May 1, 1945. W. B. MARTIN 2,375,125

TELETYPEWRITER SYNCHRONIZING ARRANGEMENT

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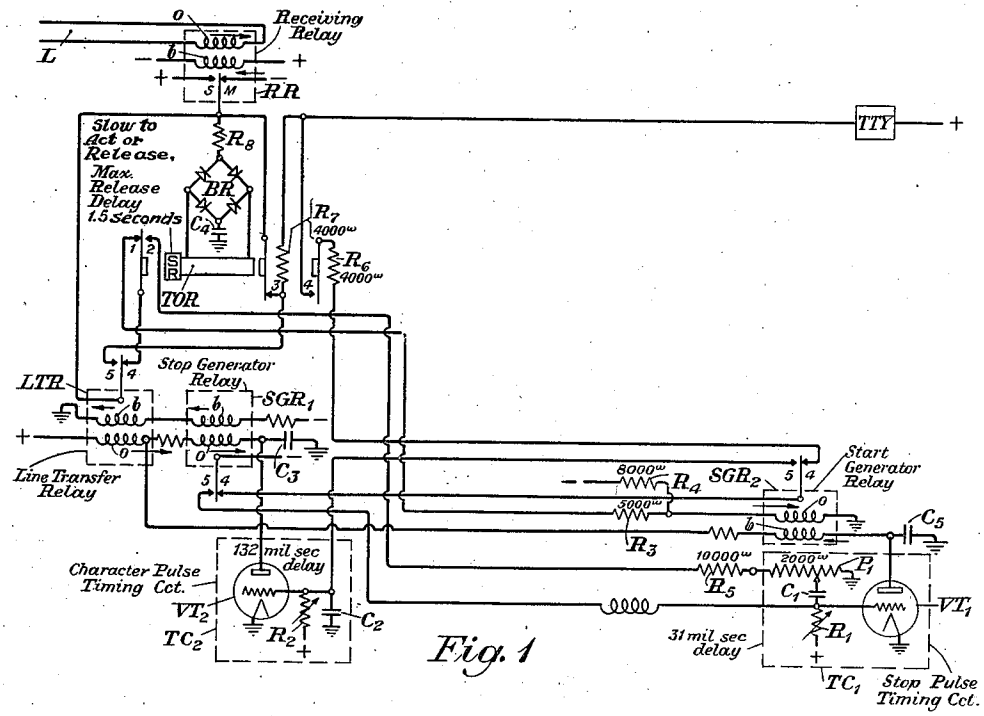


Fig. 1

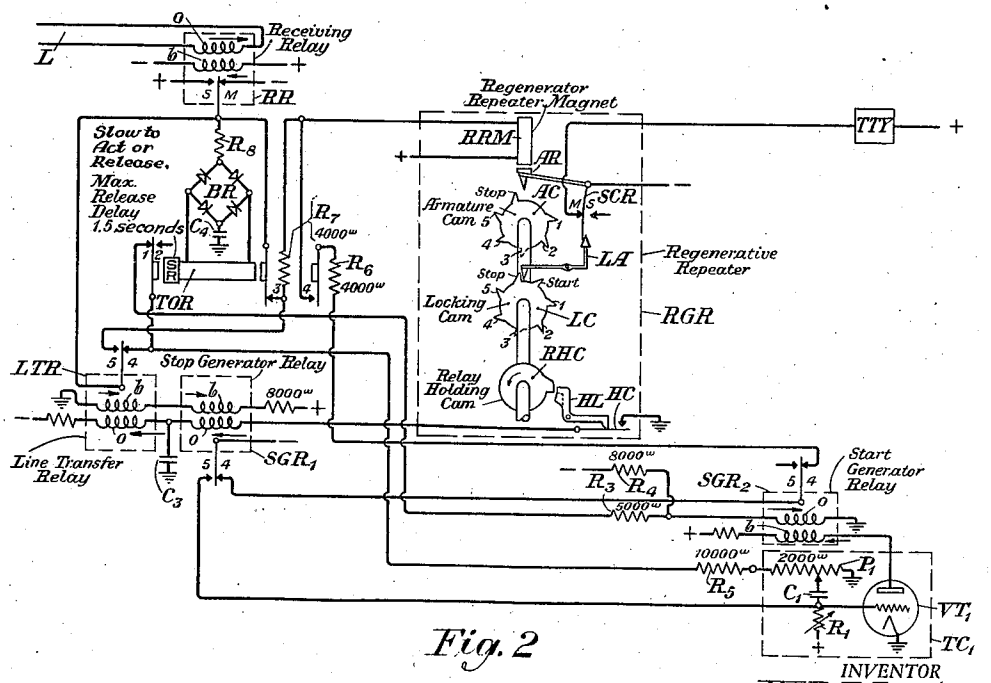


Fig. 2

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TELETYPEWRITER SYNCHRONIZING ARRANGEMENT

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This invention relates to teletypewriter systems, and particularly to arrangements to locally generate the start-stop impulses accompanying a character determining code so that such impulses wil be automatically supplied to the receiver even when, because of momentary circuit failure, they are not received from the transmitting station.

In operating teletype receivers over transmission media such as radio waves or other kinds of channels subject to numerous random failures of short duration, two types of errors occur. (1) The failure may cause an error in one or more of the five units of the Baudot code which determines the character to be printed, thus causing a wrong character to be recorded; or (2) it may result in receiving the wrong kind of pulse instead of the stop pulse or the start pulse.

The first of these conditions is not as serious as the second. If one or more of the five character determining pulses should be distorted or reversed it merely causes some other character to be printed instead of the one intended. The message will usually be intelligible in spite of the error. If, however, an improper stop pulse is received the receiving distributor does not come to a momentary stop at the end of the code combination, and hence gets ahead of the transmitter. Similarly, if an improper start signal is received, the receiving distributor is not released until a message pulse transition occurs of the same nature as the normal start pulse. The receiver therefore falls behind the transmitter.

After an early or late start is received the receiving mechanism may lose synchronism with the transmitter and a number of character errors will be received before synchronism is regained. This number may vary from one to seven. In regaining the proper phase relation the receiver may operate one time more or less than the transmitter. In receiving normal English text this will result in a number of miscellaneous letters being received, after which synchronism will be regained and the text will again be intelligible. If, however, the message is in cipher the addition or subtraction of one or more characters in the received message, as described above, will cause the deciphering code to lose synchronism with the enciphering code and the message will be unintelligible thereafter.

It is therefore the object of the present invention to overcome errors caused by circuit troubles which result in false start and stop signals. This is accomplished by associating with the receiver a local generator of start and stop pulses which will introduce such pulses into the receiver regardless of whether or not they are properly received from the transmitter.

Preferably the apparatus is so arranged that at the start of a message, after the circuit has been idle for a time, the start and stop impulses will be received directly from the line as usual. In the meantime the local stop-start pulse generator is set into action, after which the receiver is disconnected from the line while the stop pulse and the beginning of the start pulse should be received, but is again connected during the period when the end of the start pulse and the five character determining pulses are normally received, and the local stop-start generator is connected to the receiver during the time the stop and start pulses are normally sent from the transmitter.

This principle of operation is subject to the disadvantage that the locally generated stop-start pulses may gradually get out of phase with the corresponding pulses sent from the sending station. Accordingly the present invention provides means to overcome this difficulty. The apparatus is so designed that when the stop and start pulses incoming from the line are diverted from the receiver, the corresponding pulses are supplied locally, the stop-start impulses coming in from the line are applied to the local generator. The generator is so arranged that when these pulses are received without distortion, the stop to start transition automatically synchronizes the local generators.

Further details and features of the invention will be clear upon reading the following detailed description in connection with the acompanying drawing. Figure 1 of the drawing illustrates a circuit arrangement embodying the invention, said arrangement employing a vacuum tube timing circuit to control the local generation of stop and start pulses, with a similar timing circuit to control the connection of the line to the receiver during the reception of character determining pulses. Fig. 2 shows a similar circuit arrangement employing a regenerative repeater as the timing device to perform the last named function.

General description of apparatus of Fig. 1

For purposes of illustration the pulse generating apparatus herein disclosed is described as operating 368 times per minute, i. e., it completes each full cycle in 163 milliseconds. This is approximately the time ordinarily required for a start-stop system to send a start pulse, five character determining pulses and a stop pulse. The

apparatus may be caused to operate at other speeds by a change of circuit constants.

Referring to Fig. 1, RR designates a polar type receiving relay associated with the receiving loop L. This relay has an operating winding *o* connected in the loop L and a biasing winding *b* in a local circuit. The windings are so related that when a marking or closed circuit pulse is received in this loop the armature of the relay RR will rest on its marking contact and when a spacing or open circuit pulse is received the armature will be moved by the influence of the biasing winding *b* to the spacing contact. The armature of relay RR is normally connected to the local teletype receiver symbolically represented at TTY over a contact 3 of a time-out relay TOR whose purpose will appear later.

A vacuum tube timing circuit VT_1 is provided to control the local generation of stop and start pulses to synchronize the operation of the distributor (not shown) of the receiver TTY. This timing circuit includes a vacuum tube VT_1, a capacity C_1, and a variable resistance R_1, these elements being so related that when negative voltage is applied directly to the capacity and to the grid of the tube the tube will instantly become non-conductive, but when said voltage is withdrawn the condenser will be gradually discharged and a proper voltage built up to render the tube VT_1 fully conductive only after the lapse of a predetermined time. This time may be 31 milliseconds or the period of a normal stop pulse.

An adjustable potentiometer P_1 is associated with the timing circuit TC_1. The drop through a part of the potentiometer may be either positive or negative depending upon whether or not a positive start impulse or a negative stop impulse is relayed to it by the receiving relay RR. This drop is utilized to decrease or increase the time normally required to render the tube VT_1 fully conductive. This enables the timing circuit TC_1 to be brought into synchronization with the stop-start impulses transmitted from the sending station when properly received, as will appear more fully later.

A similar timing circuit TC_2 is provided to control the transmission of pulses from the receiving relay RR to the receiver TTY during the reception of character determining pulses. This timing circuit includes a vacuum tube VT_2, a condenser C_2, and a variable resistance R_2. These elements are so related and adjusted that when a negative potential is applied directly to the capacity C_2 and to the grid of the tube VT_2 the tube will instantly become non-conductive. When, however, the negative potential is removed the condenser will be gradually discharged and a voltage gradually built up which will render the tube VT_2 fully conductive after a predetermined time. This time in the case illustrated may be made 132 milliseconds, which is substantially the time required to transmit a start impulse and five character determining pulses. The timing circuit TC_2 serves to control the connection of the receiver TTY to the armature of the receiving relay RR during the reception of the character determining pulses in a manner to be described later.

Three additional polar relays are provided, a stop generator relay SGR_1, a start generator relay SGR_2, and a line transfer relay LTR. The operating windings *o* of relays SGR_1 and LTR are operated by the plate current of vacuum tube VT_2 when the latter is fully conductive. The operating winding *o* of relay LTR is also operated when tube VT_1 is conductive, the circuit being from positive battery via the operating winding of relay LTR and the biasing winding *b* of relay SGR_2 to the plate of tube VT_1. In the case of relay SGR_2 its biasing winding *b* is energized by the plate current of the tube VT_1 when said tube is fully conductive, while its operating winding *o* is energized partly by negative current supplied through a resistance R_4 and partly by current supplied through resistance R_3 from the armature of receiving relay RR.

The functions of the stop generator relay SGR_1 are to supply over contact 4 of said relay the stop pulse to the teletypwriter, and to control over contact 5 the operation of the timing circuit TC_1 which, by operating relay SGR_2 to open its contact 4, generates a start pulse to be applied to the receiver TTY locally. The functions of the start generator relay SGR_2 are to terminate the stop pulse locally supplied to the receiver, thus causing a start pulse to be supplied to the receiver, and to control the operation of the timing circuit TC_2. When the operating winding *o* of the relay SGR_1 is de-energized, as it is during the period the timing circuit TC_2 is completing its cycle and before vacuum tube VT_2 becomes conductive, during which period the start pulse and character determining pulses are normally transmitted, the armature of the relay SGR_1 is on its contact 5 and disables the vacuum tube VT_2.

When said armature of relay SGR_1 is shifted to its contact 4 a stop pulse is locally transmitted to the receiver TTY and timing circuit TC_1 begins its cycle, causing vacuum tube VT_1 to become conductive. After approximately 31 milliseconds (in the design herein disclosed) vacuum tube VT_1 becomes fully conductive so that the relay SGR_2 shifts its armature from contact 4 to contact 5 to terminate the stop pulse and produce a no current or start condition in the circuit of the receiver TTY. Also the vacuum tube VT_2 of the timing circuit TC_2 is disabled during the period necessary for timing circuit TC_2 to complete another cycle and for vacuum tube VT_2 to build up an operating current for the operating winding *o* of relay SGR_1. This current attains full operating value at the end of a period of approximately 132 milliseconds, i. e., after the last character determining pulse has been received. Then relay SGR_1 shifts its armature from its contact 5 to contact 4 and the cycle of operation begins anew.

As previously stated the operating winding *o* of line transfer relay LTR is energized by the plate circuit of vacuum tube VT_2. When the armature of relay LTR is on its contact 5 the armature of receiving relay RR is connected to the receiver TTY. Said armature will be on its contact 5 after the condenser C_5 has become charged, and while the timing circuit TC_2 is completing the execution of its cycle. Operating space current does not flow in operating winding *o* of relay LTR under these conditions. During this period the marking and spacing pulses of the Baudot code determining the characters are sent to the receiver. When the armature of line transfer relay LTR is on contact 4 the connection from the armature of receiving relay RR to receiver TTY is transferred to the potentiometer P_1. Consequently when a normal stop-start transition comes in from the loop L it controls the operation of the timing circuits TC_1 and TC_2 to synchronize the local generation of a stop-start transition with that received from the loop as will be described in further detail later.

In addition to the relays already described a time-out relay TOR is provided. This relay functions to break the normal connection from the armature of the receiving relay RR to the receiver TTY. It also substitutes alternative connections for receiving character determining pulses from the loop L, and for supplying locally generated stop-start pulses to the receiver. To energize the relay TOR a bridged rectifier unit BR is provided. The bridged rectifier unit BR includes four rectifiers arranged in the arms of a Wheatstone bridge, one junction of which is connected through resistance R_8 to the armature of the receiving relay RR, and the opposite junction of which is connected to ground through a condenser C_4. The winding of slow release relay TOR is bridged across the other two terminals of the bridge.

The four rectifiers are so poled that a pulse of current of one polarity from the armature of receiving relay RR passes through the upper right rectifier, through the winding of relay TOR from right to left, and through the lower left rectifier to charge the condenser C_4. Pulses of opposite polarity will pass from ground through the condenser C_4, through the lower right rectifier, through the winding of relay TOR from right to left, and through the upper left rectifier and resistance R_8 to the armature of relay RR. It should be noted that pulses of either polarity passs through the relay TOR in the same direction.

It is evident that as the armature of the receiving relay RR is shifted from marking to spacing and vice versa, the condenser C_4 will be alternately charged positive and negative. As the condenser is thus charged spurts of direct current pass through the winding of the relay TOR in the same direction. These spurts do not persist during the entire period that current continues in the same direction in the loop L, but occur only at the beginning of each pulse and flow only as long as is required to charge the condenser C_4 in a given direction.

The effect of the current in the winding of the relay TOR depends upon the constants of the circuit and the number of operations per second of the armature of relay RR. Single random transitions such as result from momentary circuit failures will not cause relay TOR to operate. When, however, transitions occur repeatedly at relatively short intervals, as is the case when normal teletypewriter signaling takes place, the relay TOR will operate after the reception of one or more characters, depending on the number of transitions in the characters.

The magnetism in the relay TOR will continue building up for an appreciable time as successive transitions occur. Consequently there is a wide range between the release time at the start of transmission and that after the relay has neared saturation. Due to these characteristics and those above mentioned the circuits established by the relay TOR for controlling the stop-start pulse generator can readily distinguish between actual signal transmission and circuit interference.

When the receiving relay RR remains steadily in either marking or spacing condition, due to the conclusion of signal transmission or due to line failure, the condenser C_4 will reach a steady state of charge. Spurts of current will no longer pass through the winding of relay TOR and hence it will release. The time required for it to release its armature is determined by the design and adjustment of the relay and the degree of saturation it has reached.

In actual practice the releasing time has been made 1.5 seconds following a full signal interval. With this releasing time it has been found that on the average the relay TOR was held up long enough so that if a line failure occurs after two characters have been received, one additional local stop-start transition was automatically generated thereafter. A failure after a third character resulted in two start-stop transitions. A failure after a fourth character resulted in four transitions, and after a fifth character, in six transitions. A failure occurring after receiving seven or more characters resulted in automatically generating eight to ten transitions without the line returning to normal. Thus it will be seen that the locally generated start-stop pulses will keep the receiver operating in approximate synchronization with the transmitting station for a period as long as is necessary to transmit eight to ten characters even though the line fails.

Normal or idle condition of circuit of Fig. 1

Assume that the line (not shown) has been idle and the loop L has been in closed condition over a period long enough for all apparatus to have been restored to normal condition. Under these circumstances the armature of the receiving relay RR will be resting on its contact **4**. Relay TOR is de-energized and hence the armature of relay RR is connected directly to the receiving teletypewriter TTY over contact **3** of relay TOR. Another circuit extends from the armature of relay RR over contact **4** of relay LTR, contact L of relay TOR, through resistance R_3 and operating winding *o* of relay SGR_2 to ground. As the armature of relay RR is on its marking contact negative battery is thus applied to the winding *o* of relay SGR_2, holding the armature of said relay operated to its contact **4** in opposition to the action of the space current flowing through the biasing winding of relay SGR_2 from the plate of vacuum tube VT_1.

The armature of relay SGR_2 is on its contact **4** so that the lead to the timing circuit TC_2 is open. Hence condenser C_2 has fully discharged through resistance R_2 any previous negative charge built up in it, and the grid of vacuum tube VT_2 is positive. Full operating space current therefore flows from the output of said tube through the operating winding *o* of relays SGR_1 and LTR. The armatures of said relays rest on their number **4** contacts. Relay LTR thus establishes the circuit previously traced through the winding *o* of relay SGR_2. With the armature of relay SGR_1 on its contact **4**, negative battery is disconnected from timing circuit TC_1, and the condenser C_1 has discharged to positive battery through resistance R_1, causing the grid of tube VT_1 to become positive and allowing space current to flow through vacuum tube VT_1 to bias winding *b* of relay SGR_2.

Reception of first character by circuit of Fig. 1 (relay TOR not operated)

Assume now that a start pulse is received in loop L so that an open circuit condition is produced in the loop. The biasing winding of relay RR shifts its armature to its spacing contact, thus transmitting a start pulse over contact **3** of relay TOR to receiver TTY. When the armature of relay RR is on its spacing contact, positive battery is applied over this circuit. Since positive battery is also connected to the circuit beyond re-

ceiver TTY the start pulse appears in said receiver as a no-current condition.

At the same time the change from negative to positive battery produced by relay RR results in causing positive current to flow in the circuit previously traced through resistance R_3 to winding o of relay SGR_2. Because resistance R_3 is smaller than resistance R_4 this positive current prevails over the negative current through resistance R_4, and winding o of relay SGR_2 is activated by a reduced current flowing in the opposite direction from that previously existing. Winding o of relay SGR_2 now aids biasing winding b so that the armature of said relay is shifted from contact 4 to contact 5.

With the armature of relay SGR_2 on its contact 5 negative potential is applied over contact 4 of relay SGR_1, and contact 5 of relay SGR_2 to condenser C_2 and the grid of tube VT_2 of the timing circuit TC_1. Condenser C_2 receives a full negative charge and current is immediately suppressed in the plate circuit of vacuum tube VT_2. This suppresses current in the operating winding o of relay SGR_1 but current is maintained in the operating winding of relay LTR because vacuum tube VT_1 is still conductive. Relay SGR_1 shifts its armature to its contact 5.

As the armature of relay SGR_1 leaves its contact 4, the negative battery previously applied to condenser C_2 is removed and the condenser begins to slowly discharge to positive battery through the rheostat R_2. The rheostat is adjusted so that the condenser will be completely discharged and the vacuum tube VT_2 will become fully conductive in about 132 milliseconds. This period is equivalent to the time required to transmit a start pulse and five character determining pulses to the receiver TTY.

Returning, however, to the beginning of the 132 millisecond interval, when the armature of relay SGR_1 shifted to its contact 5 due to the disabling of the tube VT_2, it connected negative battery to the condenser C_1 and grid of vacuum tube VT_1 of the timing circuit TC_1. The condenser is thus charged to negative potential and current is at once suppressed in the plate circuit of tube VT_1. However, current continues to flow in the windings o of relay LTR and b of relay SGR_2 for approximately 22 milliseconds by the action of condenser C_5. After said condenser discharges, current ceases to flow in the winding b of relay SGR_2 and the operating winding of the relay LTR, thus operating relay LTR to its number 5 contact. This disconnects the positive current from winding o of relay SGR_2 so that the negative current flowing in said winding through resistance R_4 shifts the armature of relay SGR_2 back again to its contact 4. Thus it will be seen that although relay SGR_2 operates to its contact 5 when a start pulse is received, it reverts back to its contact 4 after approximately 22 milliseconds due to the operation of relay LTR to its number 5 contact, and thus prepares a path for the stop pulse to be transmitted to the teletypewriter.

It will be noted that when the armature of relay LTR moves to its contact 5 an alternative path is established from the armature of relay RR over said contact 5 to the receiver TTY. This path, which is independent of the direct path over contact 3 of relay TOR, is established approximately 22 milliseconds after the start pulse is received, and is maintained for 110 milliseconds, the period required for vacuum tube VT_2 to become fully conductive. Thus this alternative path is maintained for a time sufficiently long to permit the five character pulses to be transmitted to the receiver over this path. The establishment of this circuit is not important at this time, however, but becomes of importance later when the relay TOR is operated, as will appear in due course.

Assuming that at the end of 132 milliseconds the relay TOR has not yet received a sufficient number of spurts of current to activate it, the following operations now take place:

Normally a stop pulse will be received about 132 milliseconds after the start pulse is received. Quite independently of the reception of the stop pulse the timing circuit TC_2 has at this time just completed its cycle and the vacuum tube VT_2 has become fully conductive. The armatures of relays SGR_1 and LTR therefore move to their contacts 4.

As the armature of relay LTR leaves its contact 5 the alternative path from the armature of relay RR to receiver TTY over contact 5 of relay LTR is broken. When the armature of relay LTR strikes its contact 4 a circuit is established from the armature of the receiving relay RR, the armature and contact 4 of relay LTR, and the armature and number 2 contact of relay TOR to the resistance R_3 and the operating winding of relay SGR_2, placing the operation of relay SGR_2 again under the control of the combined action of the receiving relay RR and vacuum tube VT_1.

As the armature of relay SGR_1 leaves its contact 5 the negative potential is removed from condenser C_1 and the grid of vacuum tube VT_1. The timing circuit C_1—R_1 starts discharging, and at the end of about 31 milliseconds the vacuum tube VT_1 becomes fully conductive so that full biasing current will flow through the winding b of relay SGR_2 and the winding o of relay LTR. The armature of relay SGR_2 will be shifted to its contact 5 at this time, if, as should be the case, the received stop impulse ends and a start succeeds it. When the armature of relay SGR_2 thus shifts to its contact 5 the cycle of timing circuits TC_2 and TC_1 are started anew.

Reception of characters by circuit of Fig. 1 after relay TOR operates

We have considered the operation of the circuit of Fig. 1 under the conditions existing while the relay TOR remains de-energized. Let us now suppose that some time during the reception of the character determining pulses identifying the second character of the message, a sufficient number of transitions from negative to positive and vice versa have occurred to energize the relay TOR. It will be remembered that while character determining pulses are being received, the armatures of relays SGR_1 and LTR rest upon their number 5 contacts, and the armature of relay SGR_2 rests upon its contact 4. The timing circuit TC_1 is therefore disabled by a negative potential applied to the grid of vacuum tube VT_1, and the timing circuit TC_2 is going through its 132 millisecond cycle at the end of which a current will flow in the plate circuit of vacuum tube VT_2.

When the relay TOR operates it shifts its left hand armature from contact 1 to contact 2. The opening of contact 1 breaks the circuit (now also open at contact 4 of relay LTR) which was previously traced from the armature of receiving relay RR through resistance R_3 to the winding o of relay SGR_2. This relay will no longer be

directly responsive to start pulses incoming from the loop L, but will now be either under the control of negative current through the resistance R_4 or of positive current from the plate circuit of vacuum tube VT_1, and will so continue as long as relay TOR remains operated.

Relay TOR at its contact 2 prepares a circuit (now open at contact 4 of relay LTR) from the armature of receiving relay RR, over contact 4 of relay LTR when closed, over contact 2 of relay TOR, through resistance R_5 and potentiometer P_1 to ground. This circuit operates, as will more fully appear later, to synchronize the operating time of the circuit TC_1 for the generation of start pulses, so that the stop-start transitions produced locally by the timing circuits will coincide with the stop-start transitions in the loop L, if proper stop-start pulses are received in said loop.

At its contact 3 relay TOR opens the direct connection for pulse transmission from the armature of receiving relay RR to the receiving instrument TTY. So long as relay TOR remains energized character determining impulses must be transmitted over the alternative path previously traced over contact 5 of relay LTR.

Relay TOR upon operating at its contact 4 also prepares a circuit from negative battery over contact 4 of relay SGR_1 (now open) over contact 4 of relay SGR_2, through resistance R_6, and over contact 4 of relay TOR to receiver TTY. Locally generated stop-start pulses will be transmitted to receiver TTY over this path under the control of relays SGR_2 and SGR_1 so long as relay TOR is energized. Thus the receiver TTY may be maintained in reasonable synchronization with the sending station even though stop-start pulses occasionally fail to be received in the loop L.

With the circuits of the receiving station modified as above described, let us consider what takes place when the last of the five character determining pulses has been sent to the receiver TTY and the stop pulse is being received. About the time the stop pulse should normally arrive, the timing circuit TC_2 will have completed its cycle and full operating current will have been built up in the plate circuit of the tube VT_2. Relay SGR_1 now shifts its armature from contact 5 to contact 4, and relay LTR similarly shifts its armature.

During the time the armature of relay SGR_1 rested on its contact 5, condenser C_1 of timing circuit TC_1 received a definite negative charge. Upon breaking contact 5 of relay SGR_1 condenser C_1 starts discharging through resistance R_1. The manner in which the timing circuit TC_1 now functions will be more fully described later, in connection with the description of the synchronizing operation determined by potentiometer P_1 under the control of stop-start pulses received from loop L.

As relay SGR_1 closes its contact 4, a circuit is established from negative battery over contact 4 of relay SGR_1, over contact 4 of relay SGR_2, through resistance R_6 and over contact 4 of relay TOR, to receiver TTY. Thus a stop pulse is sent to receiver TTY independently of the stop pulse (if any) received in loop L. This pulse continues while the timing circuit TC_1 goes through its cycle to build up full operating current in the plate circuit of vacuum tube VT_1 for the energization of the biasing winding *b* of relay SGR_2. In the meantime this pulse is maintained by the operating winding *o* of said relay which is energized by negative current through resistance R_4.

Relay LTR operates to shift its armature from contact 5 to contact 4. When the armature of relay LTR leaves contact 5 the path from the receiving relay armature to the teletypewriter is opened and the teletypewriter is now under the control of relays SGR_1 and SGR_2 as explained before. When the armature of relay LTR strikes contact 4 a circuit is completed which will serve to synchronize the local generation of stop-start pulses as will be described later. Relay LTR armature will remain on its contact 4, under the combined action of currents in its operating winding *o* from vacuum tubes VT_2 and VT_1, and the charging condenser C_5 from the start of the optimum stop pulse, until the end of the optimum start pulse, except that the start pulse may be lengthened or shortened as will be explained later.

The synchronization of the timing circuits TC_1 and TC_2 with respect to received stop-start pulses is effected by increasing or decreasing the time cycle of circuit TC_1. When the relay LTR operates to its contact 4 it opens its contact 5 and thereby opens the connection from the armature of receiving relay RR to the receiver TTY. A circuit is now established from the armature of relay RR over contact 4 of relay LTR, over contact 2 of relay TOR, through resistance R_5 and potentiometer P_1 to ground. Thus a negative or positive drop may be produced from the sliding contact of the potentiometer P_1 to ground, depending upon whether a marking stop pulse or a spacing start pulse is received by the relay RR.

It should be noted that while timing circuit TC_2 was passing through its cycle, the condenser C_1 was charged to a negative voltage with reference to ground over contact 5 of relay SGR_1. Assuming this voltage to be 130 volts negative, the condenser C_1 would be charged accordingly. This condition exists at the instant relay SGR_1 operates to remove negative battery from the condenser C_1 and the grid of tube VT_1, to start the cycle of timing circuit TC_1. With condenser C_1 charged to this voltage, rheostat R_1 is set so that the condenser C_1 will discharge through it in 31 milliseconds, and thus bring the plate current of tube VT_1 up to full operating value at the end of that period.

As previously stated potentiometer P_1 is connected to the armature of receiving relay RR upon the operation of relay LTR to close its contact 4. Let us assume that the IR drop from the sliding contact of potentiometer P_1 to ground is 10 volts, positive or negative, depending upon the position of the armature of relay RR. If this drop is negative (as it is when a stop pulse is received) the total voltage to ground of condenser C_1 is 140 volts negative. When a start pulse begins, the drop through the potentiometer is positive, and the total drop through which condenser C_1 must discharge is reduced to 120 volts negative. The condenser C_1 will therefore require more or less than 31 milliseconds to discharge, depending upon which of these two conditions exists.

Now if the potentiometer is adjusted so that, with a closed circuit marking pulse being received by the relay RR, condenser C_1 will discharge in 36 milliseconds, it would discharge in 26 milliseconds if relay RR received an open circuit spacing pulse. Therefore if relay RR should receive a mark to space transition, between 26 and 36 milliseconds after relay SGR_1 operates to open its contact 5 and start the cycle of timing circuit TC_1, the drop through the potentiometer

P_1 will be changed from negative to positive, and condenser C_1 will be fully discharged immediately. Vacuum tube VT_1 would therefore become fully conductive at the instant the transition was received by the relay RR.

The full plate current now flowing through winding *b* of relay SGR_2 will shift the armature of said relay to its contact **5**, thereby opening at contact **4** the circuit over which the local negative stop pulse reached the receiver TTY. At contact **5** of relay SGR_2 negative potential is applied to the grid of vacuum tube VT_2 causing the armature of relay SGR_1 to shift from contact **4** to contact **5**. Relay LTR will remain on its number **4** contact under the influence of current in tube VT_1. Negative potential is now applied over contact **5** of relay SGR_1 to the grid of vacuum tube VT_1 so that its plate current is instantly reduced to zero, but the current in relays LTR and SGR_2 is maintained for 22 milliseconds by the charging of condenser C_5, after which relay SGR_2 is operated to again close its contact **4**. By opening its contact **5** relay SGR_1 starts the discharge of condenser C_2 of timing circuit TC_2, thus initiating its 132 millisecond cycle. While the reoperation of relay SGR_2 to close its contact **4** closes the connection to receiver TTY over contact **4** of relay TOR at this point, said circuit is held open at contact **4** of relay SGR_1. Hence the open circuit start condition is maintained in the circuit to receiver TTY until, after relay LTR has operated to close its contact **5**, the first character determining pulse is transmitted over said contact to the receiver.

From the foregoing it will readily be seen that the combined operation of the receiving relay RR, potentiometer P_1, and the stop pulse timing circuit TC_1, operate to correct for time differentials between received and locally generated stop-start pulses of plus or minus a predetermined amount.

To summarize, it will be evident from the foregoing that a stop pulse is locally supplied to the receiver TTY during the time cycle of timing circuit TC_1. Also that at the end of said cycle a start pulse is locally supplied to the receiver and the time cycle of timing circuit TC_2 is initiated. Further it will be clear that during said cycle of timing circuit TC_2 character determining pulses are received from the loop L and transmitted over contact **5** of relay LTR to the receiver. It will likewise be seen that at the end of the cycle of timing circuit TC_2 the cycle of timing circuit TC_1 is again started, and the foregoing process is then repeated. Obviously the repetition of these operations will cause locally generated stop-start pulses to be continually supplied to the receiver TTY as long as relay TOR is operated.

General description of apparatus of Fig. 2

The circuit arrangement of Fig. 2 includes apparatus in all respects similar to that of Fig. 1, except that a regenerative repeater arrangement is substituted for the timing circuit TC_2, and certain minor changes are made in the wiring, these changes being necessitated by the use of the regenerative repeater. The use of the regenerative repeater has the advantage that it regenerates the signal pulses before they are transmitted to the receiver TTY.

The regenerative repeater is shown at RGR and includes, in addition to a receiving magnet RRM, three cams; a so-called armature cam AC, a locking cam LC, and a release holding cam RHC. The receiving magnet is of the type known as a holding magnet, in which the magnetic force is only sufficient to hold the armature after it is presented to the pole faces by the raised portions or teeth on the surface of the cam AC.

The armature is operatively connected to a flexible sending contact reed SCR, which may be caused to travel between its marking and spacing contacts. The reed SCR may be temporarily locked against either contact by means of a detent on a lock arm LA. This is controlled by the raised portions or teeth on the surface of the locking cam LC. The connection between the armature AR and the sending contact reed SCR is sufficiently flexible so that when the armature is released by the magnet RRM, and therefore drops to the surface of the cam AC, the sending contact reed may still be held locked in its marking position. Consequently it will be snapped suddenly to its spacing contact when it is released by a tooth on the locking cam LC momentarily operating the lock arm LA. As soon as the lock arm drops down on the other side of the cam tooth of locking cam LC, its detent locks the sending contact reed against its spacing contact.

Vice versa, when the armature is lifted into the field of the magnet RRM by a tooth on the armature cam AM and is held up by a marking pulse, the reed SCR remains locked against its spacing contact until it is permitted to snap back to its marking by the next tooth on cam LC operating the locking arm LA.

The teeth upon the locking cam are so off-set with respect to those on the armature cam that they permit the sending contact reed to be snapped over to its opposite contact about the middle of the pulse controlling the receiving magnet RRM. It will be noted that the sending contact reed SCR remains in either of its positions for the full interval of a pulse. Consequently the impulses repeated by it are renewed waves with square tops and are not affected by the distortion which modifies the shape of the waves received by the magnet RRM.

The relay holding cam RHC controls a contact HC which controls the current of relays SGR_1 and LTR in a manner similar to the control exercised in Fig. 1 by vacuum tube VT_2. However the relays are so poled that their armatures operate to their number **5** contacts, instead of their number **4**, when their operating windings *o* receive current. The contact HC is controlled in such a way that it is opened only when the cam assembly is near the stop position. The lever HL operating the contact is modified with respect to the corresponding lever ordinarily employed in a regenerative repeater (see dotted lines), by elongating the cam rider so that contact HC will be opened just before the receiving armature AR is presented to the magnet RRM for the stop pulse. As contact HC controls relays SGR_1 and LTR, and the former transmits the stop pulse to the receiving magnet RRM, the opening of contact HC must precede the presentation of armature AR to the magnet for the stop pulse. It will be noted that the battery connection to the windings of relays SGR_1 and LTR are reversed with respect to the corresponding relays of Fig. 1. Therefore it is only when the circuit of the biasing windings is opened that the armatures of these relays rest on their number **4** contacts, and it is the closure of contact HC that moves them to their number **5** contacts.

The receiving magnet RRM in addition to performing the functions above described, also serves in response to a start pulse to trip a latch (not

shown) which starts the rotation of the shaft upon which cams AC, LC and RHC are mounted. Operation of the trip latch permits the cam assembly to rotate under power received through a friction clutch. Upon a stop pulse being received the magnet RRM causes the trip latch to lock the shaft until released by another start pulse.

When the receiving magnet RRM receives a start impulse it releases its armature AM, and the trip latch (not shown) controlled by it releases the cam shaft. The release of the armature AR does not at once shift the sending contact reed SCR from marking to spacing, as the reed is still locked by the detent of lock arm LA. As the middle of the start pulse is approached, however, the start tooth on cam LC operates the arm LA and the reed SCR snaps to spacing. As soon as the tooth on cam LC passes the rider of lock arm LA, the detent carried by the lock arm is moved so that the reed is locked against its spacing contact.

If the first character forming pulse is also a spacing pulse, tooth 1 of cam AC presents the armature AM to the magnet RRM just before the middle of the pulse. A moment later the tooth of cam AC releases the armature, but since the magnet is not energized the armature falls back against the surface of the cam AC. When shortly afterward the number 2 tooth of cam LC releases the sending contact reed SCR, the reed remains against the spacing contact, and an instant later is locked there by the detent of the locking arm LA.

If the second character forming contact happens to be marking, when the number 2 tooth of cam AC presents armature AM to the magnet RRM the armature is held up. The reed SCR remains locked against its spacing contact until the number 2 tooth of locking cam LC releases it. It then snaps over to the marking contact and a moment later is locked there by the detent of locking arm LA. The operations for other pulses, including the stop pulse, are similar to the operations just described. The sending code reed SCR, of course, repeats the pulses to the receiver TTY.

Reception of first character by circuit of Fig. 2 (relay TOR not operated)

In general the operation is similar to that of Fig. 1. When relay TOR is not operated the start pulse, character forming pulses, and stop pulse are transmitted to receiver magnet RRM over contact 3 of relay TOR. The start pulse causes magnet RRM to release the cam shaft, which, as it rotates, repeats the pulses into the receiver TTY in the manner already described. In response to the open circuit start pulse, receiving relay RR connects positive battery over contact 1 of relay TOR to winding *o* of relay SGR_2. Relay SGR_2 shifts its armature to contact 5, but without producing any result, because the closing of contact HC by cam RHC of the regenerative repeater energizes the operating winding *o* of relays SGR_1 and LTR. It will be noted that in the idle condition of the system these windings received no current.

Relays SGR_1 and LTR now shift their armatures to their number 5 contacts, the latter about 2 milliseconds after the former (due to the action of condenser C_3), where they remain until just before the cam shaft of the repeater has completed its rotation, when the contact HL is opened. This takes place just before the stop pulse is relayed to receiver TTY. The delay of 2 milliseconds above described is sufficient to insure the operation of relay SGR_1 before relay LTR. This delay serves to remove the charging battery from condenser C_1 before potential is applied to potentiometer P_1.

Relay SGR_1 closes its contact 5 and disables vacuum tube VC_1. About 2 milliseconds later relay LTR opens its contact 4 and closes contact 5. With tube VT_1 disabled, and with contact 4 of relay LTR opened, negative battery flows through resistance R_4 to cause relay SGR_2 to restore its armature to its contact 4.

Just before the cam shaft of the repeater RGR completes its rotation cam RHC opens contact HC. This occurs just before the stop pulse is received. Relay SGR_1 now shifts its armature from contact 5 to contact 4, and 2 milliseconds later relay LTR shifts its contact. When the armature of relay SGR_1 opens its contact 5 condenser C_1 begins to discharge. The condenser is fully discharged and the tube VT_1 develops full plate current under normal conditions in about 31 milliseconds. When relay LTR closes its contact 4 negative stop current is supplied to potentiometer P_1, to be followed approximately 31 milliseconds later by positive start current from the armature of relay RR. This stop-start transition, acting through potentiometer P_1, synchronizes the time cycle of timing circuit TC_1 in the same manner as described in connection with the circuit of Fig. 1.

At the end of its cycle vacuum tube VT_1 fully energizes winding *b* of relay SGR_2, but the armature of said relay may be held against its contact 4 by the negative stop current through its winding *o* from the armature of relay RR_1. Normally the start pulse is received at once however, and the resulting positive current passing through winding *o* of relay SGR_2 from the armature of relay RR causes relay SGR_2 to again open its contact 4. The operations above described are now repeated for the next character.

Reception of characters by circuit of Fig. 2 after relay TOR operates

Let us assume that some time during the reception of the second character relay TOR operates. At this time the armatures of relays SGR_1 and LTR are on their number 5 contacts, and the armature of relay SGR_2 is on its contact 4. The operation of relay TOR opens its contact 1 and thereby removes the winding *o* of relay SGR_2 from any further control by impulses received from the loop L. At contact 3 it opens the direct pulse connection to the receiving magnet RRM of the repeater. Thenceforward character forming pulses must be transmitted to said magnet over the alternative path closed at contact 5 of relay LTR. At contact 4 of relay TOR a new stop-start pulse circuit is connected to the receiving magnet RRM, this new circuit being controlled by the armatures of relays SGR_1 and SGR_2.

Just before the cam shaft of repeater RGR completes its revolution cam RHC opens the circuit of the operating windings of relays SGR_1 and LTR. Relay SGR_1 at contact 4 now completes a negative stop pulse circuit over contact 4 of relay SGR_2, through resistance R_5, and over contact 4 of relay TOR to receiving magnet RRM. By opening contact 5 relay SGR_1 initiates the cycle of timing circuit TC_1. After the usual delay of 2 milliseconds relay LTR establishes to potentiometer P_1 the synchronizing circuit previously described.

After 31 milliseconds more or less, depending upon the synchronizing action, relay SGR_2 opens its contact 4, thus terminating the negative start pulse previously described, and causing an open circuit start condition in the circuit to the receiving magnet RRM of repeater RGR. The cam shaft of the repeater now rotates, causing relay SGR_1 to close its contact 5 and again disable the timing circuit TC_1. About 2 milliseconds later relay LTR closes contact 5, thus completing an alternative path to transmit character determining pulses from the armature of receiving relay RR to the receiving magnet RRM of the repeater. In the meantime the open circuit start pulse condition in the path over contact 4 of relay TOR continues until character determining pulses are transmitted to receiving magnet RRM over contact 5 of relay LTR.

As the cam shaft of the repeater RGR completes its revolution the circuit for the operating windings of relay SGR_1 and LTR are again closed. Relay SGR_1 opens its contact 5 and thereby starts the cycle timing circuit TC_1 to again generate locally a stop pulse followed by a start pulse.

The foregoing operations are repeated for subsequent characters so long as relay TOR remains operated.

While this invention has been disclosed in certain specific arrangements which are deemed desirable, it will be obvious that the general principles herein set forth may be embodied in many other organizations, widely different from those illustrated, without departing from the spirit of this invention as defined in the appended claims.

What is claimed is:

1. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations including character determining pulses and synchronizing pulses, a receiving device at a receiving station to record received code combinations, pulse generating means at said receiving station to locally generate synchronizing pulses in substantially the same sequence and time of duration as those normally received, and means to supply said locally generated pulses to said receiving device.

2. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations including character determining pulses and synchronizing pulses, a receiving device at a receiving station to record received code combinations, pulse generating means at said receiving station to locally generate synchronizing pulses in substantially the same sequence and time of duration as those normally received, means operating after the initial transmission of signals to prevent synchronizing pulses received from a distant sending station from being transmitted to said receiving device but permitting character determining pulses to be transmitted thereto, and means to supply said locally generated pulses to said receiving device.

3. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations including character determining pulses and synchronizing pulses, a receiving device at a receiving station to record received code combinations, pulse generating means at said receiving station to locally generate synchronizing pulses in substantially the same sequence and time of duration as those normally received, means responding to synchronizing pulses received from a distant sending station to control the operation of said pulse generating means so that the pulses generated thereby will be synchronized with said received synchronizing pulses, and means to supply the locally generated pulses thus synchronized to said receiving device.

4. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations including character determining pulses and synchronizing pulses, a receiving device at a receiving station to record received code combinations, pulse generating means at said receiving station to locally generate synchronizing pulses in substantially the same sequence and time of duration as those normally received, means operating after the initial transmission of signals to prevent synchronizing pulses received from a distant sending station from being transmitted to said receiving device but permitting character determining pulses to be transmitted thereto, means to utilize said synchronizing pulses received from a distant station to control the operation of said pulse generating means so that the pulses generated thereby will be synchronized with said received synchronizing pulses, and means to supply the locally generated pulses thus synchronized to said receiving device.

5. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, and means to supply said locally generated stop-start pulses to said receiving device.

6. In a teletypewriter system, means to transmit to a receiving station in uniform time sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, means operating after the initial transmission of signals to prevent stop-start pulses received from a distant sending station from being transmitted to said receiving device but permitting Baudot character determining pulses to be transmitted thereto, and means to supply said locally generated pulses to said receiving device.

7. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of du-

ration as those normally received, means responding to stop-start pulses received from a distant sending station to control the operation of said stop-start pulse generating means so that the stop-start pulses generated thereby will be synchronized with said received stop-start pulses, and means to supply the locally generated pulses to said receiving device.

8. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, means operating after the initial transmission of signals to prevent stop-start pulses received from a distant sending station from being transmitted to said receiving device but permitting Baudot character determining pulses to be transmitted thereto, means to utilize said stop-start pulses received from a distant station to control the operation of said stop-start pulse generating means so that the stop-start pulses generated thereby will be synchronized with said received stop-start pulses, and means to supply the locally generated stop-start pulses thus synchronized to said receiving device.

9. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including two timing devices, the first one being started upon the reception of the start pulse of the first code combination and having a time cycle substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to said receiving device after the completion of the cycle of said second timing device, and means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew.

10. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulse in substantially the same sequence and time duration as those normally received, said stop-start pulse generating means including two timing devices, the first one being started upon the reception of the start pulse of the first code combination and having a time cycle substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew, and means operating after the initial transmission of signals to prevent stop-start pulses received from a distant sending station from being transmitted to said receiving device.

11. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including two timing devices, the first one being started upon the reception of the start pulse of the first code combination and having a time cycle substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew, and means responding to stop-start pulses received from a distant sending station to synchronize the operation of said stop-start pulse generating means so that the time cycle of said second timing device will be terminated and the time cycle of said first timing device will be started anew at the instant a stop-start transition occurs between successive code combinations received from a distant sending station.

12. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said

stop-start pulse generating means including two timing devices, the first one being started upon the reception of the start pulse of the first code combination and having a time cycle substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew, means operating after the initial transmission of signals to prevent stop-start pulses received from a distant sending station from being transmitted to said receiving device, and means responding to stop-start pulses received from a distant sending station to synchronize the operation of said stop-start pulse generating means so that the time cycle of said second timing device will be terminated and the time cycle of said first timing device will be started anew at the instant a stop-start transition occurs between successive code combinations received from a distant sending station.

13. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including a first and second timing device each including a vacuum tube, a condenser associated with the grid of said tube and arranged to discharge through a resistance at a rate which determines the time required to build up the plate current of the tube to full operating value, thereby completing the time cycle of the timing device, the timing cycle of the first timing device being started upon the reception of the start pulse of the first code combination received and having a time cycle substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the timing cycle of the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to said receiving device after the completion of the cycle of said second timing device, and means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew.

14. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including a first and a second timing device each including a vacuum tube, a condenser associated with the grid of said tube and arranged to discharge through a resistance at a rate which determines the time required to build up the plate current of the tube to full operating value, thereby completing the time cycle of the timing device, the timing cycle of the first timing device being started upon the reception of the start pulse of the first code combination received and having a time cycle substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the timing cycle of the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew, and means operating after the initial transmission of signals to prevent stop-start pulses received from a distant sending station from being transmitted to said receiving device.

15. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including a first and a second timing device each including a vacuum tube, a condenser associated with the grid of said tube and arranged to discharge through a resistance at a rate which determines the time required to build up the plate current of the tube to full operating value, thereby completing the time cycle of the timing device, the timing cycle of the first timing device being started upon the reception of the start pulse of the first code combination received and having a time cycle substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the timing cycle of the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing de-

vice anew, and means responding to stop-start pulses received from a distant sending station to synchronize the operation of said stop-start pulse generating means so that the time cycle of said second timing device will be terminated and the time cycle of said first timing device will be started anew at the instant a stop-start transition occurs between successive code combinations received from a distant sending station.

16. In a teletypwriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulses generating means including a first and a second timing device each including a vacuum tube, a condenser associated with the grid of said tube and arranged to discharge through a resistance at a rate which determines the time required to build up the plate current of the tube to full operating value, thereby completing the time cycle of the timing device, the timing cycle of the first timing device being started upon the reception of the start pulse of the first code combination received and having a time cycle substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the timing cycle of the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew, means operating after the initial transmission of signals to prevent stop-start pulses received from a distant sending station from being transmitted to said receiving device, and means responding to stop-start pulses received from a distant sending station to synchronize the operation of said stop-start pulse generating means so that the time cycle of said second timing device will be terminated and the time cycle of said first timing device will be started anew at the instant a stop-start transition occurs between successive code combinations received from a distant sending station.

17. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including a first and a second timing device, said second timing device including a vacuum tube, a condenser associated with the grid of said tube and arranged to discharge through a resistance at a rate which determines the time required to build up the plate current of the tube to full operating value, thereby completing the timing cycle of said second timing device, said first timing device including a pulse operated controlling magnet, a start-stop cam shaft set into rotation when said controlling magnet received a start pulse and ceasing its rotation when said magnet receives a stop pulse, pulse regenerating cams upon said cam shaft to regenerate pulses received by said magnet and transmit them to said receiving device, the rotating time cycle of said cam shaft being substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the timing cycle of the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to the controlling magnet of said first timing device to be relayed to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to the controlling magnet of said first timing device to be relayed to said receiving device after the completion of the cycle of said second timing device, and means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew.

18. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combinations, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including a first and a second timing device, said second timing device including a vacuum tube, a condenser associated with the grid of said tube and arranged to discharge through a resistance at a rate which determines the time required to build up the plate current of the tube to full operating value, thereby completing the timing cycle of said second timing device, said first timing device including a pulse operated controlling magnet, a start-stop cam shaft set into rotation when said controlling magnet receives a start pulse and ceasing its rotation when said magnet receives a stop pulse, pulse generating cams upon said cam shaft to regenerate pulses received by said magnet and transmit them to said receiving device, the rotating time cycle of said cam shaft being substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the timing cycle of the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of the stop pulse, means to apply a stop condition to the controlling magnet of said first timing device to be relayed to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to the controlling magnet of said first timing device to be relayed to

said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew, and means operating after the initial transmission of signals to prevent stop-start pulses received from a distant sending station from being transmitted to said receiving device.

19. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including a first and a second timing device, said second timing device including a vacuum tube, a condenser associated with the grid of said tube and arranged to discharge through a resistance at a rate which determines the time required to build up the plate current of the tube to full operating value, thereby completing the timing cycle of said second timing device, said first timing device including a pulse operated controlling magnet, a start-stop cam shaft set into rotation when said controlling magnet receives a start pulse and ceasing its rotation when said magnet receives a stop pulse, pulse regenerating cams upon said cam shaft to regenerate pulses received by said magnet and transmit them to said receiving device, the rotating time cycle of said cam shaft being substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the timing cycle of the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to the controlling magnet of said first timing device to be relayed to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to the controlling magnet of said first timing device to be relayed to said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew, and means responding to stop-start pulses received from a distant sending station to synchronize the operation of said stop-start pulse generating means so that the time cycle of said second timing device will be terminated and the time cycle of said first timing device will be started anew at the instant a stop-start transition occurs between successive code combinations received from a distant sending station.

20. In a teletypewriter system, means to transmit to a receiving station in uniform timed sequence a succession of code combinations each including a start pulse, a set of Baudot character determining pulses and a stop pulse, the start pulse of a succeeding code combination immediately following the stop pulse of the preceding combination, a receiving device at a receiving station to record received code combinations, stop-start pulse generating means at said receiving station to locally generate stop-start pulses in substantially the same sequence and time of duration as those normally received, said stop-start pulse generating means including a first and a second timing device, said second timing device including a vacuum tube, a condenser associated with the grid of said tube and arranged to discharge through a resistance at a rate which determines the time required to build up the plate current of the tube to full operating value, thereby completing the timing cycle of said second timing device, said first timing device including a pulse operated controlling magnet, a start-stop cam shaft set into rotation when said controlling magnet receives a start pulse and ceasing its rotation when said magnet receives a stop pulse, pulse regenerating cams upon said cam shaft to regenerate pulses received by said magnet and transmit them to said receiving device, the rotating time cycle of said cam shaft being substantially equal to the time required to receive a start pulse and a set of Baudot character determining pulses, the timing cycle of the second timing device being started upon the completion of the cycle of the first and having a time cycle substantially equal to the time duration of a stop pulse, means to apply a stop pulse condition to the controlling magnet of said first timing device to be relayed to said receiving device during the time cycle of said second timing device, means to apply a start pulse condition to the controlling magnet of said first timing device to be relayed to said receiving device after the completion of the cycle of said second timing device, means operating after the completion of the cycle of said second timing device to start the cycle of said first timing device anew, means operating after the initial transmission of signals to prevent stop-start pulses received from a distant sending station from being transmitted to said receiving device, and means responding to stop-start pulses received from a distant sending station to synchronize the operation of said stop-start pulse generating means so that the time cycle of said second timing device will be terminated and the time cycle of said first timing device will be started anew at the instant a stop-start transition occurs between successive code combinations received from a distant sending station.

21. In a telegraph system, a start-stop regenerative repeater operable in cycles initiated by start impulses, means responsive to start impulses of received signals for starting said repeater, an incoming channel of transmission for supplying start impulses accompanied by groups of code impulses to said means of said repeater, an outgoing channel of transmission to carry regenerated start and code impulses from said repeater, and means for locally generating and impressing on said means start impulses in substantial synchronism with the corresponding impulses of received signals.

22. In a telegraph system, a start-stop regenerative repeater operable in cycles initiated by start impulses, means responsive to start impulses of received signals for starting said repeater, an incoming channel of transmission for supplying start impulses accompanied by groups of code impulses to said means of said repeater, an outgoing channel of transmission to carry regenerated start and code impulses from said repeater, and means local to said repeater for initiating one or more cycles of said repeater in the absence of one or more received start impulses, respectively.

23. In a telegraph system, a start-stop regen-

erative repeater operable in cycles initiated by start impulses, means responsive to start impulses of received signals for starting said repeater, an incoming channel of transmission for supplying start impulses accompanied by groups of code impulses to said means of said repeater, an outgoing channel of transmission to carry regenerated start and code impulses from said repeater, means local to said repeater for initiating cycles of said repeater in the absence of received start impulses, and means for disabling said local initiating means a predetermined interval after cessation of signal reception.

24. In a telegraph system, a start-stop regenerative repeater operable in cycles initiated by start impulses and terminated by stop impulses, an incoming channel of transmission for normally supplying to said repeater groups of impulses comprising the start impulse, code impulses, and the stop impulse, an outgoing channel of transmission to carry regenerated groups of start, code and stop impulses from said repeater, and means for locally generating and impressing on said repeater start and stop impulses in substantial synchronism with corresponding impulses of received signal impulse groups.

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