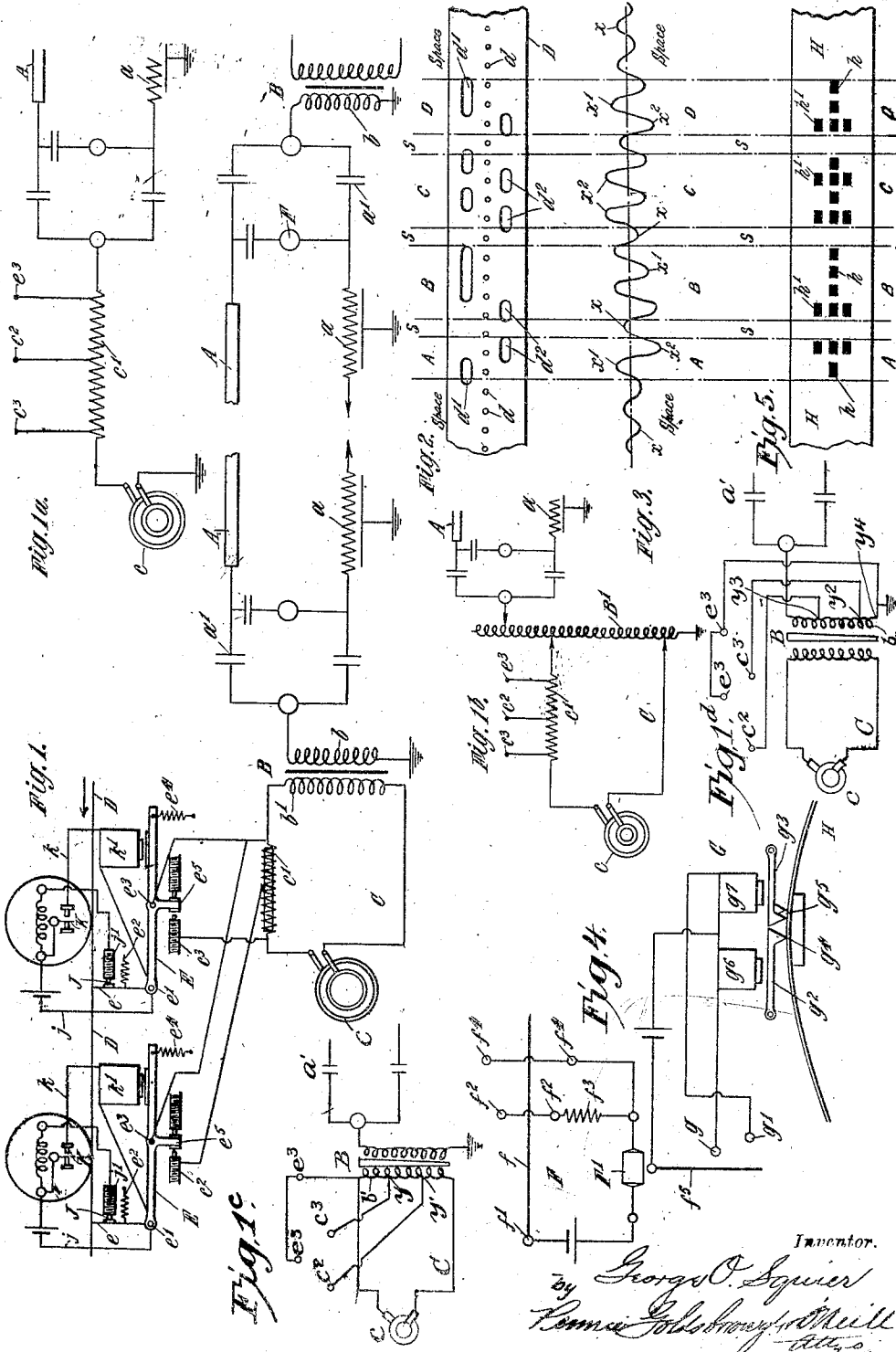


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TELEGRAPHY.

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To all whom it may concern:

Be it known that I, GEORGE OWEN SQUIER, a citizen of the United States of America, residing at 43 Park Lane, Mayfair, in the county of London, England, have invented certain new and useful Improvements in or Relating to Telegraphy, of which the following is a specification.

This invention relates to telegraphy and more especially to submarine cable telegraphy and provides an improved system of transmission intended to overcome the disadvantages due to the customary method of signaling, in which the circuit is closed and opened for the transmission of a signaling impulse.

According to my invention the messages are transmitted by an unbroken alternating current the amplitude of whose waves is varied to produce the signaling impulses. The signaling unit may be a half wave length (all signals being of equal length) and the transmitting apparatus is so arranged that the impulses are timed in accordance with the wave length. For the transmission of the dashes, dots and spaces of the usual cable code three different wave amplitudes would be employed, for example, a wave of large amplitude for a dash, of medium amplitude for a dot and of smaller amplitude for a space.

The variation in amplitude is conveniently effected by introducing variations into the transmitting or cable circuit by means usually of resistances or impedances. For this purpose a resistance or impedance element, which may be adjustable, is connected between the end of the cable (at the apex of the bridge in the duplex system) or the primary of a transmitting transformer and the current generator, while a shunt circuit passes through the transmitter, by means of which either a part or the whole of the resistance or impedance may be shunted. Three different wave amplitudes are thus produced, a relatively small amplitude representing, say, the spaces when the complete resistance or impedance is in the circuit, a moderate amplitude for the dots when part of the resistance or impedance is shunted, and a large amplitude for the dashes when the complete resistance or impedance is shunted. Three contact members might of course be employed to give a similar result, each member bringing in or shunting its own resistance.

As the phase angle between the impressed E. M. F. and the resultant current in the transmitting circuit is altered by the introduction of the various resistances or impedances the contact members of the transmitter are made adjustable longitudinally of the tape and one is displaced relatively to the other to such an extent as to compensate for the alteration in phase angle due to the change in resistance or impedance.

Shunting the whole or part of a resistance or impedance is given as a suitable method of varying the amplitude of the cable current, but it is obvious that other methods are possible, such, for example, as shunting or cutting out part of the primary or secondary of the transmitting transformer if one is used, or varying in any convenient manner the inductance of the transmitting circuit.

In order that my invention may be more clearly understood and readily carried into effect, I will describe the same more fully with reference to the accompanying drawings, in which—

Figure 1 is a diagram of the general arrangement of circuits and operating parts at the transmitting and receiving ends of a cable to which our improved system is applied.

Figs. 1^a and 1^b show two slight modifications of the transmitting end of the cable.

Figs. 1^c and 1^d show a portion of the system of Fig. 1, modified to introduce in the transformer-windings, contacts for varying the current in the transmitting circuit, and, therefore, the amplitude of the waves.

Fig. 2 shows a portion of a punched tape suitable for transmitting in this system.

Fig. 3 shows the wave form of the current produced in the cable by the aid of the portion of tape shown in Fig. 2, the form illustrated giving the beginning of the alphabet according to the Morse code.

Fig. 4 is a diagram of a relay and printer which may be provided at the receiving end of the cable, and

Fig. 5 shows the form in which messages are printed by the above printer.

A is the cable with artificial line *a* connected to earth at each end through the secondary *b* of a transmitting transformer B the primary *b'* of which is in a transmitting circuit C containing the alternator *c* and the resistance *c'* (shown as an inductive re-

sistance in Fig. 1) employed for varying the amplitude of the current impulses in the transformer and consequently the E. M. F. impressed on the cable. D is the transmitting tape. E E are the contact levers operated by the tape. F is a relay at the receiving end of the cable. G is the printer. H is the receiving tape or slip.

The tape D is intended to be fed at a constant rate by the usual star wheel acting through the central row of holes d the movement of the tape synchronizing with the alternator c . The messages are to be transmitted by the perforations d' , d^2 on each side of the holes d , the perforations d' and d^2 serving respectively for dots and dashes of the Morse code. The short perforations are for single impulses (either dot or dash according to the row d' or d^2) and the longer perforations are for two or more successive impulses of the same signification.

A transmitting apparatus of "pecker" type is shown in Fig. 1, the two levers E, one for each of the two rows of perforations d' , d^2 , carrying peckers e pivoted at e' and provided with springs e^2 tending to draw them against the adjustable contacts J in the relay circuits j , which circuits operate contact arms K in the electromagnet circuits k , the electromagnets k' of which control the levers E. For purposes of illustration the levers E and associated parts are shown displaced longitudinally in the diagram, but in practice the levers are placed side by side and turn about the same axis e' . The levers are under the control of the springs e^2 which keep the peckers e up against the tape and cause them to project through the perforations d' or d^2 as the latter pass over the peckers. The levers E each carry a contact arm e^3 connected to the cable end of the resistance c' and adapted to meet the contacts c^2 , c^3 , connected respectively to the middle and the alternator end of the resistance.

The general operation of the transmitting mechanism is as follows:—

As the tape D passes over the two peckers e immediately one of the perforations d' or d^2 meets the end of a pecker the latter is released and the spring e^2 pulls down its end of the lever, the pecker passing through the tape perforation and the contact arm e^3 meeting the contact c^2 or c^3 (Figs. 1^a or 1^b), short circuiting either a part or the whole of the resistance c' . The short-circuiting action continues until the rear end of the tape aperture meets the pecker, when continued movement of the tape pushes the end of the pecker forward around its pivot e' and against the spring e^2 , breaking the relay circuit j at the contact J. The relay circuit j is normally closed and holds the contact arm K open so that the branch electromagnet circuit k is normally open and

the electromagnet unexcited, the pressure of the pecker e against the under side of the tape holding the lever E against the spring e^2 . The action of the relay is practically instantaneous, as the moment the circuit j is broken the switch arm K returns to close the electromagnet circuit k and excite the electromagnet k' so as to raise the end of the lever E against the spring e^2 and open the shunt circuit at the contact c^2 or c^3 , the pecker by the same action being withdrawn from the tape aperture. The withdrawal of the pecker allows the spring e^2 to pull it back against the contact J and close the relay circuit j again, breaking the electromagnet circuit k (which is of lower resistance than the circuit j) and releasing the arm E ready for the next pecker operation.

The apertures d' , d^2 are of such a length that the shunting of the resistance c' occupies exactly a complete half wave period of the alternator or a multiple thereof and the length of an aperture is measured by the distance traveled by the tape in such a space of time, plus the diameter of the end of the pecker, and such correction as may be required by the movements of the pecker. The apertures therefore somewhat overlap as shown in Fig. 2. In order that the shunting of the resistance or impedance c' may occur exactly in phase with the current a relative longitudinal adjustment of the two contact devices for the perforations d' , d^2 is provided. The phase angle between the E. M. F. and current in the transmitting circuit will differ slightly according to whether the full resistance c' , part resistance or no resistance is inserted in the circuit. The perforations d' , d^2 might be displaced to give an approximate correction for constant resistance conditions but I prefer to mount the contacts J on adjusting screws j' so that by adjusting one contact forwardly or backwardly relatively to the other the difference in phase may be accurately compensated and the transmission of complete half wave impulses insured.

Instead of connecting the contacts c^2 , c^3 to points on the resistance or impedance c' as in Figs. 1^a and 1^b they may be connected, as shown in Fig. 1^c, to points y , y' on the transformer primary b' , or alternatively to points y^2 , y^3 on the secondary b as shown in Fig. 1^d, shunting or cutting out more or less of the transformer coil. If the secondary coil b is employed for this purpose the contact arm e^3 of the lever E would be connected to the secondary at y^4 instead of to the transmitting circuit C.

In Fig. 1^a a slight modification is shown in which the transformer B is dispensed with and one pole of the alternator c connected directly to the cable through the resistance c' . The other pole of the alternator is earthed. The method of sending the mes-

sages is the same as in the apparatus already described.

In Fig. 1^b the alternator c is connected to an earthed auto-transformer B' , to any suitable point of which the end of the cable is also connected. This arrangement possesses some advantages as it allows of ready adjustment of the E. M. F. impressed on the cable and also allows of the resistance c' being somewhat reduced as compared with that necessary in the arrangement employing the ordinary transformer.

According to Figs. 1^c and 1^d, adjustment of the E. M. F. is effected by regulating the number of coils that remain active in the primary or secondary of the transformer.

The resulting wave form of the current in the transmitting circuit and the E. M. F. impressed upon the cable is shown in Fig. 3 for the transmission of the first four letters of the alphabet, above the wave form being the corresponding tape perforations shown in Fig. 2. The smaller impulses x represent the spaces in the Morse code, the medium impulses x' represent the dots and the large impulses x'' the dashes, the impulses x' and x'' belonging respectively to the perforations d' and d'' of the tape D. The wave form represents, therefore, a dot and a dash for A, a dash and three dots for B, dash-dot-dash-dot for C and dash-dot-dot for D, corresponding to the perforations in Fig. 2 above. The spaces between the letters are marked S. Each impulse or half wave is of sine form, the only difference in the impulses residing in their amplitude.

Dealing now with the reception of the messages the relay F is connected across the cable and artificial line. Any suitable relay may be employed but I prefer to use a modification of the Muirhead gold wire relay in which the gold wire f (Fig. 4) when current passes through the relay, turns around the fixed end f' and makes contact between either of the small platinum posts f^2 connected through a resistance f^3 to a local wire relay F' , a second pair of posts f^4 , set farther apart than the posts f^2 , also being connected to the relay F' , which controls the printer through the arm f^5 . The second relay F' is introduced as the gold wire relay is somewhat delicate for the direct operation of the printer G. The arm f^5 is moved against the contact g belonging to the printer when the gold wire f of the relay F is brought against one of the first posts f^2 while the posts f^4 are so placed that a very small additional movement of the wire f , after meeting one of the posts f^2 , causes slight bending of the wire at f^2 so that it also meets the post f^4 at the same side and causes a further movement of the arm f^5 through the relay F' so as to bring it against the second contact g' controlling the printer.

The posts f^2 , f^4 correspond to the dots and dashes of the code and a convenient method of recording is to provide a printer having two light printing arms g^2 , g^3 arranged to mark like a siphon recorder, one arm having a central marking tip g^4 while the other has a forked tip g^5 , an electromagnet g^6 belonging to the former arm being connected to the contact g while the other electromagnet g^7 is connected to the second contact g' . The result is that the arm g^2 always prints on the recording tape H when the wire f is moved into contact with one of the posts f^2 , while the arm g^3 is operated only when the further movement of the wire connects up both posts f^2 and f^4 and consequently causes the arm f^5 to move to both the contacts g and g' . The marking on the tape is therefore of the form shown in Fig. 5, in which a central line of marks h belongs both to dots and dashes and the dashes are distinguished by bringing in the side marks h' made by the forked arm g^3 . The smaller impulses x transmitted by the cable are just too small to move the gold wire into contact with the posts f^2 , while the medium impulses x' are large enough to move the wire against these posts without further action and the large impulses x'' are sufficiently strong to give the wire a larger movement and bring it into contact with one or other of the posts f^4 . Thus the impulses x , x' and x'' represented in Fig. 3 are recorded by the marks h , h' on the tape H and can be read with great ease. It is to be understood, of course, that the relay and printing device form only one means out of many by which the messages may be received.

The present system of telegraphy allows of repunching tape or interpolation without the provision of any special synchronizing mechanism. As an unbroken alternating current is sent through the cable much higher voltages can be employed than is possible in existing systems and a substantial amount of power can be transmitted. Since the transmission of messages depends on the margin between the amplitude of the space and signal impulses the space impulses can be of considerable strength provided such margin is allowed for and the uninterrupted alternating current can be used to drive, through a suitable relay, a retransmitting slip apparatus while the slip can be punched by the aid of relays operated by the signal impulses. Since the alternating current itself controls the sending on device synchronism is obtained automatically. The apparatus is merely an adaptation of apparatus of well known type.

With regard to the general principles on which this system is based it is well understood that the most efficient method of transmission over a submarine cable would be an uninterrupted alternating current of simple

sine wave form. As all the impulses would in such a case be equal signals could not be given without some modification and the aim of the present system is to introduce the minimum possible alteration into the above ideal condition which will permit of the transmission and reception of messages. In my system the only necessary variation is in the amplitude of the waves, each signaling element occupying the same unit of time.

It will be seen that since an uninterrupted alternating current is employed consecutive impulses are necessarily in opposite directions, although of different amplitude, this insuring a condition generally recognized as desirable in cable telegraphy. Much higher voltages than is customary can be safely employed since there is no danger of sending a current of substantial duration in one direction.

One of the chief advantages attained is the more perfect balancing by the artificial line which is rendered possible by the use of unbroken sine waves. The breakage of the cable circuit by the usual transmitting method causes a sudden kick which cannot be effectively balanced and affects the reception of messages, while such disturbances are eliminated by the smooth variable curve representing the current on the new system. Better balancing allows of higher speed of duplex transmission so that the value of the cable is increased. The employment of the alternating current moreover enables me to utilize the standard forms of electrical measuring instruments for determining the behavior of the plant, in the same manner as they are at present employed in power transmission.

The cable circuit is permanently connected to earth at each end (through the low resistance coil of a transformer in the preferred arrangement) thus providing a permanent drain to earth.

While the present system is of special utility in submarine cable work it is also applicable to land lines. The system may thus be made a universal one with interchangeability between land and cable work.

What I claim and desire to secure by Letters Patent of the United States is:—

1. A method of sending telegraphic messages through a line which consists in transmitting through the line an uninterrupted alternating current of a single low frequency and in varying the amplitude of the waves of the said current so that they individually represent dots, dashes and spaces as different signaling impulses.

2. A method of sending telegraphic messages through a line which consists in transmitting through the line an uninterrupted alternating current of a single low frequency and in varying the amplitude of each half

wave of the said current to produce a dot, dash or space as a different signaling impulse.

3. A method of sending telegraphic messages through a line which consists in transmitting an uninterrupted low frequency alternating current, and varying in three stages the amplitude of the individual waves of the said current, so that they produce impulses, individually representing spaces, dots and dashes.

4. A method of sending telegraphic messages through a line which consists in transmitting an uninterrupted low frequency alternating current and in altering the resistance of the transmitting circuit in synchronism with the individual waves of the said current so as to produce signaling impulses.

5. In a system of line telegraphy, means for transmitting a single uninterrupted low frequency alternating current through the line circuit, a resistance in the said circuit and means operated in synchronism with the waves of the said current which shunts the said resistance in sections so as to vary the amplitude of the individual waves without opening the circuit.

6. In a system of telegraphy, a circuit, means for producing in said circuit, an unbroken alternating current, and means for sending over said line the three elements of the alphabet, namely, dots, dashes and spaces by complete semi-cycles of said current; said last-named means including means which vary the amplitude of the waves of said current in synchronism with the alternations of the current and thereby distinguish the signals.

7. In a system of line telegraphy, means for producing an uninterrupted alternating current in the transmitting circuit, means for introducing variations into the said circuit to produce signaling impulses without opening said circuit, an automatic transmitter controlling the said variations and adjusting means in the transmitter adapted to adjust the timing of the variations relative to the individual waves of the current so as to compensate for changes in the phase angle between the E. M. F. and resultant current due to variations in the circuit.

8. In a system of line telegraphy, means for producing an uninterrupted alternating current in the transmitting circuit, means for introducing variations into the said circuit without opening the circuit, a tape transmitter having dot and dash perforations and operated in synchronism with the alternations of the current, members actuated by the dot and dash perforations of the tape for controlling the circuit varying means, and means for relatively adjusting the said members longitudinally of the tape.

9. In a system of line telegraphy, means

for producing an uninterrupted alternating current in the transmitting circuit, means for introducing variations into the said circuit without opening the circuit, a perforated tape transmitter operated in synchronism with the alternations of the current, pecker mechanism adapted to control the circuit varying means and including pecker arms adapted to pass through the tape perforations and adjusting means for the pecker mechanism adapted to adjust the timing of the variations relative to the individual waves of the current so as to compensate for differences of phase angle in the transmitting circuit due to the variations in the said circuit.

10. In a system of line telegraphy, means for producing an uninterrupted alternating current in the transmitting circuit, means for introducing variations into the said cir-

cuit without opening the circuit, a perforated tape transmitter operated in synchronism with the alternations of the current, pecker mechanism adapted to control the circuit varying means and including pecker arms adapted to pass through the tape perforations, contacts met by the said pecker arms for circuit controlling purposes, and means for adjusting the relative positions of the said contacts.

11. In a system of telegraphy, an alternator continuously connected in the transmitting circuit and means for introducing variations in the said circuit to change the amplitude of the individual alternations so that each semi-cycle corresponds to a different signaling impulse without opening the circuit.

GEORGE OWEN SQUIER.