Dec. 7, 1937. G. C. CUMMINGS 2,101,243

TELEGRAPH SIGNAL REPEATING SYSTEM

Filed June 11, 1935

FIG. 1

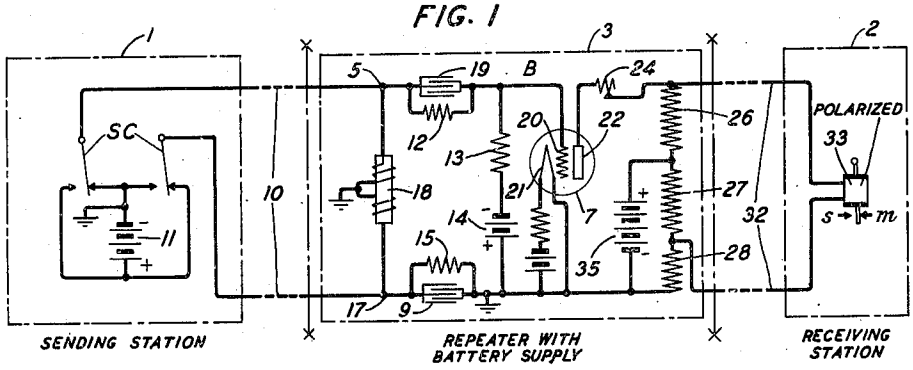


FIG. 2

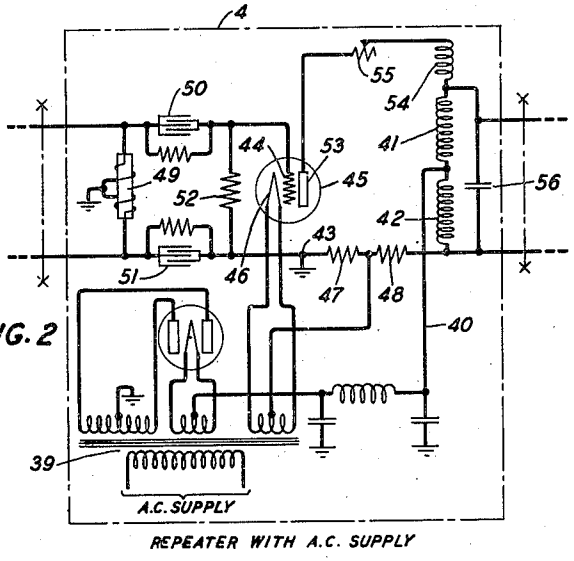


FIG. 4

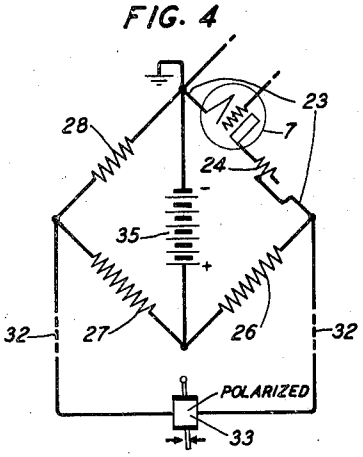
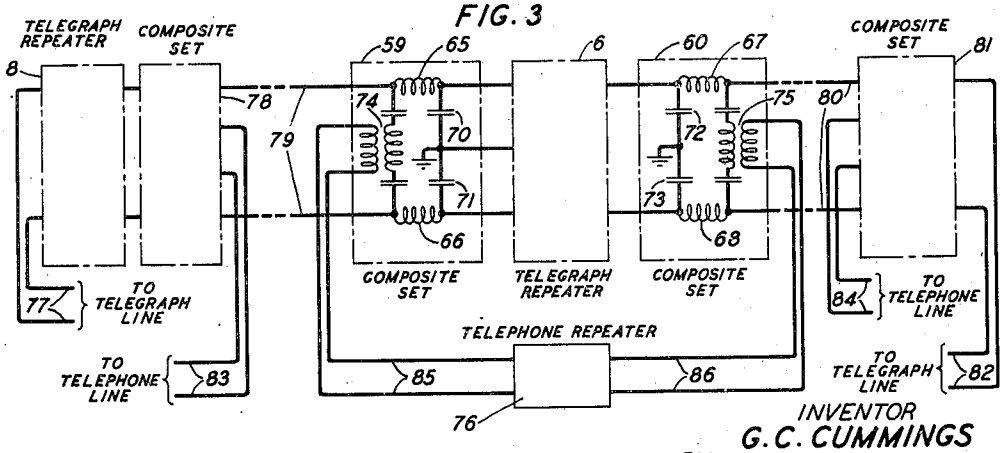


FIG. 3



INVENTOR
G. C. CUMMINGS
BY
J. W. Schmied
ATTORNEY

Patented Dec. 7, 1937 2,101,243

UNITED STATES PATENT OFFICE

2,101,243

TELEGRAPH SIGNAL REPEATING SYSTEM

George C. Cummings, Orange, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 11, 1935, Serial No. 26,030

5 Claims. (Cl. 178—70)

This invention relates to telegraph repeaters and particularly to telegraph repeaters for use in connection with telephone lines.

It is an object of the invention to provide a repeater which may be connected through the usual composite set to a telephone line without introducing noise in the telephone circuit over the line.

It is another object of the invention to provide a repeater which will produce signals of proper wave shape to prevent introduction of noise in telephone circuits.

A further object is to provide a simple telegraph repeater for use on telephone circuits and which requires no wave shaping facilities in its output circuit.

In accordance with the invention the repeater is of the type in which the wave shape in the output circuit may be controlled from the input circuit.

In accordance with another feature of the invention the repeater comprises amplifying means of the thermionic space discharge type and the input is connected directly to its line section to receive attenuated signal impulses free from audible frequencies, and the output circuit from the thermionic amplifying means is connected directly to the next line section to reproduce the received signal impulses in amplified form and with their wave shape substantially unchanged.

In accordance with a more specific feature a simple bridge circuit may be inserted in the output of the amplifying means when it is desired to transform the unidirectional impulses produced by the amplifying means into impulses of alternate direction.

In accordance with still another specific feature the metallic circuit for incoming impulses is segregated from the input circuit of the amplifying means by means of condensers of sufficient capacity to pass impulses of signaling frequency and bridged by leak circuits to prevent accumulation of charges thereon. This arrangement permits the use of ground connections and other potentials in the two segregated circuits without mutual interference. The input side of the repeater may thus be used with two-wire metallic lines or with one-wire grounded lines.

The features of the invention hereinbefore stated make it feasible to use the conductors of the telephone plant with great flexibility for telegraphic purposes, which is particularly desirable in view of the large demand for teletypewriter service. With this invention it is practicable to use ordinary small gauge telephone cable with its high specific resistance and capacitance, either for telegraph service alone, or for combined telegraph and telephone service, over long distances.

The invention will be more fully understood from the following description of certain specific embodiments in conjunction with the accompanying drawing in which,

Fig. 1 is a circuit diagram which shows a sending station and a receiving station connected together at an intermediate point by a telegraph repeater, which is arranged according to this invention and uses batteries as a source of energy.

Fig. 2 shows a repeater similar to the repeater of Fig. 1 except that the current for its operation is obtained from a rectifier supplied from a source of commercial alternating current, instead of from batteries.

Fig. 3 illustrates circuit connections for providing combined telephone and telegraph service on a line with repeaters, similar to the repeaters of Fig. 1 or Fig. 2, installed at different points on the line.

Fig. 4 illustrates in schematic form how the output circuit of the repeater is arranged in the form of a Wheatstone bridge circuit.

The operation of the invention will first be described in detail in connection with the circuit diagram shown in Fig. 1. Let it be assumed that station 1 is sending to station 2 and that sending contacts SC at station 1 are operated to the right, as shown, closing a circuit over line 10 to the repeater 3 to transmit a normal or marking impulse. This circuit may be traced from the positive terminal of battery 11, through right-hand contacts SC, lower conductor of line 10 through lower winding of retardation coil 18 to ground. The negative or grounded terminal of battery 11 is connected through the left-hand contacts SC to the upper conductor of line 10 and through upper winding of retardation coil 18 to ground. Because of the ground on the negative terminal of battery 11 and ground at the center point of retardation coil 18 no current will flow over the upper conductor of line 10 from battery 11. Accordingly, the battery 14 maintains a negative bias on grid element 20 of thermionic space discharge tube 7 with respect to cathode element 21. As a result of the negative potential of grid element 20, the resistance through tube 7 from cathode element 21 to plate element 22 is very high.

In the output or plate circuit of the tube 7 is included a regulating resistance 24, and resistances 26, 27 and 28 forming a bridge circuit supplied with current from plate battery 35 and controlled by the tube 7 to produce alternating current impulses in the line circuit 32. This arrangement is shown in a simplified form in Fig. 4, where the parts corresponding to those in Fig. 1 are similarly numbered.

Under the condition just described the plate circuit resistance is higher than resistance 28 so that current will flow over line 32 and through the winding of a sensitive polar relay 33 at the

receiving station 2 in a direction that causes relay 33 to operate to its marking contact.

Assuming now that sending contacts SC are operated to the left to send an alternate or spacing impulse, connecting the upper conductor of line 10 to the positive terminal of battery 11, and the lower conductor to the grounded or negative terminal of battery 11, the potential of grid element 20 then will be changed from negative to positive, because, due to the positive potential established on junction point 5, there is a charging current flowing through condenser 19, high resistance 13 and battery 14 to ground which will create a potential drop across resistance 13 opposite to and overcoming the negative potential of battery 14. In order to balance the line a condenser 9, equal in capacity to condenser 19, is connected in the lower conductor of line 10. High resistance 12 bridged around condenser 19 serves to discharge the condenser during transmission of marking impulses. A similar resistance 15 is connected around condenser 9.

As a result of the above described change of grid potential the resistance of the plate-cathode circuit of tube 7 now becomes much lower than resistance 28. Therefore, the current over line 32 and through the winding of relay 33 is reversed and relay 33 accordingly is operated to its spacing contact. This reversal of current may be readily understood from a consideration of Fig. 4. When the resistance of bridge arm 23, which includes the cathode plate circuit of tube 7 becomes much less than that of the arm which includes resistance 28 the potential applied to the left-hand terminal of relay 33 will be higher than that applied to the right-hand terminal, which is the reverse of the condition existing when the resistance of bridge arm 23 was very high. Variable resistance 24 which is included in the cathode plate circuit is provided so that the current flow through relay 33 may be regulated for most efficient operation. As will be seen from the hereinbefore given description, relay 33 responds in unison with the actuation of sending contacts SC as a message is transmitted from station 1 to station 2.

Having described in detail the operation of the invention in transmitting a message from station 1 to station 2 in the specific embodiment illustrated in Fig. 1, certain advantageous features of the invention hereinbefore mentioned may now be discussed.

Retardation coil 18 which is shown connected across line 10, has two windings parallelly wound, that is, the wire of each winding is laid side by side so that each winding has exactly the same number of turns. The center point of coil 18 is, as shown, connected to ground. The purpose of this is to provide a grounding path for longitudinal currents that may flow along the conductors of line 10, said currents being induced for example by the proximity of conductors carrying a varying current. This arrangement prevents these currents from causing a change in the potential of the grid element 20 of tube 7, and therefore from distorting the signals. The ground on the center of coil 18 is effectively separated from the poles of battery 14 by the interposition of the large condensers 9 and 19 thereby avoiding the possibility of the aforesaid longitudinal line currents affecting the potential of grid element 20. The use of retardation coil 18 also causes a reduction in the so-called "zero-wander" effect, which is present in cases of rapid sending and is due to the capacity between long closely twisted conductor pairs. In the arrangement of the invention shown in Fig. 1, the repeater 3 responds only to the potential drop across the coil 18, which potential at the low frequency of the zero-wander current may be made sufficiently low to avoid any distorting effects upon the outgoing signals from tube 7.

Another desirable feature of the invention is the characteristic whereby the shape of the output wave is free of high frequency components within the audible range which would introduce noises in a telephone circuit.

This follows from the fact that the signal impulses received by the repeater in passing over the high capacity line circuit has suffered attenuation which has substantially eliminated any audible frequencies produced by the contacts at the sending station, and from the further fact that the repeater does not depend upon operation of a contact device for repeating impulses, which would reintroduce clicks and telegraph thumps. Of course, when the repeater has also its input circuit connected to a telephone circuit the impulses impressed upon that circuit may be assumed to be without audible frequencies and to arrive thus at the repeater station. Accordingly, the usual noise absorbing filter arrangements required in the output circuit of relay type repeaters are not required with the repeater made in accordance with the invention which makes it particularly suitable for use on composited telephone lines.

Repeater 4 of Fig. 2 operates in connection with sending station 1 and receiving station 2 basically in the same manner as repeater 3 of Fig. 1. The current for repeater 4, however, is obtained from a full wave rectifier circuit associated with a power transformer 39, the primary winding of which is connected to a local source of alternating current. The operation of this type of rectifier is well known in the art and need not be described here in detail. Positive potential is supplied over lead 40 to the junction point between inductances 41 and 42 and negative potential is supplied at ground 43 to the inductance 42 and the tube 45. In order to provide a normal negative bias for grid element 44 of tube 45, cathode element 46 is connected through the center point of the right-hand secondary winding of transformer 39 to the midpoint connection between resistances 47 and 48. The current received over the line 10 from station 1 passes through retardation coil 49. The drop through this coil is effective through condensers 50 and 51 and high resistance 52, to cause changes in the potential of grid element 44 of tube 45, in the same manner as described for tube 7 in connection with the operation of repeater 3.

Grid element 44 becomes alternatively negative and positive causing the circuit of plate element 53 to be of high or low impedance, respectively. This causes the current passing over line 32 to be reversed as hereinbefore described in connection with Fig. 1, relay 33 operating and releasing in unison with the actuation of sending contacts SC. In Fig. 2 for the arms of the Wheatstone bridge circuit are furnished inductance coils 41, 42 and 54. Coil 54 in the plate circuit of tube 45 is in series with variable resistance 55 so that the line current supplied from repeater 4 may be maintained within limits that assure efficient operation of relay 33. Inductance coils are used for the arms of the bridge circuit, with a condenser 56 bridged across the line conductors in order to avoid transmitting over the line, current com-

ponents of audible frequency, due to the use of the commercial alternating current supply. These components, if not removed, would cause telegraphic noise in associated telephone circuits.

The invention will now be described as applied to signal repeaters operating on a line also used for telephone service, and its particular suitability for this purpose will be discussed. Fig. 3 is an arrangement showing how a telephone repeater 76, located at an intermediate point, may be installed so as to by-pass telephone currents around a telegraph repeater 6 similar to repeater 3 in Fig. 1 or repeater 4 in Fig. 2. In Fig. 3 a repeater 8, also similar to repeaters 3 or 4, is installed at the receiving end of a telegraph line 77. The output of the repeater 8 which, as hereinbefore stated, is free from audible frequency components is received by composite set 78, which may be of any well-known type, and is passed over line 79 to composite set 59 at the intermediate point. Here the telegraphic current is amplified by a repeater 6 in the manner described for repeaters 3 or 4. The output of this repeater is passed to composite set 60 and thence over line 80 to composite set 81 at the distant end. At this point the telegraphic output is taken by receiving telegraph line 82. At the sending end of the circuit a telephone line 83 is connected to composite set 78. Telephonic transmission now takes place over line 83, through composite set 78, over line 79, through composite set 59, telephone repeater 76, composite set 60, line 80, composite set 81, and telephone line 84. At the intermediate point, the telephone lines 85 and 86 may be connected directly together without using telephone repeater 76, or lines 85 and 86, may be connected each to a different telephone line.

Telegraphic impulses, being of low frequency, pass with little attenuation through the coils 65 and 66 of composite set 59 and coils 67 and 68 of composite set 60, and through similar coils of composite sets 78 and 81, which are not shown in detail. Telephone lines 85 and 86 are connected through repeating coils 74 and 75, and telephone lines 83 and 82 through similar repeating coils, not shown. The inductance of the series coils together with the shunting effect of the bridging condensers 70 and 71 and 72 and 73 is sufficient to prevent telephonic currents from affecting the telegraphic repeaters 8 and 6.

From a consideration of Fig. 3 it is evident that this invention permits of a flexible and simple arrangement for providing combined telephone and telegraph service over a single line. This follows from the fact that the use of a repeater having a thermionic tube and arranged according to this invention avoids the production of current components of audible frequency, which are characteristic of repeaters using relays, and makes unnecessary the use of expensive filters.

The circuit in Fig. 3 is arranged to show the invention as a one-way repeater using a single pair of wires. For two-way service, using the arrangement shown, four wires would be required. It is understood, however, that by using one repeater for transmission in one direction and a second repeater for transmission in the opposite direction, combined with the well-known arrangement of hybrid inductance coils and line balancing networks the system may be readily adapted to give two-way service over a single pair of wires.

What is claimed is:

1. A telegraph repeater, a first line section, a second line section, said repeater including thermionic space discharge amplifying means having an input side and an output side, capacity means having a leak path for impressing polar signal impulses from said first line section upon said input circuit, a balancing bridge circuit for impressing the impulses from said output circuit directly upon said second line section as polar impulses with substantially the same wave shape as in said input circuit.

2. A telegraph repeater, a first line section, a second line section, said repeater including thermionic space discharge amplifying means having an input side and an output side, capacity means having a leak path for impressing signal impulses from said first line section upon said input circuit, composite circuit means for impressing impulses from said repeater upon said second line section, and a conjugate metallic network for receiving unidirectional impulses from said output circuit and converting them to impulses of alternate directions for impression upon said composite circuit means with substantially no distortion.

3. A telegraph repeater for noiseless transmission of direct current signals between two line sections comprising thermionic space discharge amplifying means having a grounded input side and an output side, a metallic bridge circuit connected across said input side and having an intermediate point grounded, resistance shunted capacity means for segregating the constant potentials in said input side and in the associated line section including said bridge circuit, and circuit means for connecting said output side permanently in a metallic circuit with the other line section.

4. A telegraph repeater, a first line section, a second line section, said repeater including thermionic space discharge amplifying means having a control element included in the input circuit and an anode element included in the output circuit, capacity means having a resistance shunt and connected serially between said control element and said first line section, a potentiometer circuit connected to a point between said control element and said capacity means, and a bridge circuit including inductance means connected to a point between said capacity means and said first line section, said anode element being connected permanently in a metallic circuit including said second line section.

5. A telegraph repeater, an incoming line section, said repeater including a thermionic space discharge tube having a cathode element, a control element and an anode element, resistance shunted capacity means connected serially between one conductor of said line section and said control element, other resistance shunted capacity means connected serially between the other conductor of said line section and said cathode element, a bridge circuit including an inductance connected directly across said incoming line section and a source of control potential connected directly between said control element and said cathode element.

GEORGE C. CUMMINGS.