantom circuit.

It will be seen that the inductive shunts 35, 35′ 46, 46′ are tapped at their electrical midpoints by the conductors 36, 37, 47 and 54 respectively to connect the phantom circuit apparatus to the side circuits in non-interfering relation. In addition these shunts 35, 35′, 46 and 46′ act in combination with the battery lead resistances, as shaping networks for their respective transmitters. Additional shunts 51, 51′ act, in combination with the battery lead resistances of the phantom current sources, as shaping networks at the terminals of the phantom circuit. The battery lead resistances of the phantom circuit are indicated at 55—56 and 55′—56′; of the side circuits at 57—58 and 57′—58′, and at 59—60 and 59′—60′.

The operation of the shunt disclosed in the above mentioned patent to R. V. Morgenstern No. 1,758,900 in providing a midpoint connection of the phantom circuit to the side circuit current source, is as follows:

Signals are transmitted to the line at a terminal station by supplying current impulses to the line through the windings of the receiving relay. When transmitting signals over the side circuit, current impulses of opposite polarities are sent to line from the potential sources by way of the tap resistances, transmitter tongue, and one or the other of its contacts. There is a tendency for current to flow through the shunt by reason of its connection across the two points at which battery is applied to the terminal set on the side circuit. The inductance and resistance of the shunt are so regulated in relation to the constants of the circuit that the shunting action of the shunt circuit at the beginning of a signal is practically suppressed.

When the transmitter reverses the polarity of the signaling current, the impedance of the shunt at that instant is very high and allows a very small current to flow through it to the battery return. This means that at the beginning of the signal there is a very small increase in the voltage drop, due to the shunt on the battery supply, across the resistance placed in the connection from the potential sources to the contacts of the transmitter. The drop in voltage is so small however, that practically the same voltage is applied to the line conductor at the biginning of a signal as would be the case if this shunt were not present.

As the length of time during which the same polarity of signaling current is impressed on the circuit increases, the amount of current through the shunt increases, and the voltage across the resistance in the leads from the potential sources to the transmitter contacts also increases, thus lowering the potential applied to the line.

The action of the shunt circuit in controlling the voltage applied to the line circuit is, because of the nature of the shunt, selective with frequency. That is, the shunting action of the inductive shunt is less for the higher frequencies. The drop in voltage across the tap resistance is, therefore, greater in proportion for the lower frequencies than for the higher frequencies and reaches a maximum of zero frequency or the direct current condition. Accordingly the voltage applied to the line is greater for the higher frequencies and less for the lower frequencies. The inductive shunt thus has a tendency to distort the transmitted signal impulses, by accentuating the higher frequency components.

When the line over which the signals are transmitted has a tendency to distort the transmitted signals in the opposite sense, that is, to attenuate the higher frequency components more than it does the lower frequency components, the distortion introduced by the inductive shunt will compensate to a large extent for the distortion introduced by the line. By properly adjusting the relative values of resistance and inductance in the shunt and their values with respect to the resistance in the battery leads and the constants of the line circuit, the inductive shunt may be made to effect substantially complete compensation of the line distortion. That is, the inductive shunt and battery lead resistance form a shaping network which act to vary the voltage applied to the line in accordance with the frequency, so that the received wave at the other end of the line shall be undistorted. By this method, the difference between the attenuation to the direct current, or zero frequency, signal component and the attenuation to the highest dot frequency transmitted may be made so small that line distortion is reduced to a minimum. Thus the shortening of the pulses of single dot frequency following a long pulse of the opposite polarity is substantially entirely eliminated.

This makes it possible to reach the much desired higher speeds before the attenuation ratio at which the distortion makes operation impossible is reached.

The resistance of the shunt can be made as small as is compatible with the minimum voltage which must be applied to the line and with the ratio it must bear to the other elements of the shaping network in order that the desired shaping effect may be obtained.

It should be noted that the resistance in the battery leads is a part of the shaping circuit. The shaping effect is due to the variation with frequency of signaling voltage, that is, the voltage of the source minus the drop through the tap resistances.

In addition to this effect, when the tongue of the transmitting device rests on one contact, magnetic energy is stored in the shunt. When the tongue of the transmitting device is in mid-air passing between contacts and when it reaches the opposite contact, this magnetic energy in the shunt is given up to the line circuit. This tends to increase the peak of the transmitted signals which further increases the applied potential at the higher frequencies.

The shaping network of the invention is equally applicable to simplex or duplex working, and may be applied to any or all of the three circuits in a metallic superposed system. In Figure 3 the shaping device is applied to duplex working on each of the side circuits and on the phantom circuit of the superposed system.

As disclosed in the above mentioned application, the inductance of the shunt circuit may comprise a single coil tapped at its center whereby it offers a minimum inductive reactance to superposed currents and a maximum impedance to current in the side circuits.

It is obvious that numerous variations may be made in the specific embodiment of the invention disclosed without departing from the spirit of the invention.

We claim:

1. In a telegraph system a distorting transmission line having unequal attenuating properties for different frequencies of a signaling range, transmitting means therefor, a shaping network designed to compensate for said unequal attenuation comprising resistance and inductance connected in series with said transmitting means but in parallel to said line, and a superposed circuit connected to the electrical midpoint of said resistance and inductance.

2. A telegraph system comprising a distorting line, transmitting and receiving apparatus at each end of the line arranged for duplex operation thereover, shunt circuits connected in parallel to the line at the line terminals of the transmitting apparatus, a superposed circuit connected to the electrical mid-points of said shunt circuits, and means in said shunt circuits for adjusting its electric constants so that the potential applied to the line from its associated transmitting apparatus varies with frequency in a manner to compensate for the unequal attenuating properties of the line.

3. A telegraph system comprising a distorting line, transmitting and receiving apparatus at each end of the line arranged for duplex operation thereover, inductive shunt circuits connected in parallel to the line at the line terminals of the transmitting apparatus, a superposed circuit connected to the electrical midpoints of said shunt circuits, the inductance and resistance of said shunt circuits being so adjusted that the shunting action of the circuit is practically suppressed at the beginning of a signal and thereafter varies with frequency in a manner to compensate for the distorting action of the line for currents from said transmitting apparatus.

4. A telegraph system comprising a distorting line, transmitting and receiving apparatus at each end of the line arranged for duplex operation thereover, inductive shunt circuits connected in parallel to the line at the line terminals of the transmitting apparatus, a superposed circuit connected to the electrical midpoints of said shunt circuits, transmitting apparatus for said superposed circuit, a shunt circuit connected across the superposed circuit transmitter, the electrical constants of said shunt circuits being so adjusted that its shunting action varies with frequency in a manner to compensate for the distorting action of the line for currents from its associated transmitting apparatus.

5. A telegraph system comprising a distorting line, transmitting and receiving apparatus at each end of the line arranged for duplex operation thereover, inductive shunt circuits connected in parallel to the line at the line terminals of the transmitting apparatus, the electrical constants of said shunt circuits being so adjusted that the shunting action of the circuit is suppressed at the beginning of a signal and then varies with frequency to compensate for line distortion, a superposed circuit connected to the electrical midpoints of said shunt circuits, transmitting and receiving apparatus therefor and a shunt circuit for said superposed circuit transmitting apparatus having electrical constants so adjusted that the shunting circuit acts as a shaping network for the superposed currents to compensate for the distortion of said line for superposed currents.

6. A telegraph system comprising a pair of transmission circuits, transmitting and receiving apparatus at both ends of each transmission circuit arranged for duplex operation thereover, inductive shunt circuits connected in parallel to the transmission circuits at the line terminals of the transmitting apparatus, a superposed circuit connected to the electrical midpoints of said shunt circuits, transmitting and receiving apparatus for said superposed circuit, an inductive shunt for said superposed circuit transmitting apparatus, the electrical constants of said last mentioned inductive shunt being adjusted so that it will act as a shaping network for current from said superposed circuit transmitting apparatus to compensate for distortion of said transmission lines of current from its associated transmitting apparatus.

7. A telegraph system comprising a pair of transmission circuits, transmitting and receiving apparatus at both ends of each transmission circuit arranged for duplex operation thereover, inductive shunt circuits connected in parallel to the transmission circuits at the line terminals of the transmitting apparatus, a superposed circuit connected to the electrical midpoints of said shunt circuits, transmitting and receiving apparatus for said superposed circuit, an inductive shunt for said superposed circuit transmitting apparatus, the electrical constants of a plurality of said inductive shunts being adjusted so that the shunt will act as a shaping network for current from its associated transmitting apparatus to compensate for distortion in said transmission circuits.

8. A telegraph system comprising a pair of transmission lines, transmitting and receiving apparatus at both ends of each transmission circuit arranged for duplex operation thereover, inductive shunt circuits connected in parallel to the transmission circuits at the line terminals of the transmitting apparatus, the electrical constants of the shunt circuit being so adjusted that the shunting action of the circuit is practically suppressed at the beginning of a signal and thereafter varies with frequency in a manner to compensate for the distorting action of the transmission circuit

for currents from its associated transmitting apparatus, a superposed circuit connected to the electrical midpoints of said shunt circuits, transmitting and receiving apparatus for said superposed circuit, a shunt circuit connected in parallel to the superposed circuit at the terminals of the superposed circuit transmitting apparatus, the electrical constants of said last mentioned shunt being adjusted so that the potential applied to the superposed circuit line from the superposed circuit transmitting apparatus varies with frequency in a manner to compensate for the distorting action of the superposed circuit line for currents from said superposed circuit transmitting apparatus.

In testimony whereof, we affix our signatures.

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