Nov. 8, 1938. H. NYQUIST 2,135,596

RELAY CIRCUIT

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FIG. 1

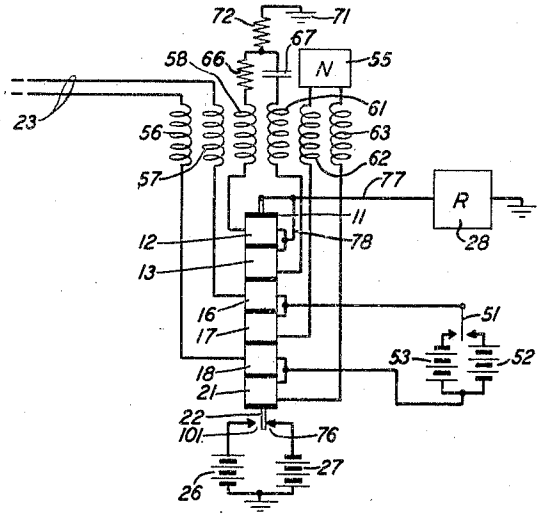
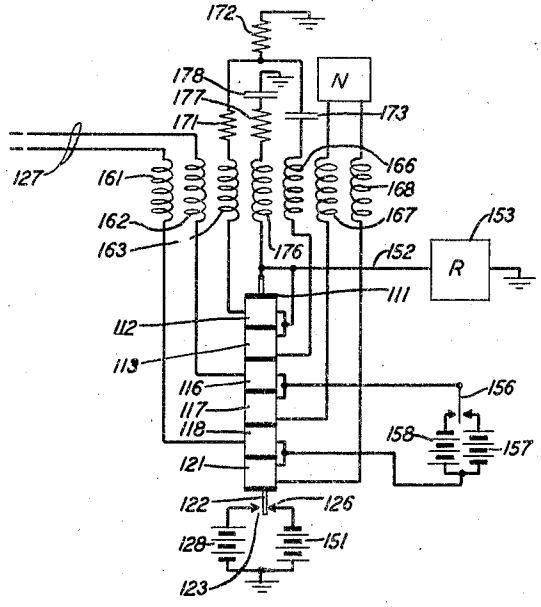


FIG. 2



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RELAY CIRCUIT

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7 Claims. (Cl. 178—88)

This invention relates to a relay circuit and particularly to a telegraph receiving relay circuit for use with a composite telephone and telegraph system.

An object of the invention is to prevent interference in the line due to operation of the receiving relay.

A more specific object of the invention is to neutralize the inductive effect upon the line windings of the relay, and therefore upon the line, of the sudden impulses occurring in the vibrating windings of the relay.

A still further object of the invention is to neutralize the inductive effect upon the line windings of the relay, and therefore upon the line, of voltages induced in the windings of the relay by the movements of the armature.

In order to improve the operation of telegraph receiving relays, particularly when such relays are to be used over cable circuits operating on comparatively weak currents, it is usual to provide in connection with the relay a so-called "vibrating circuit". This vibrating circuit ordinarily includes a winding on the relay, known as the "vibrating winding", as well as a resistance-capacity network. The arrangement usually followed is such that, while the armature is in engagement with one contact, the effect of the vibrating circuit tends to move the armature from engagement with that contact and into engagement with the opposed contact. When the armature does leave the contact, due to the effect of a current reversal in the line windings, there is a sudden accelerating force produced in the vibrating winding due to the charge on the condenser included in the vibrating circuit and, when the armature first engages with the new contact, there is a sudden force tending to hold it in engagement therewith thereby preventing so-called "chatter".

It follows from the above, therefore, that the vibrating circuit functions by virtue of sending sudden impulses into the vibrating winding and applicant has observed that these impulses, due to the transformer action of the relay windings, cause similar impulses to be set up in the line windings of the relay and to be transmitted out over the line. While these impulses are attenuated somewhat by composite sets and the like they do nevertheless, particularly in systems where the repeater gain is considerable, give rise to that particular type of interference commonly known by communication engineers as "receiving end thump".

Applicant has observed also that "thump" results from voltages induced in the windings of the relay due to the movements of the armature.

In accordance with a particular feature of the invention means are provided whereby the inductive effect upon the line windings of impulses caused either by the functioning of the vibrating circuit or by the movements of the armature are neutralized so that zero voltage is produced in the line.

In accordance with a specific embodiment of the invention a plurality of neutralizing windings are provided, one neutralizing winding being connected in series with each section of the normal windings of the relay. Impulses similar to those occurring in the normal vibrating windings, occur also in the neutralizing windings connected in series therewith and, as the neutralizing windings are all in inductive relationship, these impulses cause by induction similar impulses in the neutralizing windings connected in series with the line windings. Now the poling of the neutralizing windings is opposite to that of the relay windings so that, while the impulses set up in the neutralizing line windings are of equal intensity to those set up in the normal relay line windings, they are of opposite polarity, the result being that one neutralizes or cancels the other and zero voltage results in the line.

In accordance with a modification of the invention an additional neutralizing winding is provided, being connected in series with the relay armature and with a resistance-capacity network. This winding acts to neutralize the voltages set up in the relay windings due to movement of the armature.

A complete understanding of the arrangement contemplated by the invention and appreciation of the desirable features thereof will be had by consideration of the following detailed description in connection with the annexed drawing in which:

Fig. 1 illustrates a telegraph receiving relay circuit including neutralizing windings of the nature contemplated by the invention; and

Fig. 2 illustrates a modification of the circuit in accordance with which an additional winding is provided in series with the armature.

Referring now to Fig. 1, a telegraph receiving relay 11 as illustrated provided with a vibrating winding comprising equal sections 12 and 13 and two line windings comprising respectively equal sections 16 and 17 and 18 and 21. Armature 22 is vibrated by the effect of currents received over line 23 on the line windings of the relay and acts to transmit impulses of alternate polarity from

positive battery 26 and negative battery 27 to the receiving or recording device 28. During transmitting, switch arm 51 is vibrated by means, not shown, (a relay for example) to transmit impulses of alternate polarity from positive battery 52 and negative battery 53 out over line 23. Due to the fact that network 55 closely simulates the line impedance at the essential telegraph frequencies and as the various sections of the line windings are all nicely balanced the magnetic effect of the transmitted impulses upon the relay is negligible.

Six neutralizing windings 56, 57, 58, 61, 62 and 63, are provided. Winding 58 is connected in series with one terminal of section 12 of the vibrating winding and resistance 66 while winding 61 is connected in series with one terminal of the other section 13 of the vibrating winding and condenser 67. The network is connected to ground 71 through resistance 72. Neutralization winding 57 is connected in series with one side of line 23 and one terminal of section 16 of one of the line windings of the relay; neutralizing winding 62 is connected in series with a terminal of section 17 of the same line winding and network 55. Neutralizing winding 56 is connected in series with the other side of line 23 and a terminal of section 18 of the other line winding of the relay; neutralizing winding 63 is connected in series with a terminal of section 21 of the same line winding and network 55.

The neutralizing windings simulate the winding arrangement of the relay in that the mutual inductance between either winding 58 or winding 61 and windings 56, 57, 62 or 63 is the same as the mutual inductance between either section 12 or section 13 of the vibrating winding and sections 16, 17, 18 or 21 of the line windings. The poling of the neutralizing windings, however, is opposite to that of the normal relay windings.

Assuming now that armature 22 has just been moved into engagement with contact 76 due to a current reversal in line 23, an impulse will be transmitted from negative battery 27 over lead 77 to receiving device 28, which may be a sounder, for example. There will also be a sudden flow of current from negative battery 27, over lead 78, through section 13 of the vibrating winding and neutralizing coil 61 to condenser 67, this flow of current being effective to charge condenser 67. Substantially no current flows through section 12 of the vibrating winding at this instant as the resistance of the path through section 13 is much less. This flow of current tends to hold armature 21 in engagement with contact 76. Upon condenser 67 reaching its full charge, however, the current then flows through section 12 of the vibrating winding, neutralizing winding 58, resistances 66 and 72 to ground 71, this flow of current tending to cause armature 22 to move away from contact 76 and into engagement with the opposed contact 101. Armature 22 remains in engagement with contact 76, however, due to the effect of the current flowing in the line windings of the relay.

Immediately upon armature 22 leaving contact 76, due to change of direction of the line current, condenser 67 starts to discharge and causes a flow of current through both sections, 13 and 12, of the vibrating winding, this flow of current tending to urge or accelerate armature 22 in its travel from contact 76 to contact 101. As soon as armature 22 engages contact 101 an impulse from positive battery 26 will be transmitted over lead 77 to receiver 28 and current will be transmitted over lead 78 and through section 13 of the vibrating winding and neutralizing winding 61 to charge condenser 67, this current being in a direction tending to urge armature 22 into engagement with contact 101, thereby preventing "armature chatter". As before substantially no current flows at this instant through section 12 of the vibrating winding due to the greater resistance of this path. Upon condenser 67 becoming charged, however, current flows through section 12 of the vibrating winding, neutralizing winding 58, resistances 66 and 72 to ground 71, this current tending to move armature 22 away from contact 101 and toward the opposed contact 76.

It will be apparent from the above that impulses or sudden spurts of currents in one direction or the other are being set up almost continuously (that is, while the circuit is in use) in the vibrating winding and it has been observed, as stated above, that due to transformer action of the relay windings, similar impulses are set up in the line windings of the relay. These induced impulses, if unimpeded, are transmitted out over the line and give rise to so-called "receiving end thump". In accordance with applicant's arrangement, however, any impulses occurring in the vibrating winding of the relay occur also in neutralizing windings 58 and 61 which are connected in series with sections 12 and 13 of the vibrating winding. Now the mutual inductance between either winding 58 or 61 and windings 56, 57, 62 or 63 is the same as the mutual inductance between either section 12 or 13 of the vibrating winding and sections 16, 17, 18 or 21 of the line windings from which it follows that, for any impulse induced in any of the sections of the line windings due to impulses occurring in either section of the vibrating winding, there will be an impulse of like magnitude induced in the corresponding neutralizing winding by the impulse occurring in winding 58 or 61. Due to the fact, however, that the poling of the neutralizing windings is opposite to that of the relay windings, the impulses occurring in the neutralizing windings, while of equal magnitude to those occurring in the corresponding line windings, are of opposite polarity so that any impulses induced in the line windings are neutralized or canceled by the equal-magnitude oppositely-poled impulses occurring in the neutralizing windings. No interfering impulses occur in line 23 therefore.

In Fig. 2 a modification of the arrangement is illustrated. In accordance with this modification, an additional neutralizing winding has been provided for preventing the origination in the line of interfering currents due to motion of the armature. Here, as in the instance of the arrangement just described, we have a telegraph receiving relay 111 provided with a vibrating winding comprising two balanced sections 112 and 113 and two line windings comprising, respectively, sections 116 and 117 and sections 118 and 121. Armature 122 is moved between contacts 123 and 126 due to the effect on the line windings of current reversals in line 127. As the armature moves from one contact to the other, impulses of alternate polarity from positive battery 128 and negative battery 151 are transmitted over lead 152 to receiving device 153. During transmitting periods, switch arm 156 is vibrated by suitable means (not shown) and transmits impulses of alternate polarity from positive battery 157 and negative battery 158 over line 127. Neutralizing windings 161, 162, 163, 166, 167 and 168 correspond respectively in arrangement and function to neutralizing windings 56, 57, 58, 61, 62 and 63 described above, while resistances 171 and 172 and con-

denser 173 of the vibrating circuit correspond respectively in arrangement and function to resistances 66 and 72 and condenser 67 of the vibrating circuit of Fig. 1. In accordance with the modification illustrated in Fig. 2, however, an additional neutralizing winding 176 has been provided, being connected in series with armature 122 and a network comprising resistance 177 and condenser 178.

Applicant has observed that when armature 122 is moving from contact 123 to 126 or vice versa a counterelectromotive force is set up in the relay windings and transmitted out over line 127 giving rise to "thump". This force has been found to be approximately proportional to the velocity of the armature, building up rather gradually to a maximum as the armature moves from one contact to the other. When the armature engages the opposed contact and is brought to rest abruptly there is, of course, a sudden drop in the electromotive force. The suddenness of this change in voltage results in a wave with high frequency components and audible thump. It is at this time, therefore, that is upon engagement of the armature with a contact, that the effect of the voltages caused by armature motion is particularly troublesome. By the provision of the neutralizing winding 176 and the associated network, applicant has provided means for substantially eliminating "thump" resulting from armature motion, the arrangement operating in the following manner.

Let us assume, by way of explanation, that armature 122 is being moved from engagement with contact 123 toward contact 126 due to a current reversal in line 127. Due to the motion of armature 122 and the reaction on the electrical circuit, a counterelectromotive force is generated in the windings of the relay which gradually builds up to a maximum as the armature approaches contact 126. Now as the armature engages contact 126 it stops abruptly and there is, of course, a sudden drop in the electromotive force. The suddenness of this change in voltage results in a wave in the relay windings which, if unimpeded, would be transmitted out over line 127 causing "thump". However, just as armature 122 engages contact 126, there is a sudden flow of current from negative battery 151 through neutralizing winding 176 and resistance 177, this current rising rapidly from zero to a maximum value determined by the magnitude of resistance 177 and the operating voltage. By properly fixing the value of resistance 177 and condenser 178 it is possible to produce in neutralizing coil 176 a current wave which is the substantial counterpart, both with respect to magnitude and time-constant, of the interfering wave set up in the relay windings when the armature strikes contact 126. Similar waves are set up in the other neutralizing windings, due to the mutual induction between winding 176 and the other neutralizing windings, and, due to the opposite polarity of the neutralizing windings and the relay windings, these waves neutralize or cancel any interfering waves set up in the respectively associated relay windings.

While armature 122 rests in engagement with contact 126, condenser 178 charges so that the current through resistance 177 dies out before the next operation of the armature takes place.

While certain specific embodiments of the invention have been selected for illustration and detailed description, the invention is not of course limited in its application to these specific embodiments. The embodiments described should be taken as illustrative of the invention and not as restrictive thereof.

What is claimed is:

1. A relay comprising an armature, opposing contacts adapted to be engaged by said armature, a main winding for operating said armature between said contacts, an auxiliary winding normally tending to move the armature from the contact with which it is in engagement to the opposite contact, means effective upon disengagement of said armature from either of said contacts for causing a current impulse in said auxiliary winding effective to accelerate further movement of said armature, and means including an inductive winding for neutralizing the inductive effect of said current impulses on said main winding.

2. A relay comprising an armature, opposing contacts adapted to be engaged by said armature, a main winding for operating said armature between said contacts, an auxiliary winding normally tending to move the armature from the contact with which it is in engagement to the opposite contact, means effective upon disengagement of said armature from either of said contacts for causing a current impulse in said auxiliary winding effective to accelerate further movement of said armature, and means for neutralizing the inductive effect of said current impulses on said main winding, said last-mentioned means including a winding in series with said main winding and means for inducing therein impulses of equal intensity and opposite polarity to the impulses induced in said main winding by said impulses in said auxiliary winding.

3. A relay comprising an armature, opposing contacts adapted to be engaged by said armature, a main winding for operating said armature between said contacts, an auxiliary winding normally tending to move the armature from the contact with which it is in engagement to the opposite contact, means effective upon disengagement of said armature from either of said contacts for causing a current impulse in said auxiliary winding effective to accelerate further movement of said armature, and means for neutralizing the inductive effect of said current impulses on said main winding, said last-mentioned means including a third winding in series with said auxiliary winding and a fourth winding in series with said main winding, said third and said fourth windings being in inductive relationship and said third winding and said main winding being oppositely poled.

4. A relay comprising an armature, opposing contacts adapted to be engaged by said armature, a potential source associated with each of said contacts, a winding for operating said armature between said contacts, and means for neutralizing the effect upon said winding of impulses induced in said winding due to movement of said armature, said means including a second winding connected in series with said operating winding and means for introducing in said second winding impulses which are the substantial counterpart of said impulses induced in said operating winding and which are of opposite polarity with respect thereto.

5. A relay comprising an armature, opposing contacts adapted to be engaged by said armature, a potential source associated with each of said contacts, a winding for operating said armature between said contacts, and means for neutralizing the effect upon said winding of impulses in-

duced in said winding due to movement of said armature, said means including a second winding connected in series with said operating winding and means for introducing in said second winding impulses which are the substantial counterpart of said impluses induced in said operating winding and which are of opposite polarity with respect thereto, said last-mentioned means including a third winding connected in series with said armature and in inductive relationship to said second winding.

6. A relay comprising an armature, opposing contacts adapted to be engaged by said armature, a potential source associated with each of said contacts, a winding for operating said armature between said contacts, and means for neutralizing the effect upon said winding of impulses induced in said winding due to movement of said armature, said means including a second winding connected in series with said operating winding and means for introducing in said second winding impulses which are the substantial counterpart of said impulses induced in said operating winding and which are of opposite polarity with respect thereto, said last-mentioned means including a third winding in inductive relationship to said second winding, said third winding being connected in series with said armature whereby said third winding is effectively connected in series with a potential source upon engagement of said armature with either of said contacts and means connected in series with said third winding whereby the characteristics of the impulse produced therein upon engagement of said armature with either contact may be determined.

7. A relay comprising an armature, opposing contacts adapted to be engaged by said armature, a potential source associated with each of said contacts, a winding for operating said armature between said contacts, and means for neutralizing the effect upon said winding of impulses induced in said winding due to movement of said armature, said means including a second winding connected in series with said operating winding and means for introducing in said second winding impulses which are the substantial counterpart of said impulses induced in said operating winding and which are of opposite polarity with respect thereto, said last-mentioned means including a third winding in inductive relationship to said second winding, said third winding being connected in series with said armature whereby said third winding is effectively connected in series with a potential source upon engagement of said armature with either of said contacts and a resistance-capacity network connected in series with said third winding whereby the characteristics of the impulse produced therein upon engagement of said armature with either contact may be determined.

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