

April 28, 1931.

R. H. RANGER

1,802,736

RADIO TRANSMITTING SYSTEM

Filed Jan. 15, 1926

3 Sheets-Sheet 1

Fig. 1

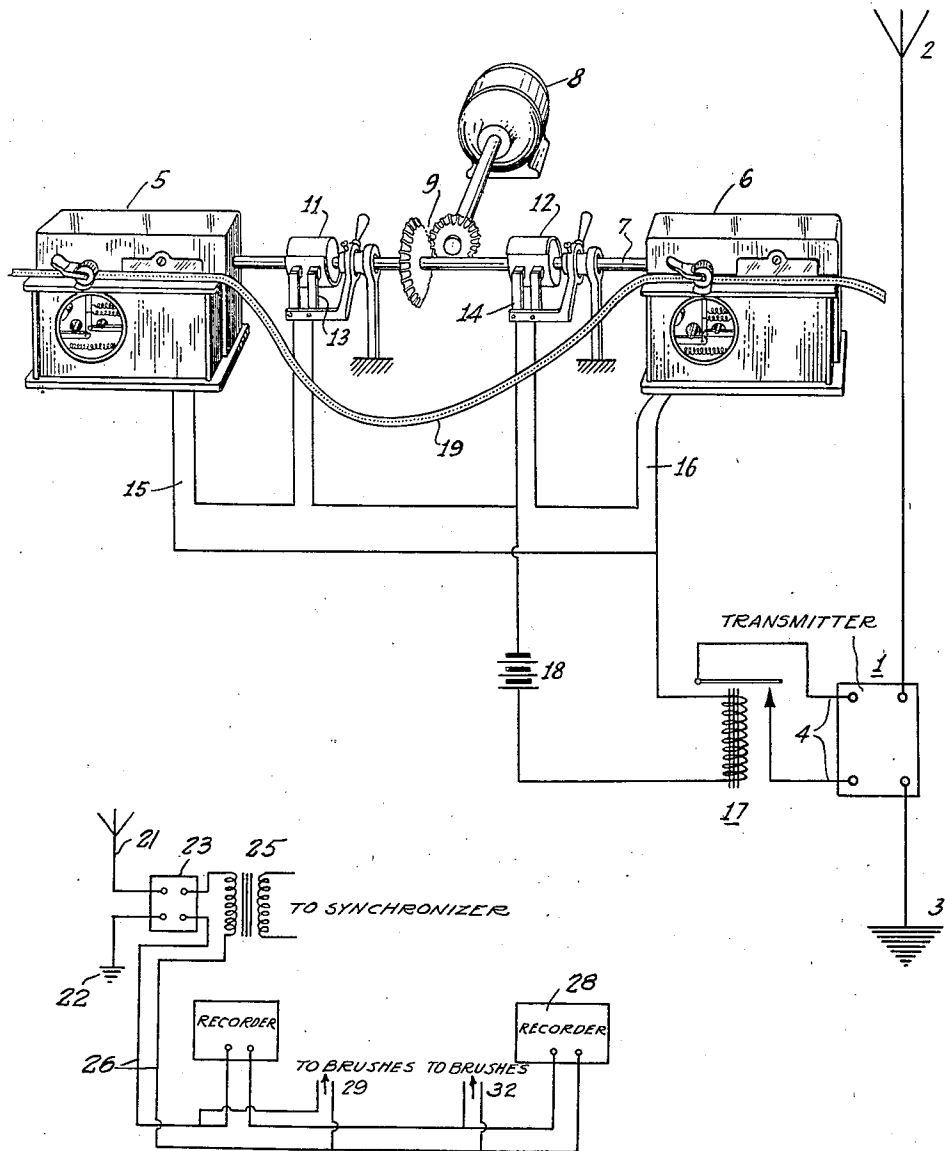


Fig. 8

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3 Sheets-Sheet 2

Fig. 3

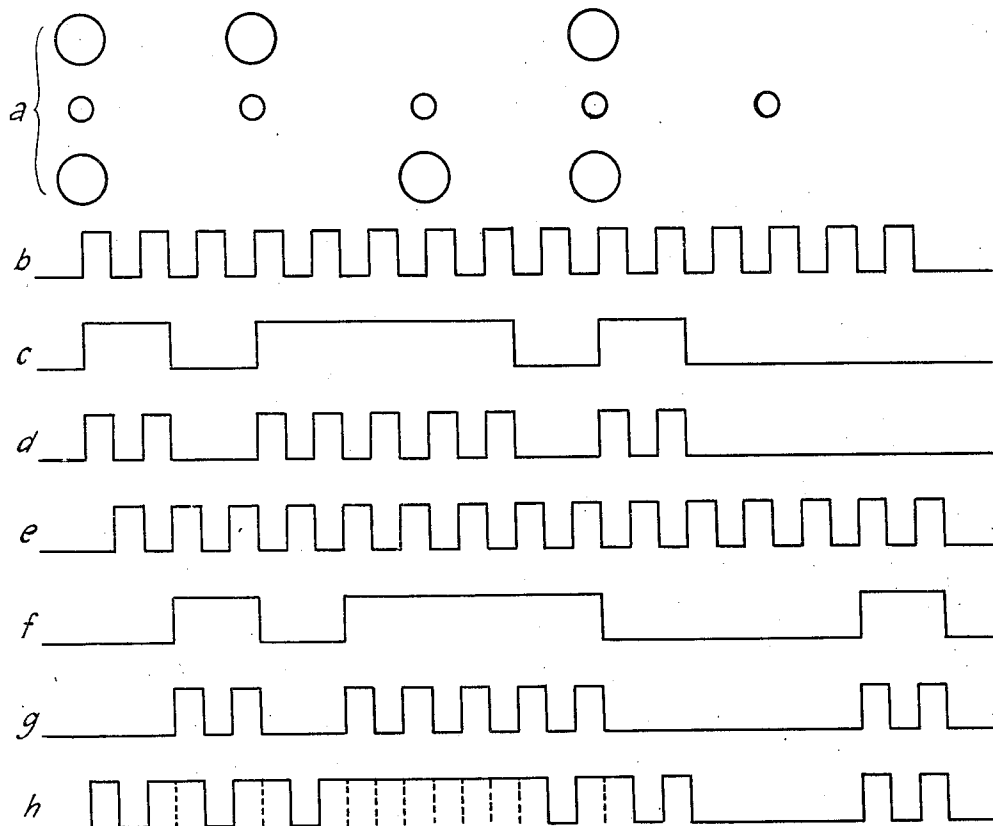
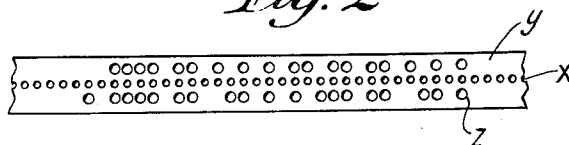


Fig. 2



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3 Sheets-Sheet 3

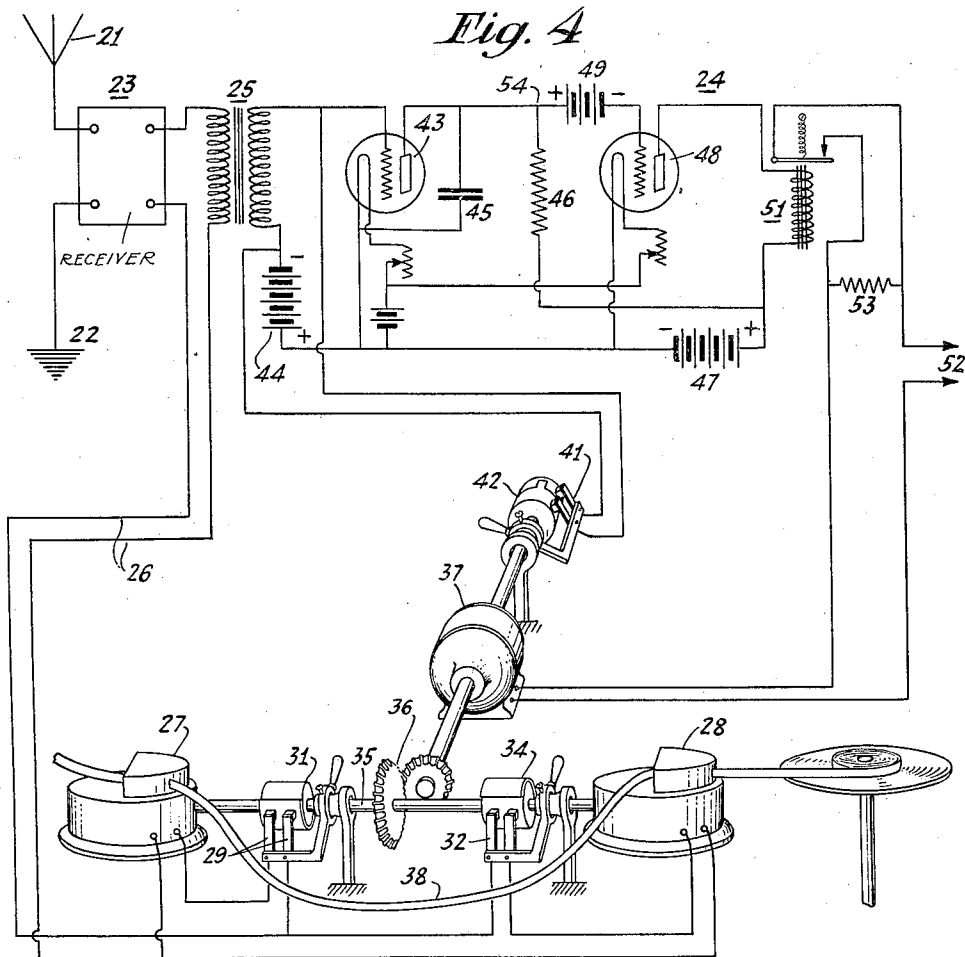


Fig. 5



Fig. 6

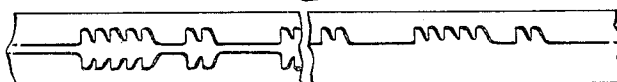
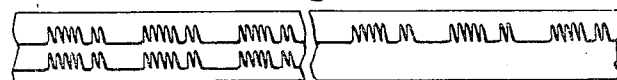


Fig. 7



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RADIO TRANSMITTING SYSTEM

Application filed January 15, 1926. Serial No. 81,321.

My invention relates to radio communication systems, and particularly to multiplex and static elimination means therein.

5 An object of my invention is to provide means for reducing the effect of static disturbances upon a radio transmission system.

Another object of my invention is to provide a multiplex radio transmission system.

10 Another object of my invention is to provide an improved synchronizing means for duplex operation of a code channel.

Another object of my invention is to provide in a radio receiving system means for visually distinguishing between signal impulses and static impulses.

15 Another object of my invention is to provide in a radio signaling system means for indicating errors in the code signal and means for indicating the correct signal.

20 Another object of my invention is to provide a radio signaling system comprising means for recording the signal and means for rendering the signal more accurately intelligible.

25 Another object of my invention is to provide an improved code for duplex signaling.

Another object of my invention is to provide means for the transmission of a code message twice from a single sending means 30 over a single channel with a small time delay between transmissions, for the reception thereof, and the recording of the separate transmissions together on a single record.

35 Another object of my invention is to provide means for increasing the speed of radio telegraph communication.

In the art of radio signaling great difficulty has been experienced from the presence of interference by so-called static or strays. These 40 impulses produce false signals which cause great difficulty in the reading of the message. It has been found that the slower the rate at which the message is sent the less interference is experienced from such impulses. It is 45 found that the accuracy of transmission can be improved and the effect of such impulses still further reduced by transmitting each word twice. Then if the receiving operator makes an error in reading a word the first 50 time, its immediate repetition gives him an

opportunity to check the correctness of his first transcription and to correct it if the first is wrong.

This system, however, slows down the rate of transmission very much. For instance, 55 under ideal conditions, the apparatus of the radio channel is capable of a speed as high as 80 words a minute, while under common conditions of static interference, the necessity of sending words twice, and slowly, may reduce 60 this speed to 20 or even 15 words per minute.

My invention provides means for duplexing the radio circuit so that the message is transmitted twice as two separate code signals, simultaneously. It further provides 65 means whereby the same message is sent over each channel with a small time delay between a given point in the two transmissions. It further provides a recording means adapted to show the character of the code produced 70 by the duplexing and to show the presence of static interference. It further provides means for recording both of the transmissions sent over the radio channel with a time delay 75 therebetween corresponding to that in the sending so that the same words in each transmission occur together on the tape. The operator thus has a message sent to him twice over separate channels and he is able to determine the presence of static at any given 80 point on the recording of one transmission which may cause an error and by reference to the other recording at the same point on the tape is able to determine the correct symbol.

By this means I am enabled to avoid the 85 repetition of words in sequence, which permits of twice the speed of transmission of a given message. I am also enabled to provide two independently transmitted copies of the message either of which may be referred to. 90 I am further enabled to provide an accurate indication of static impulses. These combined improvements enable me to obtain a signal speed under adverse conditions of static interference which is four or more times 95 as great as the speed obtainable with the ordinary system and with greater accuracy of transmission. I have found it readily possible to attain a speed which is limited only 100 by the mechanical features of the radio cir-

cuit, under all but the very worst static conditions.

Other objects and structural details of my invention will be apparent from the following description when read in connection with the accompanying drawings, wherein:

Fig. 1 is a diagrammatic representation of a radio transmitting station equipped with apparatus embodying a preferred form of my invention.

Fig. 2 is a representation of a suitable message tape for use therewith.

Fig. 3 is a representation of the perforations upon the sending tape and the signal impulses produced by the duplexing means.

Fig. 4 is a diagrammatic representation of circuits and apparatus of a preferred form of the receiving portion of my invention, including a synchronizing means.

Fig. 5 is a representation of a specimen of the recorded message.

Fig. 6 is a representation of a tape showing an alternative method of recording.

Fig. 7 is a representation of a tape made at a slower tape speed, and

Fig. 8 is a modified form of receiver with the recorders and commutators and associated brushes shunt connected.

Referring to Fig. 1, a radio sending apparatus 1, connected to an antenna 2, and a ground 3, and having a keying circuit 4, is provided. Means are provided (not shown) for perforating a paper tape according to the message to be sent. This may be the well-known Kleinschmidt or other similar perforator as for example of the character shown in the publication "Printing Telegraph Systems and Mechanisms" by H. H. Harrison published by Longmans and Co. in 1923. The usual relay controllers for actuating a circuit in response to the perforators in the tape are used. These controllers 5 and 6, are provided, and driven by a common shaft 7. The shaft 7 is driven by a motor 8 through reduction gears 9. Commutators 11 and 12 are provided upon shaft 7 and equipped with adjustable pairs of brushes 13 and 14. The controllers 5 and 6 have output circuits 15 and 16 which are connected respectively in series with the pairs of brushes 13 and 14.

A relay 17 is provided and the contacts thereof connected to the keying circuit 4 of the transmitter 1. The coil of the relay 17 is connected through a battery 18 to the output circuits 15 and 16 which are respectively in parallel to the circuit through the battery 18 and the relay 17.

The perforated message tape 19 may then be fed through the controllers 5 and 6 in sequence. The controllers then respond to the same message, with a time delay determined by the length of the loop of tape 19 between them.

The controllers 5 and 6 then have alternate control of the radio channel by virtue of the

operation of the commutators 11 and 12 and the brushes 13 and 14. The conducting segments on the commutators 11 and 12 are, as shown, arranged to close the circuit through the brushes 13 and 14 alternately.

The circuits to the keying relay 17 may thus be opened by any one of several devices. If the controller 5 at a given instant be upon marking, and the controller 6 upon spacing, the circuit of the relay 17 is opened and closed by the commutator 11 and the brush 13 at a frequency determined by the speed of the shaft 7, giving thereby an interrupted marking tone. If both controllers 5 and 6 are upon marking the circuit is closed at one commutator at the instant it is opened at the other and, therefore, current flow through the relay 17 is maintained, holding it closed and providing a steady output of radio frequency current from transmitter 1, without the interrupter tone. When both controllers 5 and 6 are upon spacing neither commutator 11 nor 12 closes the circuit.

This effect is shown diagrammatically in Fig. 3 at line *b* which indicates the character of impulse which would be sent out from the radio station under the actuation of the keying relay 17 when controller 5 is upon marking and controller 6 upon spacing. Line *c* which is similar in appearance but displaced in time by half the cycle of a pulse, shows the signal produced when controller 5 is upon spacing and controller 6 is upon marking. It is thus evident that with both controllers upon spacing no energy is sent out and with both controllers upon marking, that energy is sent out continuously.

It has been found convenient to provide a definite ratio between the pulses of the respective channels and the pulses of the code signals.

Referring to Fig. 2, a typical perforator tape having center, or sprocket holes *x*, circuit closing holes *y* and circuit opening holes *z* is shown.

It has been found by statistical methods that the average message contains words of such size that when translated into the Morse code by the perforator, 24 of the center holes will represent a word. In the drawing the word chosen contains 28 center holes.

Referring again to Fig. 3 line *a* represents the perforations of a message tape upon a largerscale than Fig. 2. The speed of the tape through the controllers 5 and 6 is determined by the speed of the motor 8, by the ratio of the gear reduction 9, by the ratio of the gear reduction within the controller and by the number of teeth on the sprocket. Referring to line *b* of Fig. 3 the commutators and brushes are arranged so that one revolution of the shaft 7 produces one marking current pulse and one space through each controller. The gear reduction within the controller is such that shaft 7 is required to make 3 revolu-

tions in moving the tape along through a distance of one center hole. One center hole represents one time unit, which is equal to a code dot and its following space, as shown in line *c* of Fig. 3. Likewise, a dash and its following space is represented by two center holes in the tape as further shown in line *c*. Thus during the sending of a dot by controller 5, commutator 11 bridges the brushes 13 three times and during the sending of a dash it bridges the brushes six times. However, during the sending of the dot the contacts in the controller are closed only while the brushes 13 are bridged the first two times and the controller contacts are open while the brushes 13 are bridged the third time. This results in the sending of two pulses followed by a space as shown in line *d*. Similarly during the sending of a dash, the contacts of the controller 5 are held closed while the brushes 13 are bridged five times and are then open for the sixth bridging. The dash is thus represented by five pulses, and its following space omits a pulse.

The brushes 14 are in circuit with the controller 6 and are bridged alternately with the bridging of the brushes 13. They are bridged during exactly the time that the brushes 13 are not bridged. This results in the sending of pulses indicated in line *e*. The sprocket wheel of controller 6 which moves the tape is displaced by one half of the distance between center holes from the setting of the sprocket of controller 5 and in consequence a dot sent by controller 6, will fall within the space following a dot sent by the controller 5 as shown by lines *f* and *c*. The sending of dots and dashes occurs by pulses exactly similar in controller 6 to those sent by controller 5 as shown in line *g*. The combined currents in relay 17 and thus the output of the radio apparatus 1 is indicated in line *h*.

It has been found convenient to control the speed of the motor 8 in the transmitting apparatus to a constant value. This may be done by any convenient one of a number of different methods, such as the cooperation between a tuning fork and a commutator or other suitable arrangement. It is desirable but not essential that an accurate speed control be maintained. It is essential only that too sudden and great changes of speed do not occur. It is also convenient to mount the pairs of brushes 13 and 14 upon a movable brush rigging in order that the opening of the circuit through one pair of brushes may be made to coincide accurately with the closing of the circuit through the other pair, since this condition results in less wear on the keying relays of the sending apparatus and avoids chatter of the relays.

Referring to Fig. 4, a receiving antenna 21 and ground 22 are provided and connected to a suitable radio receiving detector appa-

ratus 23, which may be of any convenient pattern adapted to the operating conditions of the radio channel, but may desirably incorporate therein a signal amplifier to increase the output of signal energy.

This signal energy is supplied to a synchronizing system 24 and also to the recording system 27, 28 which are connected in series. The energy is supplied to the synchronizing device 24 through the secondary winding of a transformer 25 and to the recording system through leads 26. A pair of signal recorders 27 and 28 of any suitable type are provided. The recorder 27 is connected in series to brushes 29 bearing upon a commutator 31, and recorder 28 is connected in series to brushes 32 which bear upon a commutator 34. The series combinations comprising recorder 27, brushes 29 and commutator 31, and recorder 28, brushes 32 and commutator 34 are the connected in parallel relation to the lead wires 26.

The commutators 31 and 34 are mounted upon a common shaft 35 which is driven through a pair of 2 to 1 reduction gears 36. A motor 37 drives the gears 36. Suitable reduction gearing is provided within the recorders 27 and 28 connected to shaft 35 and actuating a friction drive therein which draws the tape 38 through the respective recorders. This gear ratio may be of whatever value is found to give a suitable openness of spacing in the code message for convenient reading by the individual operator. It is, however, essential that the gear ratio be the same in both recorders.

The speed of the motor 37 is maintained in rigorous synchronism with the speed of the motor 8 at the transmitting apparatus by means of the synchronizing device 24 and therefore the shaft 35 and the commutators 31 and 34 are maintained in rigorous synchronism with the shaft 7 and the commutators 11 and 12. The pairs of brushes 29 and 32 are then adjusted to suitable angular relationship and an operating condition is obtained wherein the brushes 13 and 29 are bridged by the conducting segments of their respective commutators at precisely the same instant and the brushes 14 and 32 similarly are bridged at precisely the same instant. This condition results in a duplex operation whereby the code message sent by controller 5 is reproduced by the controller 27 with the pulses produced by the commutator device included, and the code message sent by controller 6 is similarly reproduced by the recorder 28. The recorder tape 38 is, as shown, drawn through the recorders 27 and 28 in sequence in a fashion similar to that in which the tape 19 is drawn through the recorders 5 and 6 in sequence. Two lines of code signals record are, therefore, inscribed upon the tape 38.

Alternatively the recorders 27 and 28 may be connected in shunt with the brushes 29 and

32 with the recorder and brush groups respectively in series. Under these conditions the recorders may be shunted alternately by the respective segments of commutators 31 and 34 under their respective brushes so that signal energy is alternately by-passed from one or the other of them. When brushes 29 bear upon the conducting segment of commutator 31, brushes 32 are upon an insulating segment of commutator 34. Thus with brushes 29 connected in shunt to recorder 27, brushes 32 in shunt to recorder 28, and the conducting segment under brushes 29, a marking pulse will actuate recorder 28 but will not actuate recorder 27. Upon a further revolution of the shaft 35 the position of the conducting and insulating segments upon the respective commutators 31 and 34 is reversed, and recorder 27 may then respond to signal pulses while recorder 28 is prevented from responding.

This second described modification is preferable because of the fact that if a minor deviation from synchronism occurs it will not be possible for energy which should actuate one recorder, but is restrained therefrom by slightly premature open circuiting of a given pair of brushes, to be stored up in the system, and to be discharged later into the other recorder, and so to produce a false indication therein.

It has further been found desirable that the conducting segments of the commutators 31 and 34 should not occupy the whole of 180 degrees upon the periphery. Instead they should occupy somewhat less, usually about 120 degrees, thereby allowing about 60 degrees of rotational interval within which minor deviation from synchronism, and hunting, may occur without injury to, or error in, the recorded signals.

The loop of tape between the recorders 27 and 28 may conveniently be made the same as the loop of the tape 19 between the controllers 5 and 6 and therefore the two transmissions of the message upon tape 19 which, because of the loop of tape between the two controllers are sent at different time periods, may by means of the similar loop in the tape 38 be caused to fall upon the same point in the length of the tape 38. This puts conjugate parts of the two transmissions of the message together at a given point on the record tape.

This is shown in Fig. 5 which shows the tape 38. The right hand portion of the tape shows the message corresponding to line D of Fig. 3 and the left hand portion showing the same message plus the repetition thereof corresponding approximately to line G of Fig. 3. In this tape the dots are each represented by two vertical pulses and the dashes by five vertical pulses.

In the tape shown in Fig. 5 both messages are recorded by rising movements of the re-

recorder pen. Alternatively the spacing lines of the two recorders may be brought nearer together and one recorder caused to indicate signal currents by a downward movement. This gives a message tape of the character shown in Fig. 6. Either tape is readily intelligible to the receiving operator and the choice may depend upon his individual preference. Both of these tapes represent the character of record produced when the recording tape is passed through the recorders at a relatively high rate of speed. Alternatively the tape may be run at a much slower speed and a different type of record produced as shown in Fig. 7. This also may be found preferable by certain operators since it corresponds more nearly to the usual tape message.

It is obvious that in the transmitted message each dot will be represented by two movements of the recorder pen, and have a perfectly characteristic appearance, and that each dash will be represented by five movements of the recorder pen which likewise have a characteristic appearance. However, in the event that interference is produced by static, a blurring of the characteristic form of the dots and dashes may be produced. This blurring is not apt to effect all of the pulses of a given code signal and therefore the transcribing operator is provided with an indication of the probable character of the signal sent. Furthermore, he is provided with a conclusive indication of the presence of error. When such error occurs in one transmission he has a second transmission to which he may refer. Since these transmissions were sent at different times, the same static interference will not affect both transmissions and therefore the point at which error occurred in one message may be a point of accurate transmission in the other message, or if, as may conceivably happen, errors occurred at the same point the errors are different in character and effect and the operator is still able by combining the indications and the two transmissions, to make an accurate transcription of the original message.

In consequence, the two transmissions in combination increase the certainty with which the message may be transcribed by four-fold or more.

The two transmissions of the message are carried simultaneously, which has the effect of doubling the speed of transmission when compared to "words twice". The certainty of transmission has been increased by four-fold or more which permits a further doubling, or greater increase, of the speed of transmission of the message. In consequence the same accuracy of transmission under difficult conditions of interference is attained at four times or more the speed which is attainable by the straight "words twice" transmission of the present system.

The synchronizing device of my invention is an essential element of the system, which is made possible by the peculiar character of the transmitting code message.

The synchronizing device consists of a transformer 25 through which signal energy is transferred. Across the terminals of the secondary of the transformer 25 is connected a pair of brushes 41 which bear upon a commutator 42 mounted upon the shaft of the motor 37. A triode vacuum tube 43 is provided, the cathode of which is suitably energized and connected through a grid bias battery 44 to one terminal of the secondary of the transformer 25. The grid of the triode 43 is connected to the other terminal of the transformer 25. A condenser 45 is connected between the cathode and anode of the triode 43. A resistance 46 which may desirably have a value of about 500,000 ohms is connected between the anode of the triode 43 and the positive terminal of a plate battery 47.

A second triode 48 is provided with its cathode connected in parallel with the cathode of the triode 43, both cathodes being connected to the negative terminal of the plate battery 47. The grid of the triode 48 is connected through a second grid bias battery 49 to the plate circuit of the triode 43. The anode of triode 48 is connected through the coil of the relay 51 to the positive terminal of the plate battery 47. The motor 37 is supplied with power through the leads 52 with a resistance 53 in series. The resistance 53 is shunted by the contacts of relay 51 as shown in the drawing.

In the operation of the synchronizing device, the resistance 53 is adjusted to such a value as to cause the motor 37 to run at a speed just slightly below the speed of the motor 8 at the transmitting station. The windings of the transformer 25 are then connected in such manner that the beginning of a signal pulse, as shown in line H of Fig. 3, tends to make the grid of the triode 43 more negative, the cessation of a signal pulse tends to cause the grid of triode 43 to become more positive. The grid bias battery 44 is, however, of such size as to make the grid sufficiently negative so that in the absence of signal pulses, no current flows therethrough. Under the condition of no signals, the plate battery 47 causes current to flow through the resistance 46 to charge the condenser 45 to its full value and to establish a positive potential at the point 54 of connection between the plate of the triode 43 and the grid of the triode 48. This positive potential is greater than the potential which the grid bias battery 49 tends to produce upon the grid of the triode 48, and therefore the plate current will flow through the relay 51 holding its contacts open.

Upon the arrival of signals, the beginning of a signal pulse which would tend to make

the grid of the triode 43 more negative is without effect on the current flow through the triode. The cessation of a signal pulse, however, would tend to make the grid of the triode 43 more positive. If, however, the motor 37 is running in synchronism with the received pulses, the circuit including the brushes 41 is closed by the segment of the commutator 43 and the positive pulse delivered from the transformer 25 is short-circuited and dissipated in the transformer 25 and the circuits to brushes 41, and therefore no positive charge is impressed upon the triode 43. When, however, the speed of motor 37 has dropped slightly, the brushes 41 are not short-circuited at the instant at which the signal produced its positive pulse and therefore a positive potential is impressed upon the grid of the triode 43, which may depend in magnitude upon the deviation of motor 37 from synchronism.

If the positive pulse is sufficiently great to overcome the negative bias produced by the battery 44, current flows through the triode 43 discharging the condenser 45 and causing the point 54 to become less positive. In consequence the bias battery 49 causes the grid of the triode 48 to become more negative and reduces the current flowing through the triode 48. This reduction in current may reduce the current in relay 51 by a sufficient amount to release its armature and close the contacts, thereby shunting the resistance 53 and causing the motor 37 to speed up. The amount of increase in speed obtained will depend upon the length of time the contacts of the relay 51 are closed, which in turn depends upon the size of the positive pulse delivered by the transformer 25, which in its turn depends upon the time interval between the cessation of a signal pulse and the close circuiting of the brushes 41.

This effect is integrated for successive pulses since a definite time is required after the application of the positive pulse of current to the grid of the triode 43, before the condenser 45, which is discharged by that pulse, can be re-charged to its previous value through the resistance 46. A number of positive pulses may, therefore, be integrated through this effect, the number depending upon the size of the condenser 45. By this means I have found it possible to obtain very accurate synchronization between the motor 37 of the receiving apparatus and motor 8 of the sending apparatus. This synchronization is, however, more easily obtained if the motor 8 is also accurately speed governed, as by the previously mentioned tuning fork control.

It is to be noted that in the above described synchronizing system, that the synchronization is obtained by the integration of a series of correction pulses and not by a single effective pulse. This is highly essential in a

synchronizing system which contains a radio link, since otherwise the presence of a single surge of static at a random moment might introduce a speed changing pulse which would throw the rotating systems entirely out of synchronism.

By the apparatus of my invention, I am able to obtain accurate synchronization between the sending and receiving systems of a duplex transmitting channel without the use of special synchronizing circuits or signals.

By means which utilize the code signals only, I am further enabled to increase both the speed and accuracy of the transmission of signals, especially the transmission of signals over a radio channel. I have further provided a simple, accurate and dependable radio duplexing means which, under the conditions of good transmission, may be utilized for the simultaneous transmission of two independent messages and under bad signal conditions may be utilized for the transmission of a signal message twice in sequence for the improvement of the certainty of transcription.

While I have shown but a single embodiment of my invention, it is capable of modifications therefrom without departure from the spirit thereof and it is desired therefore that only such limitations shall be imposed thereon as are required by the prior art or indicated by the appended claims.

I claim as my invention:

1. The method of improving the accuracy of transmission of signals which comprises converting dots into two current pulses and dashes into five current pulses, transmitting said current pulses comprising a given message twice, recording said characteristic pulses side by side upon a recording surface, indicating the presence of errors in one record by deviation from the characteristic form so as to permit correction of errors by making reference to the other recording.

2. A signal transmission system comprising a pair of relay controllers, each having a message tape passing therethrough, a speed governed motor for driving said controllers, a signal channel cooperating with said controllers, commutator means for energizing said signal channel alternately through each of said controllers and thereby duplexing said channel, and means provided by said relay controllers for causing a predetermined time delay between said alternate transmissions of the same message.

3. A signal transmission system comprising a pair of relay controllers, a speed governed motor connected thereto for driving the same, a signal channel cooperating with said relay controllers, commutator means driven from said motor for duplexing said channel, a message tape adapted to pass through said relay controllers in sequence,

and means provided by said relay controllers whereby the message represented by said tape is transmitted over said duplex channels with a small time delay between said transmissions.

4. A signal transmission system comprising a pair of relay controllers, a speed governed motor for driving said controllers, a signal channel cooperating with said controllers, commutator means driven from said motor for duplexing said channel, a message tape adapted to pass through said relay controllers in sequence, means whereby the message represented by said tape is transmitted over said duplex channels with a small time delay between said transmissions, and a receiving apparatus comprising a pair of signal recorders adapted to record from the signals of each of the duplex circuits of the channel with a time delay between recordings whereby conjugate portions of the message are recorded side by side upon the record tape.

5. In a duplex code signalling system wherein a duplex signal channel is actuated by a pair of message sending devices driven at predetermined speeds, a signal receiving system including a pair of signal recorders actuated in accordance with signals received over said duplex channel, a driving means for said recorders, a pair of vacuum tubes responsive to current pulses due to received signals over said duplex channel at periods of phase variance of the movements of said recorder driving means and the time of arrival of signals, and means operable from said vacuum tubes for increasing the speed of said recorder driving means during periods of non-coincidence of the two said current pulses in said vacuum tubes for maintaining said recorders in synchronism with corresponding elements of the transmitter.

6. In a duplex code signalling system of the type having a pair of machine code senders adapted to sequentially actuate a duplex signal channel and having a driving motor therefor operated at a predetermined speed, a signal receiving system including a pair of signal recorders actuated in accordance with received signal energy, a motor for driving said signal recorders, a short circuiting commutator associated with said drive motor, and means operative during periods of phase difference between the occurrences of current pulses due to received signals in said duplex channel and the periodicity of operation of the segments of the said commutator for applying a force to said recorder motor for increasing the speed thereof whereby the current pulses in said duplex channel maintain the speed of the said driving means for said recorders in rigid synchronism with corresponding elements of the transmitter.

7. In a duplex code signalling system transmitting a plurality of messages at a pre-

determined rate, a signal receiving means including a pair of code recorders, a motor for driving said recorders, an electric circuit serving as an input source for said motor, a
5 short circuiting commutator connected with the driving means for each of said code recorders, a transformer connected with said signal receiving means and having its primary circuit connected with each of said code
10 recorders and its secondary circuit connected with said short circuiting commutator, a pair of thermionic tubes connected in the secondary circuit of said transformer and in parallel with said commutator connection,
15 and means for causing a response in said thermionic tubes during periods of variance between the receipt of signal energy pulses in said receiving means and the movements of said short circuiting commutator, and means
20 responsive to the current flow through said thermionic tubes for controlling the speed of said recorder drive motor whereby the speed thereof is maintained in rigid synchronism with a corresponding drive means
25 for like elements at the transmitter.

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