Aug. 13, 1929. C. F. NELSON 1,724,803

CABLE TELEGRAPHY

Filed Jan. 13, 1928 2 Sheets-Sheet 1

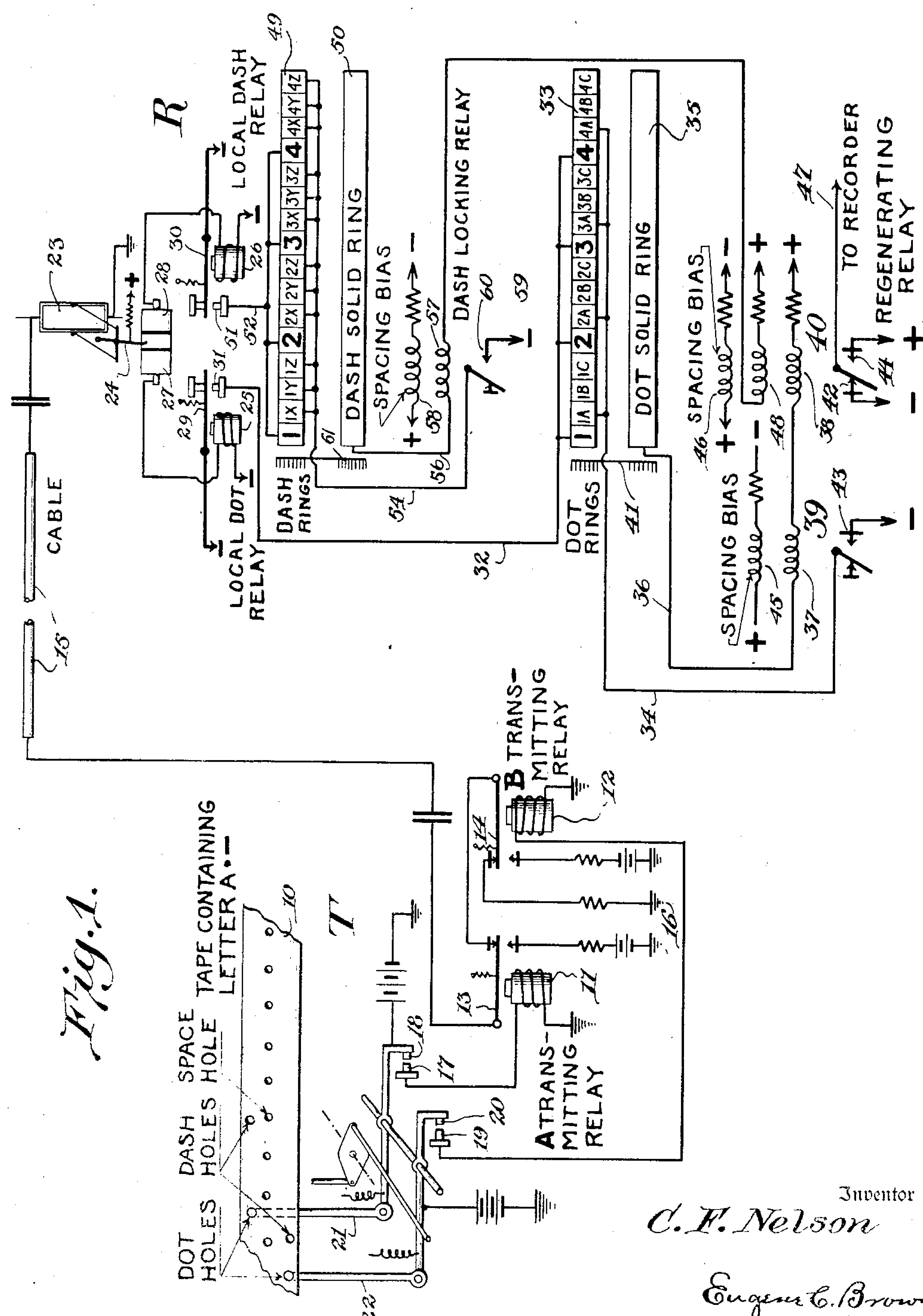

Fig. 1.

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Fig. 2.

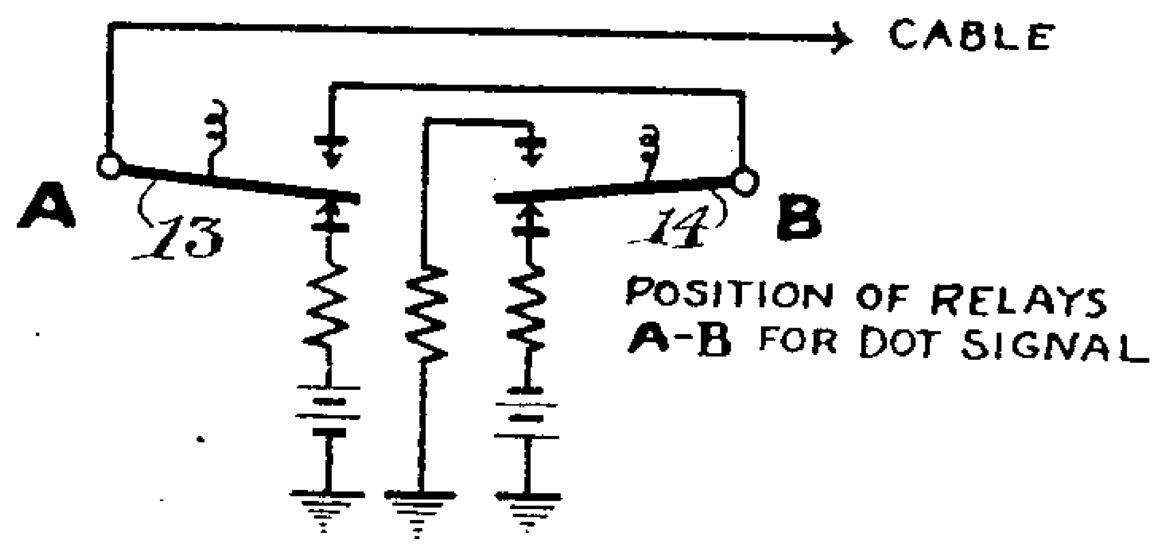

Fig. 3a

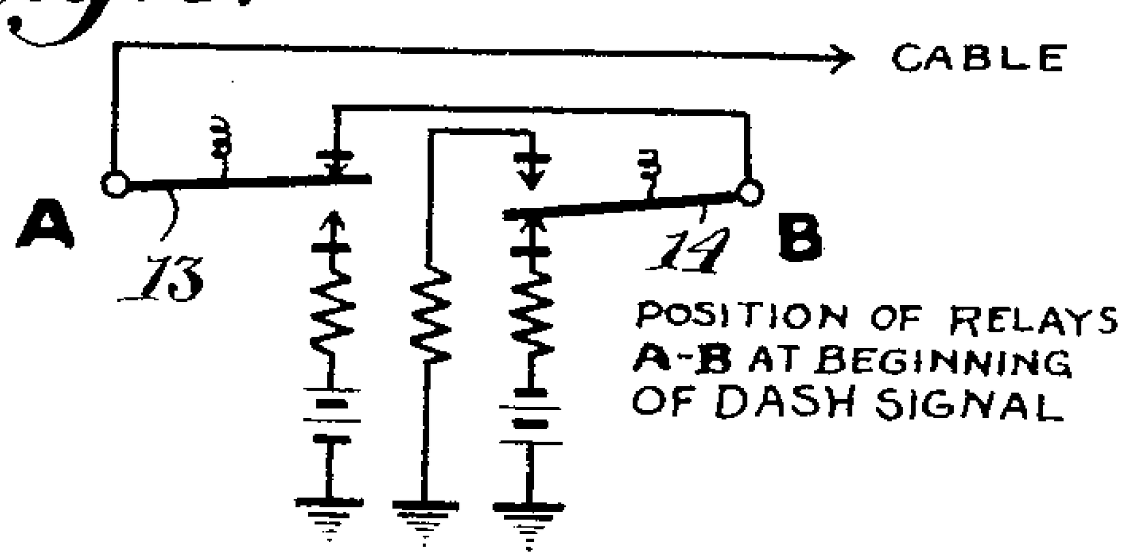

Fig. 3b

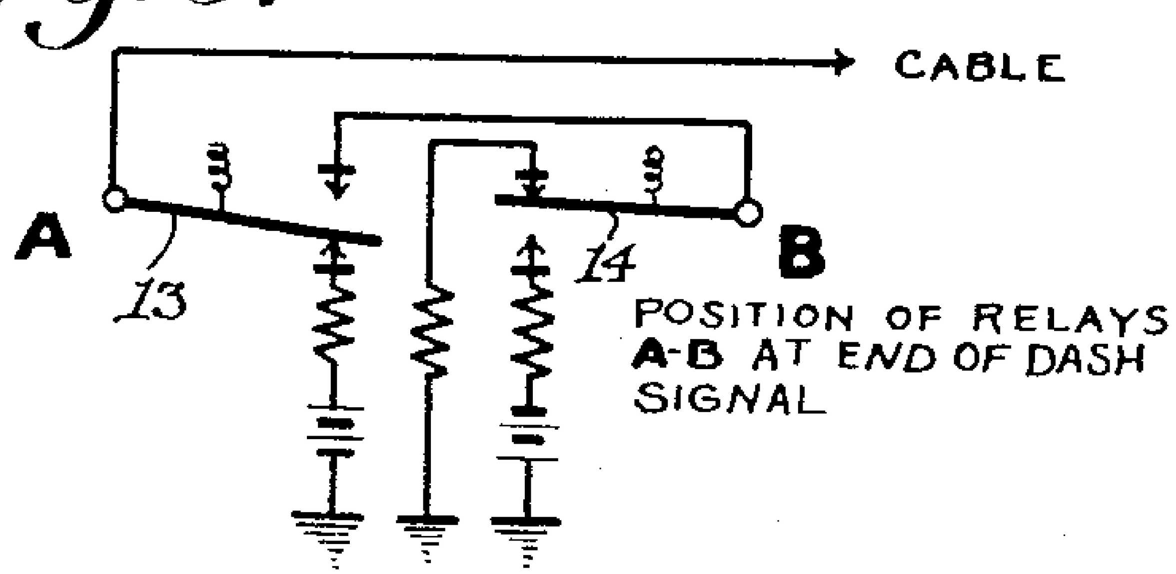

Fig. 4.

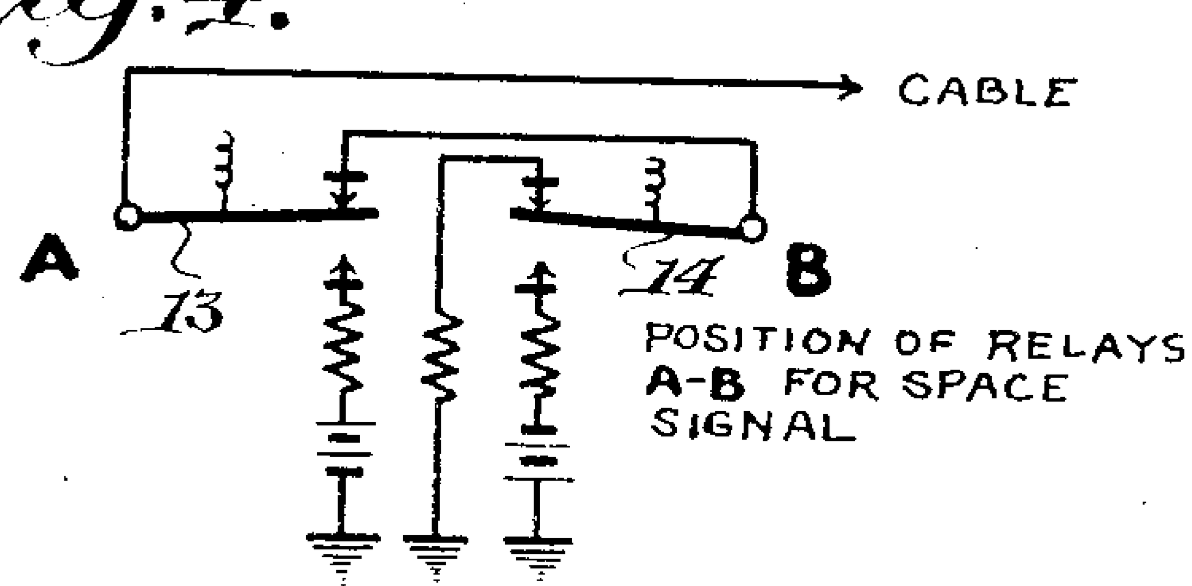

Fig. 5.

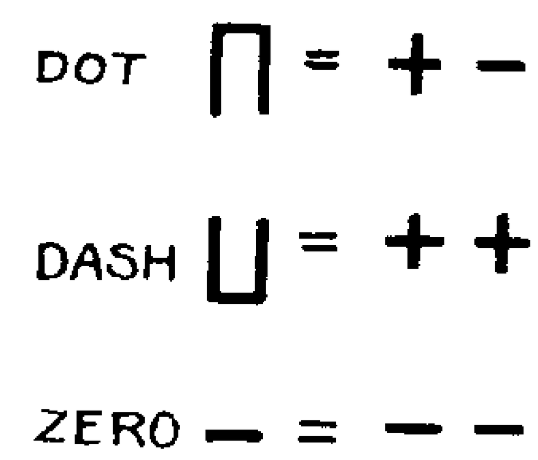

Fig. 6.

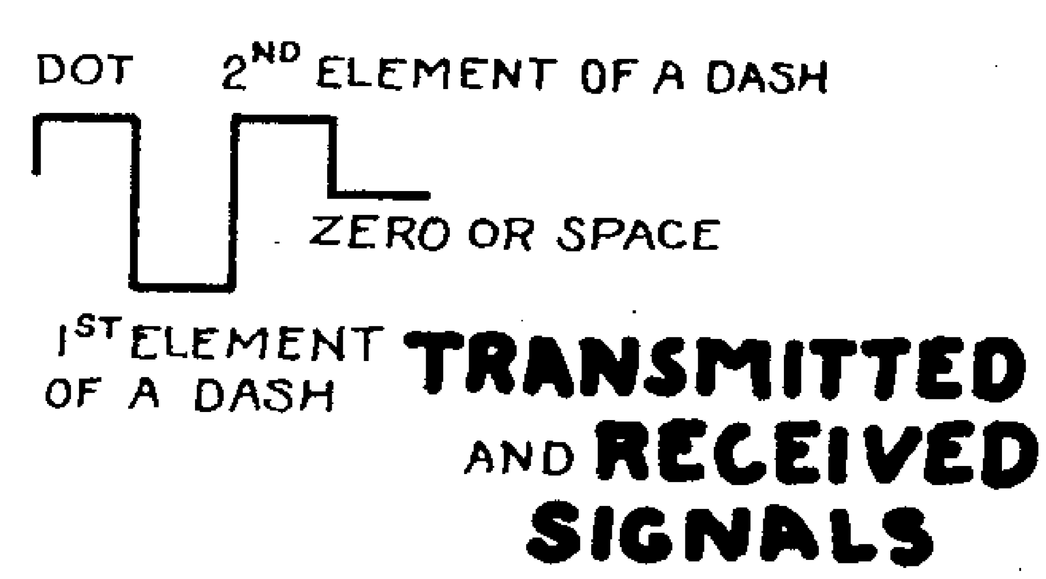

Fig. 7.

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Patented Aug. 13, 1929. **1,724,803**

UNITED STATES PATENT OFFICE.

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CABLE TELEGRAPHY.

Application filed January 13, 1928. Serial No. 246,580.

This invention relates to telegraphy, and in particular to a method of and means for effectively increasing the speed of Wheatstone-Morse operation over ocean cables.

Broadly, the invention relates to a method of telegraphically transmitting a signal made up of a large number of signal impulses by condensing it into a signal made up of a smaller number of signal impulses, in the ratio of 2 to 1 or any other suitable ratio, in accordance with a predetermined conversion key, transmitting the condensed signal, receiving the condensed signal and automatically converting it back into the original signal by a complementary 1 to 2, or the like, transformation.

When applied to the conversion of a Wheatstone-Morse code signal into one utilizing cable Morse code signal impulses, the invention covers the use of a cable Morse code transmitter for transmitting a Wheatstone-Morse code signal and a special receiver designed to convert the received cable Morse code signal impulses into a Wheatstone-Morse code signal.

The Wheatstone-Morse code contains approximately 8.5 units per letter and the cable Morse code 3.7 units per letter.

In order to operate ocean cables with Wheatstone-Morse code so that the output in letters per minute will approximately equal the output obtained with the shorter cable Morse code, it has been proposed to increase the rate of transmission to the necessary extent, but this method is possible only provided the signal thus distorted by rapid transmission is still receivable at the far end of the cable. A system for doing this is disclosed in a British patent to Judd and Davies, No. 9768 of 1913. In their system they speed up the rate of transmission to twice that of the cable Morse code transmission or to a point where the single waves are so attenuated by the cable that they practically disappear at the receiving end of the cable and are filled in by local apparatus.

However, this method of speeding up the transmission has the disadvantage that the higher rate of transmission disturbs the cable duplex balance. The present invention avoids this undesirable feature while still providing the desired increase in output, by transmitting the Wheatstone-Morse code at the same fundamental rate of frequency as the cable Morse code. Analysis of the nature of the Wheatstone-Morse code will show how the desired result may be accomplished without the accompaniment of the objectionable feature of high speed transmission.

It so happens that the Wheatstone-Morse code can be arranged into three combinations of currents, each combination containing two signal-impulse units as follows: (+-) (++) (--). For instance, in a letter "A", Wheatstone-Morse code, we have the combinations +- ++ +- --. Every other letter can be similarly analyzed into its component parts, and these will be found to comprise various arrangements of the two-unit combinations.

With the Judd and Davies method the letter "A", is transmitted with eight time units in a given time, and with the system according to the present invention, it is transmitted with four time units in the same given time. In other words, the fundamental rate of transmission with the Judd and Davies method is twice that with the method according to the present invention.

To accomplish the purpose, the invention provides that a Wheatstone-Morse code dot shall be produced at the far end of the cable by transmitting a single cable Morse code dot thereover, and a Wheatstone-Morse code dash is produced by transmitting a cable Morse code dash and dot, and, finally, a Wheatstone-Morse code space is produced by transmitting a cable Morse code space. At the end of the cable a single dot impulse is converted into one positive and one negative impulse, a single dash impulse into two positive impulses and a single space or zero impulse into two negative impulses. In this manner the original Wheatstone-Morse code message is built up at the receiving end of the cable, from the cable Morse code impulses into which it was condensed before transmission.

The method of the invention will be best understood by reference to the accompanying drawing on which:—

Fig. 1 represents the usual Morse code transmitter being fed with a strip of Wheatstone-Morse code tape and the receiving circuit at the other end of the cable including the apparatus for converting the signals received at the end of the cable into Wheatstone-Morse signals.

Fig. 2, Figs. 3ª and 3ᵇ and Fig. 4 show the position of the transmitting relays for a dot signal, a dash signal and a space signal, respectively.

Fig. 5 shows a conversion key for changing from cable Morse code into Wheatstone-Morse code, and vice versa.

Fig. 6 represents the converted signal (in Wheatstone-Morse code).

Fig. 7 represents the transmitted and received signals (in cable Morse code).

In Fig. 1, the letter "A" is perforated on the Wheatstone-Morse code tape 10 which is being fed into the usual cable Morse code transmitter T. A special receiving apparatus R at the other end of the cable cooperates with the cable Morse code transmitter T to produce the signal at the receiving end in Wheatstone-Morse code.

The transmitter T comprises the usual pair of transmitting relays 11 and 12, having armatures 13 and 14 which on their normal, upper contacts connect the transmitting end of the cable 15 to earth at 16. The armatures are spring held against these upper contacts in the non-energized condition of the relays.

An energizing circuit for relay 11 is provided from battery through a pair of contacts 17 and 18, and a similar circuit for relay 12 through a pair of contacts 19 and 20. The pair of contacts 17, 18 are closed when pin 21 penetrates a hole in tape 10 and, upon energization of relay 11 a circuit is closed from positive battery through armature 13 to cable 15, the armature being held against its lower contact. When, on the other hand, pin 22 penetrates a hole in the tape, contacts 19, 20 are closed and a circuit is completed from battery through the closed contacts to the winding of relay 12, and armature 14 is moved against its lower contact. The lower contact for armature 14 is connected to negative battery and if relay 11 is not energized, provides a path to cable 15 for negative current flow.

However, if relays 11 and 12 are both energized, armatures 13 and 14 both being held against their lower contacts, the circuit from negative battery to cable 15 is interrupted at the upper contact of relay 11. Under these conditions the energization of relay 12 is non-effective, while the energization of relay 11 is effective to connect positive battery to the cable.

The various possible positions of the transmitting relays 11 and 12 are shown in Figs. 2, 3ª and 3ᵇ, and 4. They will be explained hereinafter in connection with the transmission of the letter "A" by suitable perforation of the tape 10.

At the receiving end of the system, a cable relay 23 controls, by its tongue 24, the operation of two relays 25 and 26 hereinafter referred to as the local dot and dash relays, respectively. When the cable relay is deflected to its left hand contact 27, circuit is closed from positive battery through tongue 24, dot contact 27 and winding of dot relay 25 to the other terminal of battery. When the cable relay is deflected to its right hand contact 28, a similar circuit is closed from positive battery through tongue 24, dash contact 28, winding of dash relay 26 to the other terminal of battery.

The armature 29 of relay 25 through its lower contact 31 connects battery by way of a conductor 32 to the segments 1, 2, 3 and 4 of a dot ring 33. Segments 1A, 2A, 3A and 4A adjacent the above mentioned segments are connected to a common conductor 34, while the rest of the segments 1B, 2B etc. and 1C, 2C etc. are dead segments, being unconnected in the circuit, for a reason which will be apparent from the description of the operation below.

The dot solid ring 35 is connected by way of conductor 36 to the operating windings 37 and 38 of a dot locking relay 39 and a regenerating relay 40. The brush 41 completes circuit for the dot locking and regenerating relays in series when it bridges segment 1 and the dot solid ring 35. When brush 41 passes over onto segment 1A of ring 33 a locking circuit is completed for the locking and regenerating relays 39 and 40 by way of contact 43, armature of the dot locking relay, conductor 34, segment 1A, brush 41, dot solid ring 35, conductor 36, windings 37 and 38 of the dot locking and regenerating relays to battery. This locking circuit is maintained until brush 41 passes off segment 1A onto the dead segment 1B. The dot locking and regenerating relays are therefore energized during the passage of the brush over segments 1 and 1A, but this energizing circuit is open while the brush is passing over dead segments 1B and 1C when the energizing circuit is open, biasing winding 46 of relay 40 causes a deflection of the armature of the regenerating relay 40 to its left hand or negative contact 42.

The dot locking relay is provided also with a winding 45 through which a spacing current provides a bias to normally maintain the armature of the locking relay in its left hand, non-operative position.

The regenerating relay 40 is also provided with a winding 46 through which a permanent spacing current flows to normally hold the armature of the regenerating relay on its left hand contact 42. The left hand contact is connected to negative battery and the right hand contact 44 to positive battery, so that deflection of the armature connects one or the other battery to conductor 47. This conductor may lead to a recorder or the like, or to another transmission circuit, if desired.

The regenerating relay 40 has still a third winding 48, an operating winding which is under the control of the local dash relay 26 and a distributor comprising rings 49 and 50. As in the case of the local dot relay, operation of the local dash relay effects the connection of battery to lower contact 51 of armature 30 and by way of a conductor 52 to the segments 1, 2, 3 and 4 of dash ring 49. However, in this case all the other segments of the ring 1X, 2X etc., 1Y, 2Y, etc., 1Z, 2Z, etc., are connected to a common conductor 54, there being no dead segments. The dash solid ring 50 is connected by conductor 56 to operating winding 57 of dash locking relay and to the second operating winding 48 of the regenerating relay 40. A biasing winding 58 of the dash locking relay holds the armature normally against its left hand, non-operative contact. When brush 61 bridges segment 1 of ring 49 and solid ring 50, the dash locking and regenerating relays are energized. When brush 61 passes onto segment 1X, a locking circuit is completed for relays 59 and 40 from battery and right hand contact 60 of relay 59, conductors 54 and 56, windings 57 and 48 back to battery. This locking circuit is maintained during the whole interval that brush 61 is passing over segment 1X, 1Y, 1Z of ring 49. It is apparent, therefore, that operation of local dash relay 26 produces twice as long an energization of the regenerating relay 40 as does operation of the local dot relay 26.

Briefly stated, the receiving apparatus is so designed that operation of the local dot relay causes the regenerating relay to transmit a positive impulse followed by a negative impulse, while operation of the local dash relay causes the regenerating relay to transmit a prolonged positive impulse having a duration equal to that of both positive and negative impulses produced by operation of the local dot relay, or in other words, equal to twice the duration of the positive impulse produced by operation of the dot relay. When neither local relay, dot or dash, is energized the biasing winding of the regenerating relay is effective to cause the transmission of a negative, spacing impulse.

The operation of the system to transmit a Wheatstone-Morse code signal will be apparent from the following:

It is desired to transmit the letter "A" of the Wheatstone-Morse code, represented in Fig. 6. Using the conversion key shown in 5, a cable Morse dot or positive impulse represents **+ -**, a dash or negative impulse represents **+ +**, and zero or spacing current represents **- -**. The signal to be transmitted by the cable Morse code transmitter then becomes that shown in Fig. 7, a dot or positive impulse equal in time value to **+ -**, followed by negative and positive impulses having a time value equal to **+ + +**, and, finally, a zero or spacing impulse having a time value equal to **- -**. As explained above, the Wheatstone-Morse code dash is represented by a cable Morse code dash and dot, so that the Wheatstone-Morse code dash may be treated as comprising two elements, as represented in Fig. 7.

If the signal represented in Fig. 7 is transmitted at the same fundamental rate of frequency as a true cable Morse code signal; it is apparent that in effect, the rate of transmission of the signal, considered as a Wheatstone-Morse code signal, will be doubled.

The tape 10 having been perforated to represent the letter "A" according to the principles just explained, the strip is caused to pass through the cable Morse code transmitter T. As indicated in Fig. 1, the dot holes will cause pins 21 and 22 to close both pairs of contacts 17, 18, and 19, 20, and both relays 11 and 12 will be energized, armatures 13 and 14 being moved to their lower contacts (see Fig. 2). However, energization of relay 12 is non-effective, and energization of relay 11 connects positive battery to the cable. At the receiving end, the tongue 24 of cable relay 23 is deflected to its left hand dot contact and local dot relay 25 is energized. An energizing circuit is established for dot locking relay 39 and regenerating relay 40 by way of segment 1 of ring 33, and energization is maintained by the action of relay 39 in lock-up over a circuit by way of segment 1A. Up to this point the regenerating relay has transmitted a positive signal of two segments in length.

Now the brush 41 passes off segment 1A and rides over the dead segments 1B and 1C. The locking circuit is opened and the dot locking relay and regenerative relay are deflected to their left hand contacts by permanent spacing current in windings 45 and 46, during the time that the brush 41 passes segments 1B and 1C. Up to this time the dot signal has been converted into a positive and negative signal of equal length as shown in Fig. 6 at WW.

Referring again to Fig. 1, the dash holes of the letter "A" as they pass over the pins 21 and 22, first will cause the dash pin 22 to pierce the lower dash hole and operate the dash transmitting relay 12. As shown in Fig. 3^a, this first part of the Wheatstone dash signal causes the transmission of a negative impulse or cable Morse code dash. At the receiving end, the tongue 24 of cable relay 23 is deflected to the right or dash contact, and the local dash relay 26 is energized. The armature 30 of the dash relay energizes segment 2 of the dash ring via its contact 51 and conductor 52. As the brush 61 of the dash ring passes segment 2 it connects current to the dash solid ring, and by way of conductor 56 causes energization of the dash locking relay 59 and regenerating relay 40. The armatures of these two relays move to their right hand contacts.

When the brush 61 reaches segment 2X it picks up negative current by way of conductor 54 from right hand contact and armature of dash locking relay 59 and keeps the dash locking relay and the regenerating relay 40 locked through conductor 56 by way of the dash solid ring. Since there are no dead segments on the dash ring, the regenerating relay is held over on its right hand contact for the length of four segments. Up to this point, the beginning or first impulse of the Wheatstone dash signal has been converted into a positive current signal equal in length to the two units of the Wheatstone dot signal as shown at XX, Figure 6.

Referring again to Fig. 1, upon further movement of the tape 10, the dot pin 21 pierces the upper dash hole, producing the second part of the Wheatstone dash signal. The dot transmitting relay 11 alone is energized, and, as indicated in Fig. 3[b], its operation causes a positive current to be sent into the cable by way of the armature of relay 11. At the receiving end, the cable relay is deflected to its left or dot contact and in turn operates the local dot relay 25. It has already been shown how a dot signal sent over the cable is converted into a positive and negative signal. The second part of the Wheatstone dash signal, which was received on segment 3 of the dot ring, has been converted into a positive and negative signal as shown at YY, Figure 6.

The space signal of the letter "A" is sent with the transmitting relays in the position shown in Fig. 4. The space signal has no pin holes and therefore the pins 21 and 22 cannot close contacts 17, 18 or 19, 20, and neither transmitting relay is energized. As shown in Fig. 4 the transmitting end of the cable is grounded at 16 to transmit the spacing signal.

At the receiving end of the cable, the cable relay is deflected neither to left nor right but takes up its position midway, at "no-mans-land", for the spacing signal. In this case neither the local dot nor local dash relay is operated, and no current is connected to either the dot or dash segments 4. However, the permanent spacing current in the biasing windings 45, 46, 58 of the locking relays and regenerating relay is free to operate these three relays to their spacing contacts where they are held for the length of four segments or until the brushes pass from segments 4 to segments 1.

Up to this point the Wheatstone space signal has been converted at the receiving end into a negative current of two units shown at ZZ, Fig. 6.

The complete cycle of operation for transmitting and receiving the letter "A" Wheatstone code is shown in Figures 7 and 6 in which Fig. 7 represents the transmitted and received impulses for the letter "A", and Fig. 6 represents the received impulses converted into Wheatstone-Morse code.

It will be perfectly obvious that other assignments of the current signs may be made to accomplish the same results. For instance, a dot signal may be transmitted as ++, the dash as − −, and the zero as + −. In this case the circuit arrangement for the transmitting relays and the receiving distributor segments would be changed correspondingly to make the necessary conversion at the sending and receiving ends.

The specific arrangement of circuits shown on the drawing is illustrative only as it will be obvious that other specific arrangements may be made without departing from the spirit of the invention.

I claim:

1. In a cable system, a cable Morse code transmitter, a cable, and a receiver comprising a cable relay and a regenerating relay, means for operating said regenerating relay to produce positive and negative signal impulses in accordance with the Wheatstone-Morse code, and means responsive to received cable Morse code impulses in said cable relay for selectively controlling operation of said regenerating relay.

2. In a telegraph receiving system, a cable relay selectively responsive to positive, negative and earthing signal impulses, a regenerative relay provided with means to transmit a prolonged signal of one polarity, a prolonged signal of the other polarity, or a signal made up of successive short impulses of both polarities, and means under control of the cable relay for causing selective actuation of said regenerative relay.

3. In a telegraph receiving system, a receiving relay adapted to respond to current impulses of opposite polarities to close the circuits of either of a pair of local relays, means under the control of the first of said pair of relays for producing double actuation of a regenerating relay to transmit in sequence impulses of opposite polarities and means under the control of the second of said pair of relays for producing a single actuation of said regenerating relay to transmit an impulse of one polarity only, equal in duration to the combined impulses of opposite polarities.

4. In a telegraph receiving system, a receiving relay adapted to respond to current impulses of opposite polarities to close the circuits of either of a pair of local relays, means under the control of the first of said pair of relays for producing double actuation of a regenerating relay to transmit in sequence impulses of opposite polarities, means under the control of the second of said pair of relays for producing single actuation of said regenerating relay to transmit an impulse of one polarity only and

means operative during the non-operative condition of said receiving relay to produce a single actuation of said regenerating relay to transmit an impulse of the other polarity.

5. In a cable telegraph receiving system, a cable relay having a three position armature responsive to positive, negative and earthing impulses, a regenerative relay, means biasing the relay so as to transmit an impulse of one polarity, means for actuating said regenerative relay to transmit an impulse of opposite polarity, and means intermediate the cable relay and the regenerative relay for effecting alternate operation of said actuating and biasing means upon receipt by the cable relay of a signal impulse of one polarity, means for effecting prolonged operation of said actuating means upon receipt of a signal impulse of opposite polarity and means for effecting prolonged operation of said biasing means upon receipt of an earthing impulse.

6. In a cable telegraph receiving system, a regenerating relay having alternate contacts connected to sources of current of opposite polarity, a biasing winding adapted to close one contact to transmit current of one polarity, operating windings under control of separate distributors adapted to close the other contact to transmit current of the other polarity, a cable relay, a pair of local relays and a pair of distributors, means under control of the cable relay and a local relay to establish a circuit from a source of current through the corresponding distributor to an operating winding of the regenerating relay and means under control of the respective distributors for maintaining circuit through one operating winding of the regenerative relay for a period twice as long as that during which circuit is maintained through the other operating winding of the regenerative relay.

7. In a cable telegraph receiving system, a regenerating relay having alternate contacts connected to sources of current of opposite polarity, a biasing winding adapted to close one contact to transmit current of one polarity, operating windings under control of separate distributors adapted to close the other contact to transmit current of the other polarity, a locking relay for each operating winding of said regenerating relay and means under control of its corresponding distributor to establish an operating circuit and a locking circuit for said locking relay, a cable relay and a pair of local relays, means under control of the cable relay and a local relay to establish a circuit from a source of current for said locking and regenerating relays through the corresponding distributor, segments of said distributor being so arranged that operation of one of said local relays causes its locking relay to maintain a circuit through the operating winding of the regenerative relay for a period longer than that during which circuit is maintained through the other operating winding of the regenerative relay upon operation of said other local relay.

8. The method of transmitting a Wheatstone-Morse code signal which comprises condensing said signal into a cable Morse code signal in accordance with a predetermined conversion key, transmitting said condensed signal and automatically expanding the received condensed signal into the original Wheatstone-Morse code signal.

9. The method of operating an ocean cable which comprises recording a Wheatstone-Morse code signal, transmitting in accordance with said record a cable Morse code signal whose signal impulses represent the impulses of the Wheatstone signal in accordance with a conversion key, receiving said cable Morse code signal and automatically reconverting it into a Wheatstone-Morse code signal in accordance with said conversion key.

10. The method of rendering the output of an ocean cable in letters per minute with the Wheatstone-Morse code equal to the output obtainable with the shorter cable Morse code, which comprises condensing a Wheatstone-Morse code signal into a signal having substantially half the number of signal impulses and transmitting the condensed signal at the same fundamental rate of frequency as that of the cable Morse code.

11. The method of effectively increasing the speed of transmitting telegraphic signals which comprises transmitting single signal impulses in predetermined order and sequence to represent each a characteristic combination of signal impulses, receiving the single signal impulses and controlling by each impulses the further transmission of its characteristic combination of signal impulses.

12. In a cable system, a cable Morse code transmitter and in combination therewith a tape perforated in accordance with a Wheatstone-Morse code signal.

13. In a cable system a cable Morse code transmitter comprising a pair of relays, and in combination therewith a tape perforated in accordance with the Wheatstone-Morse code cooperating with the elements of the transmitter so that a dot signal permits simultaneous operation of both relays, a dash signal permits operation of the two relays one at a time in sequence, and a space signal prevents energization of both relays.

14. In a cable system, a cable Morse code transmitter and a receiver including a regenerating relay adapted to send positive and negative impulses, said regenerating relay comprising two windings each adapted to cause actuation of the relay to transmit an impulse of a given polarity, and a third winding adapted to cause actuation of the relay

to transmit an impulse of the other polarity, and means selectively responsive to positive, negative and zero impulses from said transmitter to selectively control energization of said windings.

15. In a cable system, a cable Morse code transmitter and a receiver including a regenerating relay adapted to send positive and negative impulses, said regenerating relay comprising three windings, means responsive to an impulse of one polarity from said transmitter to permit energization of one of said windings, means responsive to an impulse of the opposite polarity from said transmitter to permit energization of two of said windings, and means normally biasing said relay by energization of the third winding.

16. In a cable system, a cable Morse code transmitter and a receiver including a two-contact relay having three windings, one of said windings providing normal bias against one of said two contacts and the other two windings being arranged to permit operation of the relay against the other contact, a source of current having opposite poles connected to said contacts, means responsive to a signal impulse of one kind in said receiver to permit energization of one of said other two windings and means responsive to a signal impulse of another kind in said receiver to permit energization in sequence of the second of said other two windings and the biasing winding.

In testimony whereof I affix my signature.

CRESCENT F. NELSON.