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W. C. SPENCER ET AL
TELEGRAPH APPARATUS

2,498,588

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2 Sheets-Sheet 1

Fig. 1

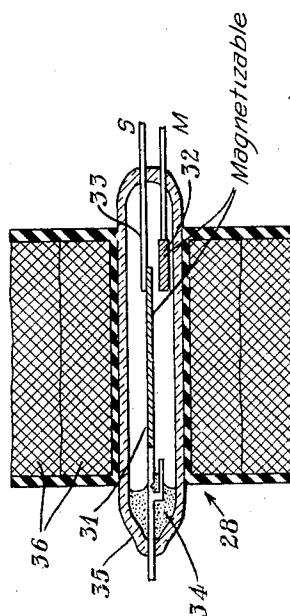
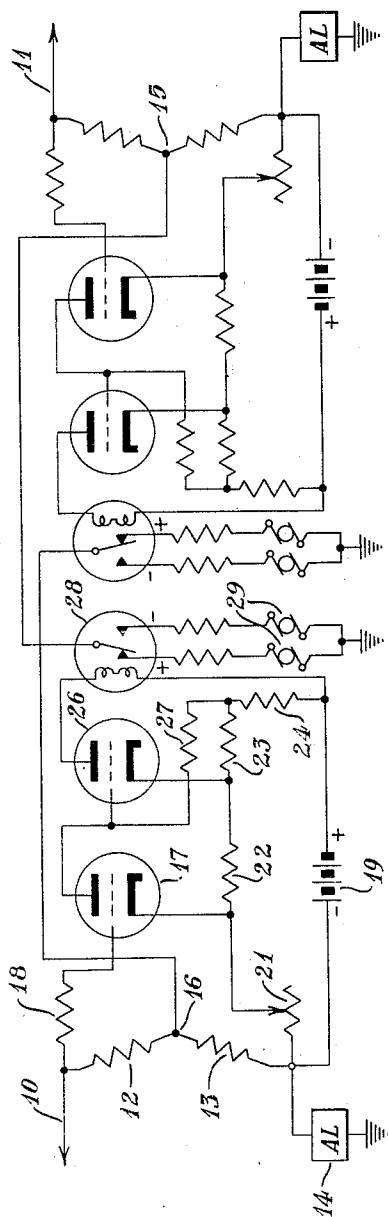


Fig. 4

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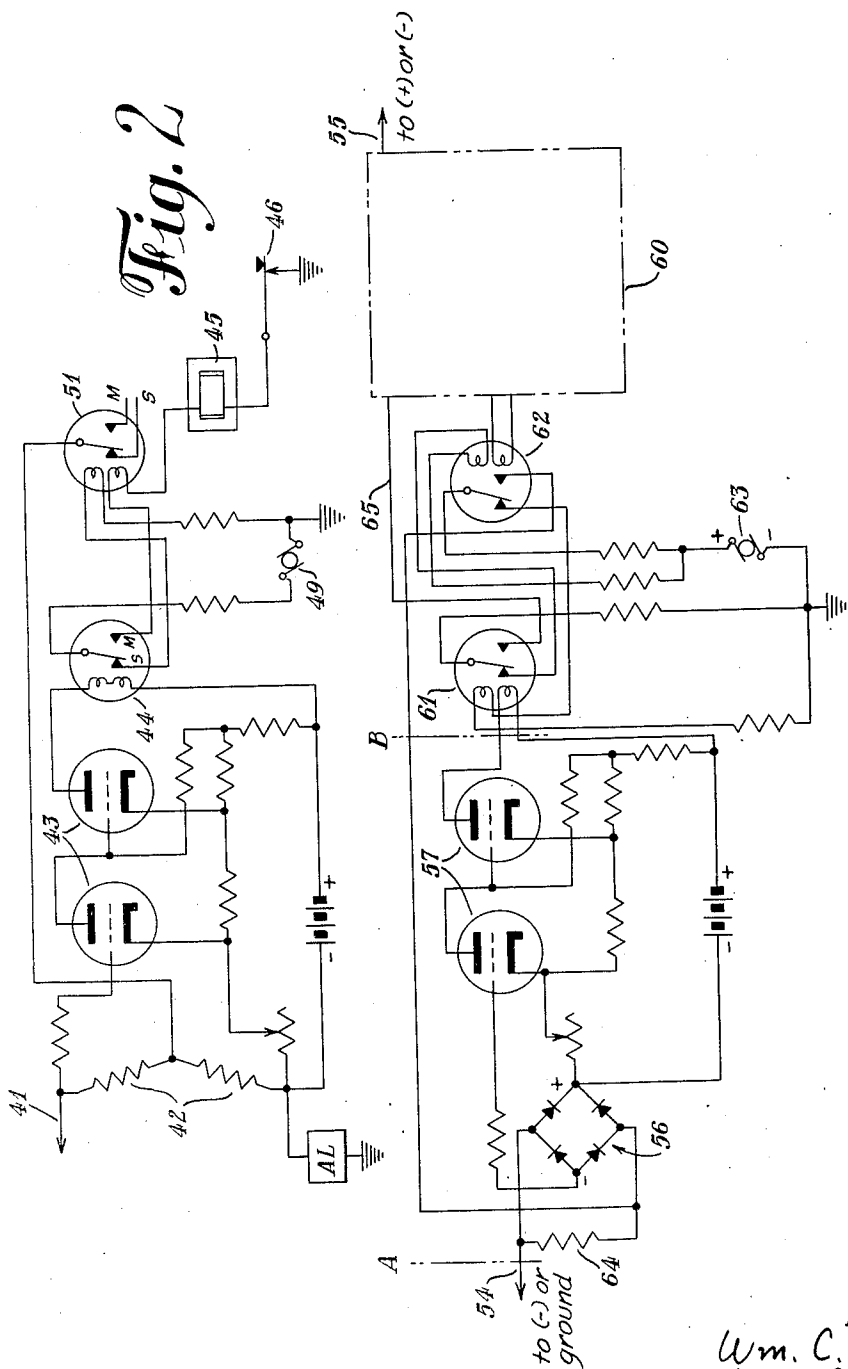


Fig. 3

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TELEGRAPH APPARATUS

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1 Claim. (Cl. 178—71)

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This invention relates to telegraph transmitting and receiving apparatus, and more particularly to telegraph repeaters or terminal sets.

Telegraph systems, especially those employing high-speed printers, are seriously affected by changes in line characteristics and in the adjustment or condition of the terminal equipment. Consequently maintenance of the system is frequently a major problem, particularly where dependable continuous service is required. When properly designed and adjusted, repeater or terminal equipment can be relied upon to regenerate the line signals and thus increase the speed and improve reliability of operation.

In general terms, the object of the present invention is to improve the reliability and operating characteristics of telegraph apparatus of the above-mentioned character.

Another object of the invention is to provide a telegraph repeater or terminal set having novel signal-regenerating means for re-shaping the line signals.

A further object of the invention is to provide a telegraph repeater or terminal set having enhanced stability and markedly increased efficiency under actual operating conditions.

Other objects and advantages of the invention will appear from the following description of the preferred embodiments thereof shown in the accompanying drawings, wherein

Fig. 1 is a circuit diagram of a full duplex telegraph repeater embodying the invention;

Figs. 2 and 3 are similar diagrams of modifications adapted to function as a half-duplex terminal set and a single line repeater, respectively; and

Fig. 4 is a side elevational view of the magnetic relay employed in the apparatus shown in Figs. 1-3.

According to the invention, the direct-current telegraph signals received over the line are amplified and impressed on the coil of a high-speed relay of the sealed make-and-break contact type. The detailed construction and characteristics of a suitable relay will be described hereinafter. The preferred type of relay comprises fixed and movable contacts sealed together with a small quantity of mercury in a glass envelope containing gas under pressure. The contacts are wetted by the mercury, and thus provide an "area-contact" of low electrical resistance between the engaging surfaces. Furthermore, the coating of mercury on the contacts insures a make-before-break contact function as the movable contact is actuated between the fixed contacts. These

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characteristics of the relay are permanent under normal operating conditions and result in improved efficiency and reliability of the equipment. The movable tongue of the relay and its marking contact are magnetizable, and are thus rapidly moved into contact when magnetized by an external coil, the tongue being spring-biased against the spacing contact when the coil is de-energized. The manner in which a sensitive high-speed relay of this type is connected in a telegraph repeater or terminal set, in accordance with the invention, will be explained in connection with a detailed description of Figs. 1-3.

Referring to Fig. 1, a full duplex repeater is shown connected between the lines 10 and 11. Each line terminates in a bridge circuit, comprising for the line 10 the equal series-connected resistors 12 and 13, and the balancing artificial line 14. As well understood by those skilled in the art, a full duplex repeater is arranged to repeat polar signals received over the line 10 into the line 11, the regenerated signals being impressed upon the apex 15 of the bridge circuit associated with the line 11. Similarly, polar signals received over the line 11 are repeated into the line 10, the outgoing signals being impressed in this instance upon the apex 16 of the bridge circuit associated with the line 10. Since the half of the repeater associated with one line is identical with the other half, it will be sufficient to limit the description to one half only.

If it is assumed that the marking signal condition is represented by negative potential, when a negative marking signal is received over the line 10 the control electrode of the amplifier tube 17 becomes negative with respect to the cathode. As shown, said electrode is connected to the line terminal of resistor 12 through a resistor 18, and the cathode to the outer terminal of resistor 13 (and the negative terminal of a floating battery 19) through an adjustable potentiometer 21 to facilitate adjustment of the bias of the amplifier. The anode of the tube 17 is connected to the control electrode of an amplifier tube 26 and to a grid-bias resistor 27, so that the negative line signal reduces the plate current flow in the tube 17 and increases the current flow in the tube 26. The series-connected resistors 21, 22, 23 and 24 bridged across the terminals of the battery 19 are selected to apply the proper grid and anode potentials to the tubes 17 and 26. For example, if a dual-triode such as a 6SN7 is employed, the following values may be used with a 300-volt battery: for potentiometer 21, 0-100 ohms, for resistors 22, 23, and 24, 1000 ohms, 2000 ohms and

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7500 ohms, respectively. However, other values may be employed and various changes made in the amplifier without departing from the scope of the invention.

From the foregoing description of the amplifier, it will be evident that when a positive spacing signal is received over the line 10, the space current in the tube 17 increases, thus reducing the space current in the associated tube 26. The amplified signals, both marking and spacing, are impressed upon the operating coils of relay 28 having its tongue connected to the apex 15 of the bridge associated with the line 11. The marking and spacing contacts of relay 28 are connected to the usual batteries or current sources 29 of opposite polarity, so that the equipment repeats the marking and spacing signals into the line 11 in amplified and re-shaped form.

The characteristics of the transmission lines, particularly resistance and leakage, weaken and distort the signals. By using resistors 12 and 13 of low resistance, say 100 ohms, instead of the usual relay coils possessing considerable inductance, and higher resistance, the attenuation of the incoming and outgoing signals is reduced, the power required to operate the relay 28 being provided by the sensitive high-gain amplifier 17-26. The wave-shape distortion of the signals is substantially eliminated by the relay 28 and associated amplifier. The set may be designed to operate on a current variation of less than 2 milliamperes in the line resistors 12 and 13.

The detailed construction of relay 28 is shown in Fig. 4, the preferred relay being similar in certain respects to that described in the patent to Ellwood, No. 2,289,830, granted July 14, 1942. This relay as modified for apparatus according to the invention comprises a hinged tongue 31, a marking contact 32, both of magnetizable metal, and a fixed spacing contact 33, sealed together with a globule of mercury 34 in a glass envelope 35. The tongue 31 is spring supported or biased to normally engage the spacing contact 33. However, when the tongue 31 and contact 32 are longitudinally magnetized, as by energizing the coils 36 surrounding the envelope, the tongue is attracted to the contact 32, and by reason of the small mass of the tongue its movement is very rapid. The tongue, which is mounted vertically with its lower end dipping in the pool of mercury 34, becomes wetted with the mercury which affects the contact operation in two ways. In the first place, electrical contact between the tongue 31 and both of the fixed contacts is made over a surface of appreciable area, thus establishing a low-resistance contact of large current-conducting capacity without the possibility of burning or welding the contact surfaces. Secondly, during the movement of the tongue 31 between the stationary contacts, the mercury pulls out between the tongue and particular contact which it previously engaged, until the tongue engages the opposite contact, when the inertia of the thread of mercury breaks the connection. Thus a positive make-before-break contact is secured, which characteristic is maintained without readjustment during a prolonged period of operation or throughout the life of the relay. This important feature, maintained without attention or maintenance during long periods of use, greatly enhances the performance and efficiency of the repeater apparatus.

When the relay is used as a polar transmitting relay, as in Fig. 1, the make-before-break operation of the contacts maintains the apex of the

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bridge circuit effectively closed to ground during crossover, thus contributing to improved shaping of the signals. Other advantages are realized when a relay of this type is used in half-duplex or single line repeater sets, as will be explained in connection with Figs. 2 and 3. The reliability, sensitivity and speed of the relay, combined with the non-inductive circuits and amplifier characteristics of the regenerating apparatus embodying the invention, enable the attainment of high efficiency and maximum reliability.

The invention may be embodied in several types of repeating or regenerating equipment. Fig. 2 illustrates, by way of example, a half-duplex terminal set in which the line 41 terminates in a bridge circuit 42 connected to an amplifier 43 and receiving relay 44 in the same manner as in the repeater shown in Fig. 1. In this type of set a sounder or teleprinter 45 is used which is arranged to respond both to incoming messages and to the operation of the home key or keyboard 46. The receipt of a marking signal over the line 41 actuates the tongue of relay 44 against the right-hand or marking contact, as described above. A circuit is closed from local battery or generator 49 through the tongue and marking contact of relay 44, the lower coil of relay 51, the sounder 45 and key 46 to ground, whereupon the sounder is operated and relay 51 is held in the operated or marking condition. Similarly, when a spacing signal is received, the tongue of relay 44 is actuated to its spacing contact, breaking the circuit through the sounder 45 but closing a second circuit through the upper coil of relay 51 for holding said relay in the marking condition, said circuit including the battery or generator 49 and the spacing contact of relay 44. Since relay 44 is preferably of the type shown in Fig. 4 and operates to close the spacing contact before opening the marking contact and vice versa, relay 51 remains operated during the travel of the tongue of relay 44. Relay 51, which may also be of the type shown in Fig. 4, responds to the operation of the key 46, while a steady marking condition is being received over line 41, since it breaks the circuit through the lower coil of the relay. The tongue of relay 51 is connected to the apex of the bridge circuit 42, and thus the signals generated by the key 46 are transmitted over the line circuit, while the home sounder or printer 45, being connected in series with the key, is also operated.

Fig. 3 shows a single line repeater in which by way of example the line 54 is battered with negative battery or grounded, and the line 55 is grounded at the repeater and battered at the distant end with either polarity. Since the rectifier 56 and amplifier 57 of one half of the repeater are identical with corresponding elements of the other half of the repeater, these elements between the lines A-B are represented by the block 60 in the diagram. In addition, the repeater comprises relays 61 and 62, similar to relay 28 described above, and a local battery or generator 63. In this arrangement, a spacing signal transmitted over either line 54 or 55 is repeated to the other line but is not reflected back to lock the repeater in an all-spacing condition.

As shown, two terminals of the rectifier 56 are connected across the line resistor 64, the other terminals of the rectifier being connected to the input circuit of the amplifier 57. The rectifier 56 may be of the copper-oxide, selenium, crystal or vacuum tube type. When the line 54 is opened, there is no voltage drop across resistor 64, and

the grid of the first tube of amplifier 57 is no longer negatively biased by the line signals with respect to the cathode. The grounded tongue of relay 61 is actuated against its left-hand spacing contact, thus opening the line 55 which is normally connected through conductor 65 to the marking contact of relay 61. At the same time, a circuit is closed through the spacing contact of relay 61 and the upper coil of relay 62 to hold the latter relay operated. It will be evident that in a similar manner, if a spacing signal is received over the line 55 to operate relay 62 to spacing, a no-current spacing signal is repeated over the line 54. For the duration of the spacing signal relay 61 is held operated by a circuit including the spacing contact of relay 62 and the upper coil of relay 61. Under the marking conditions in both lines, with all keys closed, current flows in both lines from the local battery 63 in the case of line 54 and from the remote battery in the case of line 55.

It will be apparent that by the use of the present invention a simple and highly efficient signal repeating and regenerating system is provided. The invention is adapted to be used in a telegraph terminal set or in a duplex or single-line repeater, as described. Various modifications in the arrangements shown and described for the

purpose of explaining the invention may be made without departing from the scope thereof.

We claim:

In a full duplex repeater, a low-impedance bridge circuit having an apex on each side of the repeater, a relay connected to each bridge circuit, each relay comprising a coil connected to the line terminal of one bridge circuit and a tongue connected to the apex of the opposite bridge circuit, and further comprising two contacts alternately engaged by the tongue as it moves, an envelope enclosing the tongue and contacts, and mercury wetting the tongue to insure make-before-break contact operation, and sources of marking and spacing potentials connected respectively to each of said relay contacts.

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