Dec. 27, 1938. J. BAUMFALK 2,141,372

TELEPHONE SYSTEM

Filed Oct. 16, 1935 6 Sheets-Sheet 1

FIG. 1

FIG. 4	FIG. 5
FIG. 6	FIG. 7

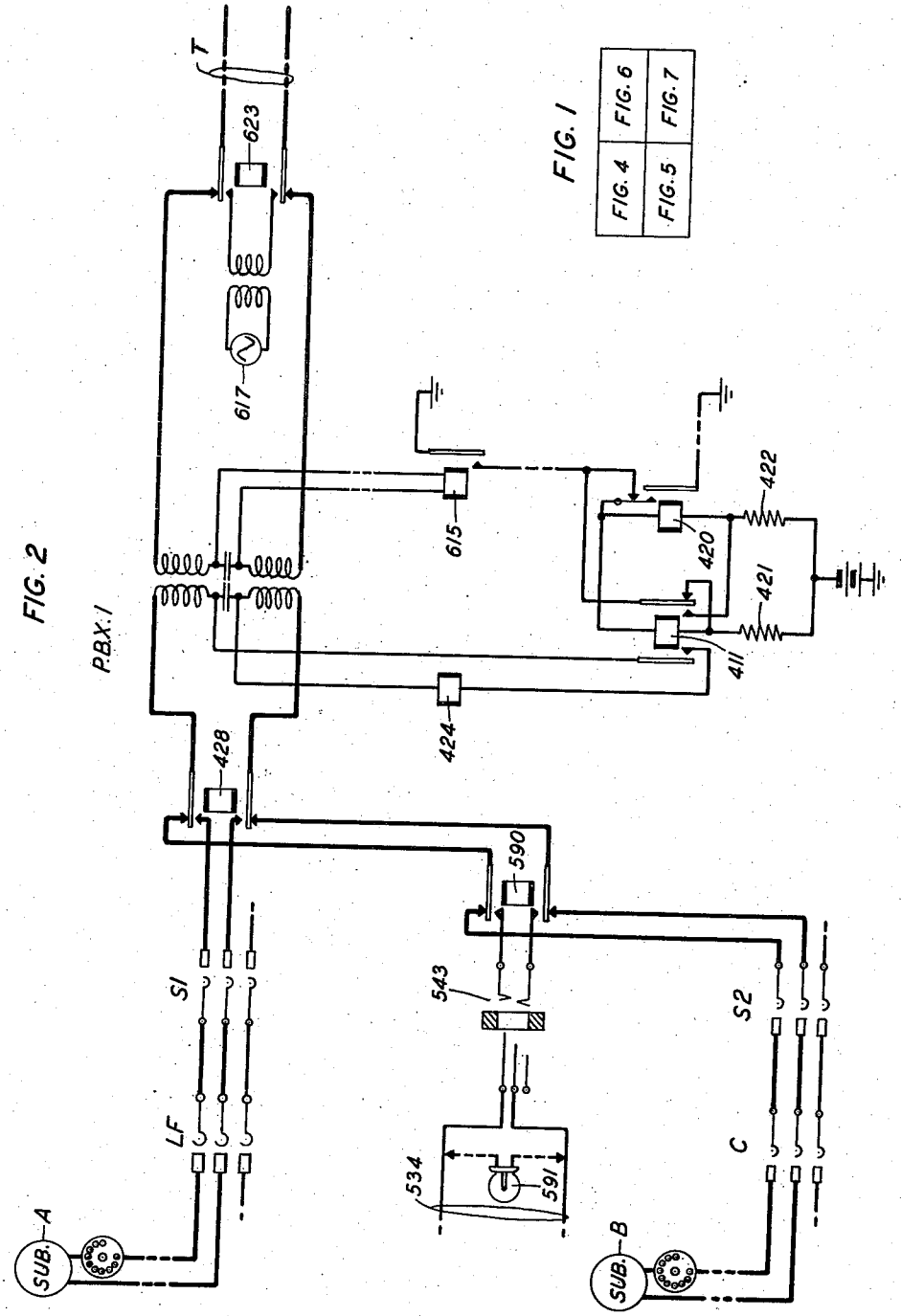

FIG. 2

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TELEPHONE SYSTEM

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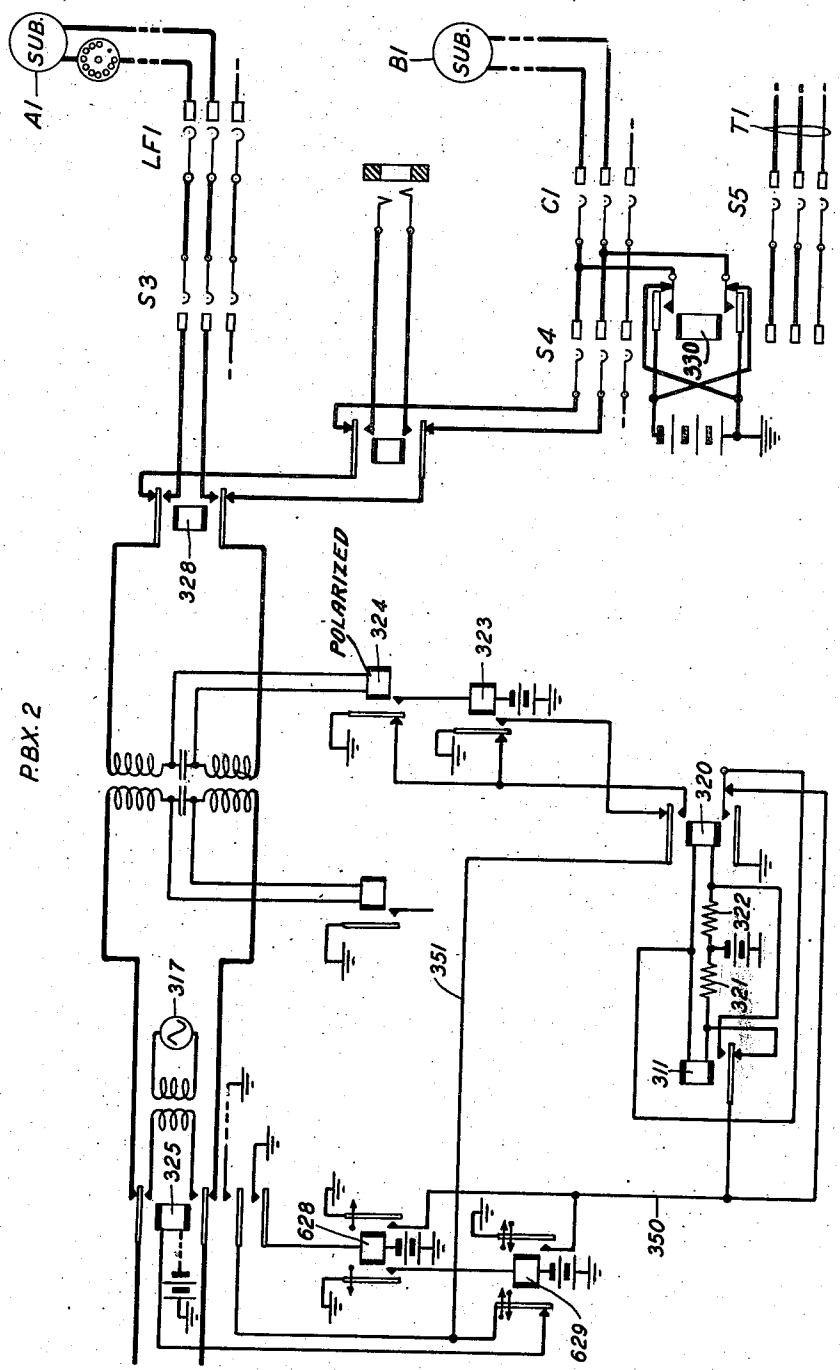

FIG. 3

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TELEPHONE SYSTEM

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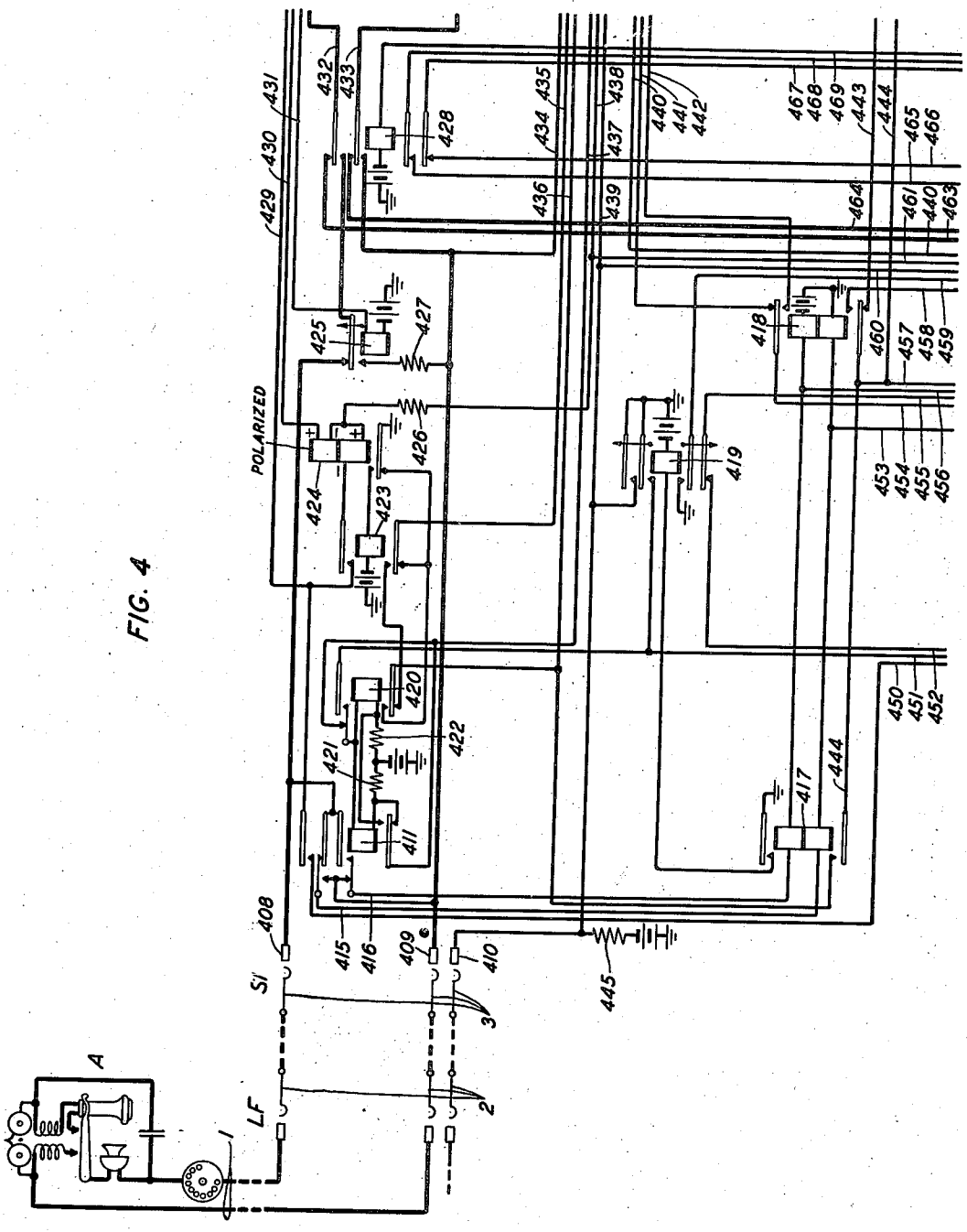

FIG. 4

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TELEPHONE SYSTEM

Filed Oct. 16, 1935 6 Sheets-Sheet 4

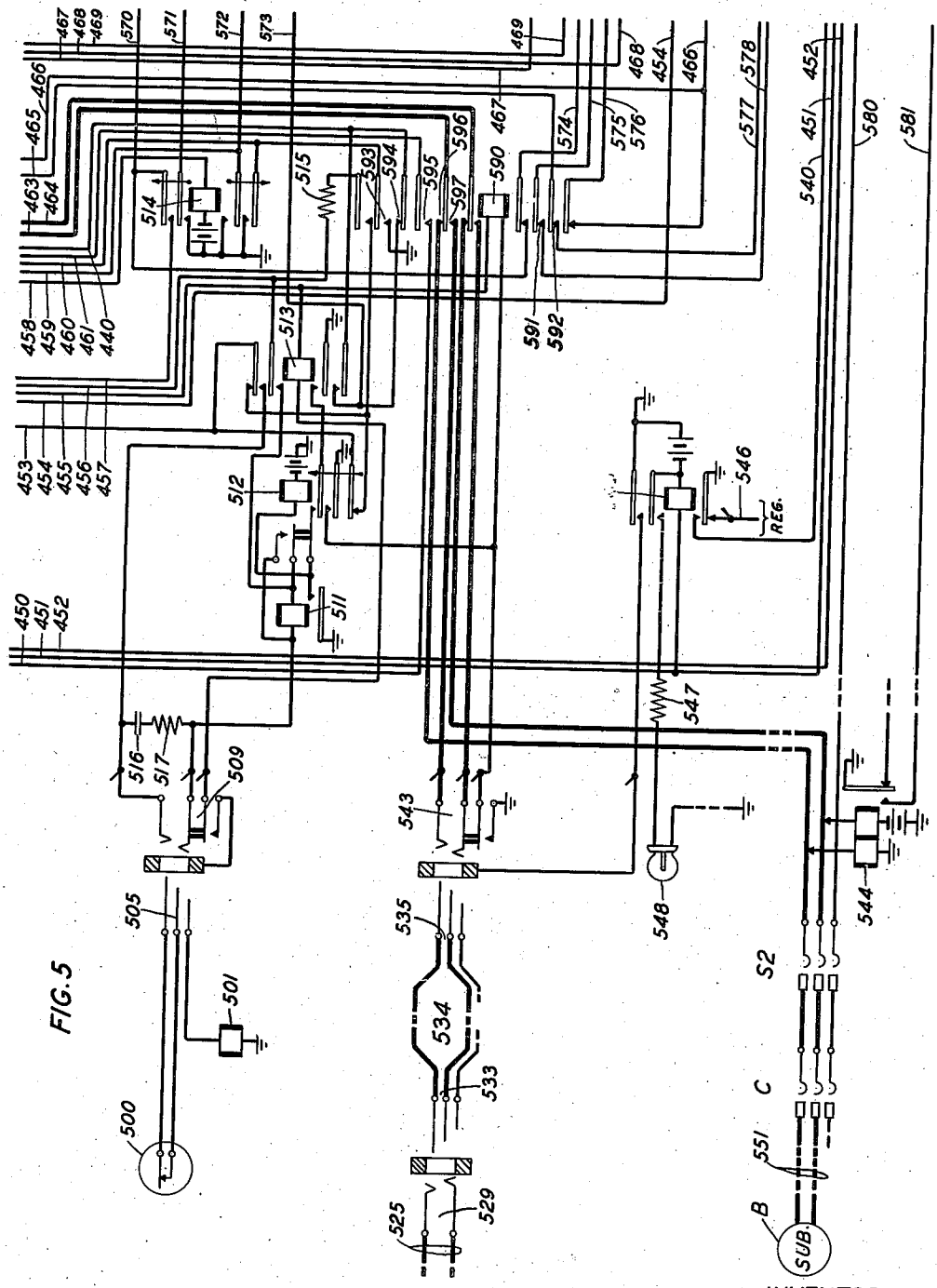

FIG. 5

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TELEPHONE SYSTEM

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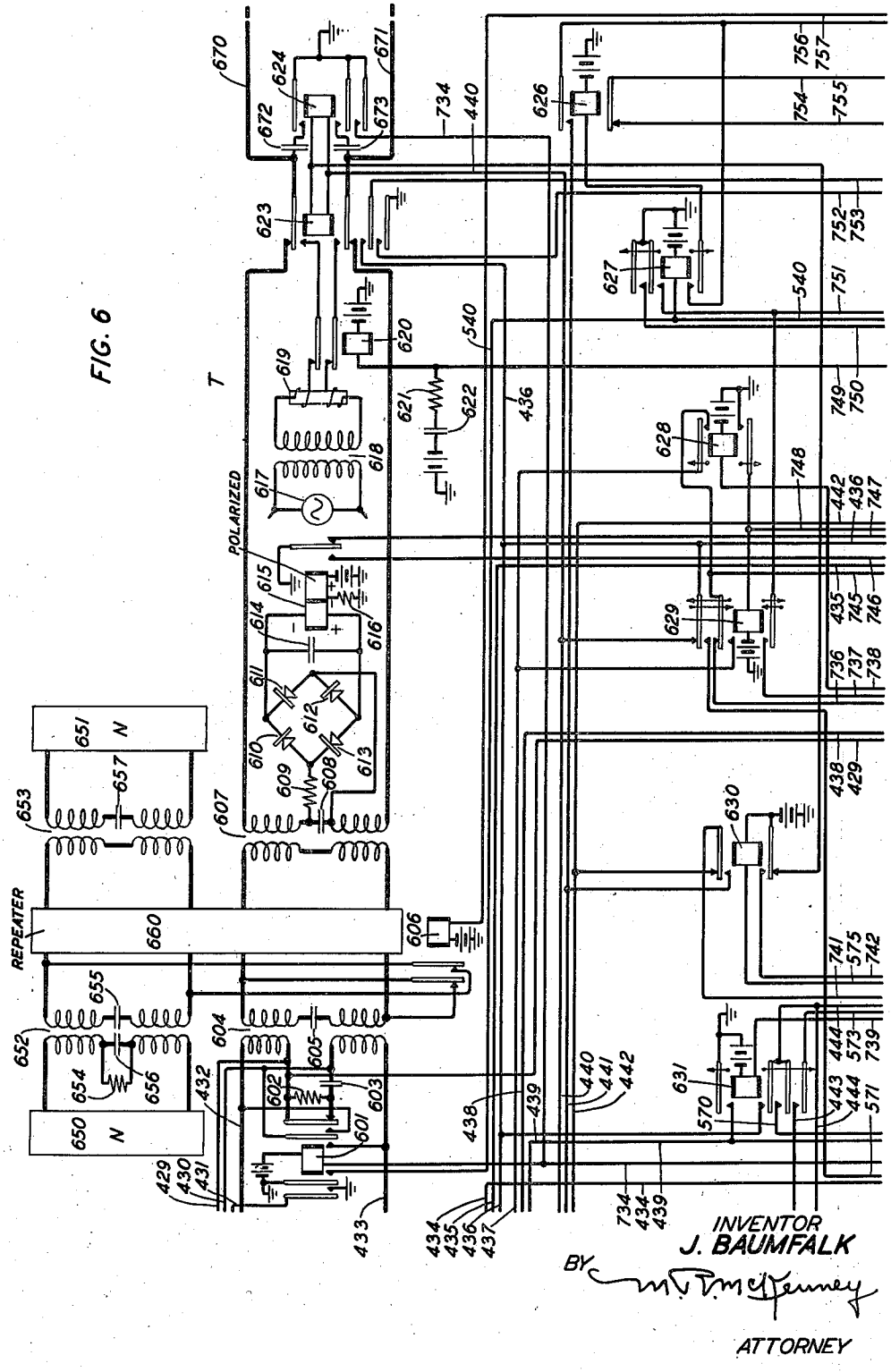
FIG. 6



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TELEPHONE SYSTEM

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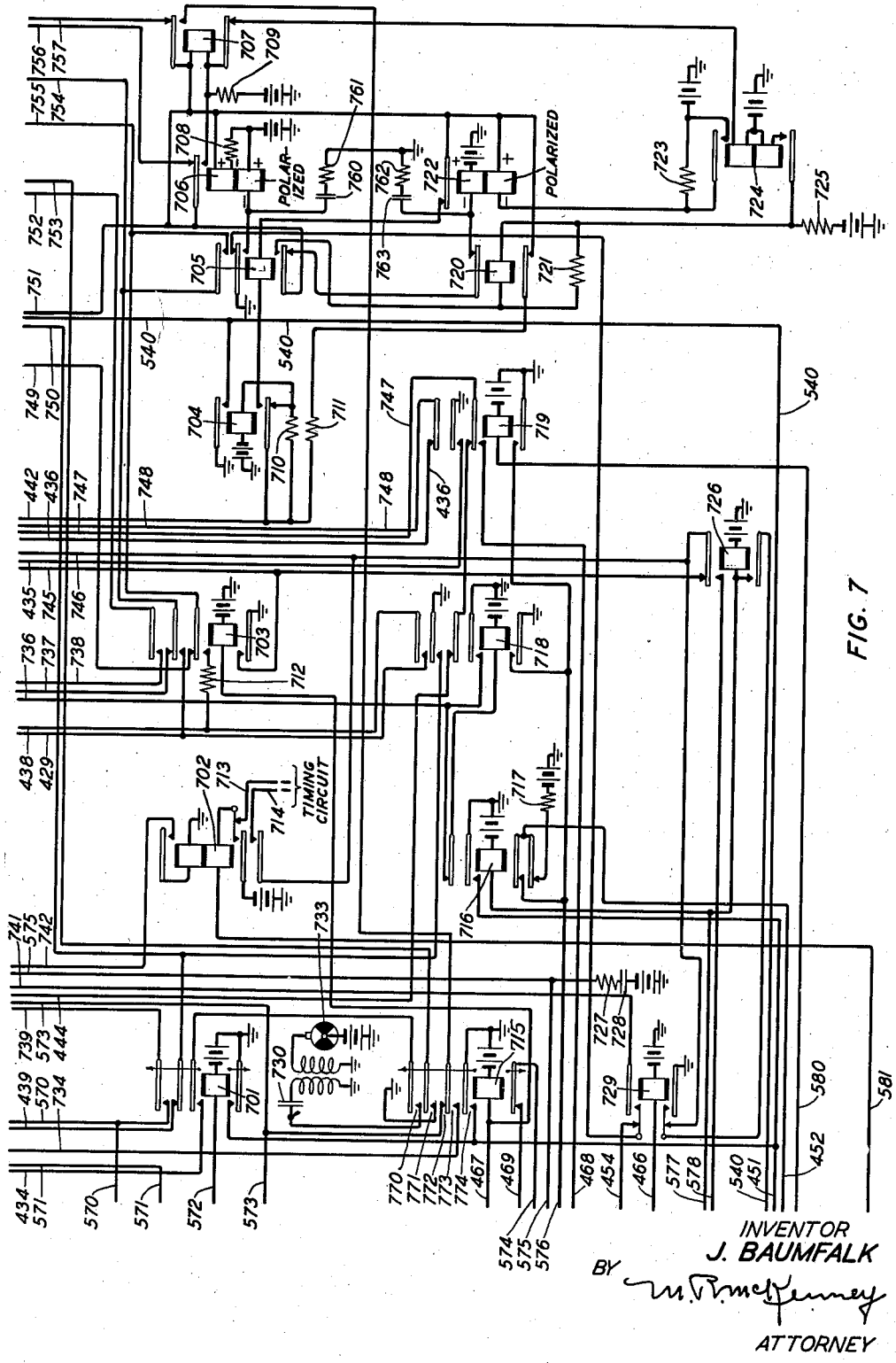

FIG. 7

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UNITED STATES PATENT OFFICE

2,141,372

TELEPHONE SYSTEM

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Application October 16, 1935, Serial No. 45,185

26 Claims. (Cl. 179—27)

This invention relates to telephone systems and particularly to systems involving circuits for transmitting and repeating operating and supervisory current impulses.

The objects of the invention are to extend the operating range of trunk lines, arranged for completing calls in either direction, by the use of a novel impulse repeating mechanism; to enable the use of a single repeating mechanism for the outward calls originating in each of a plurality of branches of said trunk; to enable the use of said repeater for all outward calls originating as just noted and also for all calls incoming over said trunk in the other direction; to improve the transmission of both switch operating and supervisory impulses by converting all direct current pulses into corrected alternating current pulses for transmission over the trunk line; to facilitate the passing of supervisory signals from one exchange to another by converting the alternating supervisory currents into either reversals of direct current or direct currents with open and closed periods according to the source from which the call originated; and to improve otherwise the efficiency and effectiveness of systems of the kind herein described.

Repeating mechanisms have been devised heretofore for repeating impulses in either direction over a transmission line. It is also old to correct the repeated impulses when transmitted in one direction. Other systems have been proposed in which alternating current is used for sending both switch operating and supervisory signals over trunk lines in either direction.

According to the present invention, however, a two-way trunk line is provided with a branch for originating outward calls and a second branch for receiving calls incoming over said trunk together with a repeater arranged to have its input circuit associated either with said first mentioned branch or said trunk and its output circuit either with said trunk or said second branch, according to the direction of the call.

Another feature is an arrangement in which either of two call originating circuits, one for manual calls and the other for automatic calls, may be connected to the trunk outgoing to the distant office, whereas calls coming over the trunk in the opposite direction are extended over a third circuit for completion by automatic switches, and in which a single impulse repeater is so designed that for outward calls pulses are delivered to its input circuit by either one of said call originating circuits and corrected pulses from its output circuit are converted into alternating current and sent out over the trunk to the distant office, while for inward calls over the trunk the incoming alternating pulses are first converted into direct current pulses which are delivered to said input circuit, and the corrected pulses from said output circuit are delivered to said third circuit to operate the automatic switches and complete the call.

According to another feature supervisory signals, such as the answering and disconnect signals, are first converted into alternating current and then sent over the trunk to the distant office where they are converted into another form and applied to either the manual or the automatic call originating circuit depending on which one is involved in the connection. If the call was extended from the manual circuit, the incoming alternating supervisory signals are converted into signals of direct current with open and closed circuit periods to operate a lamp at an operator's position. If on the other hand it was extended from the automatic branch, the incoming signals are converted into reversals of direct current to cause the well-known supervisory effects in the automatic circuits.

Another feature is an impulse repeater having a single input and a single output circuit so arranged that the impulses which represent the call, whether incoming or outgoing over the trunk line, are delivered to said input circuit and the repeated impulses in said output circuit are, according to the direction of the call, either delivered to the trunk for transmission outward to the distant office or to the switches on the incoming end of the trunk in the case of an inward call, together with means whereby all impulses delivered to the repeater are corrected thereby regardless of the direction of the call.

Another feature of this invention is a supervisory signal arrangement wherein a series of signals are repeated from one circuit to another in such a way that the repeated signals in the outgoing circuit are sent in synchronism with the originating signals in the incoming circuit until the rate of the incoming signals passes a certain frequency. Beyond this frequency value the frequency of the outgoing signals remains fixed, but before each outgoing signal is sent the incoming circuit is tested to determine whether its condition has changed since the last repeated signal was sent. This makes it possible to repeat a series of irregular signals such as switch-hook flashes from one circuit to another to flash an operator's lamp in the second circuit without the repeated signals that flash the lamp necessarily being in synchronism with the switch-hook operation and yet to

have the last repeated signal leave the operator's lamp dark if the subscriber's receiver is off the switch-hook when he finishes flashing or lighted if he replaces the receiver at the end of flashing.

These and other features of the invention will be described more fully in the following specification and will also be set forth in the appended claims.

A better understanding of the invention may be had by reference to the accompanying drawings, in which:

Figs. 2 and 3 illustrate diagrammatically a system involving a plurality of exchanges, such as private branch exchanges, together with interconnecting two-way trunk lines; and

Figs. 4, 5, 6 and 7, when taken in the order indicated in Fig. 1, disclose, partly in detail and in part diagrammatically, the equipment located at one of the exchanges. Fig. 4 shows a calling subscriber's station, a line finder switch, a first selector switch and one branch of the outgoing two-way trunk. Fig. 5 shows an attendant operator's dial and cord circuit and a second branch of the trunk over which calls may be originated. This figure also illustrates a called subscriber's line and selector and connector switches for extending to said line calls incoming over the two-way trunk. Figs. 6 and 7 show the outgoing conductors of the trunk, which extend from the distant exchange, and the repeating and controlling mechanism for use in connection with both outgoing and incoming calls.

The subscribers' stations are provided with the usual telephone sets and with dials for controlling the establishment of the desired connections. The line finder, selector and connector switches may be of any well-known type, such as the step-by-step Strowger switch. Switches of this type are described in pages 53 to 67, inclusive, of the second edition of "Automatic Telephony" by Smith and Campbell.

Referring first to Figs. 2 and 3, which show the system as a whole, any two exchanges in the system, such as exchanges P. B. X. 1 and P. B. X. 2, are interconnected by a two-way trunk T. Calling stations, such as station A in exchange P. B. X. 1, may complete calls in the usual manner to other stations in the same exchange or may extend a connection to a distant exchange, P. B. X. 2. To make a distant call, the connection is extended over line finder LF, selector S1 and thence over the two-way trunk ciruit T to the exchange P. B. X. 2, thence over an incoming selector S4 and a connector C1 to the called station, such as station B1. On the other hand, stations in the exchange P. B. X. 1 may obtain calls with the assistance of the attendant. In this case the attendant dials for the called station, and a connection is completed by way of her cord circuit 534, jack 543 and thence over the trunk as above described. All incoming calls from a distant exchange by way of the trunk T are completed in the exchange P. B. X. 1 by way of incoming selector S2 and connector C. The foregoing explanation also applies to exchange P. B. X. 2. In addition to calls from one exchange to another, a station in any exchange may make calls to distant exchanges by way of one or more intermediate exchanges. For example, station A may obtain a connection over trunk T through selectors S4 and S5 in exchange P. B. X. 2 and thence over trunk T1, which is similar to trunk T, to a third exchange and by way of switches therein to the called station.

In all of the connections completed over trunk T in either direction the dial and supervisory impulses are transmitted over the trunk by means of alternating current. At the originating exchange the direct current dial and supervisory signals are converted into alternating current signals for transmission over the trunk, and at the incoming end of the trunk in the distant exchange these signals are again converted into direct current signals. The dial impulses are repeated at the outgoing end by means of a repeating mechanism that serves not only to convert the impulses from direct current into alternating current but also to correct them for fast and slow dials. The same repeating mechanism serves on incoming calls to receive the incoming alternating current dial impulses and to convert them into direct current impulses for operating the local switches.

Since the equipment located in one exchange is similar to that in each of the other exchanges, the detailed disclosure in Figs. 4 to 7 has been limited to a single exchange. It is assumed that the equipment in these figures is located at exchange P. B. X. 1, and it will be understood that the equipment at exchange P. B. X. 2 at the other end of the two-way trunk T is identical with that shown in detail in Figs. 4 to 7.

While the exchanges interconnected by the two-way trunks are referred to herein as private branch exchanges, the invention is not so limited but may be applied to systems involving other kinds of exchanges and offices.

Outgoing call from dial station

The system will now be described in detail, and for this purpose it will be assumed first that station A in the exchange P. B. X. 1 wishes to call station B1 in exchange P. B. X. 2. When the receiver is removed from the switch-hook at station A to originate the call, the line finder LF hunts for and extends the line 1 through its brushes 2 to the first selector S1. When the calling subscriber dials the first digit of the called subscriber's number, the brushes 3 of selector switch S1 are advanced to the corresponding group of terminals. The selector S1 then automatically hunts for and seizes an idle set of terminals in the selected group. Assume that the selected set of terminals 408, 409, and 410 is connected to the trunk circuit T. When the terminals 408, 409 and 410 are seized by the selector S1, the loop circuit is closed from battery through the upper winding of relay 418, the upper winding of relay 417, conductor 416, the upper inner back contact of relay 411, ring terminal 409, the subscriber loop, tip terminal 408, the upper outer back contact of relay 411, conductor 415, the lower winding of relay 417 to ground through the lower winding of relay 418. Relays 417 and 418 become energized over this loop circuit. Operation of relay 417 establishes a circuit from ground through the upper front contact of relay 417 to battery through the winding of relay 419 thereby causing relay 419 to become energized. Operation of relay 419 closes a circuit from ground through the upper outer front contact of relay 419 to the sleeve terminal 410 of the selector S1 to make the selected set of terminals test busy to other selectors and to hold the preceding switches. Ground is supplied also through the upper inner front contact of relay 419, over conductor 451 to battery through the winding of relay 545. Relay 545 energized, furnishes battery from the upper inner front contact of relay 545 through resist-

ance 547 to ground through the filament of lamp 548 causing lamp 548 to light as a busy signal to the operator at the multiple jack 543 and the multiples thereof. Ground is furnished also through the upper outer front contact of relay 545 to the sleeve terminal of jack 543 as a busy condition. Ground through the lower front contact of relay 545 is furnished over conductor 540 to battery through the winding of relay 627 which operates and furnishes off-normal ground to the trunk circuit. Opening the lower outer back contact of relay 419 opens the circuit through relays 513 and 590 in order to prevent mutilation of a call if the operator should plug into either jack 509 or jack 543 over the busy signal. Operation of relay 417 also establishes a circuit from ground through the right back contact of relay 615, conductor 747, the upper inner back contact of relay 719, the upper back contact of relay 718, conductor 444, the lower front contact of relay 417, conductor 436, the upper back contact of slow-to-operate and slow-to-release relay 629, conductor 440, the windings of relays 623 and 624 in parallel, the lower back contact of relay 630 to battery thereby causing relays 623 and 624 to become energized. At the same time, the ground from the right back contact of relay 615 which was closed to conductor 436 in the manner outlined heretofore is extended from conductor 436 through the upper outer back contact of relay 719, conductor 748, to battery through the winding of slow-to-operate and slow-to-release relay 629. Relay 629, being slow to operate, permits relays 623 and 624 to operate before the upper back contact of relay 629 is broken.

Operation of relay 418 closes a circuit from ground on conductor 444 supplied from the right back contact of relay 615 as previously described, through the lower front contact of relay 418, conductor 458 to battery through the winding of slow-to-release relay 514 causing relay 514 to become energized. Operation of relay 418 also completes a circuit from ground on the upper back contact of relay 705, through the upper back contact of relay 729, conductor 454, the upper front contact of relay 418, conductor 442, the lower back contact of relay 704 to battery through the winding of relay 704. Relay 704 is energized and locks in a circuit through resistance 710 to the operating ground on conductor 442. Operation of relay 704 closes a circuit from ground through its upper front contact, conductor 540 to battery through the winding of relay 627. Operation of relay 704 also removes the short circuit from around resistance 710 placing resistance 710 in series with the winding of relay 704 in order to reduce the current drain. Relay 627 being energized furnishes a ground through its upper inner front contact, conductor 751, the upper back contact of relay 722, winding of relay 705, the lower front contact of relay 704, resistance 710, winding of relay 704 to battery. Relay 705 does not operate at this time because it is short-circuited by the operating ground for relay 704 which ground was previously traced to the lower armature of relay 704.

Relay 627 operated, also places a bias on polarized relay 722 over a circuit extending from ground through the upper inner front contact of relay 627, conductor 751, the lower back contact of relay 705, the upper back contact of relay 720 to battery through the upper winding of polarized relay 722 thereby preventing the operation of polarized relay 722. The ground on conductor 751 is extended to battery through the upper winding of polarized relay 706 and resistance 708, and also through the upper back contact of relay 707, conductor 757 to battery through the winding of relay 606. Relays 706 and 606 become energized. Relay 606 energized removes the short circuits from certain of the windings of the repeater 660 by opening the back contacts of relay 606. Polarized relay 706 operated, establishes a circuit from ground through the upper inner front contact of relay 627, conductor 751 to the upper end of the winding of relay 707, and through the upper front contact of polarized relay 706 to the lower end of the winding of relay 707 thereby short-circuiting relay 707 and preventing the operation of relay 707, and through the lower back contact of relay 707 to battery through the upper winding of relay 724. Relay 724 operated places a short circuit around resistance 723. Relay 627 operated also prepares a circuit from battery, winding of relay 626, lower front contact of relay 627, conductor 756 to the upper back contact of polarized relay 706 so that relay 626 will operate when the circuit is closed to ground on conductor 751 by the release of polarized relay 706.

Operation of slow-to-release relay 514 closes a circuit from ground through the lower inner front contact of relay 514, conductor 572 to battery through the winding of slow-to-release relay 701 which now operates. Relay 701 operated closes a circuit from ground furnished on conductor 444 from the right back contact of relay 615 in a manner previously described herein through the upper outer front contact of relay 514, conductor 570, the upper outer front contact of relay 701, conductor 739 to battery through the winding of relay 631. Relay 631 is thus energized.

Operation of relay 514 also closes a circuit from ground on the right back contact of relay 615, conductor 747, the upper inner back contact of relay 719, the upper back contact of relay 718, conductor 444, conductor 457, the upper outer front contact of slow-to-release relay 514, the lower inner back contact of relay 590, conductor 574, the lower back contact of relay 715, conductor 469 to battery through the winding of relay 428. Relay 428 energized transfers the trunk from the selector S2 to the selector S1 and opens the operating path for relays 716, 726, 703 and 715. Closure of the upper inner front contact of relay 514 furnishes a ground over conductor 571, the upper outer front contact of relay 629 to conductor 436 thereby supplementing the ground supplied from the right back contact of relay 615 to conductor 436 as described heretofore. The ground from the upper inner front contact of relay 514 is also extended from conductor 436 through the upper outer back contact of relay 719 to battery through the winding of relay 629 thereby holding relay 629 operated after the seizure pulse is completed. Ground is also supplied through the lower front contact of relay 514 over conductor 460 to sleeve terminal 410 of the selector S1 as a busy condition.

Relay 623 operated, connects the conductors 670 and 671 through the inner front contacts of relay 623, windings of retard coil 619, to the right winding of the transformer 618. Induction from the left winding of transformer 618 connected to the source of alternating current supply 617 thereby supplies alternating current to the line as a signal to the distant exchange P. B. X. 2. Relay 624 operated closes circuits from conductors 670 and 671, through condensers 672 and 673 to

ground through the upper front contact and the lower inner front contact of relay 624 in order to prevent acoustic shocks. Relay 624, operated, also closes a circuit from ground through the lower outer front contact of relay 624, conductor 734, to battery through the winding of relay 601 thereby causing relay 601 to become energized. Operation of relay 601 closes a circuit from ground through the left outer front contact of relay 601, conductor 431 to battery through the winding of relay 425 causing relay 425 to become energized. Relay 601 operated, also closes a circuit from ground through the left inner front contact of relay 601 to battery through the winding of relay 627. Relay 627 is held energized. After a predetermined interval has elapsed after the operation of the relay 417 the slow-to-operate relay 629 operates and opens the operating circuit for relays 623 and 624 through the upper back contact of relay 629 and thus permits the release of relays 623 and 624. Release of relay 623 disconnects the alternating current from the conductors 670 and 671 and terminates the seizure signal. Relay 624 released removes the ground from condensers 672 and 673 and opens the circuit to the winding of relay 601 which in turn releases and removes the ground from conductor 431 permitting the release of relay 425. Operation of relay 629 establishes a circuit from battery, through resistance 421, in parallel circuit with resistance 422 and winding of relay 420, the upper back contact of relay 420, conductor 437, the upper inner front contact of relay 629, conductor 745, the upper back contact of relay 726, conductor 746 to the right front contact of relay 615 for supervisory purposes which will be explained hereinafter. Also, operation of relay 629 establishes a circuit from ground through the upper inner front contact of relay 627, conductor 737, the lower front contact of relay 629, the upper outer back contact of relay 703, conductor 754, the lower back contact of relay 626, conductor 755, the upper inner back contact of relay 703, conductor 749 to battery through the winding of relay 620. Relay 620 is energized. Relay 629 holds under control of relay 631.

Relay 631 operated, connects an auxiliary ground over conductor 439 to the sleeve terminal 410 of selector S1, provides an auxiliary holding path for relay 629, holds relay 428 and provides an operating path for relays 623 and 624 when relay 418 releases on pulsing or disconnect.

Calling station dials

When the loop circuit through the substation A is opened by the first open pulse of the dial, the holding circuit through relay 418 is opened and relay 418 releases. When relay 418 releases, the circuit previously traced through the upper front contact of relay 418 for the operation of relay 704 and for short-circuiting relay 705 is opened. With the short circuit around relay 705 removed, relay 705 operates in a circuit extending from battery through the winding of relay 704, resistance 710, the lower front contact of relay 704, winding of relay 705, the upper back contact of relay 722, conductor 751 to ground through the upper inner front contact of relay 627. Relay 704 holds operated over this same circuit. Relay 418 released, also closes a circuit for the operation of relays 623 and 624. This circuit extends from battery through the lower back contact of relay 630, windings of relays 623 and 624 in parallel, conductor 440, contact 594 of relay 590, conductor 573, the lower outer front contact of relay 631, conductor 443, the lower back contact of relay 418, conductor 444, the lower inner front contact of relay 631, conductor 436, the upper outer front contact of relay 629, conductor 571 to ground through the upper inner front contact of relay 514. Relays 419, 514, 631 and 701 being of the slow-to-release type remain operated during the pulsing period.

Relay 705, operated, removes the ground supplied to the armature of relay 418 over a circuit previously described, closes a circuit from ground on the upper inner front contact of relay 705 to battery through the lower winding of relay 706 which opposes the upper winding of relay 706 causing relay 706 to release, and removes the ground from the biasing circuit which has previously been traced through the lower winding of relay 722. When off-normal ground through the lower back contact of relay 705 is removed, condenser 763 which has been discharged by this ground now charges in a circuit from battery through the upper winding of relay 722 to ground through condenser 763 and resistance 762. Current will continue to flow through the upper winding of relay 722 during the charging of condenser 763 and the ampere turns produced by the charging current in the upper winding of relay 722 oppose the ampere turns in the lower winding of relay 722. As the condenser 763 becomes charged, the ampere turns in the upper winding of relay 722 decrease and the relay 722 is caused to operate by the ampere turns in the lower winding of relay 722 in a manner well known to the art. Relay 705 operated also causes relay 720 to operate in a circuit extending from the upper inner front contact of relay 627, conductor 751, the lower front contact of relay 705, the winding of relay 720 and resistance 721 in parallel, to battery through resistance 725. When relay 706 releases the upper front contact of relay 706 is opened and the short circuit around the winding of relay 707 is removed. Relay 707 operates in a circuit extending from ground on the upper inner front contact of relay 627, conductor 751, winding of relay 707, to battery through resistance 709. Closure of the upper back contact of relay 706 establishes a circuit from ground on the upper inner front contact of relay 627, conductor 751, upper back contact of relay 706, conductor 756, lower front contact of relay 627, to battery through the winding of relay 626. Relay 626 operates. Operation of relay 707 opens the circuit through the upper winding of relay 724. Relay 724 remains operated in a circuit from battery through its lower winding and its lower front contact in parallel with resistance 725 and in series with the winding of relay 720 and resistance 721 to ground on the upper inner front contact of relay 627 over the circuit previously traced. Relay 707 operated also opens the circuit previously traced from off-normal ground on the upper inner front contact of relay 627, to the winding of relay 606 permitting relay 606 to release. Relay 707 operated, also closes a circuit from off-normal ground on the upper inner front contact of relay 627, conductor 751, the upper front contact of relay 707, contact 772 of relay 715, conductor 573, contact 594 of relay 590, conductor 440, windings of relays 623 and 624 in parallel, to battery through the lower back contact of relay 630 thereby holding relays 623 and 624 operated. Relay 624 operated causes relay 601 to operate over a circuit previously described. Relay 601 operated causes relay 425 to operate over a circuit previously described. Relay 601 oper-

ated also short-circuits the upper left and the lower left windings of repeating coil 604. Relay 425 operated opens the circuit to terminal 408 and connects the upper end of the winding of resistance 427 through the front contact of relay 425, the upper front contact of relay 428, to conductor 432, thereby connecting the resistance 427 across the upper left and the lower left terminals of repeating coil 604. Relay 606 released short-circuits the telephone repeater 660. Relay 623 operated connects the line to the armatures of relay 620. Relay 624 operated connects condensers 672 and 673 to ground in the manner previously described. Relay 720 operated opens the circuit through its lower back contact to the resistance 711 thereby removing the shunting resistance 711 from around the winding of relay 705.

When the relay 722 operates it opens its upper back contact and thus opens the holding circuit previously described for relays 704 and 705 permitting these relays to release. Relay 704 released short-circuits resistance 710 through the lower back contact of relay 704. Relay 705 released reconnects the ground on the upper back contact of relay 705 to the armature of relay 418 over a circuit previously described, and removes the ground from the lower winding of relay 706. This ground has previously discharged condenser 760. Now when the ground is removed, condenser 760 charges in a circuit from battery through the lower winding of relay 706 to ground through condenser 760 and resistance 761. Current will continue to flow through the lower winding of relay 706 during the charging of condenser 760 and the ampere turns produced by the charging current in the lower winding of relay 706 oppose the ampere turns in the upper winding of relay 706. As the condenser 760 becomes charged the ampere turns in the lower winding of relay 706 decrease and the relay 706 is caused to operate by the ampere turns in the upper winding of relay 706 in a manner well known to the art. Relay 705 released also opens the holding circuit previously described for relays 720 and 724, and the holding circuit previously described for relay 620 since relay 626 is now operated. Relay 620 released connects alternating current to the line through its back contacts in the manner described hereinbefore. The relay 724 released removes the short circuit from resistance 723. The relay 720 released closes a circuit from ground on the upper inner front contact of relay 627 over conductor 751, the lower back contact of relay 720, resistances 711 and 710 to battery through the winding of relay 704 which does not energize relay 704 sufficiently to cause it to operate but sufficiently to cause relay 704 to operate quickly when relay 418 is operated on the next dial pulse. Relay 720 released also closes a circuit from ground on the upper inner front contact of relay 627 over conductor 751, the lower back contact of relay 705, the upper back contact of relay 720 to battery through the upper winding of relay 722 causing relay 722 to release and close its back contact.

Let us assume that the dial at station A has a speed in excess of the average speed of such dials. Relay 418 reoperates on the succeeding closure of the loop circuit through station A and causes relay 704 to reoperate over a circuit previously described. Relay 418 releases on the succeeding open period of the dial pulse and permits relay 705 to reoperate over a circuit previously described. Relay 705 operated closes the circuit through the lower winding of relay 706 before the upper winding of relay 706 overcomes the lower winding, thereby preventing the operation of relay 706. Relay 705 operated also causes relay 620 to operate over a circuit previously described thereby disconnecting the alternating current from the line and terminating the previous pulse. Thus on high dial speeds the period between pulses during which alternating current is connected to the line is determined by the operating time of the relay 722 minus the operate time of relay 620 plus the release time of the relays 705 and 620 regardless of the per cent break of the pulses received.

Let us assume that the dial at the calling station A has a speed below the average. Relay 418 reoperates on the succeeding closure of the loop circuit through station A and causes relay 704 to reoperate over a circuit previously described. However, before the relay 418 releases on the succeeding open period of the pulse to permit the operation of relay 705 which closes the circuit through the lower winding of relay 706 the upper winding of relay 706 is energized in a circuit previously described and relay 706 operates. Operation of relay 706 opens the holding circuit previously described for relay 626 permitting relay 626 to release and release the relay 620 which in turn releases and connects the alternating current to the line as described hereinbefore sending a pulse to the distant office. Thus, on slow dial speeds, the period between pulses during which no alternating current is connected to the line is determined by the operate time of relays 706 and 620 plus the release time of relay 626 minus the release time of relay 620 regardless of the percentage break of the pulses received. The relay 706 operated also short-circuits the winding of relay 707 but relay 706 reoperates on the next pulse before relay 707 has time to release. The condenser 622 and the resistance 621 are bridged about the winding of relay 620 in order to improve pulsing.

On single pulse digits or on the last pulse of other digits, the period of the pulse during which no alternating current is connected to the line is the same as on slow dial speeds regardless of the speed of the pulsing received. In this case, the relay 706 operated, short-circuits the winding of relay 707, causing relay 707 to release and in turn operate the relays 606 and 724 and release the relays 623 and 624 over circuits previously described. Relay 623 released, reconnects the conductors 670 and 671 to the right windings of repeating coil 607. Relay 624 released, releases relay 601 and disconnects ground from condensers 672 and 673 in the manner previously described. Relay 601 released removes the short circuits from the left windings of repeating coil 606 and releases relay 425. Relay 425 being slow-to-release prevents acoustic shocks to the originating party before reestablishing the talking circuit. Relay 606 operated removes the short circuits from the telephone repeater 660. Relay 724 operated short-circuits the resistance 723. The relay 724 being operated during the operating time of the relay 722 on the first pulse of each digit increases the current in the lower winding of relay 722, thereby making relay 722 faster to operate so as to compensate for the fact that the relays delivering pulses to this circuit are slower to release on the first pulse of a digit than on succeeding pulses.

Called subscriber answers

When the pulsing is completed and the called party answers, a pulse of alternating current is

received over the loop established from conductor 670 through the upper right winding of repeating coil 607, resistance 609, copper oxide rectifiers 610, 611, 612 and 613, the left winding of relay 615, the lower winding of repeating coil 607 to conductor 671. The manner in which this answering supervisory pulse is sent from the distant end will be described hereinafter in connection with an incoming call. Relay 615 operates on the rectified current and establishes a circuit from ground through the right front contact of relay 615, over conductor 746, the upper back contact of relay 726, conductor 745, the upper inner front contact of relay 629, conductor 437, the upper back contact of relay 420, winding of relay 420, to battery through resistance 422. Relay 420 operated locks in a circuit extending from battery through resistance 422, the winding of relay 420 the upper front contact of relay 420 to ground through the upper inner front contact of relay 419. At the end of the supervision pulse, relay 615 releases on the open circuit and removes the short circuit from the winding of relay 411. Relay 411 operates in a circuit extending from battery through resistance 421, winding of relay 411, the upper front contact of relay 420 to ground on the upper inner front contact of relay 419. Relay 411 operated reverses battery and ground toward the originating end. This reversal may be used for any of the purposes well known in the art, such as message register control or operator's supervision. The circuit is now ready for talking. During talking, relays 411, 417, 418, 419, 420, 428, 514, 545, 606, 620, 627, 629, 631, 701, 704, 706 and 724 remain operated.

Release of connection

If the called end disconnects first, a pulse of alternating current is received from the distant private branch exchange causing relay 615 to operate in the manner described hereinbefore. Operation of relay 615 places a ground on the conductor 437 as described heretofore. This places a short circuit through the lower front contact of relay 411 around the winding of relay 420. Relay 420 releases and opens the holding circuit described for relay 411. Relay 411, however, remains operated through the upper back contact of relay 420 to the ground supplied from the front contact of the relay 615. When the pulse of alternating current from the distant private branch exchange terminates, relay 411 releases and again reverses the battery and ground to the originating end. If the called party removes his receiver again before the originating end disconnects, alternating current will be connected again to the conductors 670 and 671, and the relays 615, 411 and 420 will operate in the manner described heretofore.

If the calling party A disconnects first, relays 417 and 418 release on open circuit. Relay 417 released, releases relay 419. Relay 418 released, releases relay 514 and operates relays 623 and 624 in a circuit previously traced herein. Relay 418 released, removes the short circuit around the winding of relay 705. Relay 623 operated disconnects the conductors 670 and 671 from the repeating coil 607. Relay 624 operated, operates relay 601 which in turn operates relay 425 as described heretofore. When the short circuit is removed from relay 705 by the release of relay 418, the relay 705 operates in series with resistance 710 and the winding of relay 704. Relay 705 operated holds the relay 620 operated to ground on the upper inner front contact of relay 627 over a circuit previously described, releases relay 706 by applying ground to the lower winding of relay 706, and operates relays 720 and 722 in the manner previously described herein. When the relay 706 releases, the relays 626 and 707 operate over circuits described heretofore. Relay 707 operated, releases relay 606. When relay 722 operates, relays 704 and 705 release. Relay 705 released, releases relays 722, 720 and 620, holds relay 626 operated over a circuit including the upper contact of relay 626 and normal contacts of relays 418 and 729, and again permits relay 706 to operate in the manner described heretofore. Relay 620 released connects conductors 670 and 671 to the alternating current source in the manner described heretofore as a disconnect signal to the distant private branch exchange. Relay 706 operated, releases relay 707. Relay 514 released, releases relay 701. Relay 701 released, releases relays 631, 411, 420 and 545. Relay 631 released, releases relays 428, 623, 624 and 629, and removes ground from the sleeve terminal 410 of the selector S1. Relay 623 released, terminates the alternating current pulse that is sent to the distant private branch exchange. Relay 624 released, releases relay 601 which in turn releases relays 425 and 627. Relay 627 released, releases relays 626, 706 and 724, removes ground from the sleeve of the selector S1 and thereby restores the circuit to normal.

Outgoing call from attendant to distant exchange

When a subscriber desires a private branch exchange attendant to complete a call over this trunk, he dials for the attendant in the usual manner. The attendant inserts the plug 533 of the cord 534 into the calling jack 529 and obtains the number desired by the calling subscriber and inserts the plug 505 of the dial cord associated with the dial 500 into the dial jack 509 associated with the trunk circuit. Also, the attendant inserts the plug 535 associated with the cord 534 into the talking jack 543 associated with the trunk circuit. The trunk circuit is so arranged that a cord may be connected to either the dial jack 509 or the talk jack 543 first. Assuming that the attendant plugs into the dial jack 509 first, relay 513 operates in a circuit extending from ground through the winding of relay 501 in the attendant's dialing cord, the sleeve of plug 505 and the sleeve of jack 509, the winding of relay 513, conductor 455, the lower back contact of relay 419, conductor 452, the lower back contact of relay 716 to battery through resistance 717. No other relays operate until the plug 505 is fully seated in jack 509. When the plug 505 is fully seated in the jack 509, relay 511 operates in series with relay 418 in a circuit extending from ground through the lower winding of relay 418, conductor 453, the upper outer front contact of relay 513, the tip conductor of jack 509, the tip conductor of plug 505, the loop circuit through the dial 500, the ring conductor of plug 505, the ring conductor of jack 509, winding of relay 511, the upper inner front contact of relay 513, conductor 456 to battery through the upper winding of relay 418. Relay 511 operated, operates relay 512 in a circuit extending from ground through the lower front contact of relay 511 to battery through the winding of relay 512. Relay 512 operates and locks in a circuit extending from battery through the winding of relay 512, the lower inner front contact of relay 512 to ground through the lower inner front contact of relay 513. Relay 512 operated, closes its upper outer front contact to short-circuit relay

511. Relay 511 releases. Relay 512 operated, also closes a circuit from ground through the lower outer front contact of relay 512 through the winding of relay 590, conductor 455, the lower back contact of relay 419, conductor 452, the lower outer back contact of relay 716 to battery through resistance 717. Relay 590 operated, connects ground to the sleeve terminal 410 of the selector S1 in a circuit extending from ground through contact 593 of relay 590, conductor 460 to sleeve terminal 410 of selector S1 as a busy condition. Relay 590 operated also transfers the trunk from the incoming selector S2 to the tip and the ring conductors of the talk jack 543. Relay 418 operates over the circuit previously traced for the operation of relay 511. The relay 428 does not operate on this type of call since the operating path for relay 428 is open at the lower inner back contact of relay 590. After relay 418 operates, the circuit functions as described heretofore in the description of a call being completed from a subscriber at substation A and prepares the tie line circuit in the distant private branch exchange for receiving dial pulses. The circuit is now ready for dialing.

Assume that the attendant inserts the plug 535 of the cord 534 into the talk jack 543 before she inserts the plug 505 of the dialing cord into the dialing jack 509. Relay 590 operates in a circuit extending from ground through the make contact of talk jack 543, winding of relay 590, conductor 455, the lower back contact of relay 419, conductor 452, the lower outer back contact of relay 716 to battery through resistance 717. Relay 590 operated, closes a circuit from ground through the lower winding of relay 418, conductor 453, the upper back contact of relay 513, the upper outer front contact of relay 590, resistance 515, conductor 456 to battery through the upper winding of relay 418. Relay 590 operated, also grounds the sleeve of the selector S1 over a circuit previously described, connects the tip and ring of the trunk to the talk jack as previously described, opens its lower outer back contact, thereby preventing the operation of relays 715, 729 and 627, opens the operating path for relay 428 as previously described, and opens the operating paths for relays 630, 716 and 726.

In the dialing operation the attendant dials the desired number by means of dial 500, and the dial pulses cause relay 418 to operate, and the circuit functions in the manner outlined heretofore and supplies the corrected alternating current dial pulses to the distant private branch exchange. When dialing is completed, the attendant removes the plug 505 from the dial jack 509. Relays 513 and 512 release but relay 418 remains operated under control of relay 590.

Called party answers

When the called party answers, a pulse of alternating current is connected to conductors 670 and 671 as previously described and causes relay 615 to operate. Operation of relay 615 furnishes a ground through its right front contact which causes relays 411 and 420 to function in the manner outlined heretofore in completing a call from a subscriber at substation A. Relay 411 in operating connects the upper low resistance winding of relay 424 in series with resistance 426 across the tip and ring conductors of the trunk to give the attendant an answering supervisory signal. The circuit may be traced from tip conductor of talking jack 543, contact 597 of relay 590, conductor 463, upper back contact of relay 428, conductor 432, upper left winding of coil 604, conductor 429, upper front contact of relay 411, conductor 450, contact 595, conductor 451, resistance 426, upper winding of relay 424, conductor 430, lower left winding of coil 604, conductor 433, back contact of relay 428, conductor 464, innermost upper front contact of relay 590 to the ring of jack 543. Direct current flowing over this circuit from the attendant's cord 534 gives her a signal in a well-known manner that the called party has answered.

Release of the connection

If the called party disconnects first, a pulse of alternating current is received from the distant office over conductors 670 and 671. This alternating current pulse causes relays 615, 411 and 420 to function in the manner described heretofore for the completion of a call from the subscriber at substation A. The release of relay 411 disconnects the relay 424 and resistance 426 from the trunk, causing the attendant to receive a disconnect signal. If the calling end disconnects first, relay 590 releases and in turn releases relay 418, and the circuit functions in the manner described heretofore in the completion of a call from a subscriber at substation A.

Incoming call

Assume that it is desired to make a call from the line A1 in a distant exchange, such as P. B. X. 2 to a line, such as line B, in P. B. X. 1. Referring to Figs. 2 and 3, such a connection is extended by way of line finder LF1, selector S3, trunk T, selector S2, and connector C. When the trunk circuit T is seized by the distant P. B. X. 2, a pulse of alternating current is received over conductors 670 and 671 (Fig. 6) and is rectified by copper oxide rectifiers 610, 611, 612 and 613 in a manner well known to the art. This rectified current operates relay 615 in the manner previously described. Relay 615 operated, completes a circuit from ground through the right front contact of relay 615 over conductor 746, the upper back contact of relay 726, conductor 745, the upper inner back contact of relay 628, conductor 736, the upper back contact of relay 716 to battery through the winding of relay 718. Relay 718 operated, connects ground to the sleeve terminal 410 of the selector S1 as a busy condition over a circuit extending from ground, through the upper middle front contact of relay 718, the upper back contact of relay 701, conductor 439 to the sleeve terminal 410 of the selector S1. Relay 718 locks in a circuit extending from battery through the winding of relay 718, the upper back contact of relay 716 to ground through the upper inner front contact of relay 718. Relay 718 operated establishes a circuit from the upper outer armature of relay 718 over conductor 438, through resistance 426, the upper winding of relay 424, conductor 430, the lower left winding of repeating coil 604 to the ring conductor 433 of the trunk circuit, the upper inner back contact of relay 428, conductor 464, the upper inner back contact of relay 590 to the ring terminal of the selector S2. A circuit is also closed from the upper outer front contact of relay 718 over conductor 429, through the upper left winding of repeating coil 604, tip conductor 432, the upper outer back contact of relay 428, conductor 463, contact 596 of relay 590 to the tip conductor of the incoming selector S2. Thus the upper winding of relay 424 is connected in series with resistance 426 and the left windings of the

repeating coil 604 and across the tip and the ring conductors of the incoming selector S2. Operation of relay 718 also closes a circuit from ground through the lower front contact of relay 718, over conductor 576, through the lower outer back contact of relay 590 over conductor 466 to the battery through the winding of relay 729. This ground is extended also from conductor 466 through the lower outer back contact of relay 428 over conductor 467, to battery through the winding of relay 715 and also to battery through the winding of relay 703. Relays 703, 715 and 729 operate. A ground is also connected from the lower front contact of relay 718, through the lower inner back contact of relay 716, over conductor 452, lower back contact of relay 419, conductor 455, thereby short-circuiting the winding of relays 590 and 513. The operating circuit of relay 590 was previously traced from battery through resistance 717 and the lower outer back contact of relay 716 to conductor 452. This prevents the operation of relays 509 and 513 thereby preventing mutilation of a call if an operator at P. B. X. 1 plugs into the jack 509 or 543 over a busy test. At the termination of the alternating current pulse, relay 615 releases. Relay 703 operated, holds the upper winding of relay 424 in series with resistances 712 and 426 in series with the left windings of repeating coil 604 and the pulsing contacts of relays 705 and 626 across the tip and the ring conductors of the incoming selector S2. This circuit includes the loop from conductor 429 through the upper middle front contact of relay 703, the upper outer front contact of relay 705, in parallel with the circuit through the lower back contact of relay 626 completed over conductors 754 and 755 through the upper inner front contact of relay 703 and resistance 712 in addition to the loop circuit previously traced through the upper winding of relay 424 and resistance 426. Relay 703 operated also establishes a circuit from battery through the winding of relay 628, over conductor 738, through the upper outer front contact of relay 703, over conductor 752 to the lower outer front contact of relay 623 for supervisory purposes. Relay 715 operated, opens its lower back contact thereby opening the circuit previously traced for the operation of relay 428. A circuit is also closed from ground through contact 774 of relay 715, over conductor 451 to battery through the winding of relay 545, thereby causing relay 545 to operate and apply a busy ground to the sleeve terminal of jack 543 and to apply a battery through resistance 547 to ground, through lamp 548 causing lamp 548 to light as a busy signal to the attendant. Operation of relay 715 also closes a tone circuit from ground, through the left winding of transformer 731, through condenser 730, through contact 770 of relay 715 to the upper inner front contact of relay 701 which then leads over conductor 434 to the ring conductor of the outgoing trunk circuit. This tone is furnished by the interrupter 733 which makes and breaks a battery circuit through the right winding of transformer 731. A tone is induced in the left winding of transformer 731 as a busy tone to the outgoing selector S1 in case of a double connection. Relay 729 operated, establishes a circuit from ground on the upper back contact of relay 705, through the upper front contact of relay 729, over conductor 741, through the upper back contact of relay 630, through conductor 442, through the lower back contact of relay 704 to battery through the winding of relay 704. This places relay 704 under control of relays 705 and 630.

When the incoming selector S2 functions, ground is connected over the sleeve of the incoming selector S2, conductor 580 to the battery through the winding of relay 719. Relay 719 operated, causes the operation of relays 726 and 716 and holds relays 715, 729 and 703 operated. The operating circuit for relays 726 and 716 extends from ground on the right back contact of relay 615, over conductor 747, through the upper inner front contact of relay 719, conductor 468, the lower inner back contact of relay 428, conductor 465, contact 592 of relay 590, conductor 577 to battery through the windings of relays 716 and 726. The holding ground for relays 715, 729 and 703 extends from the lower front contact of relay 719, over conductor 576, through the lower outer back contact of relay 590 to conductor 466 and thence to the windings of relays 729, 715 and 703 over circuits previously traced. Relays 726 and 716 operated, lock under control of relay 729, over circuits extending from ground, through the lower front contact of relay 729, the lower front contact of relay 726 to battery through the winding of relay 726 and to battery through the winding of relay 716. Relay 726 operated connects the front contact of relay 615 to the winding of relay 630 in a circuit extending from the front contact of relay 615, over conductor 746, through the upper front contact of relay 726, conductor 578, contact 591 of relay 590, conductor 575 to battery through the winding of relay 630 for pulsing. Relay 716 operated, opens the operating circuit previously traced for relay 718 and opens the operating path of relay 590. Relay 716 operated, also removes ground from the resistance 717 to prevent current drain and provides a holding path for relay 545 in a circuit extending from ground, through the upper front contact of relay 716 to conductor 451 and thence to the winding of relay 545. Relay 545 closes another holding path through relay 627 in a circuit extending from ground, through the lower front contact of relay 545, over conductor 540 to battery through the winding of relay 627.

Calling party dials

Relay 615 follows the alternating current pulses from the distant P. B. X. 2 and in turn causes the relay 630 to pulse over a circuit previously described. Relay 630 operates on the first pulse of relay 615 and opens the short circuit around relay 705 permitting relay 705 to operate in a circuit extending from battery through the winding of relay 704, resistance 710, lower front contact of relay 704, the winding of relay 705, the upper back contact of relay 722 to ground supplied to conductor 751 from the upper inner front contact of relay 627. The resistance 727 and the condenser 728 are bridged around relay 630 in order to aid in pulsing. The relay 704 remains locked in the operated position. Relay 705 operated removes the ground supplied to the upper armature of relay 630 over the circuit previously described, closes a circuit from ground on the upper inner front contact of relay 705 to battery through the lower winding of relay 706 which opposes the upper winding of relay 706 causing relay 706 to release, and removes the ground from the biasing circuit which has previously been traced through the lower winding of relay 722. When off-normal ground through the lower back contact of relay 705 is removed from the upper wind-

ing of relay 722, condenser 763 which has been discharged by this ground now charges in a circuit from battery through the upper winding of relay 722 to ground through condenser 763 and resistance 762. Current will continue to flow through the upper winding of relay 722 during the charging of condenser 763 and the ampere turns produced by the charging current in the upper winding of relay 722 oppose the ampere turns in the lower winding of relay 722. As the condenser 763 becomes charged, the ampere turns in the upper winding of relay 722 decrease and the relay 722 is caused to operate by the ampere turns in the lower winding of relay 722 in a manner well known to the art. Relay 705 operated also causes relay 720 to operate in a circuit extending from the upper inner front contact of relay 627, conductor 751, the lower front contact of relay 705, the winding of relay 720 and resistance 721 in parallel, to battery through resistance 725. Relay 720 operated, opens the circuit through the lower back contact of relay 720 to resistance 711 thereby removing the shunting resistance 711 from around the winding of relay 705. When relay 706 releases, the upper front contact of relay 706 is opened and the short circuit around the winding of relay 707 is removed. Relay 707 operates in a circuit extending from ground on the upper inner front contact of relay 627, conductor 751, winding of relay 707, to battery through resistance 709. Closure of the upper back contact of relay 706 establishes a circuit from ground on the upper inner front contact of relay 627, conductor 751, the upper back contact of relay 706, conductor 756, lower front contact of relay 627, to battery through the winding of relay 626. Relay 626 operates. Operation of relay 707 opens the circuit through the upper winding of relay 724. Relay 724 remains operated in a circuit from battery through its lower winding and its lower front contact in parallel with resistance 725 and in series with the winding of relay 720 and resistance 721 to ground on the upper inner front contact of relay 627 over the circuit previously traced. Relay 707 operated, also opens the circuit previously traced from off-normal ground on the upper inner front contact of relay 627, to the winding of relay 601 thereby permitting relay 606 to release. Relay 707 operated, also closes a circuit from off-normal ground on the upper inner front contact of relay 627, conductor 751, the upper front contact of relay 707, contact 773 of relay 715, conductor 734, to battery through the winding of relay 601. Relay 601 operated, causes relay 425 to operate over a circuit previously described. Relay 601 operated, also short-circuits the upper left and the lower left windings of repeating coil 604 and connects resistance 602 and condenser 603 across the pulsing loop to the incoming selector S2 in order to improve the pulsing. Relay 425 operated, performs no function at this time.

When the relay 722 operates, it opens its upper back contact and thus opens the holding circuit previously described for relays 704 and 705 permitting these relays to release. Relay 704 released, short-circuits resistance 710 through the lower back contact of relay 704 so that relay 704 operates quickly when its operating circuit is reclosed. Relay 705 released, reconnects the ground on the upper back contact of relay 705 to the upper armature of relay 630 over a circuit previously described, and removes the ground from the lower winding of relay 706. This ground has previously discharged condenser 760. Now when the ground is removed condenser 760 charges in a circuit from battery through the lower winding of relay 706 to ground through condenser 760 and resistance 761. Current will continue to flow through the lower winding of relay 706 during the charging of condenser 760 and the ampere turns produced by the charging current in the lower winding of relay 706 opposes the ampere turns in the upper winding of relay 706. As the condenser 760 becomes charged the ampere turns in the lower winding of relay 706 decrease and the relay 706 is caused to operate by the ampere turns in the upper winding of relay 706 in a manner well known to the art. Relay 705 released, also opens the holding circuit previously described for relays 720 and 724, and the bridge across the tip and ring conductors of the incoming selector S2 as previously described since relay 626 is now operated. The relay 720 released closes a circuit from ground on the upper inner front contact of relay 627 over conductor 751, the lower back contact of relay 720, resistances 711 and 710 to battery through the winding of relay 704. Relay 704 does not energize sufficiently to operate but only sufficiently to cause relay 704 to operate quickly when relay 630 is released on the next dial pulse. Relay 720 released, also closes a circuit from ground on the upper inner front contact of relay 627 over conductor 751, the lower back contact of relay 705, the upper back contact of relay 720 to battery through the upper winding of relay 722 causing relay 722 to release in a manner well known to the art and close its back contact. When the bridge across the tip and the ring conductors of the incoming selector S2 is opened by the release of relay 705 the incoming selector S2 will step.

Let us assume that the dial used at the distant P. B. X. 2 has a speed in excess of the average. Relay 630 releases, reoperating relay 704 in the circuit previously traced. Relay 630 reoperates in the succeeding operation of relay 615, permitting relay 705 to reoperate in the circuit previously described. Relay 705 operated closes the circuit through the lower winding of relay 706 before the upper winding of relay 706 is energized thereby preventing the operation of relay 706. Relay 705 operated also closes the loop circuit previously described to the incoming selector S2, terminating the previous pulse. Thus on high dial speeds the period between pulses during which the circuit to the incoming selector S2 is closed is determined by the operating time of the relay 722 plus the release time of the relay 705 regardless of the per cent break of the pulses received.

Let us assume that the dial used at the distant P. B. X. 2 has a speed less than the average. Relay 630 releases on the succeeding open period of the pulse and reoperates relay 704 in the circuit previously traced. Before relay 630 reoperates on the succeeding pulse relay 706 operates in a circuit through the upper winding of relay 706 as previously described. Operation of relay 706 opens the holding circuit previously described for relay 626 permitting relay 626 to release and release the relay 620 which in turn releases and closes the loop to the incoming selector S2 causing a pulse. Thus, on slow dial speeds, the period between pulses during which the circuit to the incoming selector S2 is opened is determined by the operate time of relay 706 plus the release time of relay 626 regardless of the percentage break of the pulses received. The relay 706 operated also short-circuits the wind-

ing of relay 707 which is slow in releasing but relay 706 reoperates on the next pulse before relay 707 has time to release.

On single pulse digits or the last pulse of other digits, the period of the pulse during which the circuit to the incoming selector S2 is opened is the same as on slow dial speeds regardless of the speed of the pulsing received. In this case, the relay 706 operated, short-circuits the winding of relay 707 causing relay 707 to release and in turn operate the relays 606 and 724 over circuits previously described and release the relay 601. Relay 601 released removes the short-circuits from the left windings of repeating coil 604, releases relay 425 and closes through the transmission circuit. Relay 606 operated removes the short-circuits from the telephone repeater 660. Relay 724 operated short circuits the resistance 723. The relay 724 being operated during the operating time of the relay 722 on the first pulse of each digit increases the current in the lower winding of relay 722, thereby making relay 722 faster to operate so as to compensate for the fact that the relays delivering pulses to this circuit are slower to release on the first pulse of a digit than on succeeding pulses.

Called party answers

When the pulsing is completed and the called party answers, battery and ground are reversed in the connector C in a manner well known to the art. This reversal causes polarized relay 424 to operate over the loop circuit previously described. Operation of relay 424 operates relay 423 in a circuit from ground through the lower front contact of relay 424 to battery through the winding of relay 423. Relay 423 operated, operates relays 623 and 624 in a circuit extending from ground on the upper middle front contact of relay 719 over conductor 435, the lower front contact of relay 423, the lower back contact of relay 420, conductor 436, the upper back contact of relay 629, conductor 440, the windings of relays 623 and 624 in parallel, to battery through the lower back contact of relay 630. Relay 624 operated connects ground through condensers 672 and 673 to the tip conductor 670 and the ring conductor 671 of the line to the distant P. B. X. 2, to reduce the amount of induction in other lines and operates relay 601 which in turn operates relay 425 over circuits previously described. Relay 623 operated sends a pulse of alternating current as a supervisory signal to the calling party in the manner previously described, and establishes a circuit from ground through the lower outer front contact of relay 623 over conductor 752, the upper outer front contact of relay 703, conductor 738 to battery through the winding of relay 628. Relays 623 and 624 lock in a circuit extending from ground through contact 771 of relay 715, conductor 753, the lower middle front contact of relay 623, the upper outer back contact of relay 629, windings of relays 623 and 624 in parallel, to battery through the lower back contact of relay 630. After an interval relay 628 operates and operates relay 629 from ground through the lower front contact of relay 628. Operation of relay 628 also closes a circuit from ground on the lower front contact of relay 703, conductor 745, the upper front contact of relay 628, conductor 437, winding of relay 420 to battery through resistance 422 thereby energizing relay 420. Operation of relay 629 releases relays 623 and 624 and holds relay 420 which locks to ground supplied over conductor 451 from contact 774 of relay 715 and from the upper front contact of relay 716. When relays 623 and 624 release, the alternating current is disconnected from conductors 670 and 671 of the line to the calling P. B. X. 2, the transmission circuit is closed and relays 601, 425, 628 and 629 release. When relay 629 releases relay 411 operates over the circuit previously described but performs no function at this time. The circuit is now ready for talking.

Release of connection

If the called party B disconnects first, battery and ground are reversed in the connector C, and, since relay 424 is a polarized relay, it releases and in turn releases relay 423. Relays 423 and 424 released, operate relays 623 and 624 under control of relays 420 and 629 over circuits previously traced. Relay 623 operated connects the source of alternating current to the calling P. B. X. 2 in the manner described heretofore, locks independently of relays 423 and 424 to ground on contact 771 of relay 715 over a circuit previously described, and closes the operating circuit previously described for relay 628. Relay 628 operated, in turn operates relay 629 as previously described. Relay 629 operated releases relays 623, 624 and 420. Relay 623 released, terminates the pulse of alternating current to the calling P. B. X. 2, and releases relay 628 which in turn releases relays 629 and 411. If the called party B comes in on the connection again before the calling P. B. X. 2 disconnects, relays 424 and 423 reoperate and the circuit functions in the manner described heretofore. If the called end flashes, the circuit is so arranged that no matter how fast the flashing, a disconnect signal will not be given to the calling P. B. X. 2.

If the calling end disconnects first, a pulse of alternating current is received from the calling end as described heretofore. Relay 615 operates and in turn operates relay 630 as described heretofore. Relay 630 operated removes the short circuit around the winding of relay 705 and removes the operating battery from relay 623 preventing operation of relay 623 if the originating end disconnects before the calling end. When the short circuit is removed from relay 705 by the operation of relay 630 the relay 705 operates in series with resistance 710 and the winding of relay 704 over the circuit previously traced. Relay 705 operated, releases relay 706 by applying ground to the lower winding of relay 706, operates relays 720 and 722 in the manner previously described herein, and holds the loop to the called end closed. When the relay 706 releases, the relays 626 and 707 operate over circuits described heretofore. Relay 707 operated releases relay 606 and operates relay 601 which in turn operates relay 425. When relay 722 operates, relays 704 and 705 release. Relay 627 now holds under control of relay 601 to ground on the left inner front contact of relay 601. Relay 705 released, opens the loop to the called end, releases relays 722 and 720 and again permits relay 706 to operate in the manner described heretofore. If relay 424 is operated when the calling end disconnects, relay 424 releases when the loop to the called station B is opened. However, release of relay 424 is ineffective since the operating battery for relays 623 and 624 is still held open by relay 630. The resistance 721 is connected in parallel with relay 720 to make relay 720 slow to release to insure the release of relay 704 before relay 722 releases. Relay 706 operated, releases relay 707 which in

turn operates relay 606 over a circuit previously described, and releases relay 601 which in turn releases relay 425. When the incoming selector S2 releases, ground is removed from the sleeve releasing relay 719. Relay 719 released, releases relays 703, 715 and 729. When relay 729 releases the relays 726 and 716 remain operated under control of relay 615 over a circuit previously traced. At the end of the disconnect signal, relay 615 releases, in turn releasing relays 726, 716 and 630. Relay 716 released, releases relay 545. Relay 545 released, releases relay 627 which in turn releases relays 706 and 606, and removes ground from the sleeve terminal 410 of the outgoing selector S1 thereby restoring the circuit to normal.

Flashing supervision

A detailed description will now be given of the operation of the system when a called station flashes his switch-hook for the purpose of securing the attention of an attendant operator. In order that this feature of the invention may be more clearly understood, those parts of the detailed circuits necessary for its disclosure have been included in the diagram of Figs. 2 and 3.

With reference, therefore, to these figures assume that a connection has been extended from a station in exchange P. B. X. 1 by way of the attendant operator's cord circuit 534 over the trunk T to the exchange P. B. X. 2 and thence through selector S4 and connector C1 to a called station B1. Assume also that, after the connection has been fully established in the manner already described in detail, the party at station B1 wishes to attract the attention of the operator and that he flashes his switch-hook. While the called party's receiver is off the switch-hook, supervisory relay 324 and relay 323 are in an operated condition, the relay 324 receiving current from battery at the connector switch C1. Also, relays 311 and 320 are operated. Upon the first opening of the loop at the called station when the called party begins to flash his switch-hook, the called line supervisory relay 330 releases and current is reversed in the connector switch C1 in the well-known manner and the polarized supervisory relay 324 releases, in turn releasing relay 323. The release of relay 324 causes the operation of relay 325 to send a signal of alternating current as a disconnect signal from the source 317 over the trunk to the originating end. The circuit of relay 325 extends from the grounded contact of relay 324, front contact of relay 320, conductor 351, back contact of relay 629 to the winding of relay 325. The operation of relay 325 closes an energizing circuit for relay 628, which in turn closes an operating circuit for relay 629. Relay 628 closes a circuit from ground through its right-hand armature, thence through the front contact of relay 311 and resistance 322 to battery. This shunts relay 320 which thereupon releases. Relay 311 continues to hold in a circuit from battery, through resistance 321, winding of relay 311, normal contact of relay 320, conductor 350 to ground at the contact of relay 628 and later to ground at the contact of relay 629. Relay 629, which is slow to operate and slow to release, operates after an interval and opens the circuit of relay 325, which releases and removes the alternating current from the trunk. Relay 325 in turn opens the circuit of relay 628, which releases after an interval and brings about the release of relay 629 after a further interval. When ground is removed from conductor 350, relay 311 releases.

On the next closure of the loop at the called station, supervisory relay 330 reoperates to reverse the direction of current, and relays 324 and 323 again operate. Relay 323 completes a circuit from ground through its front contact, upper back contact of relay 320, conductor 351, left contact of relay 629 through the winding of relay 325 to battery. Relay 325 operates and applies alternating current to the line to indicate that the called subscriber's receiver is off the hook. Relays 628 and 629 again operate. When ground is applied to conductor 350, relay 320 operates in a circuit extending from said conductor through the normal contact of relay 320, winding of said relay, resistance 322 to battery. Relay 320 operates and locks to its own grounded contact. Relay 320 in operating opens the circuit of relay 325, which releases and removes the alternating current impulse from the line. Relay 325 also causes the release of relays 628 and 629. When ground is removed from conductor 350, a shunt is removed from the winding of relay 311, and this relay now operates over a circuit leading to ground through the operated contact of relay 320.

This procedure continues so long as the called party does not open and close his switch-hook contacts faster than the rate at which the relays are designed to transmit the alternating current impulses over the trunk. In practice, however, the called party is likely to operate his switch-hook at a rate greater than the pulsing rate of the relays. And, unless some provision were made the last alternating current impulse transmitted when the called party had finished operating his switch-hook might or might not represent the condition in which the called party leaves the switch-hook after his flashing operation. That is to say, he may leave the receiver off the hook following flashing or he may hang it up. Obviously it is necessary that the last signal impulse of alternating current should represent the condition of the switch-hook at that time in order that the equipment at the originating office may so operate as to advise the operator of the exact condition of the called party's switch-hook. In order that this requirement may be met, the circuits are so designed that the alternating current pulses are sent at the same rate as the flashing of the called party's switch-hook until the rate of the switch-hook flashing exceeds that of the impulse transmitting relays, and thereafter alternating current impulses are transmitted at the rate for which the controlling relays are designed. But the transmitting relays in every case test the condition of the called party's switch-hook before transmitting the alternating current impulse. For example, if the last alternating current impulse transmitted represented the closed condition of the called party's loop, when the relays are ready to transmit the next alternating current impulse representing the open condition of the loop, a test is first made to determine whether the loop is in the open or closed condition. If, at that instant, it is in a closed condition no impulse will be sent until the loop is found to be in an open condition. Then an alternating current impulse is sent representing the open condition of the called party's loop. In this way each alternating current impulse represents the exact condition of the called party's loop at the time it is sent regardless of how many times the loop may be opened and closed by the

switch-hook between the transmission of successive alternating current impulses.

An analysis of the circuits will show that the test for the condition of the called party's loop is made alternately at the front and back contacts of supervisory relay 324, which is controlled by said loop. If the loop is in a closed condition, relays 324 and 323 are energized; also, switching relays 320 and 311 are energized, and relay 325 after having sent the last pulse is now released. Should the loop be opened suddenly following its last closure, relay 324 would release and close a circuit from ground through the front contact of operating relay 320 to conductor 351. Had a sufficient interval elapsed between the last closure of the loop and the next opening, the timing relay 629 would have released, and the circuit by way of conductor 351 would now be completed to the relay 325. However, since the loop was opened suddenly following its closure, relay 629 does not have time in which to release, and, therefore, the release of relay 324 does not cause the immediate reoperation of relay 325. If the loop, which is now opened, remains opened until relay 629 measures its interval and releases, relay 325 will then be operated to transmit an impulse representing the opened condition of the called loop. But, if the loop is immediately closed again and is in a closed condition when relay 629 releases, relay 325 is not operated for the reason that relays 324 and 323 are now operated due to the closure of the loop. It follows, therefore, that relay 325 will not operate again to transmit a signal representing the open condition of the loop until relay 629 has released and the loop is again opened following the release of said relay 629. When this occurs, relay 325 operates and transmits the impulse to the originating end. Likewise, relay 325 having operated to transmit an impulse representing the open condition of the loop, this relay cannot again be operated to transmit a closed loop signal until relay 629 has measured its full interval and the loop is brought to a closed condition thereafter.

Therefore, no matter how rapidly the switch-hook is flashed, the signal impulses are sent to the originating end in an orderly manner, representing alternately the open and closed condition of the called station loop. And, when the party at the called station finally ceases flashing the switch-hook, the last pulse to be sent to the originating end will definitely represent the condition in which the switch-hook is left.

Referring now to the originating exchange P. B. X 1, the effect of these supervisory impulses on the operator's supervisory lamp 591 will now be briefly described. Each alternating current impulse transmitted over the trunk T operates the relay 615 in the manner fully described hereinbefore. Assuming that an impulse representing a closure of the called party's loop is transmitted, relay 615 operates and closes a circuit from ground through its armature, normal contact and winding of relay 420, resistance 422 to battery. Relay 420 operates and locks through its front contact. Relay 420 completes a circuit from battery, through resistance 421, relay 411 to ground through the front contact of relay 420. Relay 411, however, is shunted by a circuit from battery, through resistance 421 and back contact of relay 411 to ground at the armature of relay 615. When relay 615 releases at the end of the impulse, the shunt is removed and relay 411 operates. Relay 411 bridges the relay 424 across the tip and ring conductors of the connection leading to the operator's cord circuit 534. In the well-known manner this bridge causes the extinguishment of the operator's supervisory lamp 591, indicating that the called party's receiver is off the hook.

When the next impulse is sent over the trunk T representing the open condition of the called line, relay 615 operates and closes a circuit from ground, through its contact, front contact of relay 411, resistance 422 to battery. Relay 420 is shunted by this circuit and releases. Relay 411 remains energized in a circuit from battery, through resistance 421, winding of relay 411, closed contacts of relay 420 to ground at the contact of relay 615. At the end of the alternating current impulse relay 615 again releases and the circuit of relay 411 is opened. Relay 411 opens the bridge across the tip and ring conductors and the operator's supervisory lamp 591 lights to indicate that the called loop is opened.

Traffic registration

On either an incoming call from a distant P. B. X. 2 or an outgoing call to a distant P. B. X. 2, relay 545 operates thereby opening one of the multiple paths of the traffic register circuit over conductor 546. When all the tie lines in a particular group are busy, all the relays 545 in the various tie lines operate and the ground circuit to the traffic register is opened, thereby causing a registration.

Seizure without subsequent dialing

If relay 615 operates falsely due to surges or if relay 615 operates on an incoming call and if no dialing follows the seizure, the tie line will automatically time out in the following manner. When the circuit is seized the various relays and equipment function in the manner previously described under seizure on an incoming call. When the incoming selector S2 is seized, ground is connected from the incoming selector S2 to conductors 580 and 581 in a manner well known to the art. If no dialing occurs, conductor 581 remains grounded and battery on conductor 713 is supplied from a timing circuit in a manner well known to the art through the lower winding of relay 702 to the ground on conductor 581. Relay 702 operates and locks to battery through the lower inner front contact of relay 702. After an interval, ground is supplied from the timing circuit over conductor 714 and is extended through the lower outer front contact of relay 702, the upper front contact of relay 726, conductor 578, contact 591 of relay 590, conductor 575, to battery through the winding of relay 630. Operation of relay 630 causes the circuit to function as described heretofore under disconnection. Relay 702 locks in a circuit from ground through the upper winding of relay 702, the upper front contact of relay 702, conductor 742 to battery through the lower front contact of relay 630. After an interval, ground is removed from conductor 714 thereby permitting the circuit to restore to normal.

What is claimed is:

1. In a telephone system, a distant office, a trunk line leading to said distant office, an impulse repeater having an input circuit and an output circuit, a relay in said input circuit for causing repeated impulses to be produced in said output circuit, two circuit branches for said trunk for extending outgoing calls over the trunk to the distant office, means for producing impulses representative of a call in either of said

branches, a relay for delivering the impulses for either branch to the relay in said input circuit, and means for delivering the impulses produced in said output circuit to said trunk.

2. In a telephone system, a distant office, a trunk line leading to said distant office, an impulse repeater having an input circuit and an output circuit, a relay in said input circuit for causing repeated impulses to be produced in said output circuit, a branch for said trunk over which calls are extended by automatic switches, a second branch for said trunk over which calls are extended by an operator, means for producing impulses in either of said branches, a relay for delivering the impulses for either branch to the relay in said input circuit, and means for delivering the impulses produced in said output circuit to said trunk.

3. In a telephone system, a trunk line extending to a distant point, an impulse repeater having an input circuit and an output circuit, two circuit branches for said trunk for extending outgoing calls over the trunk to the distant point, means for producing impulses representative of a call in either of said branches, and a single impulse relay common to both branches and serving to deliver to the input circuit of said repeater impulses produced in either of said branches.

4. In a telephone system, a two-way trunk having two branches at one end thereof, an impulse repeater having an input circuit and an output circuit, means for producing impulses representative of a call in either of said branches, means for delivering impulses for either branch to the input circuit of said repeater, means for delivering the impulses in the output circuit of said repeater to said trunk on an outgoing call, and means to deliver impulses incoming over said trunk to said input circuit.

5. In a telephone system, a distant office, a two-way trunk extending to said distant office, a first branch for said trunk for originating calls outgoing over the trunk, a second branch for receiving calls incoming over said trunk, an impulse repeater having an input circuit and an output circuit, and means for delivering the impulses from either said first branch or from said trunk to said input circuit and for delivering the impulses in said output circuit either to said trunk or to said second branch according to the direction of the call.

6. In combination, a repeater having an input circuit and an output circuit, means for sending either direct current or alternating current impulses toward said repeater, means in said input circuit operable in accordance with either said direct current or said alternating current impulses, and means responsive to the impulses produced in said output circuit for sending either alternating current or direct current impulses away from said repeater.

7. In combination, a repeater having an input circuit and an output circuit, means for sending alternating current impulses, means for converting said alternating current impulses into direct current impulses and for delivering said direct current impulses to the input circuit of said repeater, means for transmitting direct current impulses and for delivering them to the input circuit of said repeater, means for producing direct current impulses in the output circuit of said repeater, and means for converting said latter impulses into impulses of alternating current.

8. In combination, an impulse repeater having an input circuit and an output circuit, means for sending either direct current or alternating current impulses toward said repeater, means in said input circuit operable either in accordance with said direct current or said alternating current impulses, means for producing corrected impulses in the output circuit of said repeater, and means responsive to said corrected impulses for sending either alternating current or direct current impulses.

9. In combination, an impulse repeater having an input and an output circuit, a trunk line over which impulses may be sent in either direction, means for switching said input circuit so as to receive impulses coming in either direction over said trunk and for switching said output circuit so as to send out impulses in either direction, and means for correcting the impulses received by the input circuit regardless of the direction of transmission over said trunk.

10. The combination with an impulse repeater having an input circuit and an output circuit of a trunk line over which impulses may be sent in either direction, means for switching said input circuit so as to receive impulses coming in either direction over said trunk and for switching said output circuit so as to send out impulses in either direction, and means effective if the speed of impulse transmission is too high or too low for correcting the impulses received by the input circuit.

11. In a telephone system, a trunk leading to a distant point, two branches for said trunk for originating outgoing calls, means for sending signaling currents over said trunk from the distant point, means for converting said currents into supervisory signals of one character if the call originated in one of said branches, and means for converting said currents into supervisory signals of a different character if the call originated in the other of said branches.

12. In a telephone system, a trunk line extending to a distant office, two branches for said trunk for originating outgoing calls, means for sending signals of alternating current over said trunk from the distant office, means for converting said alternating currents into direct current supervisory signals of reverse polarity if the call originated in one of said branches, and means for converting said alternating currents into open and closed circuit direct current supervisory signals if the call originated in the other of said branches.

13. The combination with an incoming circuit and an outgoing circuit of means for sending signals over said incoming circuit at a given rate, means operable while said incoming signals are being sent for sending signals over said outgoing circuit at a different rate, and means for making a test to determine the condition of said incoming circuit prior to the sending of an outgoing signal.

14. The combination with an incoming circuit and an outgoing circuit of means for sending signals over said incoming circuit at a given frequency, means responsive to the incoming signals for sending signals over said outgoing circuit at a different frequency, and means for making a test to determine the condition of the incoming circuit before each outgoing signal is sent.

15. The combination with an incoming circuit and an outgoing circuit of means for producing signals in said incoming circuit at a given frequency, means operable while said signals are being produced in said incoming circuit for send-

ing signals over said outgoing circuit at a different frequency, and means for making a test of the incoming circuit before each outgoing signal is sent to determine if the incoming circuit has changed its condition since the last outgoing signal was sent.

16. In a signaling system, an incoming circuit and an outgoing circuit, means for sending signals over the incoming circuit at a given frequency, a transmitting device, and means responsive to said incoming signals for operating said device at a frequency differing from that of said incoming signals to send on each operation thereof a signal over said outgoing circuit, and means for rendering each operation of said transmitting device dependent on a change in the condition of said incoming circuit.

17. In a signaling system, an incoming circuit and an outgoing circuit, means for sending signals over the incoming circuit at a given frequency, a transmitting device, and means responsive to said incoming signals for operating said device at a frequency differing from that of said incoming signals to send on each operation thereof of a signal over said outgoing circuit, and means for rendering each operation of said transmitting device dependent on a change in the condition of said incoming circuit as compared with the condition existing on the preceding operation of said device.

18. In a signaling system, an incoming line and an outgoing line, means for producing signals in said incoming line at a given rate, and means operable while said signals are being produced in said incoming line for sending over the outgoing line a series of signals at a different rate and for synchronizing each outgoing signal with an incoming signal.

19. In a signaling system, an incoming line and an outgoing line, means for sending over said incoming line a variable number of signals comprising signals of one character occurring in alternate succession with signals of a second character, and means operable during the interval said signals are being sent for sending over said outgoing line a different number of successive signals and for synchronizing the outgoing signals with incoming signals of both characters.

20. The combination with an incoming circuit and an outgoing circuit of means for sending signals over said incoming circuit at varying rates, and means for sending over said outgoing circuit signals in synchronism with said incoming signals provided the rate of the incoming signals remains on one side of a limiting value, for sending said outgoing signals at a fixed rate if the rate of the incoming signals passes to the other side of said limiting value, and for synchronizing the sending of each outgoing signal with one of the incoming signals.

21. The combination in a signaling system of an incoming circuit and an outgoing circuit, means for sending over said incoming circuit signals of varying duration and at varying frequencies, and means operable while said incoming signals are being sent for sending over said outgoing circuit signals of fixed duration and of a frequency corresponding to the frequency of the incoming signals only if the frequency of said incoming signals is within certain limits and for synchronizing the sending of each outgoing signal with one of the incoming signals.

22. The combination in a signaling system of an incoming signaling circuit having a signal receiving relay therein, switch-hook means for controlling said circuit to send signals to said relay, an outgoing signaling circuit, a source of current for sending signals of different character over said outgoing circuit while said relay is operating in response to said incoming signals, a transmitting relay for applying said source to said outgoing circuit, a circuit for operating said transmitting relay, and means for directing said circuit alternately to a front contact and to a back contact of said signal receiving relay to test the condition of said signal receiving relay before transmission of each outgoing signal.

23. In a signaling system, an incoming line and an outgoing line, means for sending a variable number of successive signals over said incoming line, and means operable during the interval said signals are being sent for sending over said outgoing line a different number of successive signals and for synchronizing each of the outgoing signals with one of the incoming signals.

24. In a signaling system, an incoming line and an outgoing line, means for sending a variable number of successive signals over said incoming line, and means operable during the interval said signals are being sent for sending over said outgoing line a succession of signals the number of which differs from the number of signals sent over the incoming line and varies according to the frequency of the signals sent over said incoming line.

25. In a signaling system, an incoming line and an outgoing line, means for sending over the incoming line a variable number of signals comprising signals of one character occurring in alternate succession with signals of a second character, and means operable during the interval said signals are being sent for sending over said outgoing line a different number of signals of the same character and for synchronizing said outgoing signals with incoming signals of both characters.

26. In a signaling system, an incoming line and an outgoing line, means for sending over the incoming line a variable number of signals comprising signals of one character occurring in alternate succession with signals of a second character, and means operable during the interval said signals are being sent for sending over the outgoing line a different number of successive signals all of like character, each outgoing signal being synchronized with an incoming signal of one character and the succeeding outgoing signal with an incoming signal of the other character.

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