

Feb. 15, 1944.

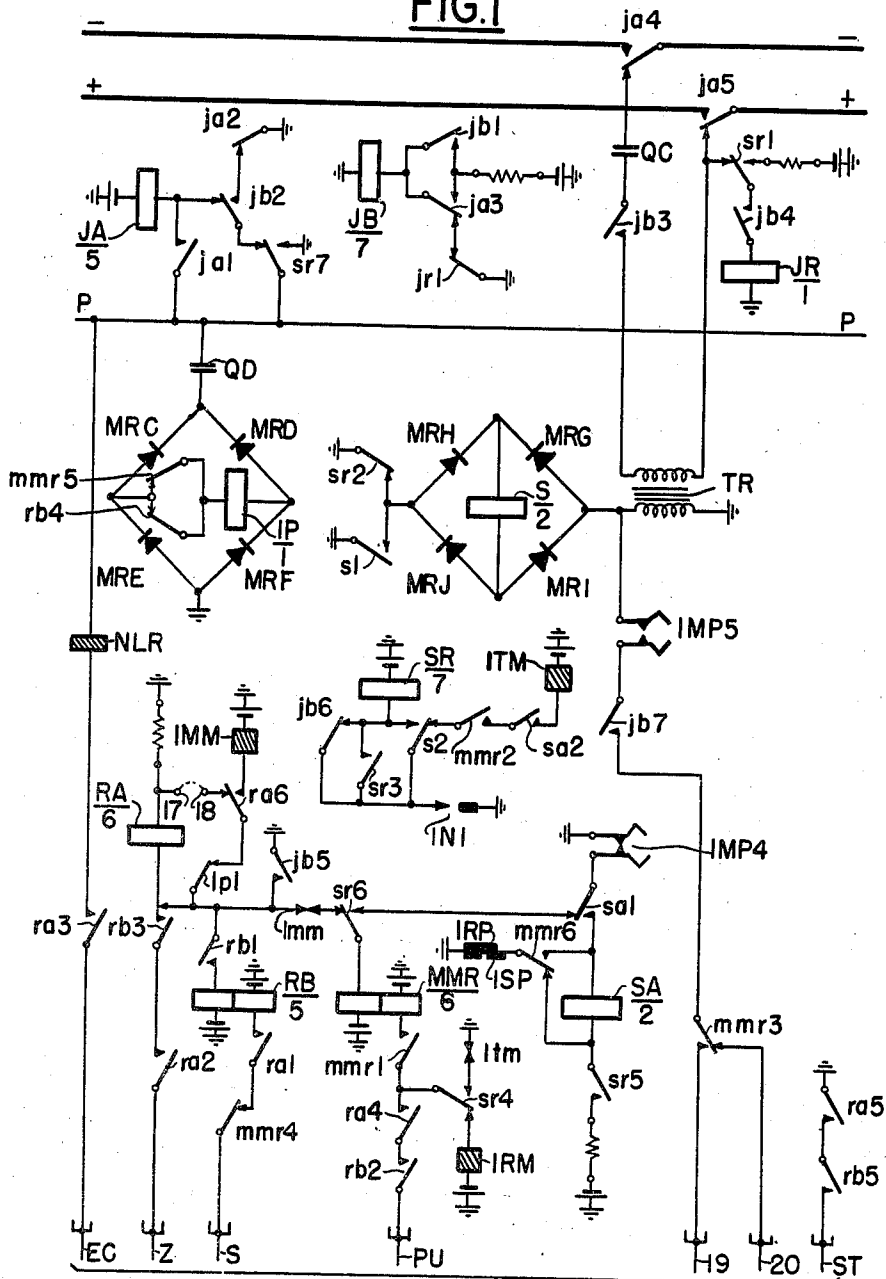
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2,341,746

TELEPHONE SYSTEM

Original Filed April 15, 1940 4 Sheets-Sheet 1

FIG. 1



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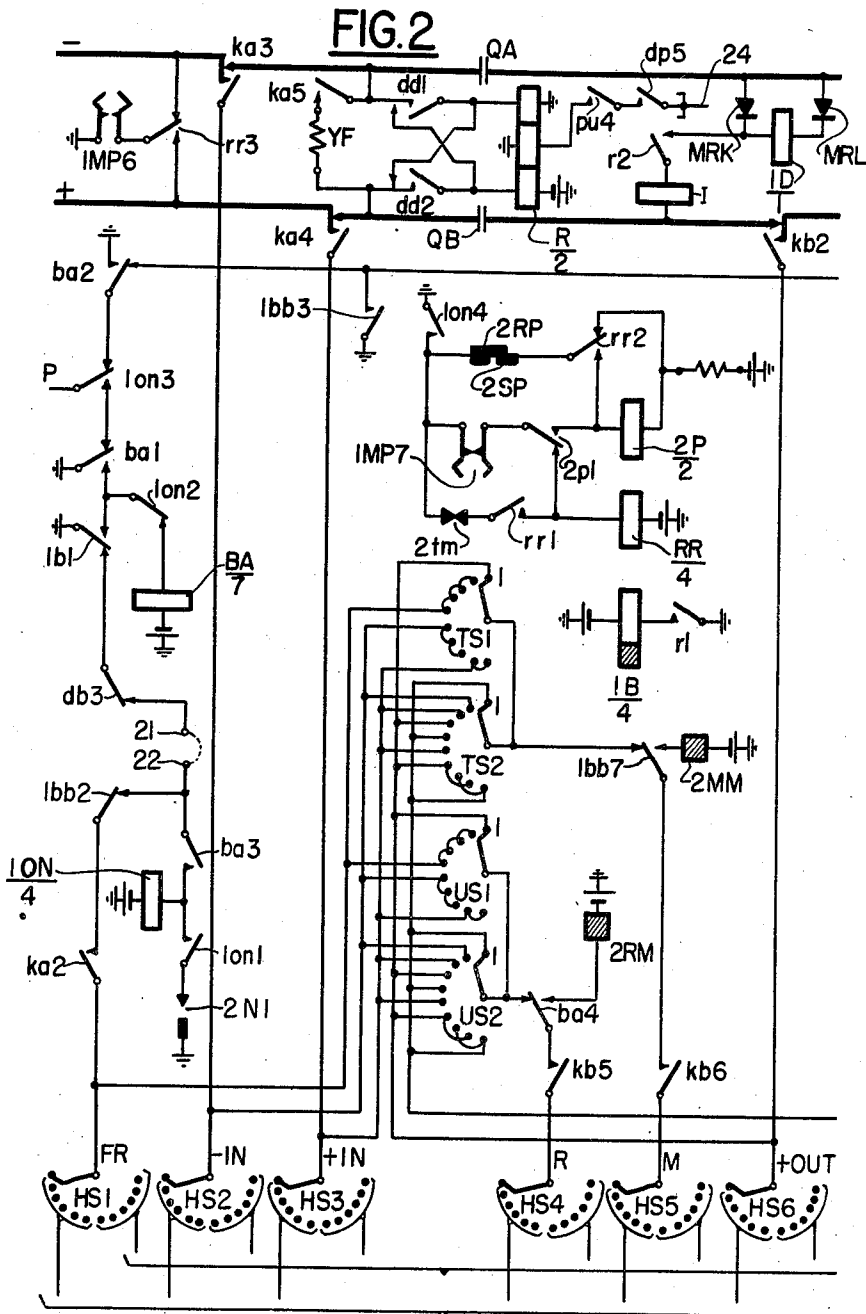
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Original Filed April 15, 1940 4 Sheets-Sheet 2



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Original Filed April 15, 1940 4 Sheets-Sheet 3

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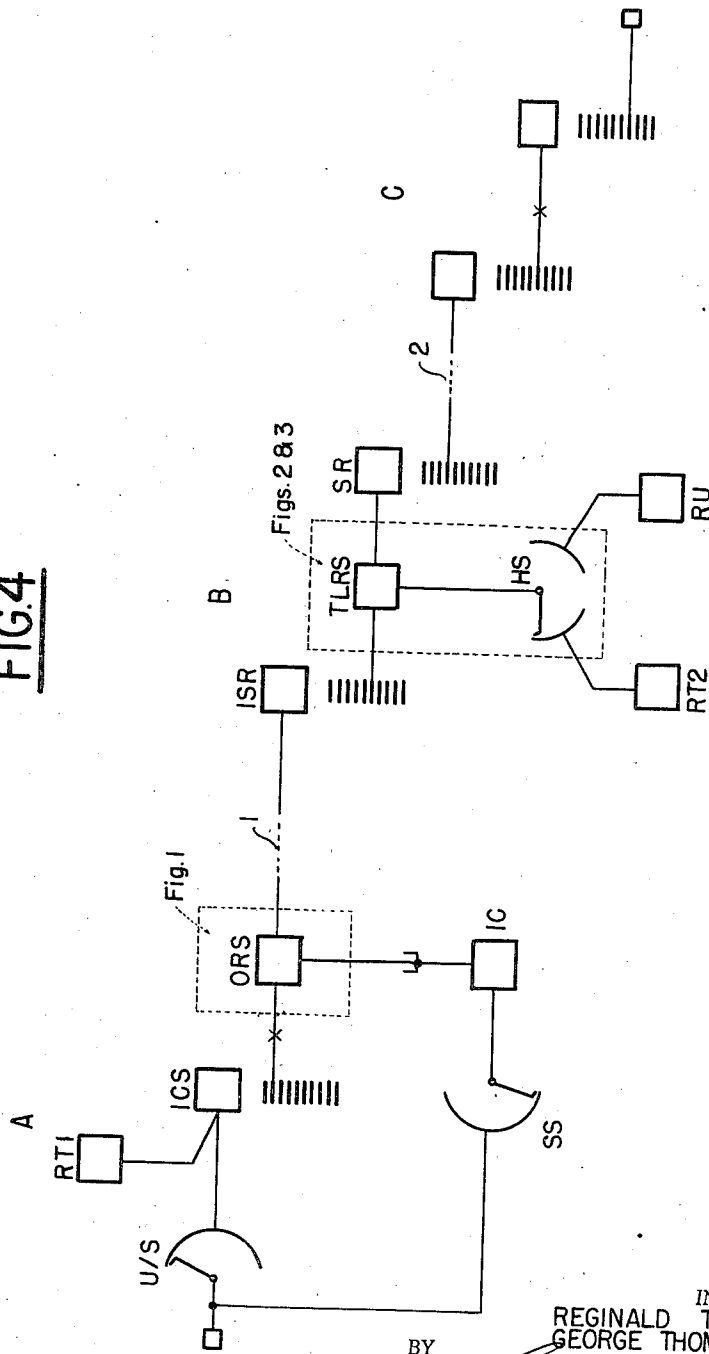
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Original Filed April 15, 1940 4 Sheets-Sheet 4

FIG. 4



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2,341,746

TELEPHONE SYSTEM

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Original application April 15, 1940, Serial No. 329,608. Divided and this application June 12, 1942, Serial No. 446,784. In Great Britain May 5, 1939

14 Claims. (Cl. 179—18)

The present invention concerns improvements in or relating to mechanical impulse regenerators, and is a division of our copending United States application Serial No. 329,608, filed April 15, 1940. While particularly applicable to arrangements for setting up connections in telephone systems and to improved arrangements for dealing with connections which must be recorded for charging purposes, the invention has other applications.

The object of the present invention is to provide a cheap and economical method of transmitting items of information over a connection from one stage to another in the shortest possible time, for instance to transfer a calling or called party's number to a recording position. In the case of a called party's number involving a large number of digits the provision of separate storing means for each digit is liable to prove very expensive and it is a feature of the present invention that a plurality of digits may be stored by the mere displacement of selected pins in a mechanical impulse regenerator in a manner which enables more digits to be stored than previously has been possible with such a device.

According to one feature of the invention a mechanical impulse regenerator is provided with a plurality of impulse responding means operable in different combinations in accordance with impulses received in code form and transmitting means controlled by said impulse responding means to send out impulses in regenerated form corresponding to the impulses received.

According to a further feature of the invention a mechanical impulse regenerator comprises means for responding to two sets of pulses, the pulses of one set having a definite timed relationship to the pulses of another set and in which impulse regenerative means are controlled to retransmit two sets of pulses corresponding to and having the same relationship as those received.

According to a further feature of the invention a mechanical impulse regenerator includes a receiving magnet by which a member is moved to an extent determined by one set of pulses and members which are selectively displaced during said movement in response to a second set of pulses having a definite timed relationship in respect to said first set.

Conveniently the impulse regenerator is constructed as described in United States Patent No. 2,188,461, issued Jan. 30, 1940, to McClew and Woodland, and according to the invention a member is moved by a receiving magnet to an extent determined by one set of pulses while pins are displaced during such movement in response to a second set of pulses acting upon a marking magnet, such second set of pulses having a definite timed relationship with respect to the first set, an impulse generator controlled thereby is adapted when released to operate and generate

pulses corresponding in number to said first set of pulses and to the extent of movement of said member while a further impulse generator is adapted to be operated as each displaced pin is encountered to generate pulses corresponding to the second set of pulses.

By making the number of pulses constant both in said first and second set of pulses it will be immediately apparent in the event the number of pulses of said sets when received include a different number that there is a fault and hence a lost pulse is immediately detected. An extra pulse interpolated by interference is also immediately detected.

These and other features of the invention will be better understood from a description of the following embodiments thereof which are given by way of example, reference being had to the accompanying drawings comprising Figs. 1, 2, 3 and 4.

Fig. 1 illustrates circuit arrangements at an outgoing relay set for controlling a mechanical impulse regenerator according to the invention, so that it will receive the identification of a calling line in code and subsequently retransmit it to the recorder.

Figs. 2 and 3, when placed side by side with Fig. 2 to the left of Fig. 3, illustrate circuit arrangements for a similar regenerator at the recording exchange to receive the pulses in code form corresponding to the called party's number and retransmit them to the recorder.

Fig. 4 is a schematic trunking diagram illustrating the arrangement of certain apparatus (including that shown in Figs. 1, 2 and 3) involved in a typical connection from a calling subscriber in one exchange to a called subscriber in a different exchange.

Referring first to Fig. 4, the operation involved in the extension of a connection from a calling subscriber in exchange A to a called subscriber in exchange C will be described briefly. When the calling subscriber removes his receiver the uni-selector US automatically operates to connect him to a first code selector ICS which has associated with it certain register-translator equipment RT1. This equipment serves to receive and store the digits of the called subscriber's number when they are dialed by the calling subscriber; upon receipt of the called subscriber's number, register-translator RT1 transmits routing digits dependent on said called subscriber's number, which digits control the first code selector ICS to seize a trunk line 1 via the outgoing relay set ORS and then control the incoming selector ISR over said trunk line to seize an idle toll line relay set TLRS. When the latter is seized, the hunter switch HS immediately associates an idle register-translator RT2 with the toll line relay set. Thereupon a signal is trans-

mitted from the toll line relay set back over the connection to register-translator RT1, and in response to this signal the called subscriber's number stored in RT1 is transmitted over the connection to register-translator RT2. In RT2 the called subscriber's number is converted from decimal form into code form and transmitted to the toll line relay set TLRs where it is registered on a mechanical impulse regenerator as will be described more in detail presently.

The register-translator RT2 also transmits routing digits dependent upon the called subscriber's number; these digits control the outgoing selector SR to seize a trunk line 2 extending to exchange C and then control switching apparatus in exchange C to complete the connection to the called subscriber.

Upon seizure of trunk line 1 by the first code selector ICS as described above, the outgoing relay set ORS initiates the operation of identification control relay set IC which with the aid of the identification switch SS causes the calling line's number to be transmitted in code form over the switches SS, US, and ICS to the outgoing relay set ORS where it is registered on a mechanical impulse regenerator as will be explained below. The identification equipment is preferably of the type disclosed in our copending United States application Serial No. 321,783, filed March 1, 1940, to which reference may be had for details of its operation.

When the calling subscriber hangs up his receiver at the end of the call, the hunter switch HS operates to associate an idle recording unit RU with the toll line relay set TLRs whereupon the mechanical impulse regenerators in the outgoing relay set ORS and in the toll line relay set TLRs operate in turn to transmit the stored calling and called subscribers' numbers, respectively, to the recording unit, where facilities are provided for printing these items of information on a ticket.

Considering briefly the construction of the mechanical impulse regenerator this will be better understood from details given in Patent No. 2,188,461, previously mentioned, from which it will be seen that the device comprises essentially a receiving disc and sending disc which are arranged on either side of a plate carrying a circular row of pins. The receiving disc is rotated step-by-step in response to the impulses received on a stepping magnet and carries with it a marking lever which is released on de-energization of the marking magnet, not at the end of each train of impulses as in the Patent No. 2,188,461, but, according to the present invention, in a definite timed relationship with the pulses operating the receiving magnet. The marking magnet pushes pins corresponding thereto through the pin plate into the path of the sending disc. For each of such operations of the marking magnet a corresponding pin is pushed through the plate and these pins serve to regulate the movement of the sending disc which controls the generation of outgoing impulses by the regenerator impulse springs.

To initiate the transmission of the outgoing impulses, a pin which was previously displaced into the path of the sending disc is pushed back to its normal position by a resetting pin upon energization of the retransmitting magnet, but owing to the stepped head on the reset pin the sending disc is not immediately released and remains held until the retransmitting magnet is de-energized. This magnet disconnects a relay

which thereupon opens the magnet energizing circuit as fully described in the patent referred to, whereupon the sending disc is released and rotates until the reset pin comes up against the stop pin indicating the first of the pulses operating the marking magnet. The rotation of the disc controls the generation of one set of pulses and the successive engagement of the pins which are successively reset controls the generation of a second set of pulses having a definite timed relationship to the first set.

During the sending out of impulses, it will be noted that since the reset pin is not connecting with any stop pin the relay above referred to cannot be re-operated, while during this time the first impulses received are sent out in regenerated form by way of impulse springs controlled from the regenerator device. In this case no timing is required as the stop pins are reached, the control of the timing arrangements between series of pulses shown in the said specification being utilised according to the present invention to generate a pulse of the second series.

It will be appreciated that the two operations of reception and retransmission may go on simultaneously but independently of each other.

Turning now to Fig. 1, when the outgoing relay set is seized it will be understood that earth is extended forward on the private lead P to operate relay JA and this relay brings up relay JB at its armature *ja3* and at its armatures *ja4* and *ja5* connects the incoming left-hand negative and positive conductors through to the outgoing junction to the tandem exchange. An impulse repeating loop is thereupon extended forward from the first code selector right through the outgoing relay set to the incoming selector at the tandem exchange, and the remainder of the routing digits transmitted from the register-translator in the originating exchange serve to route the call to a toll line relay set at the tandem exchange which is shown in Figs. 2 and 3.

Returning again to the outgoing relay set it is assumed that immediately on seizure calling line identification equipment will be set into operation to communicate details of the identification of the calling party's number to the outgoing relay set where it will be stored. Hence relay JB in operating at armature *jb5* extends earth via armature *jb3* to operate relay RA, assuming that the strapping connections between terminals 17 and 18 are disconnected. In other circumstances where the outgoing junctions to the tandem exchange are assumed to serve both call recorded traffic and ordinary metered traffic the terminals 17 and 18 will be strapped so that relay RA can only be operated if a discriminating signal of alternating current (indicating that the call is to be recorded) has been sent forward over the private lead P to operate relay IP which is an ordinary direct current relay connected in a full wave rectification circuit comprising rectifiers MRC—MRF and connected to the incoming P lead via condenser QD.

Relay RA in operating at its armature *ra6* completes an energizing circuit for the regenerator marking magnet IMM via armatures *jb5*, *ip1* and *ra6* and at armatures *ra1*—*ra5* connects the outgoing relay set to the common leads extending to the calling line identification equipment.

In connection with the calling line identification equipment it will be understood that this is of the general type in which the private lead associated with each line in an exchange is marked

with a code which is indicative of that particular line. The marking thereupon passes along the P lead of the connection set up by the calling party and is received at the outgoing relay set where this information is required.

As regards the code, this may be preferably of the well-known five unit type in which every digit to be transmitted or stored consists of five parts and by sending signals in one or more of these parts the various digits are indicated. Parts or units without a signal are known as spacing pulses and those with a signal are called marking pulses. In the five unit code every digit comprises two marking pulses and three spacing pulses, the marking signals being transmitted along the private lead to the outgoing relay set while the spacing or synchronising pulses are supplied independently of the talking train over common leads from the identification equipment to the outgoing relay set.

Assuming for instance that the five parts of the code are designated V, W, X, Y, Z, respectively, then digit 1 will be transmitted by sending a marking pulse in the parts V, W, the coding for the various digits being indicated in the following table:

VW—1
VX—2 WX—5
VY—3 WY—6 XY—8
VZ—4 WZ—7 XZ—9 YZ—0.

Thus for a four digit number a total of four groups of five pulses each will be transmitted and may be stored on the impulse storage and regenerative device on the outgoing relay set in the same five unit code as received. Each five pins in sequence on the regenerator form a digit and pins in each of these groups of five are displaced in accordance with the marking pulses received.

On referring back to the circuit of the outgoing relay set it will be understood that when relay RA operates, if the subscriber identification equipment, or line marking equipment as it may be alternatively termed, is not already in operation and performing a cycle of identification then there will be an earth potential on the common lead S which will bring up relay RB over its right-hand winding, and this relay thereupon locks via armatures *rb1* and *rb5* to earth on its left-hand winding. At armature *rb2* the regenerator receiving magnet IRM is connected up to the pulsing lead PU in readiness for receiving spacing impulses, while at armature *rb3* the initial energizing circuit for relay RA is opened and this relay is now held operated to the common lead Z which it will be understood is earthed in the line marking equipment and remains earthed until shortly before the end of a complete identification cycle, when earth is momentarily removed therefrom in order to signal the completion of a cycle to all calls which have received a complete identification. At armature *rb5* earth is extended from armature *ra5* on to the common start lead ST in order to initiate a line marking cycle. During the identification or line marking cycle each step thereof causes an earth spacing impulse to be applied to the PU wire, and the regenerator receiving magnet IRM therefore steps the receiving disc and marking arm around the circulator row of pins.

Each time a marking impulse which, it will be understood, is of the alternating current type, is received over the private lead relay IP will be operated, and in so doing at its armature *ip1* disconnects the marking magnet IMM. This

magnet in restoring releases the marking lever carried by the receiving disc, and a pin opposite which it is positioned is pushed into the path of the sending disc, while at the same time contacts *imm* controlled by the marking magnet close after having been opened during the energization of the magnet, and in so doing complete a circuit for relay MMR over its left-hand winding. Relay MMR at its armature *mmr5* disconnects the circuit of relay IP which releases to re-energise the marking magnet IMM, while at its armature *mmr1* it locks over its right-hand winding to the earthed pulse lead PU until the pulse is completed.

At the end of the pulse relay MMR releases and reconnects relay IP on to the private lead in readiness for a subsequent marking pulse.

Assuming that the calling subscriber's number is 1359, then twenty code signals will be received by the regenerator, of which pulses Nos. 1 and 2, 6 and 9, 12 and 13, 18 and 20, are marking pulses, the remainder being spacing pulses. Corresponding pins are displaced in a row of twenty consecutive pins on the regenerator, and in this manner the subscriber's number can be stored in code by means of displaced pins.

If the calling subscriber has the usual register-translator exchange number comprising three letters and four numerical digits the first part of the number will be the same for all subscribers on the exchange and hence this can be received directly from the line marking equipment without having to be transmitted over the talking train.

The code signals indicative of the initial digits of the number are received from the line marking equipment via the "exchange code" common lead EC which connects with the P lead and relay IP via a non-linear resistance NLR which, in response to the application of a suitable alternating current potential on to lead EC, lowers its resistance sufficiently to allow relay IP to operate in series therewith. The five unit code is utilised to communicate the initial digits of the number to the impulse regenerator and when this has been completed the numerical part of the number is communicated over the P lead in the manner already described.

When the identification cycle is completed, earth is momentarily removed from the Z common and relay RA releases. The circuit now remains in this condition until the end of the call when the calling subscriber restores his receiver, but before considering what will happen at this point, consideration will first be given to the setting up of the toll call via a toll line relay set at the parent tandem exchange.

During the identification cycle which is initiated on seizure of the outgoing relay set, trains of routing impulses will be extended therethrough to set up the call to a parent tandem exchange toll line relay set such as is shown in Figs. 2 and 3.

The function of this relay set is firstly to gain access over a 25 point uniselector switch HS to register translating equipment serving the switch train, and afterwards to gain access to call recording equipment. It is also adapted to store the called number on an impulse storage and regenerative device, while furthermore, the duration of the call which is also required for the purpose of call recording is determined therein by means of two 10 point reverse drive electromagnetically operated stepping switches TS and US operating in conjunction with the 25 point switch

HS which is actuated by a six seconds earth pulse during conversation for timing purposes.

Other particulars which are required for the purpose of call recording such as the identity of the calling number and the time of occurrence of the call may be obtained respectively from the outgoing relay set at the originating exchange as already described, and from a common date and time unit to which access is had from the call recording equipment when this information is required.

When the toll line relay set is seized a loop is extended forward from the originating exchange register-translator via the first code selector, the outgoing relay set, junction to the tandem exchange and incoming tandem exchange selector to operate relay R in the tandem exchange toll line relay set. A polarized relay in the register-translator at the originating exchange is included in this loop circuit. The battery connections to line via relay R are such as not to operate the polarized relay at the originating exchange, and so hold up the sending out of the impulse trains stored in the register-translator thereat until access has been had via the hunting switch HS to the routing register-translator equipment serving the toll switch train.

Relay R in operating, at its armature *r1* brings up relay IB and this relay in turn brings up relay BA. Relay BA in operating at its armature *ba1* completes a locking circuit for itself, at armature *ba2* extends a guarding and holding earth on to the P lead, at armature *ba5* completes an operating circuit for relay KR and at armature *ba6* completes an operating circuit for relay MD.

Relay KR in operating at armature *kr6* completes a self-interrupted driving circuit for the magnet HSM of switch HS via the magnet interrupter contacts *hsm*.

It will be remembered that the hunter switch HS is arranged to have access either to register-translators or to recording units, and it is initially arranged that hunting shall only take place over bank contacts wired out to register-translators. This is ensured by arranging that an operating circuit for the wiper switching relay K can only be completed via contacts on the banks of switch HS which are wired out to register-translators, and whenever the wipers of this switch are resting on such contacts earth will be extended from armature *kr1* over the homing bank and wiper HS9, armatures *1b4*, *k2* and *kr1*, resistance YC, armature *kr2*, windings of relay K in series to the testing or P wiper HS8 of switch HS.

If the outlet on which the HS switch wipers are standing is engaged then relay K will fail to operate and the switch will step its wipers on to the next set of contacts. A self-interrupted driving operation continues until an idle register-translator is found, when wiper HS8 will encounter an idle resistance marking battery and relay K will operate. In operating it disconnects the magnet driving circuit at armature *k3* to arrest the motion of the switch, operates relay KA at armature *k2* and at its armature *k1* extends a guarding and holding potential on to the test wiper HS8 by way of its low resistance lower winding.

Relay KA in operating at its armature *ka1* disconnects the circuit of the slow-to-release relay KR and brings up relay KB, at armatures *ka3* and *ka4* the incoming negative and positive conductors are connected through to the hunter switch wipers HS2 and HS3, a holding circuit

being maintained to relay R via resistance YF, and armature *ka5*, while at armature *ka6* an operating circuit is completed for relay IBB.

Relay K in operating also at its armature *k2* disconnects one section of its original operating path and its upper winding of this relay is now energised in an opposing direction to its lower winding from earth via armature *k1*, upper winding, armature *kr2*, resistance YC and YD to battery in order that suitable release conditions for this relay may be obtained in the remote case where K relays in two toll line relay sets attempt to switch substantially simultaneously into the same register-translator.

In this case of a dual connection, the two K relays are allowed to operate to the same idle marking battery, but the holding flux produced in each due to the current through their low resistance lower windings will be halved, while the opposing flux due to their upper windings will remain the same. In these circumstances both the K relays will release satisfactorily and cause the respective hunter switches to continue searching.

Due to the difference in speed of any two switches, after a few steps one will reach a free outlet before the other, whereupon the associated K relay will operate to guard the outlet and to disconnect the magnet driving circuit.

The energization of the upper winding of relay K in an opposing direction to that of the lower winding is maintained until release of relay KR after which the circuit to the upper winding is disconnected and relay K remains securely held on its lower winding alone.

Relays KB and IBB in operating at armatures *kb1* and *kb2* and *1bb5* and *1bb6* connect the outgoing negative and positive conductors on the right-hand side of the circuit through to the negative and positive out pulsing leads of the register-translator, while at armature *kb3* the magnet driving circuit is further disconnected. Relay IBB in operating further at its armature *1bb1* locks independently of relay KA.

The distant register-translator at the originating exchange is now connected through the toll line relay set to the register-translator which is in turn connected out via the toll line relay set to the outgoing toll train switches at the tandem exchange.

It will be understood that the battery connections to the incoming negative and positive leads in the tandem register-translator are the reverse to those obtaining with relay R so that the aforementioned polarized relay in the register-translator at the originating exchange now operates and initiates the sending out of the dialled number.

This information is received in the tandem register translator in order to effect the necessary translation to set up the call to the required subscriber, while at the same time the information is communicated therefrom to the impulse storing and regenerative device in the toll line relay set in the following manner.

On the operation of relays KB and IBB it will be noted that the regenerator receiving and marking magnets 2RM and 2MM are connected up over wipers HS4 and HS5 to the register-translator seized, and it will be understood that the marking magnet 2MM is immediately energized to lift the marking lever clear of the pins in readiness for the reception of impulses on the receiving magnet 2RM.

It will be understood that the decimal impulse

trains received in the tandem exchange register-translator are also changed over into the five-unit code form previously described in connection with the line marking equipment and are transmitted over banks and wipers HS4 and HS5 to the regenerator receiving and marking magnets 2RM and 2MM. For each digit received the receiving magnet 2RM receives five pulses, and a marking pulse is delivered over bank and wiper HS5 on two out of each group of five impulses, each marking pulse comprising a disconnection of the earth potential applied to bank HS5 and releases the marking magnet 2MM so as to displace certain pins in accordance with the particular digits involved as described in connection with the storage of the calling number in code form in the outgoing relay set regenerator.

When the tandem register-translator completes the sending out of the routing digits to route the call to the required subscriber its function is completed and it thereupon removes the marking battery from the contact on which wiper HS8 is standing, thereby releasing relay K in the toll line relay set. Relay K in releasing in turn releases relays KA and KB, and furthermore, since the register-translator at the originating exchange will have dropped out of the connection by this time, the conversational channel will be completed, the completion of this channel in the toll line relay set being completed over the resting armatures *ka3* and *ka4*, condensers QA and QB and resting armatures *kb1* and *kb2*. Relay KB in releasing also at armature *kb3* completes a homing circuit for the HS switch over the following circuit: lead 21 which is earthed via delayed alarm equipment which comes into operation if the switch should fail to home, armature *kr7*, wiper and bank HS9, armatures *kr3* and *kr5* according to the position of the wiper HS9 on the bank, armatures *ab5*, *k3* and *kb3*, magnet interrupter contacts *hsm*, magnet HSM to battery, and the HS switch wipers are accordingly rotated to the home position.

On the completion of the setting up of the call, the called subscriber is rung from the distant exchange final selector in the usual way, and when he replies a battery reversal will be extended backwardly over the speaking conductors and the subsequent operations including supervision and timing of the call will take place as described in the main application, Serial No. 329,608.

When the calling subscriber hangs up relays R, IB and IBB release in turn, but relay BA remains operated to guard the toll line relay set over its armature *ba2* and to provide for the switching through of this relay set to call recording equipment.

Call recording now takes place in the following manner: Should it be desired to record effective calls only it will be understood that terminals 21 and 22 in the circuit of relay 10N are strapped so that if relay DB has not been operated as a result of the called party replying, then on release of relay IB relay 10N will be operated to release relay BA at its armature *lon0* and so initiate the release of the toll line relay set without having gained access to the call recording equipment.

Should relay DB have been operated and locked, however, or should the strapping connection between terminals 21 and 22 not be provided, relay KR in re-operating on the release of relay IBB over armatures *ba5*, *ka1* and *bb4* will cause at *kr6* the hunter switch HS to step over that part of its bank giving access to register-trans-

lators and hunt over that part of its bank giving access to printer controllers.

When a free recording unit which is marked, as in the case of a free register-translator, by a resistance marking battery is found, relay K operates to cut the drive and to once again bring in relays KA and KB and to release relay KR. Relay KA in operating at armatures *ka3* and *ka4* switches the incoming negative and positive leads into the recording unit in readiness for the reception of code signals indicative of the calling number, while relay KB in operating at its armature *kb5* and *kb6* prepares a circuit for transmitting the duration of conversation over the banks of the switches US and TS to the recording unit.

The first information to be received by the recording unit is the identity of the calling party in order that the junction between the originating exchange and the tandem exchange may be freed as soon as possible, and the sending out of this information is initiated by the transmission from the recording unit of a 50 cycle alternating current pulse.

In the circuit of the outgoing relay set when the calling subscriber replaces his receiver, the seizing earth extended forward from the first code selector over the P lead is removed.

If the call is as being described, such as to require call recording as distinct from single or multi-fee metering earth momentarily disconnected from the P lead provides the requisite disconnect period for the release of intermediate switches and apparatus in the train between the first code selector and the outgoing relay set.

When the toll line relay set finds a recording unit the negative battery is disconnected from the positive lead at armature *ka4* in the toll line relay set. Thereupon relay JR in the outgoing relay set (Fig. 1) releases, and, by short-circuiting relay JB at armature *jr1* initiates the release of relay JB.

A 50 cycle alternating current impulse is transmitted from the recording unit on seizure to the outgoing relay set and this extends via condenser QC and the windings of transformer TR to operate relay S. Relay S in operating at armature *s2* operates relay SR from the earthed regenerator off-normal springs IN1 and provides an auxiliary operating earth for itself at armature *s1*. Relay SR in operating at armature *sr1* reoperates relay JR so that the short-circuit is removed from relay JB before it has had time to release. At armature *sr2* the circuit for relay S is made dependent on the armature *s1*, at armature *sr3* a locking circuit is completed for relay SR, at armature *sr6* relay MMR is operated over its left-hand winding from the earthed regenerator interrupter springs IMP4. Relay MMR thereupon locks on its right-hand winding to earth via armatures *mmr1* and *sr4* and regenerator sending magnet interrupter contacts *itm* while at armature *sr7* a guard earth is maintained on the P lead independently of relays JA and JB.

At the conclusion of the alternating current signal from the toll line relay set relay S releases, whereupon earth is extended over regenerator off-normal contacts IN1, and armatures *s2*, *mmr2* and *sa2* to energize the regenerator sending magnet ITM, relay SA having operated on the operation of relay MMR. Magnet ITM in energising opens the holding circuit of relay MMR at contacts *itm*, whereupon relay MMR in releasing opens the magnet energising circuit at armature *mmr2*.

On release of the magnet ITM the sending disc is released in the usual manner and commences to

rotate under the stored up energy of the regenerator driving clock spring.

The sending disc in rotating sends out the calling subscriber's number in the five unit code form previously described, discrimination between marking and spacing impulses being effected by transmitting a 50 cycle impulse for each spacing impulse and by transmitting a 50 cycle impulse together with a 150 cycle impulse for each marking impulse.

Assuming that a four digit number is to be transmitted, then a total of twenty impulses will be transmitted over the line and the 50 cycle frequency which is transmitted during every pulse operates a suitably tuned relay in the recording unit which advances a receiving switch step-by-step through twenty positions. Whenever a marking pulse is transmitted comprising the 50 and 150 cycle impulses together, then another relay is operated in addition and connects earth to a wiper of said receiving switch which energises a particular storage relay in accordance with the position of the wiper. Four sets of storage relays will be provided in the recording unit, each set comprising relays V, W, X, Y and Z by means of which the received five unit codes can be interpreted on an ordinary numerical basis.

For the purpose of sending out the required marking and spacing impulses comprising the code, the regenerator in the outgoing relay set is provided with two sets of impulse springs IMP4 and IMP5, the former being closed whenever the latter are open and vice versa.

When the sending disc is freed and commences rotation it closes the impulse springs IMP5, whereupon impulse springs IMP4 open and release relay SA in readiness for re-operating relay MMR. With relay MMR normal a combined earthed 50 and 150 cycle frequency source connected up over common lead 20 is extended via the impulsing springs IMP5 to the transformer TR and the 50 and 150 cycle frequencies then extend through over the line to the tandem exchange recording unit. The receiving switch thereat is caused to step off its home position 1 to position 2 connecting with the V storage relay in the first group in readiness for receiving the calling number, it being noted that the reception of the two frequencies at this initial point in the operations are without effect on the storage relays.

At the end of the impulse, impulse springs IMP5 open and impulse springs IMP4 close to pull up relay MMR. If the reset pin 1RP in the sending disc has not now come up against a displaced stop pin such as 1SP indicating the first marking impulse stored on the regenerator then relay MMR in operating will lock over its right-hand winding to the earthed sending magnet interrupter contacts 1tm. The second time the springs IMP5 close, since relay MMR is operated, a 50 cycle earthed alternating current source connected to common lead 19 extends via transformer TR and the junction line to the recording unit, and this spacing pulse brings about the stepping of the receiving switch thereat to the second position 2.

The transmission of 50 cycle frequency impulses continues until the re-set pin in the sending disc encounters a displaced stop pin, when a circuit will be completed from the earthed re-set pin 1RP and stop pin such as 1SP, armature mmr6, winding of relays SA to battery via armature sr5, and relay SA in operating locks to the impulse springs IMP4 (now closed), via its ar-

mature sal. The magnet 1TM is again energised and at contacts 1tm releases relay MMR which in turn disconnects the energising circuit for magnet 1TM. With relay MMR normal the next code pulse to be sent out to line will be a 50+150 cycle pulse or marking impulse, and will bring up a corresponding storing relay in the recording unit.

If the next pin is not displaced then when the impulse springs IMP4 reclose at the end of the 50+150 cycle impulse, relay MMR will be operated, relay SA having been released during the open period of the springs IMP4 when springs IMP5 are closed and in this manner the information stored in code on the regenerator in the outgoing relay set is sent out in the same code to the tandem exchange recording unit.

When all the signals stored in the regenerator have been re-transmitted the sending disc S will catch up with the receiving disc R, whereupon the off-normal contacts 1N1 open and release relay SR which removes the guarding potential from the P lead.

To ensure that the junction is not seized again before the tandem exchange equipment is ready to handle further calls it will be arranged to extend a holding battery potential over the positive line back to the outgoing relay set so as to maintain relays JR and JB operated and so maintain a guarding earth on the P lead on release of relay SR.

As soon as a junction becomes available for further calls the holding condition is removed therefrom at the tandem exchange and relay JR in releasing shunts down relay JB to free the junction for further outgoing traffic.

In case the call should not be completed and recorded and particulars thereof should not be therefore required relay JR will not be held operated over the positive line on the release of relay JA when the calling subscriber hangs up so that relay JB will be short-circuited and released. Relay JB in releasing at armature j66 operates relay SR and this relay in operating initiates the sending out of the stored information from the regenerator, but the impulses are ineffective in this instance since the secondary circuit of the transformer TR is disconnected at armature j63.

Returning again to the toll line relay set of Figs. 2 and 3, it will be understood that when all the particulars of the calling number have been received by the recording unit an earth is extended over bank and wiper HS1 to operate relay 1ON. Relay 1ON in operating locks over its armature 1on1 to the earthed off-normal contacts 2N1 of the regenerator and at armature 1on2 disconnects relay BA. During the release period of relay BA an unguard is given on the incoming P lead so as to allow the earlier part of the switch train in the tandem exchange to release, and this equipment in releasing removes the holding condition back to the outgoing relay set at the originating exchange so as to free this for further common use as already described.

Relay 1ON in operating also at armature 1on3 allows the incoming P lead to be re-guarded from the resting armature ba1 and at armature 1on4 completes an operating circuit for relay RR.

Relay RR in operating locks over its armature rr1 and completes an operating circuit for relay 2P at armature rr2. Relay 2P in operating at armature 2p2 completes an energising circuit for the regenerator sending magnet 2TM and at its armature 2p1 renders the operation of relay RR dependent on the sending magnet interrupter

contacts *2tm*, so that when these contacts are opened relay *RR* restores and disconnects the magnet energising circuit.

The magnet *2TM* in releasing frees the regenerator sending disc in the usual manner, and this in rotating drives two sets of impulse springs *IMP6* and *IMP7* arranged in the same manner as those in the outgoing relay set.

Meanwhile the receiving equipment in the recording unit will have been made suitable for receiving code impulses indicative of the called number from the impulse springs *IMP6*, it being arranged that spacing pulses will be transmitted by means of impulses over the positive *IN* lead to the recording unit via armatures *ka4* and *rr3* and marking pulses over the negative *IN* lead via armatures *ka3* and *rr3*.

The first impulse transmitted from the regenerator will always be effected with relay *RR* normal, and accordingly it will extend from the impulse springs *IMP6* via armatures *rr3* and *ka3*, the negative *IN* lead and wiper and bank *HS2*.

During the extension of this pulse, the break impulse springs *IMP7* open and release relay *2P* so that when they reclose at the end of the impulse, relay *RR* will be operated. If no displaced pin such as *2SP* is encountered by the reset pin *2RP* in the sending disc then the next pulse will be sent with relay *RR* operated over the positive *IN* lead. Until such time as a displaced pin is encountered spacing pulses comprising pulses over the positive *IN* lead, and wiper and bank *HS3* will be sent into the recording unit, while as soon as a displaced pin is encountered the sending out is stopped by the reset pin *2RP* engaged with the displaced stop pin *2SP*, and a circuit is completed from armature *1on4*, the reset pin *2RP*, typical pin such as *2SP* and armature *rr2* to re-energize relay *2P*. Relay *2P* in operating completes an energising circuit for magnet *2TM* which in turn disconnects the circuit of relay *RR*, and this relay in turn disconnects the energising circuit of magnet *2TM*.

The sending disc is again released and since relay *RR* is normal the first impulse delivered will be a marking impulse comprising an earth on the negative *IN* lead.

During this impulse the break impulse springs *IMP7* in opening release relay *2P* as before, and at the end of the impulse when these impulse springs re-close relay *RR* is operated and spacing pulses comprising earth on to the positive wire continue to be sent out until another displaced pin indicating a marking pulse is encountered.

In this manner the called number is transmitted from the toll line relay set into the recording unit.

When the recording unit has received the called number it now prepares for receiving the duration of the call from the toll line relay set as described in the main application, Serial No. 329,608.

The recording unit now has all the information it requires from the toll line relay set for recording the call and it thereupon removes the resistance holding battery from the test bank *H3*. Relay *K* now releases and in turn releases relays *KA* and *KB*. Relay *R* releases on release of relay *K* and in turn drops relay *1B* and other relays held operated therefrom, while on release of relay *KB* a homing circuit is completed for the hunter switch *HS*. At the same time homing circuits are completed for the switches *US* and *TS* in turn, the first circuit extending from earth

over armatures *ba6* and *kb4*, *US* switch off-normal contacts *USN1*, magnet *USM*, interrupter contacts *usm*, magnet *USM* to battery. When this switch reaches its home position the homing circuit is disconnected at the contacts *USN1* which in restoring completes a homing circuit to the switch *TSM*. In this manner the toll line relay set is freed for further common use.

What we claim as new and desire to secure by Letters Patent is:

1. In an impulse storage and regenerating system, wherein two sets of impulses are transmitted concurrently, one set having at least two less impulses than the other set, and the impulses of said one set having a definite timed relationship to the impulses of said other set, means for receiving and storing both sets of impulses, and impulse generating means controlled by the said last means to transmit two sets of impulses corresponding to and having the same timed relationship as those received.

2. An impulse storage and regenerating system as claimed in claim 1, wherein said two sets of received impulses comprise a single digit.

3. In an impulse storage and regenerating system as claimed in claim 1, means controlling said retransmission so that the impulses are stored for a variable interval of time.

4. An impulse storing and regenerating system as claimed in claim 1, wherein said two sets of received impulses comprise a single digit, and wherein the number of impulses in each of said sets is always the same for every digit regardless of the value of that digit.

5. In a mechanical impulse storage and regenerating device a series of pins, a member, a magnet for receiving certain impulses and for moving said member over said pins in accordance with said impulses, means carried by said member and controlled by other impulses having definite timed relationship to said certain impulses to displace certain of said pins during such movement and the member over said pins, two impulse generators then operated under control of said certain pins, one of said generators effective to transmit impulses corresponding to said certain impulses and the other of said generators effective to transmit impulses corresponding to said other impulses.

6. In a storage and regenerating system wherein different items of information are transmitted in the form of different impulse codes, each code comprising the same total number of impulses as the other codes but differing from them in the arrangement of such impulses, a code register having the same number of movable elements as there are impulses in a code, means for receiving a transmitted code and, under the control thereof, displacing selected ones of said elements in conformity with the arrangement of the impulses in said code, and means thereafter controlled by said elements for transmitting a code corresponding in the number and arrangement of impulses to said received code.

7. In a storage and regenerating system wherein different items of information are transmitted in the form of different impulse codes, each code comprising the same total number of impulses as the other codes but differing from them in the arrangement of such impulses, a code register having a series of elements, means for receiving a plurality of codes in succession and, under the control of each code, marking off a group of elements equal to the number of impulses in such

code and characterizing selected ones of the marked off elements in conformity with the arrangement of the impulses in said code, and means thereafter controlled by each marked off group of elements for transmitting a code corresponding in the number and arrangement of impulses to the received code for that group of elements.

8. In a storage and regenerating system wherein different items of information are transmitted in the form of different codes, and wherein each code comprises two impulse trains transmitted concurrently, one train being identical for all codes and the other train varying, from one code to another, in the relationship of its impulses to the impulses of said one train, a separate means for responding to each impulse train of a received code, a common register controlled conjointly by said separate responding means to register both trains of impulses of said code, and means subsequently controlled by said register for transmitting concurrently two impulse trains having a relationship corresponding to the relationship of the trains in said received code.

9. In a storage and regenerating system wherein different items of information are transmitted in the form of different codes, wherein each code comprises two trains of impulses which together contain the same total number of impulses as the corresponding impulse trains of the other codes, and wherein the impulses of the two trains comprising each code occur in a distinctive relationship indicative of the item of information to which that code relates, a series of elements each having a normal position, a member, means for receiving one said impulse train of a certain code and for moving said member step-by-step in accordance therewith, thereby to associate said member with the elements of said series in sequence, means for receiving the other said impulse train of the same code and for operating said member in accordance therewith, said member effective upon each such operation to displace the element with which it is then associated, and means thereafter controlled by said elements for transmitting two impulse trains whose respective impulses occur in a relationship dependent upon which elements of said series were displaced by said member during said step-by-step movement thereof.

10. In a system wherein different items of information are transmitted in the form of different codes, wherein each code comprises two trains of impulses which together contain the same total number of impulses as the corresponding impulse trains of the other codes, and wherein the impulses of the two trains comprising each code occur in a distinctive relationship indicative of the item of information to which that code relates, a register comprising a series of elements each having a normal position, a member, means for receiving one said impulse train of a certain code and for moving said member step-by-step in accordance therewith, thereby to associate said member with the elements of said series in sequence, and means for receiving the other said impulse train of the same code and for operating said member in accordance therewith, said member effective upon each such operation to displace the element with which it is then associated.

11. In a storage and regenerating system wherein different items of information are transmitted in the form of different codes, wherein each code comprises two trains of impulses which together contain the same total number of impulses as the corresponding impulse trains of the other codes, and wherein the impulses of the two trains comprising each code occur in a distinctive relationship indicative of the item of information to which that code relates, a series of elements each having a normal position, a member, means for receiving one said impulse train of a certain code and for moving said member step-by-step in accordance therewith, thereby to associate said member with the elements of said series in sequence, means for receiving the other said impulse train of the same code and for operating said member in accordance therewith, said member effective upon each such operation to displace the element with which it is then associated, means subsequently operated to test the elements of said series in sequence, means controlled by said testing means for transmitting one train of impulses in dependence upon the displaced elements encountered during said testing operation and for transmitting another train of impulses in dependence upon the undisplaced elements encountered during said testing operation.

12. In an impulse sender, a series of elements, means for characterizing random ones of said elements in a particular way thereby to distinguish them from the uncharacterized of said elements, means then operated to test the elements of said series in sequence, and means controlled by said testing means for transmitting one train of impulses solely in dependence upon the characterized elements encountered during said testing operation and for transmitting another train of impulses solely in dependence upon the uncharacterized elements encountered during said testing operation.

13. In an impulse sender, a series of elements, means for characterizing random ones of said elements in a particular way thereby to distinguish them from the uncharacterized ones of said elements, means for generating a train of electrical impulses, the impulses of said train corresponding respectively to the elements of said series, two impulse transmission paths, and means controlled by said elements for causing each impulse corresponding to a characterized element to be transmitted only over one of said paths and each impulse corresponding to an uncharacterized element to be transmitted only over the other of said paths.

14. In an impulse sender, a series of elements, means for characterizing random ones of said elements in a particular way thereby to distinguish them from the other ones of said elements, means for transmitting a series of substantially uniformly spaced impulses, the impulses of said series corresponding respectively to the elements of said series, and means controlled by said elements for characterizing the impulses corresponding to said characterized elements, thereby to distinguish them from the other impulses of said series.

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